

The American Phytopathological Society

ABSTRACTS

A1

AFLATOXINS, THE BIRTH OF MODERN MYCOTOXICOLOGY. R. J. Cole, National Peanut Research Laboratory, 600 Forrester Drive, Dawson, GA 31742.

A historical background for the birth and development of the science of mycotoxicology and a discussion of significant works prior to and subsequent to the 1960 outbreak of "Turkey X Disease" as they relate to the birth and development of the science of mycotoxicology are presented.

A2

FUSARIUM TOXINS AND THEIR IMPORTANCE IN MYCOTOXICOLOGY. E.B. Smalley, D. Cullen, and R.W. Caldwell, Dept. of Plant Pathology, University of Wisconsin, Madison, WI 53706.

Fusarium colonized foodstuffs are recognized around the world as serious hazards to human and animal health. The species of Fusarium involved and the toxins they produce vary greatly between different geographic locations, climates and regional cultures. In the Northcentral United States, haemorrhagic syndrome, emesis and feed refusal in farm animals results from ingestion of various toxic sesquiterpenes, 12-13 epoxytrichothecenes. Hyperestrogenism which is particularly common in swine is caused by the polyketide, zearalenone. Most of the research to date has been directed towards identifying cultural conditions which affect toxin synthesis and detection methodology. The etiology of Fusarium induced toxicosis is still poorly understood, and the literature is confused by strain misidentifications and taxonomic uncertainties. We present data describing relationships between toxin production, interspecific and interclonal sexual and vegetative compatibility, and the taxonomic positions of Fusarium species.

A4

MYCOTOXICOLOGY. INTRODUCTION TO THE MYCOLOGY, PLANT PATHOLOGY, CHEMISTRY, TOXICOLOGY, AND PATHOLOGY OF NATURALLY OCCURRING MYCOTOXICOSES IN ANIMALS AND MAN. Walter F.O. Marasas, National Research Institute for Nutritional Diseases, P.O. Box 70, Tygerberg 7505, South Africa.

Mycotoxicology is a multidisciplinary science which requires close cooperation between plant pathologists and veterinarians, medical practitioners, chemists, and other scientists. Because of this complex nature, courses in mycotoxicology are not taught at most universities. A significant contribution to the recognition and the control of the mycotoxin problem will be made by the introduction of courses in mycotoxicology in departments of Plant Pathology as well as veterinary and medical schools around the world. The above course is designed to give students an introduction to naturally occurring mycotoxicoses in animals and man. Each mycotoxicosis is treated in a standard way to include the mycology and plant pathology of the toxigenic fungus, clinical signs, pathology and epidemiology of the mycotoxicosis, chemistry and toxicology of the mycotoxin, and methods to control the mycotoxicosis. A set of 72 color slides is included.

A5

MYCOTOXINS AS CHEMICAL/BIOLOGICAL WARFARE AGENTS. C.J. Mirocha,

Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Leaf tissue, yellow powder, whole blood, tissues and urine of victims, and water were received from Kampuchea and Laos and analyzed for trichothecene mycotoxins. The samples were collected in areas exposed to aerial dispersal of chemical agents and from victims of such exposure. The toxins found included T-2 toxin, diacetoxyscirpenol, deoxynivalenol, nivalenol and zearalenone. All of these metabolites are produced as natural products of Fusarium spp. Control samples of soil, water, cereal grains and blood were negative when analyzed for trichothecenes. All samples were analyzed by combination gas chromatography-mass spectrometry using both packed and capillary columns. Full mass spectra of most of the components were obtained in both electron impact and chemical ionization modes.

A6

TWENTY-FIVE YEARS OF DISEASE FORECASTING. J. C. Zadoks, Laboratory of Phytopathology, Binnenhaven 9, 6709 PD Wageningen, The Netherlands

The disease forecasting methods developed hitherto seem to depend on either one of two distinct principles: the critical period principle and the disease monitoring principle. Many systems, from the highly sophisticated to the highly simplified, can be reduced to the critical period principle, which is characterized by (a) the disregard of the pathogen and be (b) the construction of a boolean variable which is false under one set of physical conditions and true under another set; when true, a treatment is to be applied. The disease monitoring principle is characterized by (a) its use of the concept of damage thresholds to construct its boolean variable, and (b) its disregard of physical data. A third principle of disease forecasting utilizes the state of the crop, including variety, nutritional status, and developmental stage. This principle is used in conjunction with either of the other two principles rather than independently. Recent forecasting methods combine these three principles.

A7

PREDICTIVE SYSTEMS IN USE: POTATO LATE BLIGHT. W. E. Fry, Cornell University, Ithaca, NY 14853.

Forecasts for potato late blight that indicate the need for the initial spray and/or the frequency of subsequent sprays have been evaluated for more than fifty years. In spite of the availability of several such forecasts, many growers remain unenthusiastic about them. Analysis using computer simulation indicated that use of Blitecast to determine the spray frequency under disease-favorable conditions was no better at suppressing late blight than regularly scheduled applications. Field experiments and experience support the simulation results. In field experiments plant resistance had a greater influence on fungicide requirements than did variations in weather. Subsequently, two techniques for adjusting fungicide application frequency to complement plant resistance have been developed. One technique establishes longer fixed intervals for moderately resistant cultivars than for susceptible ones. The other was weather-sensitive because it identified spray frequency as a function of weather as well as plant resistance. Both techniques provided adequate control in field experiments.

A8

PREDICTIVE SYSTEMS FOR FIRE BLIGHT. S.V. Thomson. Utah State University, Logan, UT 84322. Fire blight has long been a devastating disease and notoriously unpredictable. Two systems have recently been described to forecast fire blight; The California (Plant Dis. 66:576-579) and the Billing's (Ann.Appl.Biol.95:341-364) systems. The California system is based on the calculation of daily mean temperatures during the bloom period. The epiphytic colonization of pear flowers occurs soon after the daily mean temperature exceeds means ranging from 16.5 to 14C. This system predicts when to apply bactericides and has been used successfully with slight modification for 8 yrs. in the western U.S. Attempts to adopt this system for apples in Eastern U.S. and Canada were not successful. It was suggested that the lack of a large epiphytic population prevented its usage. The Billing's system estimates the potential doubling of *Erwinia amylovora* based on maximum and minimum temperatures and includes rainfall as the initiation of infection periods. This system is used in Europe to indicate periods of high disease risk. It has been applied to U.S. weather data and predicts high risk years but not when to treat. The Billing's formula for calculating infection periods is not difficult but not likely to be used by most growers.

A9

PREDICTING STRIPE AND LEAF RUST OF WHEAT IN NORTHWESTERN UNITED STATES. Roland F. Line - ARS, USDA, WSU, Pullman, WA 99164.

Stripe rust (SR) and leaf rust (LR) are destructive, indigenous diseases of wheat in the Pacific Northwest (PNW). Epidemics of SR and LR have become more frequent in the PNW because management practices now provide a nearly continuous host for the rusts; warm winters since 1958 favor rust survival; and new, virulent races can attack previously resistant cultivars. A method for predicting the rusts was developed based on the distribution, prevalence, and pathogenicity of the rusts; vulnerability of local cultivars; accumulated negative degree days in winter and positive degree days in spring; and relationship of yield loss to rust intensity. The predictive system accurately predicted rust in 1979-1982. Prediction of a severe epidemic in 1981 enabled emergency registration of Bayleton for control of rust, which increased wheat production in the PNW by more than 1,000,000 bu (27,000 metric tons). Success of the prediction system would not have been possible without cooperation and participation of research and extension personnel, regulatory agencies, and the agricultural industry.

A10

PREDICTIVE SYSTEMS FOR PLANT VIRUSES. James E. Duffus, U.S. Dept. of Agriculture, ARS-WR, P. O. Box 5098, Salinas, CA 93915.

Predictive systems are effective tools for the control of plant virus diseases. The basic techniques of phenological systems were developed over 50 years ago and have been used with a number of plant virus diseases with marked success. In general, the systems were based on simple virus-vector-plant disease relationships and involved late-warning procedures to control virus vectors. Although these simple control procedures have been successful in the past, there is little utilization of these methods in today's agriculture. The application of predictive systems to complex virus diseases involves virus-vector relationships, bionomics of vectors, migratory pathways, natural and crop virus reservoirs and plant virus interactions on several crop and weed species. The implementation will require a new enthusiasm and cooperation between traditional epidemiologists, virologists, entomologists, and mathematicians but should result in control of some of our most destructive diseases.

A11

PREDICTIVE SYSTEMS IN USE: NEMATODES. Larry Duncan, Dept. of Nematology, Univ. of California, Riverside, California 92521. Pest management systems based on anticipated nematode damage to plants evolved through qualitative epidemiological research. To optimize management benefits, such systems have been enhanced by principles from quantitative population biology. Application of quantitative methods to specific fields is constrained by ecological variation that results in sampling and experimental error. Sources of variation include climate, soil-texture and biotic agents of plant stress in addition to nematodes. Biologically descriptive, mathematical models of nematode-host interactions can be modified to accommodate additional variables. For example, models of plant damage by multiple nematode species utilize parameters derived from single species models. In contrast, models derived by statistical methods such as factor analysis and multiple regression require historical data from multi-nematode species

systems. Within-field covariation of various pest populations suggests the utility of predictive models for systems in which key species are defined as present or absent. Niche-similarity combined with symbiotic and competitive interactions may reliably mediate covariation of pest populations.

A12

FUTURE TRENDS AND DEVELOPMENTS IN THE USE OF PREDICTIVE SYSTEMS IN DISEASE MANAGEMENT. D. R. MacKenzie. Department of Plant Pathology, 205 Buckhout Laboratory, The Pennsylvania State University, University Park, PA 16802

The merging of new high technologies will contribute to a surge of activity in pest predictive systems in the next decade. Contrasted to methods for scheduling fungicides (eg. BLITECAST), these new systems will actively monitor growing conditions and interpret events to project the hazards of pest development. Present fungicide scheduling systems can only score the contribution of past and present weather on disease development and use gross epidemiologic assumptions for a specific disease. They lack true forecasting. The promised new technology will incorporate a greater understanding of complex biological relationships, provide more regional assessment of crops and weather, and give more specific and timely information for individual growers. The cost of providing such information will continue to decline as high tech innovations are expected to continue but the risk aversion of some growers may limit adoption of programs.

A13

VIRUS-HOST SPECIFICITY. G. A. de Zoeten, Department of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

A clear understanding of the infection process is lacking in the studies concerned with virus-host specificity. Such understanding is needed to provide the impetus to advance our knowledge of specificity. Based on current information, an overview of the plant virus [ss-(+)-RNA] infection process and the replication strategies of different plant viruses will be provided. Sites in viral life cycles where specificity could be operable will be pointed out and existing evidence for or against infection constraints resulting in specificity will be discussed. Approaches to the study of virus-host specificity based on knowledge of replication strategies and nucleotide sequence will be outlined. Finally, an argument will be made that wide host range viruses (lacking specificity) may be preferable over narrow host range viruses (specificity) as model systems to study virus-host specificity.

A14

RECOGNITION AND SPECIFICITY IN BACTERIAL DISEASES. Ann G. Matthysse, Department of Biology, University of North Carolina, Chapel Hill, N.C. 27514.

Interactions between pathogenic bacteria and compatible plant hosts have been shown to involve recognition and attachment in the case of *Agrobacterium*. Attachment appeared to play a role in determining the host range of *Agrobacterium* since bacteria did not attach to, nor produce disease on, monocots. The bacterial receptors for attachment appeared to involve both LPS and protein. Plant receptors appeared to have a protein component. The role of bacterial recognition and attachment in incompatible, hypersensitive responses remains unclear. In some cases mutants of virulent bacteria lose virulence and acquire the property of becoming bound to host cells simultaneously. In other cases no relationship between binding and lack of virulence or the hypersensitive response could be demonstrated.

A15

RECOGNITION AND SPECIFICITY IN FUNGAL DISEASES. Charles A. West, Department of Chemistry and Biochemistry, University of California, Los Angeles, CA 90024.

In recent years a number of substances of fungal origin capable of eliciting the production in higher plants of phytoalexins and other stress metabolites thought to have a defensive role in fungal disease have been identified and partially characterized. Included among these fungal elicitors are cell wall oligosaccharides, glycoproteins, lipids and extracellular enzymes. Most of these elicitors appear not to be very specific in their ability to stimulate a response in closely related host plants. The structural basis for host recognition of these elicitors and the molecular basis for their action as elicitors are subjects of

current investigations in a number of laboratories. Studies in my laboratory and the laboratory of P. Albersheim and his associates at the University of Colorado have also implicated oligosaccharides originating from the breakdown of pectic substances of the plant cell wall in the elicitation process. The results of recent investigations of the role of these pectic fragments in elicitation will be discussed.

A16

RECOGNITION AND SPECIFICITY IN NEMATODE DISEASES. U. Wyss, Institut für Phytopathologie der Universität Kiel, W. Germany

This paper will cover present knowledge of intimate associations between root tissues and root parasitic nematodes. Very little is yet known about recognition in nematode diseases, but recent advances in the elucidation of nematode cuticle surface carbohydrates, especially near cephalic chemoreceptors, allow some speculation how nematodes may find their hosts and how plants may recognize the parasites. Root parasitic nematodes induce and maintain a wide range of specific host cell modifications to supply them with nutrients for development and reproduction. Differences and common features between these cell adaptations to parasitism will be illustrated for two primitive migratory ectoparasites Trichodorus and Tylenchorhynchus, for two advanced migratory ectoparasites Longidorus and Xiphinema and for the most advanced sessile endoparasites Heterodera and Meloidogyne.

A17

DISEASE RESISTANCE IN BEANS FOR THE TROPICS. M.A. Pastor-Corrales, CIAT, Apartado Aéreo 6713, Cali, Colombia.

The broad spectrum of pathogens attacking Phaseolus vulgaris and their variability are two of the most important factors responsible for low bean yields in the tropics. The most important pathogens are rust, anthracnose, angular leaf spot, common bacterial blight and bean common mosaic virus; web blight and bean golden mosaic virus are severe in certain locations in some years. In Africa halo blight is relatively more damaging. Most breeding for disease resistance has not been conducted in the tropics and has emphasized qualitative resistance. The common cultivars grown in the tropics are susceptible to the major diseases. The International Center for Tropical Agriculture (CIAT) in Cali, Colombia, has global mandate to help improve bean productivity. Its principal objective in collaboration with national programs, is to stabilize and increase yields by incorporating multiple disease resistance into commercial cultivars. Strategies for obtaining durable resistance to some bean pathogens in the tropics are discussed.

A18

MULTI-ADVERSITY RESISTANCE FOR DEVELOPING DURABLE HOST PROTECTION FROM DISEASES AND INSECTS. L.S. Bird, Dept. Plant Sciences, The Texas Agr. Exp. Sta., Texas A&M Univ., College Station, TX 77843.

The multi-adversity resistance (MAR) cotton improvement system uses selection for seed resistance to mold, slow germination, immunity to races of the bacterial blight pathogen and resistance to seedling pathogens to obtain broad resistance to major diseases and insects. Four MAR hybrid pools have been processed. Change from MAR-1 to MAR-4 in improving resistance follows: from none to intermediate for preservation of seed quality, seed-seedling cold performance, and resistance to seedling pathogens; from resistance to immunity to bacterial blight; partial to resistance to Verticillium wilt; low to high resistance to Fusarium wilt-nematodes; none to resistance to Phymatotrichum root rot; from none to intermediate resistance to fleahoppers, boll weevil, Heliothis spp. and plant bugs; and improved fiber, maturity, and yield. Immunity to bacterial blight has been lost twice to new races, but was regained by using the new races in the MAR procedure. The results show that genes accumulated with the procedure are durable with respect to countering pathogen variability.

A19

A BREEDER'S PERSPECTIVE OF DURABLE RESISTANCE. N.W. Simmonds, Edinburgh School of Agriculture, West Mains Road, EDINBURGH, EH9 3JG, Scotland.

Operationally, four kinds of resistance can be distinguished: VR (vertical resistance due to pathotype-specific major genes); NR (pathotype-non-specific major gene resistance);

HR (horizontal resistance due to pathotype-non-specific polygenes); IR (interaction resistance due to VR genes in heterogeneous populations). The above classification is appropriate to all kinds of pathogen. Certain operational qualifications are necessary. Durability is essentially a matter of avoiding the inappropriate use of VR against mobile (generally airborne) pathogens.

A20

A COMMERCIAL PERSPECTIVE FOR BREEDING FOR CROP DISEASE RESISTANCE. J.L. Dodd, Cargill Seed Division, Aurora Research Station, P.O. Box 470, Aurora, IL 60507.

Commercial crop breeding has the main objective of developing varieties with dependable, superior yield. Evaluation of the potential threat to yield stability by each disease facing a crop during use of a particular breeding gene pool is essential to a commercial breeding program. Significance of a disease greatly influences amount of effort given to incorporating resistance, to restrictions on use of gene pools, to screening method employed, and to levels of resistance acceptable for release of a commercial variety to the sales organization. The above factors influence decisions to screen for resistance at population improvement, line development or hybrid testing stage of breeding. Resistance breeding is generally most efficient when using recurrent selection with populations, but emergencies occasionally require backcross methods into elite developed materials. Polygenic systems are preferred, but in some cases there are no successful screening systems identified. Resistance breeding must be completely integrated into breeding program.

A21

Global Impact of Crop Losses. L. Brader. Shell Internationale, The Hague, The Netherlands.

Any paper presenting crop protection for justifying a research grant, a development project, new equipment, constructions or any action in general will in one way or another come up with a dramatic figure of the amount of agriculture produce that could have been, and hopefully in the future, will be saved. However, this magic figure of around 30 per cent has been rather static over the last decades. And in fact it appears that we are not really achieving an improved plant health situation. This is the more so if one considers the increased amounts of efforts devoted to matters such as extension, education, research and regulatory activities. Anyhow, crop losses are still enormous and it is in the first place the responsibility of the scientific community to analyse this situation, to identify causes and to develop appropriate solutions. A real reduction in crop losses is more than a challenging problem in plant health, it constitutes the *raison d'être* for plant protection activities. A number of examples will be analysed to attempt to define the global impact of crop losses. This will serve as a basis to review causes of the current situation and to discuss possible solutions and topics for future research and development activities.

A22

WORLD-WIDE IMPACT OF FOREST DISEASES ON WOOD AND FIBER PRODUCTION. Frank G. Hawksworth, USDA For. Serv. Rocky Mt. For. and Range Exp. Stn, 240 W. Prospect, Fort Collins, CO. 80526

Forest diseases exact a significant toll in world-wide wood and fiber production, but no assessments of this impact have been made. A 1964 meeting of FAO/IUFRO at Oxford discussed forest diseases world-wide but concentrated on diseases (chestnut blight, white pine blister rust, Dutch elm disease) that were potentially dangerous if introduced into new areas. The 1967 Munich FAO/IUFRO meeting also addressed forest diseases as damaging agents but only in Africa and Asia. Among the few national tree disease loss estimates that have been published are 4.9 billion cu. ft/year, United States; and 1.0 billion cu. ft/year, Canada. Major causes of loss are dwarf mistletoes, hardwood cankers, white pine blister rust, root diseases, Dutch elm disease, native rusts, and decays. Examples of losses from specific diseases include 10-50% in spruce due to Fomes annosus (Europe), 5-35% in pines due to Cronartium flaccidum (Europe), and decay incidence in old Abies stands of 50% (Japan).

A23

CROP PROTECTION ECONOMICS: STABILITY VS. SUSTAINABILITY. Thomas C. Edens, Department of Entomology, Michigan State University, East Lansing, MI 48824. Economic analyses of crop protection and disease control usually

rely on sub-optimization techniques. Such analyses necessarily focus on a subsector of the agricultural system and are undertaken in pursuit of maximum profits over a specified (usually short) time horizon. Short term economic stability of the system is often an expressed objective. This analytical process does not address the larger (and longer-term) issues of biological stability and system sustainability. It also ignores the distinction between renewable and non-renewable resource inputs to the agricultural production process. To redress this imbalance in emphasis, it is necessary to establish a more eclectic research agenda that promotes longer term objectives and perceives system design as a management variable. The effective promotion of these objectives is largely the responsibility of the land grant institution and will necessitate a firm commitment to basic research supporting alternative agricultural management strategies.

A25

ROLE OF TOXINS IN PLANT DISEASE DEVELOPMENT. R.P. Scheffer, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Discussion will cover past and potential contributions of toxin studies to an understanding of the molecular basis of plant diseases and of disease resistance. Known toxins have been described as "pathogenicity factors" (required for tissue colonization) or "virulence factors" (contribute to virulence). Several low mol wt toxins in each category have been characterized. Known pathogenicity factors are host-selective; i.e., they are toxic only to hosts of the producing fungus. Genetic and other data show that resistance to each fungus is the same property as tolerance to its toxin. Various data also show that the toxins are major determinants of pathogenicity, disease development, and host selectivity. The sites of biochemical lesions for selective toxins are poorly known, although a mitochondrial site is evident in one case. Lesions for some virulence factors are better known; several are inhibitors of known enzymes. The possibility that resistant plants lack toxin receptors or possess lesion bypass steps will be discussed.

A26

PHYTOALEXINS: PAST, PRESENT AND FUTURE. H. D. VanEtten, Dept. Plant Pathology, Cornell University, Ithaca, NY 14853.

When K. O. Müller coined the term phytoalexin (PA) in 1940, he proposed that compatibility in host-pathogen interactions could be determined by the rate of PA synthesis. In 1962 I.A.M. Cruickshank suggested that differential sensitivity of microorganisms to PAs could influence their pathogenic potential. These two ideas still constitute the basic dogma of the PA theory of disease resistance. Researchers in the past 20 years have identified numerous PAs, elucidated their biosynthetic pathways, identified microbial elicitors or suppressors of their production, and determined how some pathogens can avoid their toxic effects. Some information is available about the enzymology and regulation of PA biosynthesis and about the mode of action of PAs. Progress in these areas will ultimately lead to the development of chemical or genetic means to specifically inhibit or stimulate PA synthesis, and to alter PA sensitivity of potential pathogens. Such tools will allow a rigorous evaluation of the role PAs play in plant disease resistance.

A27

ROLE OF PLANT SURFACES IN DISEASE. W. K. Wynn, Plant Pathology Department, University of Georgia, Athens 30602.

Although plant surface chemistry and topography affect most pathogens directly or indirectly, only the filamentous fungi have found it necessary to evolve elaborate mechanisms to cope with specific external barriers on their hosts. Most preinfection responses by fungi are attempts to solve problems of orientation, recognition, and penetration. Successful disease initiation frequently depends on close adherence of germ tubes, hyphae, or infection structures to plant surfaces and on the ability to respond correctly to various contact stimuli. The problem we face as plant pathologists is whether we can successfully manipulate these adaptations of fungi to surface features as a practical means of reducing disease. I feel optimistic about managing preinfection resistance in the future for three reasons: surface differences in divergent plant groups contribute to non-host immunity, failures of fungi to recognize specific features reduce infection frequencies on hosts, and responses to surface stimuli appear to be race-nonspecific.

A29

TUMORIGENESIS. Tsune Kosuge, Department of Plant Pathology, University of California, Davis, CA 95616. Formation of tumor-like outgrowths on plants is a characteristic of the diseases caused by Agrobacterium tumefaciens (crown gall) and Pseudomonas syringae pv. savastanoi (oleander and olive knot). In both cases, the outgrowths are caused by phytohormone imbalances created in host tissue by the pathogen. However the fundamental mechanisms for tumorigenesis differ. In crown gall a fragment of an A. tumefaciens plasmid, T-DNA, is integrated into host genome. Genetic determinants on the T-DNA then are expressed in the plant thereby conferring the neoplastic state. Mutations in T-DNA affect both phytohormone concentrations and tumor morphology; genetic determinants on T-DNA either are directly concerned with or must control phytohormone synthesis. In P. savastanoi, pathogen synthesis of indoleacetic acid (IAA) is primarily responsible for tumor formation by the host. Genes for indoleacetic acid production comprise an operon and are plasmid-borne in oleander strains and on the chromosome in olive strains. In pv. savastanoi, concepts on expression of virulence can be related to principles of metabolic regulation.

A30

PERSPECTIVES OF BIOLOGICAL CONTROL. Kenneth F. Baker Horticultural Crops Research Laboratory, USDA-ARS, Corvallis, OR, 97330

Biological control may increase agricultural yield, usually without increasing energy demands, environmental pollution, or risk of developing pathogen resistance. A biologically active soil is more suppressive than a depauperate soil because of its greater biomass; these resident antagonists, operating with cultural practices, provide some of the most effective controls. Use of an abundant single antagonist is sometimes effective, particularly if competition from total soil biota is decreased by treatment; this approach is promising for glasshouse ornamentals. Application of single beneficial micro-organisms to plant propagules may also increase crop growth and yield by inhibiting nonparasitic pathogens in the rhizosphere. Biocontrol integrated with chemical application or with thermal soil treatments (aerated steam, solarization) are promising new approaches.

A31

BIOLOGICAL CONTROL - USEFUL APPROACHES FOR ORNAMENTAL PLANT DISEASES. R. G. Linderman, USDA-ARS Horticultural Crops Research Laboratory, Corvallis, OR 97330

Ornamental plants are distinguished by diversity of plant types, methods of propagation, and commercial production system. Such diversity presents both unique challenges and opportunities for disease control. Potential for biological control is high because of the opportunities to manage biocontrol agents in soil or potting mixes, or place them directly in or on the plant propagule at the disease infection site. These opportunities occur because of the production cultural practices employed - such as soil treatment with heat or chemicals, chemo- or thermotherapy of plant propagules, even aseptic tissue cultures as well as the environmental controls used in growth structures. Biological control of diseases of ornamental plants is presently limited only by availability of effective agents, found in nature or genetically engineered, and by lack of baseline knowledge of how best to manage them in cultural systems. Examples of successful biocontrol of ornamental plant diseases will be discussed.

A32

PATHOGEN-SUPPRESSIVE CONTAINER MEDIA. H. A. J. Hoitink, Department of Plant Pathology, The Ohio State Univ., OARDC, Wooster, OH.

During the past decade, pathogen suppressive container media have become increasingly adopted for production of ornamentals. Tree barks are the most widely used organic component in these media. In practice they are not sterilized. Physical properties of such media are more nearly optimum for plant growth. Fresh pine barks and green composted hardwood barks (CHB) contain inhibitors that lyse zoospores and reduce sporangium production of some Phytophthora spp. Mature CHB suppresses several diseases including Phytophthora (P) and Pythium (PY) root rots, Rhizoctonia (R) damping off and Fusarium wilts, but suppressiveness varies from batch to batch. Heating (60 C) negates this suppressive effect. Suppression to P, PY and R can be restored by adding antagonists to heated mature CHB. Trichoderma spp. are the most prominent fungal antagonists in CHB. Addition of antagonists to mature CHB before it becomes recolonized by mesophiles,

yields consistently suppressive compost. Composts undoubtedly will become increasingly important in the formulation of container media as sources of peats decline.

A33

PATHOGEN-SUPPRESSIVE SOILS. Ralph Baker, Department of Botany and Plant Pathology, Colorado State University, Fort Collins, Colorado 80523.

If soils are suppressive to plant pathogens because of biological entities, the factor may be transferred to conducive soils. Such transfer is applicable to synthetic soil mixes used in floriculture. This type of agriculture is mechanized and the associated manipulations afford opportunities for insertion of biological control agents. Also, the system may be manipulated so that environment is favorable for their antagonistic activity and persistence. While the efficiency of such control is substantial in some systems (e.g. diseases induced by *Fusarium* spp. and *Rhizoctonia solani*), it may not match that achieved by other methods. However, agents are or can be mutated to become compatible with fungicides. The integrated control achieved is additive. Even so, grower acceptance requires more than the promise of disease control; the increased growth responses observed after application of agents inducing suppressiveness adds to incentives for practical use in commercial systems.

A34

CURATIVE STRAINS OF FUNGAL PATHOGENS FOR BIOLOGICAL CONTROL OF TREE DISEASES. Sandra L. Anagnostakis. The Connecticut Agricultural Experiment Station, Box 1106, New Haven, CT 06504.

Biological control of diseases that affect aerial parts of plants presents specialized problems, especially when the pathogens have no contact with the soil during their life cycles. Pathogens free of soil contact are not subjected to the naturally suppressive factors present in soil. In addition, trees and other long-lived host plants may be reinfected repeatedly increasing the difficulty of biological control. There are reports of biotherapy succeeding against rusts, cankers, and vascular wilts of trees, but few cases of human-induced biological control. Chestnut blight and Dutch elm disease continue to be targets for biotherapy. The possibilities for using curative (hypovirulent) strains of the pathogens to incite stable biological control will be discussed.

A35

CONCEPT OF A NATIONAL NETWORK OF MICROBIAL COLLECTIONS OF IMPORTANCE TO AGRICULTURE. K.D. Fisher, Life Sciences Research Office, Federation of American Societies for Experimental Biology, 9650 Rockville Pike, Bethesda, Maryland, 20814.

Collections of microorganisms and germplasm are essential to research and teaching of agriculture, biology, and medicine. They range from national repositories of many species to isolates of a single species. The former serve many scientific interests, the latter are typically limited in scope and time. In plant pathology and nematology, the importance of microbial collections is growing with research emphasis on genetic manipulation of crop plants and host-parasite interactions. An improved system of microbial culture collections is needed. Such a system will require mechanisms to coordinate the efforts of many scientists as well as administrative sanction and support. It would build on existing resources and would have a defined scope and purpose. Components, resources, and needs of a national network of microbial culture collections of importance to agriculture will be presented.

A36

INDIVIDUAL SCIENTISTS: THE CORNERSTONE OF NATIONAL COLLECTIONS. Robert E. Stevenson, American Type Culture Collection, 12301 Parklawn Drive, Rockville, Maryland 20852

Public collections of microorganisms are to microbiology as international standards are to physical measurements and the atomic table is to chemists. The evolutionary process of a research isolate to a new type species or novel strain will be described, the investment calculated, and the importance of individual contributors to the collections emphasized. Creation of an international strain data bank while desirable, awaits adoption of standardized procedures for metabolic/functional attributes. The World Federation for Culture Collections and the U. S. Federation for Culture Collections were founded to promote the exchange of culture material and information. A revised directory of collections and their holdings by the

WFCC is now available. Failure to recognize collection activities as a necessary part of research publication is jeopardizing our scientific heritage.

A37

EXAMPLES OF RESOURCE COLLECTIONS. T. A. Toussoun, Department of Plant Pathology, The Pennsylvania State University, University Park, PA 16802.

Resource collections are of 2 types: 1) collections of living organisms, 2) collections of dead organisms. The latter, herbaria, are well known and have been in existence for many years. Resource collections of living organisms are more attuned to present day needs because they retain, in living form, the many variations, the gene pools of species that exist. These collections range from the all-encompassing but generalized American Type Culture Collection, to the highly specific but very valuable collections of the individual researcher. The development of the Fusarium Research Center at The Pennsylvania State University is given as an example in order to encourage such collections, especially the highly specialized ones, because the unique expertise of their collector-curators promotes excellence.

A38

ROLE OF AND ISSUES FACING WORKING COLLECTIONS: BACTERIA. A. Kelman, Department of Plant Pathology, 1630 Linden Drive, University of Wisconsin-Madison, Madison, WI 53706.

Progress in research and teaching in phytobacteriology depends on availability of virulent, accurately identified strains of bacterial plant pathogens. The problems associated with establishment of one national collection containing a full range of all bacterial plant pathogens appear to be insurmountable at present. Thus, it is essential to utilize more efficiently the major reference collections that are now available and the numerous other specialized research collections that have been developed by individual scientists. An organizational network for culture collections should be established with a computerized data bank that would provide the essential information on cultures in these established collections. Additional research is needed to develop improved procedures for maintenance in long-term storage of the unique genetic characteristics of bacterial plant pathogens.

A39

THE ROLE OF AND ISSUES FACING WORKING COLLECTIONS--FUNGI. George A. Zentmyer, Department of Plant Pathologist, University of California, Riverside, CA 92521.

The maintenance of working collections of plant pathogenic fungi, such as our collection of 1700 isolates of 27 species of the genus *Phytophthora*, is a difficult and expensive project, but has many positive and significant aspects. Our *Phytophthora* collection emphasizes two species: *P. cinnamomi* and *P. palmivora*, and includes approximately 800 isolates of these two species, from many countries and many hosts. With these isolates and with those of the other species of *Phytophthora*, this collection provides a unique and valuable repository of this genus -- a collection representative of the great variability in the two species particularly, and a valuable source of isolates of all of the species for detailed research in genetics, taxonomy, physiology, morphology, and pathology of *Phytophthora*. Similar collections of other plant pathogenic fungi are in existence. Problems of selectively maintaining the most useful portions of such collections in stable form, in terms of locale and of method of preservation, are complex and have not yet been resolved.

A40

PLANT VIRUS WORKING COLLECTIONS, PRESENT AND FUTURE. R. O. Hampton, USDA ARS, Dept of Botany & Plant Pathology, Oregon State University, Corvallis, Oregon 97331.

Forty plant virus researchers, representing 17 specialties in 17 states, maintain almost 2,000 virus isolates in viable, stored form. Only a minority of the accessions were incompletely identified or possible virus mixtures. Most of the stored isolates were obtainable by colleagues upon request. Few colleagues requesting isolates from working collections reportedly had provided documented permission to move plant pests across state borders. The degree of redundancy in collections among scientists or with ATCC was undefined. Among laboratories generally known to produce plant virus antisera, colleague-requests for

antisera have exceeded requests for virus isolates by 4:1. All respondents felt that working collections were valuable to research, and 86% regarded this resource as indispensable. Future needs include standardized criteria for establishing isolate identity and purity, improved accessibility to and support for collections, and coordinated national cataloging and computerization of working collection data.

A42

ROLE OF AND ISSUES FACING WORKING COLLECTIONS: NEMATODES. Golden, A. M., USDA, ARS, Nematology Laboratory, Beltsville, MD 20705

Since only an estimated 10% of the total nematodes thought to exist have been described, nematode collections are of critical importance and provide the foundation for sound progress in nematology now and in the future. Collections are the basis for taxonomic research; accurate identifications on which other research, control and regulatory measures depend; stable nomenclature; and provide data on nematode hosts, occurrence and distribution. Also, collections, as a reference in the future, serve as a permanent repository for type specimens of various categories and for voucher specimens from surveys, important new occurrences and hosts, tests to develop resistant crop varieties, and other significant research. Issues of concern include: increased financial support; improved and expanded access to pertinent literature; greater use of computers and related technology; and better recognition of the value and interactions of collections within the scientific community.

A43

POSTHARVEST LOSSES - HOW BIG IS THE PROBLEM? J. M. Ogawa. Dept. of Plant Pathology, Univ. of Calif., Davis, CA 95616.

The need for food and fiber is becoming critical as world population increases and land for agricultural use diminishes. Production of both wild and cultivated crops is severely curtailed by postharvest losses, which may be as high as 10-20 percent of the harvested crop. Losses must be reduced during harvest, storage, and transportation to the consumer. Suppression or eradication of quiescent infections has reduced losses for some crops, including stone and pome fruits, grapes, citrus, bananas, and papayas. Integrated control has minimized deterioration and mycotoxin production in cereal crops. Although hand sorting has improved quality in canned products, it has also resulted in price increases. Unfortunately there still are tremendous postharvest losses for over 200 crops. Research efforts to lower postharvest decay to the tolerance levels set by industry and government are at an infant stage. If decay levels are not reduced, food shortages and higher prices are inevitable.

A44

POOR ROOT HEALTH AS A FACTOR IN THE YIELD PLATEAU FOR MAJOR FOOD CROPS. S. D. Van Gundy and L. H. Stolzy, University of California, Riverside, CA 92521.

Poor root health is a chronic problem in maintaining and increasing food production. The production of a crop requires a well-functioning root system which involves a host of biotic and abiotic factors. Some of the biotic factors to be considered are soil-borne fungi, nematodes and rhizobacteria. The abiotic factors include soil strength, water, temperature and soil oxygen. Major obstacles to continuous cropping of food crops are pests and supply of water and nutrients. Future solutions to poor root health will require a multidisciplinary research approach.

A45

IMPACT OF AIR POLLUTANTS ON CROP PRODUCTIVITY. J. Troiano¹, J.A. Laurence¹ and R.J. Oshima². ¹Boyce Thompson Institute for Plant Research, Ithaca, N.Y., 14853 and ²California Dept. of Food and Agric., Sacramento, Ca, 95814.

The assessment of crop loss by air pollutants presents problems in experimental design, application of treatments and data evaluation. Although similarities exist with studies that assess losses by plant pathogens, modeling efforts for air pollutants require special considerations due primarily to their origin, occurrence and biological activity. Prevalent approaches that quantify the relationship between development of disease and loss of yield are inadequate. For example, with air pollutants, there is no spread of disease because propagules are not produced. Thus, area under the disease progress

curve (AUDPC) is an inappropriate measure of plant response to injury by an air pollutant. Instead, models need to be developed that consider the temporal occurrence of air pollutants in relation to stage of plant development. In general, improvements in techniques for expressing pollutant dosage and subsequent plant response need to be explored.

A46

PEST-PROVOKED YIELD COMPENSATION IN CROPS. L. P. Hart, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

"Competition arises from the reaction of one plant on the physical factors about it, and the effect of the modified factors on its competitors. Two plants, no matter how close, do not compete so long as water, nutrients, light and heat are in excess of the needs of both. When the immediate supply of a single necessary factor falls below the combined demands of the plants, competition begins." Planting densities for crop plants achieve the maximum yield per unit area at the expense of yield per individual plant. Planting densities giving the highest yield per unit area for buckwheat, wheat, corn, and broad beans reduced yields per plant by 92, 77, 69, and 67%, respectively, compared with wider row spacings. Loss of some plants at high planting densities may increase yields of remaining plants, but depends on the competitiveness of the plants. Some crop plant diseases will decrease the plant's ability to utilize physical resources, making these resources available to adjacent plants, resulting in no change in yield per unit area.

A48

ROLE OF PROTOPLASTS AND CELL CULTURES IN STUDYING HOST-PARASITIC INTERACTIONS. Elizabeth D. Earle, Dept. of Plant Breeding, Cornell University, Ithaca, NY 14853.

Modern tissue culture techniques offer plant pathologists new ways to identify, select, manipulate and study disease-resistant material. *In vitro* selection for resistance, followed by plant regeneration, has yielded plants with altered response to pathogens. Altered plants have also been obtained from populations regenerated from cells not subjected to *in vitro* selection. Even when plant regeneration is difficult, work with protoplasts and cell cultures can help clarify the cellular basis of host-pathogen interactions. This is particularly true when phytotoxins implicated in disease development can substitute for a living pathogen. Cultured cells and protoplasts have been excellent material for biochemical, physiological, and ultrastructural studies of toxin action and also for toxin bioassays. Current research on cereal cultures and fungal phytotoxins illustrates most of these approaches.

A49

THE ROLE OF CELL CULTURES IN STUDYING DISEASE RESISTANCE. John P. Helgeson. ARS USDA. Department of Plant Pathology, University of Wisconsin, Madison, WI 53706

Plant tissue and cell suspension cultures can provide useful experimental systems for studying disease resistance. Under the appropriate conditions, race specificity is expressed and common host responses such as hypersensitivity and phytoalexin production can be seen with tissue culture/pathogen combinations. In this presentation the status of work with tissue cultures and fungi or fungal-derived materials will be reviewed. Items that are essential for establishing such systems will be discussed. These include proper culture conditions, inoculation procedures and comparisons with intact plants. Examples from the author's work with tobacco tissue cultures and *Phytophthora parasitica* var. *nicotianae* will be used to illustrate various points in the presentation. The author acknowledges support from the following grants: NSF-PCM 77-23326, USDA-CRGO 80-00239 and USDA-CRGO 8200054.

A50

VARIATION IN PLANTS REGENERATED FROM PROTOPLASTS. Gary A. Secor, Dept. Plant Pathology, N.D. State Univ., Fargo, ND 58105. Field and laboratory studies of potato plants regenerated from protoplasts (= 'Protoclones') have demonstrated a high frequency of non-induced variants. Significant variation in vine morphology, tuber yield and composition, maturity and flowering among protoclones was observed. Protoclones have been stable for four growing seasons. Protoclone-environmental interaction occurs with some protoclones since growing conditions affect plant characteristics. Variability of potato protoclones in reaction to

late blight and early blight, and lettuce and tobacco proto-clones to physiological stresses have been reported. Other plants regenerated from protoplasts, including eggplant, asparagus, cassava, rape, alfalfa and petunia, have not been tested for variability. Variability in disease resistance and other characters is also reported in plants regenerated from single cells or calli. Protoplast regeneration offers a source of variability for modification of existing cultivars, and in breeding programs for development of new cultivars. Selection of beneficial clones *in vitro* will require improved screening systems, particularly for disease resistance.

A51

SELECTION USING HOST-SPECIFIC AND NON-SPECIFIC TOXINS. Carole P. Meredith, Dept. of Viticulture & Enology, University of California, Davis, CA 95616.

Toxins produced by plant pathogens may be used as selective agents with cultured plant cells for the isolation of resistant mutants. Plants regenerated from toxin-resistant cells may also be resistant to the toxin and perhaps to the pathogen. The successful application of this strategy requires that several conditions be satisfied. The toxin must inhibit the cultured cells and the effect must be via the primary mode of action of the toxin. Potential resistance mechanisms must be operative in cultured cells. The plant species must be amenable to cell culture manipulations, especially plant regeneration from cultured cells. The toxin must be the primary determinant of pathogenicity if toxin resistance is to confer disease resistance. Even if these conditions are fulfilled, there are a number of reasons why a resistant plant may not be obtained. This strategy is obviously of limited applicability but may be very successful in certain situations.

A52

PROTOPLASTS IN THE STUDY OF VIRUS-HOST INTERACTIONS. H.H. Murakishi¹, M.S. Lesney², and P.S. Carlson³, Department of Botany and Plant Pathology¹; Department of Horticulture², Michigan State University, East Lansing, MI 48824; and Crop Genetics International³, Dorsey, MD 21076.

The use of protoplasts in studies of virus- and viroid-host interactions has attracted considerable attention since the pioneering work of Cocking (1967) and Takebe and Otsuki (1969). An increasing array of protoplast-virus systems representing 18 plant genera and 26 viruses and viroids have now been developed. Earlier work was concerned with determining parameters of infection and time course of virus synthesis. These studies made progress possible in determining synthesis of virus-related proteins and RNAs. Protoplasts have been useful in further elucidating the nature of cross-protection, genetic resistance, and correlation of cellular symptoms with virus infection. More recently, protoplasts and viruses have received attention because of their potential in genetic engineering. Examples of the use of protoplasts in the study of virus-host interactions will be discussed.

A53

NEW FUNGICIDE GROUPS AND THEIR MODE OF ACTION. Hugh D. Sisler, Department of Botany, University of Maryland, College Park, MD 20742

Chemotherapeutic action of recently developed antifungal compounds is based on one of the following: (a) direct fungitoxicity (b), suppression of parasitic activity in the fungus or (c) modification of host resistance. The ergosterol biosynthesis inhibitors are the most important group of new fungicides in category (a). These compounds block sterol C-14 demethylation and possibly similar reactions in other pathways. Category (a) also includes vinclozolin, procymidone and iprodione for which the mechanism of action is uncertain. Metalaxyl also belongs in category (a) and is reported to interfere with RNA synthesis. The non-fungitoxic compounds tricyclazole and pyroquilon fall into category (b). These compounds specifically block melanin biosynthesis which leads to defective appressoria incapable of penetrating the host epidermis. Aluminum tris-0-ethyl phosphonate and the dichlorocyclopropane carboxylic acids are representatives of category (c). These compounds accentuate host resistance in certain host-parasite combinations.

A54

THE ROLE OF INDUSTRY IN DEALING WITH FUNGICIDE RESISTANCE, T. Staub, Agricultural Division, CIBA-GEIGY AG, 4002 Basel, Switzerland.

The agrochemical industry is involved with fungicide

resistance for several reasons, including offering the farmer solutions for disease control and protecting them against crop damages that can arise through the appearance of resistant forms of the pathogen. Such solutions should prolong the useful life of fungicides. Industry should include the evaluation of the resistance risk, the design of adequate use strategies, the assessment of and the reactions to rumors and real developments of resistance in practice. The possibility of cross resistance among fungicides with the same mode of action has led to growing cooperation among the respective producers in the areas of resistance monitoring and the design of strategies that delay or prevent the appearance of resistance. Finally, industry is challenged to search for new types of disease control agents, both chemical and biological, in order to increase the diversity of weapons which the ever adapting plant pathogens can be confronted with.

A55

THE ROLE OF STEROL-INHIBITING FUNGICIDES IN INTEGRATED PEST MANAGEMENT PROGRAMS. A.L. Jones, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Since the late 1960's, a number of fungicides have been discovered that inhibit ergosterol biosynthesis in fungi. Several of these fungicides have a broad spectrum activity at extremely low rates and also exhibit local systemic activity. Because of the novel way these compounds control fungal pathogens, their use differs from the traditional methods of chemical control with conventional fungicides. They are particularly suited for use in pest management programs where timing of controls are based on the identification of infection periods. When mixed with conventional fungicides, increased intervals between application are possible, since protective and curative activities are combined. The details of how these new fungicides can be utilized for disease control will be discussed, and several examples from research on tree-fruit crops will be presented.

A56

FUTURE CHEMICAL CONTROL MEASURES FOR PHYTOPARASITIC NEMATODES. R.H. Brown, Plant Research Institute, Burnley Gardens, Swan Street, Burnley, Victoria 3121, Australia.

For nearly 40 years, nematicides have been commercially in many countries. Their use can be justified economically, only on those crops having a high value per unit area of land. Relatively few nematicides have been developed, and there are few, if any, indications that, in the future, the range will be greatly widened. Thus, it is likely that new uses will be found for existing products, although nematicide formulations may change. Changes in technology, as have occurred in Australia with the chemical control of cereal cyst nematode in wheat, will permit the use of nematicides on crops hitherto considered uneconomic to treat.

A57

STRATEGIES FOR DEVELOPMENT OF COMPOUNDS WITH PROMISE FOR VIRUS CONTROL. W. O. Dawson, Department of Plant Pathology, University of California, Riverside, CA 92521.

Presently there are many diseases caused by viruses for which there is no control. There are no effective control measures for any virus diseases after plants become infected. The development and use of antiviral chemicals would be of enormous value to agriculture, particularly in perennial crops where virus cause chronic losses.

Because of the intimate association between the virus and host, the popular belief has been that it would be impossible to effectively control virus diseases with chemicals. However, recent successes in chemotherapy of animal virus diseases is encouraging. A chemical is needed that will specifically block a virus-specific function without affecting the host. The small number of virus-coded functions greatly increases the difficulty of finding an effective antiviral chemical. Potential targets for antiviral chemicals and screening procedures to identify these chemicals will be discussed. Progress toward utilizing chemicals to control virus diseases will be reviewed.

A58

MANAGING A HEALTHY FOREST. John C. Gordon, Dept. of Forest Science, Oregon State Univ., Corvallis, OR 97331

The keys to managing healthy forests are 1) a commitment to pre-

vention rather than cure and 2) written silvicultural prescriptions that make the prevention of stress explicit and a part of routine management activities. Integrated forest protection (IFP) is the process of preparing and carrying out such prescriptions. "Integrated" implies that one prescription covers both production and protection (operations to ameliorate stress). "Forest" indicates a crop-ecosystem point-of-view, in which interactions are recognized and predicted. "Protection" refers to protection of the forest owner's ability to achieve objectives rather than the shielding of absolute biological or economic norms. IFP is an operational, rather than a research, concept; it is applied through silvicultural prescriptions, and it is focused on alleviations of plant stress related to landowner objectives, rather than on pest organisms.

A59

DISEASE IMPACT ON NATURAL FORESTS. F. W. Cobb, Jr., Dept. of Plant Pathology, Univ. of Calif., Berkeley, CA 94720.

Pathogens have been a component of natural plant communities for millions of years and had regulatory roles in forests long before humans began to evolve. These include selection of the best individuals or species for a site; maintenance of stability and diversity in the gene pool; regulation of stand composition usually toward diversity; establishment of geographic limits; regulation of stocking; regulation of stand-age structure; and promotion of species rotation. Pathogens became problems only when humans began competing with them for resources. Our activities in forests, often under the guise of management, have disrupted natural balances and caused larger problems. We introduced pathogens, planted exotic trees on unsuitable sites, and changed such stand-site factors as composition, stocking, age structure, incidence of wounding and soil characteristics. Natural forests must continue to provide most of our wood and other forest products for generations to come. Thus, forest pathologists must continue to develop information, at an accelerated pace, that is useful to the resource manager, and we must be convincing in our insistence that he use it.

A60

DISEASE IMPACT ON FOREST PLANTATIONS. S. A. Alexander, Dept. of Plant Path. & Physiol., VPI & SU, Blacksburg, VA 24061.

Wood and fiber needs in the future will be met in large part by intensively managed forest plantations. These monocultures are more efficient economically than natural forests but are in general more susceptible to the ravages of disease because of a lack of functional diversity and because of intensive management. For instance, diseases such as fusiform rust and annosus root rot increased dramatically with the establishment of loblolly and slash pine plantations. White pine plantations are not planted in some areas because of white pine blister rust. Canker diseases also have increased as the number of hardwood plantations have increased. In order to produce healthy plantations, it will be necessary to better understand the effects of predisposing factors, host resistance and management practices on disease development. This information must be used to develop pest management strategies for integration into forest management systems.

A61

SUCCESSSES AND FAILURES IN FOREST PATHOLOGY. D.W. French, University of Minnesota, St. Paul, MN 55108.

The relatively few forest pathologists have been reasonably successful in spite of the number and complexity of tree diseases. Important unsolved problems remain. Forest pathology has lagged behind plant pathology partly because of the difficulty in studying long term perennials, which often occur in mixed stands with little uniformity. The causes of many diseases have been determined, and reasonable control measures developed for some. Among the successes are the increased knowledge of dwarf mistletoes and the rust fungi, and the concept of compartmentalization in relation to decay of living trees. Forest pathologists have contributed valuable information covering deterioration of wood products. The disappointments include chestnut blight and Dutch elm disease, in spite of many announced cures, and the ineffective white pine blister rust control programs. Tree diseases due to complex factors remain unsolved as well as those caused by the bacteria, viruses, mycoplasmas and nematodes. In spite of modest accomplishments much more needs to be done.

A62

TEACHING FOREST PATHOLOGY: THE PAST 75 YEARS. W. Merrill, 210 Buckhout Lab, University Park, PA 16802.

Forest pathology education began in the US circa 1900 as grad-

uate studies related to descriptive mycology. The first undergraduate course was developed by H.R. Fulton in 1908. Several courses were developed (primarily in forestry schools) in the 1920's and 30's, and many more (in plant pathology departments) after WW II. The teaching of forest pathology has been distinct from other instruction in plant pathology, stressing primarily diagnosis based on the type-disease concept, some control, and little else. Texts used have been Hartig's, then Hubert's, and later Boyce's. Recently there has been a proliferation of texts of generally less scholarship and utility. Graduate education in forest pathology has occurred in relation to actual or perceived disasters: white pine blister rust, Dutch elm disease, oak wilt, annosus root rot, and fusiform rust. Teaching has been seriously eroded in recent years by the pretense that foresters no longer have to be biologists. Several management mistakes have been perpetrated by foresters lacking pathological education and training.

A63

THE FUTURE OF FOREST PATHOLOGY. T. Miller, Southeastern Forest Experiment Station, School of Forest Resources and Conservation, University of Florida, Gainesville, Florida 32611.

Predicting the future of forest pathology requires some assessment of where we have been and where we are now. Since forest pathology became a recognized specialty, we can point with pride to many research accomplishments. Looking critically at how many of these research successes have become disease management successes, the number decreases. The reason is not related to the quality of the research but rather a gap in our knowledge of most major diseases—a component that is crucial to our future. We have not produced the research necessary to put monetary gains on disease management recommendations because we have no means of accurately assessing damage and losses in the absence of such practices. Other factors critical to our continued existence are: increased coordination among researchers and forest managers in planning, increased research interaction between ourselves and other disciplines, and recruitment of bright, dedicated young scientists.

A64

INTRODUCTORY REMARKS ON BIOLOGICAL CONTROL OF WEEDS David O. TeBeest, Department of Plant Pathology, 217 Plant Science, University of Arkansas, Fayetteville, AR 72701

In recent years certain destructive diseases of weeds have been extensively studied and used to reduce weed related losses in agriculture and overgrowth in waterways and rangelands. Two approaches, the mycoherbicide and classical, relating to the application of biological control of weeds have evolved from this work. Academic successes have been reported in the identification and basic understanding of these natural diseases of weeds. Technological successes have been achieved in the registration and commercial use of several fungi as biological control agents. In this symposium, speakers will address themselves to questions concerning the levels of our understanding of endemic diseases of weeds, whether additional pathogens and methods can be developed, whether these agents and methods can be integrated with current agricultural practices, our understanding of the constraints on biological control of weeds, and the requirements for commercial success and grower acceptance.

A65

BIOLOGICAL CONTROL OF WEEDS WITH MYCOHERBICIDES. George E. Templeton, Dept. of Plant Pathology, University of Arkansas, Fayetteville, AR 72701.

Discrete, modest achievements have been made in use of fungal plant pathogens for weed control with the registration and commercialization of two mycoherbicides, DEVINE™ and COLLEGO™. Disease uniqueness precludes generalization of the concept as a solution to other weed problems. For certain weeds, however, increased interest and redirection of resources to discover, evaluate and develop fungi as mycoherbicides appears warranted as energy and environmental concerns increase. Interdisciplinary collaboration among plant pathologists, weed scientists, and fermentation scientists will be essential and close public-private sector interaction will be necessary to extend the concept from this modest beginning. Research to gain a fundamental understanding of pathogen and host biology at the organismal level; the nature of virulence, specificity, stability at the molecular level; and chemical modification of host resistance will provide insights for greater progress in this challenging pest control area.

A66

INTEGRATION OF BIOLOGICALS AND CHEMICALS IN PEST MANAGEMENT PROGRAMS FOR U.S. RICE PRODUCTION. Roy J. Smith, Jr., U.S. Dep. Agric., Agr. Res. Ser., Stuttgart, AR 72160.

Integration of all available weed control technologies is required to reduce losses in yield and quality of rice; systems combine preventive, cultural, mechanical, chemical, and biological practices. Weed control programs must integrate with other plant protection technologies. Two fungal pathogens, *Colletotrichum gloeosporioides* f. sp. *aeschynomene* (c.g.a.) and *C. gloeosporioides* f. sp. *jussiaeae* (c.g.j.) infect *Aeschynomene virginica* and *Jussiaea decurrens*, respectively. Tank mixtures control both weeds. They integrate with herbicides to control the more than 50 weed species that infest rice in the U.S. C.g.a. and c.g.j., tank mixed with acifluorfen, control *Aeschynomene* and *Jussiaea* and *Sesbania exaltata*; tank mixed with bentazon they control the former two and *Ammannia* spp. Most rice herbicides e.g. propanil and phenoxy injure the pathogens when tank mixed, but do not when applied in sequence. C.g.a. successfully integrates with rice disease and insect controls by tank mixing it and herbicides and applying them sequentially with fungicides and insecticides.

A67

COMMERCIALIZATION OF MICROBIAL AGENTS IN AN AGRICULTURE BASED ON CHEMICALS. D.S. Kenney, Abbott Laboratories, Long Grove, IL 60047.

With few exceptions, pest control in modern-day agriculture is based on chemicals. To successfully introduce a biologically-based pest management system into agriculture requires that a minimum of new technology or requirements be placed on the total distribution system. This applies to all parameters of the product: shelf life, handling, compatibility with other pesticides, efficacy, and above-all, cost per acre treated. There is little real interest for "environmentally-safe" products in the presently depressed agricultural market. A biologically-based product must be able to fill a real need in the market place and must be able to do it through the established channels now used by chemicals.

A68

BIOLOGICAL CONTROL OF AQUATIC WEEDS. R. Charudattan, Plant Pathology Department, University of Florida, Gainesville, 32611

Several pathogens have been studied as biocontrol agents for aquatic weeds such as *Eichhornia crassipes* (waterhyacinth), *Hydrilla verticillata* (hydrilla), *Myriophyllum spicatum* (eurasian watermilfoil), and *Alternanthera philoxeroides* (alligatorweed). Yet, biocontrol with pathogens now is possible only for floating and emergent weeds, but not for submerged weeds. Using hydrilla as an example, the problems of biocontrol of submerged weeds will be discussed. A successful biocontrol agent, *Cercospora rodmanii*, may soon be commercialized as a mycoherbicide for waterhyacinth control. A *C. rodmanii* formulation from Abbott Laboratories is being evaluated for possible registration. Ninety-nine percent control has been obtained when *C. rodmanii* is integrated with arthropod biocontrol agents, which alone are not completely effective. *C. rodmanii* can be used also with ultralow rates of 2,4-D for improved control. Biocontrol of aquatic weeds with pathogens will be more effective when integrated with other types of controls and/or used during periods of low host resistance or stress.

A69

VIRUSES OF GREEN ALGAE. James Van Etten and Russel H. Meints, Dept. of Plant Pathology and School of Life Sciences, Univ. of Nebraska, Lincoln, NE 68583-0722.

Four large, dsDNA viruses which replicate in *Chlorella*-like green algae symbiotic with *Hydra* and *Paramecium* have been identified. One of them, PBCV-1, replicated in two culturable *Chlorella* isolates. This has allowed the production of mg quantities of virus as well as the development of a plaque assay. Thus, the PBCV-1-*Chlorella* system is the first example of a virus infecting a eukaryotic plant which can utilize procedures directly adapted from those used to study bacteriophage. PBCV-1, which resembles the icosahedral cytoplasmic deoxyriboviruses, contains at least 40 polypeptides and an internal lipid component; the dsDNA weighs ca. 190 x 10⁶. PBCV-1 has a latent period of ca. 180 min and a burst size of 300 PFUs when the host is grown in the light. Viral replication also occurs in the absence of host photosynthesis. PBCV-1 infection occurs by enzymatic digestion of a portion of the host cell wall probably followed by injection of the viral DNA.

A70

RNA VIRUSES AS CLONING VEHICLES. A. Siegel, Wayne State University, Detroit, Michigan, 48202.

Certain viral RNAs should be suitable vectors for introducing foreign genetic material into plants. The strategy is to insert foreign messenger RNA into viral RNA without destroying the capacity to replicate and spread from cell to cell. The insertion should be close to the translation initiation site of a viral gene in the proper reading frame. Depending on intended use, it is desirable, but not essential in all cases, that the modified RNA have low virulence, wide host range and be seed transmitted. Technology is unavailable to make the construction directly with RNA. Thus, efforts are being made to obtain a cDNA clone of viral RNA, insert into this a cDNA copy of a messenger RNA and recover an infectious RNA transcript containing the insertion. Feasible candidates for a starting RNA are TMV RNA, tobacco rattle virus RNA-2 and tobacco necrosis virus RNA because they remain infectious when their capsid protein gene is non-functional. Thus, this gene can be substituted. Our current efforts are to develop TRV RNA-2 as a vector.

A71

PLANT VIROID RNA REPLICATION AND PATHOGENESIS. Hugh D. Robertson and Andrea D. Branch, The Rockefeller University, New York, New York 10021.

Plant viroid RNA replicates by a series of RNA intermediates created by host enzymes. The steps of our proposed replication pathway for potato spindle tuber viroid (PSTV) RNA involve (a) synthesis of multimeric minus strands from infecting circular plus viroid RNA's by a rolling circle mechanism; (b) synthesis of multimeric plus strands using minus strand multimers as template; (c) cleavage of plus strand multimers to yield linear monomers; and (d) circularization by an RNA ligase to yield mature progeny PSTV RNA's. A pre-existing host pathway to deal with circular RNA's is thus indicated. The role of this pathway in normal plant cells--and its relationship to viroid pathogenesis--is being explored using closely related PSTV strains with mild, intermediate or severe symptoms. Regions of the PSTV genome related to pathogenesis will be identified and subjected to directed mutagenesis using PSTV sequences recently cloned into the *E. coli* plasmid pBR322.

A72

GENETICS AND EVOLUTION OF INFLUENZA VIRUSES

Peter Palese, Dept. of Microbiology, Mt. Sinai School of Medicine of CUNY, New York, N.Y. 10029

Influenza is caused by highly variable RNA viruses with a segmented genome. There are three types of influenza viruses (A, B and C), but only the A type has an animal as well as a human reservoir. All of these viruses are capable of changing the genes coding for their nonsurface proteins as well as for their surface proteins. The molecular mechanisms responsible for these changes in the type A influenza viruses have been extensively studied and include recombination (reassortment) of genes and deletions, insertions and sequential point mutations in genes. Although the genetics of influenza B and C viruses are less well understood, it appears that influenza A viruses vary to a greater degree than do the other types. The unique capability of influenza virus for change is probably the cause of the frequent occurrence of influenza epidemics and pandemics.

A74

PHYTOPATHOGENIC SPIROPLASMAS. G. N. Oldfield, USDA, ARS, University of California, Riverside, CA 92521.

The proven phytopathogenic spiroplasmas, corn stunt (CSS) and *Spiroplasma citri*, the citrus stubborn disease agent, are transmitted by leafhoppers, are pathogenic to their vectors, and cause stunting and chlorosis (but not floral virescence) in their plant hosts. CSS, fastidious in vitro, is known to infect only *Zea mays* and its near relatives in nature but is experimentally transmissible to at least two dicotyledonous plants. *S. citri*, less fastidious in vitro, naturally infects members of several dicotyledonous families, is experimentally transmissible to plants representing 20 plant families (including the Liliaceae), and can infect several non-vector arthropods. CSS ranges from central USA to South America. *S. citri* occurs in citrus in the Mediterranean area and in the Southwest, and infects cultivated brassicaceous plants in Washington and Illinois. In North America, it shares much of its geographical range and

many of its hosts with the beet leafhopper, one of its vectors. Symptoms of spiroplasma infection are frequently masked in plants doubly infected with CSS or *S. citri* and non-helical MLOs.

A75

THE YELLOWING AGENTS. R.E. McCoy, University of Florida Agricultural Research Center, Fort Lauderdale 33317, USA.

The yellowing agents including the spiroplasmas and mycoplasma-like organisms (MLO) inhabit the sieve tubes of plants and the leafhopper vectors that transmit them from plant-to-plant. Cultivation of the spiroplasmas has led to their taxonomic characterization and inclusion in the Division Mollicutes. The MLO have resisted attempts at cultivation and their characterization at present must rely on the rather imprecise methods of host range, symptomatology and vector specificity. Approaches to purification of MLO and subsequent serological characterization are under investigation in several laboratories and additional effort is needed in this direction. Alternative approaches to culture of the MLO should also be considered. Control of the yellowing diseases is primarily through host resistance, although avoidance of vectors, eradication of weed hosts, and tetracycline therapy are also important.

A76

NON-PHYTOPATHOGENIC MYCOPLASMAS IN THE PLANT ENVIRONMENT. R. E. Davis. Plant Virology Laboratory, PPI, ARS, USDA, Beltsville, MD 20705

Until recently, mycoplasmas and spiroplasmas associated with plants were known only as internal parasites presumed or proven to cause certain plant diseases previously attributed to viruses. However, newer findings have revealed that probably some wall-less prokaryotes associated with plants are not plant pathogens. Taxonomically diverse mycoplasmas and spiroplasmas present on aerial plant parts are now recognized as a significant component of the epiphytic microbial flora. Some may even be capable of limited invasion of plant tissues under special circumstances. Among the intriguing questions provoked by the discoveries of these unusual wall-less prokaryotes are those related to the nature of their associations with plant tissues and their possible pathogenicity in non-plant hosts including vertebrates as well as arthropods.

A77

NUTRITION OF SPIROPLASMAS. Tseh An Chen. Plant Pathology Dept. Cook College--Rutgers University, P.O. Box 231, New Brunswick, NJ 08903.

Di-, oligo and polysaccharides can be converted to glucose when incubated with horse serum or serum fraction in the absence of spiroplasmas. Thus, study on substrate utilization and nutritional requirements of spiroplasmas in media containing serum may not be clear. A chemically defined medium (CC-494) was then developed in our laboratory. Nutritional requirements of two flower spiroplasmas (*S. floricola* and SR-3) and honey-bee spiroplasma (HB) were investigated using CC-494. All three spiroplasmas fermented glucose, fructose and mannose but, in addition, *S. floricola* utilized trehalose, sucrose and raffinose; SR-3, sucrose; and HB trehalose. HB required at least one purine and one pyrimidine base for growth while the two flower spiroplasmas could grow with only one base added. Oleic acid, cholesterol and bovine serum albumin were essential to all three spiroplasmas which, on the other hand, varied greatly in their requirements of amino acids for growth.

A78

XYLEM-INHABITING BACTERIA. D. L. Hopkins, Agricultural Research Center, University of Florida, Leesburg, FL 32748.

The fastidious, xylem-limited bacteria (XLB) consist of the coryneform type, represented by the bacterium associated with ratoon stunting of sugarcane, and the Gram-negative type, represented by bacteria associated with numerous diseases and referred to as "rickettsia-like". The ratoon stunt bacterium, unlike the Gram-negative group, has a narrow host range and is readily transmitted on agricultural equipment. The Gram-negative XLB are implicated as the cause of diseases of several economically important crops (grape, peaches, almonds, plum, and citrus) and of important urban shade trees. These diseases are especially severe in areas with tropical or subtropical climates. These Gram-negative XLB have a wide host range

and may cause many other decline and wilt type diseases that are not yet understood or described. The external symptoms of the diseases caused by XLB suggest xylem dysfunction as a major characteristic of the diseases.

A79

NUTRITION OF XYLEM-INHABITING BACTERIA. M. J. Davis, AREC, Univ. of FL. 3205 SW College Ave., Ft. Lauderdale, FL 33314

The bacterium causing Pierce's disease (PD) of grapevines was grown on a semi-defined agar medium containing 13 amino acids, 2 carboxylic acids, hemin chloride, activated charcoal, inorganic salts, and agar. The bacterium causing ratoon stunting disease (RSD) of sugarcane was grown in a defined broth medium containing 9 amino acids, 4 purines, 4 pyrimidines, 3 vitamins, glucose, hemin chloride, bovine serum albumin, and inorganic salts. Although both organisms have similar natural habitats, their nutritional requirements appeared quite different. The PD bacterium differed from the RSD bacterium by utilizing citrate and succinate, but not glucose, and by not requiring vitamins and nucleic acid bases. Both organisms were similar in their need for bovine serum albumin, charcoal, or starch, probably as detoxicants and hemin chloride, probably as a source of iron. Besides a well balanced nutritional environment, physical factors probably also contribute to the fastidious nature of both organisms.

A80

BIOLOGICAL CONTROL OF SOILBORNE PLANT PATHOGENS: INTRODUCTION. Thor Kommedahl. University of Minnesota, St. Paul, MN 55108.

"The field of biological control has been ill-served by many brief, inconclusive, and prematurely terminated studies" -- this statement by K.F. Baker (1975) is illustrated by experiments made in laboratories and greenhouses that either are not repeated in or reported from the field. Researchers have quit when results from trials in the greenhouse were not confirmed in the field, or were not reproducible in successive field trials. Thus variability in performance of a given antagonist discouraged continued research. One should identify factors that account for variability: factors that affect the antagonist (age, longevity, and amount of inoculum; strains; method of establishment) in relation to environment (soil type, fertility, amendments, temperature, moisture, pH) and genotype (cultivar, plant age) as well as disease and method of application. We need ecological information, for, as S.D. Garrett (1965) concluded, "Biological control is a problem, or rather an endless series of individual problems, in applied microbial ecology". When we know more, we can do more.

A81

ASPECTS OF RESEARCH ON BIOLOGICAL CONTROL OF SOIL-BORNE PATHOGENS IN JAPAN. Hajimu KOMADA, Soil-borne Disease Laboratory, Agricultural Research Center, Yatabe, Tsukuba, 305 Japan
During recent 10 years, many kinds of, a large quantity of and often indecomposed organic by-products, supplied by agriculture itself or by many other industries, have been applied to the field in order to biologically control various soil-borne diseases in vegetable growing. Although the effects have been varied with type of soil, with quality of organic matter, with species of host or with species of pathogen, some of them are used practically (e.g. crab-shell to strawberry Fusarium yellows, pig-dung to cucumber Fusarium wilt, etc.). Continuous application of CDU (2-oxo-4-methyl-6-hydroxypyrimidine), synthetic N-fertilizer, is effective on Fusarium wilt, possibly due to increase of CDU-decomposing bacteria antagonistic to the pathogen. Cross-protection of Fusarium wilt of sweet potato with non-pathogenic *F. oxysporum* is hopeful of practical use in the field. Transplanting in many kinds of vegetable crops is more advantageous than direct seeding in colonizing antagonistic or cross-protecting agents to the root system. Suppressive soil to *Fusarium* are also discussed.

A82

EFFECTIVENESS OF FUNGAL ANTAGONISTS FOR BIOCONTROL OF DISEASE. R. D. Lumsden, USDA, ARS, Beltsville, MD 20705

Numerous examples exist of naturally induced suppression of disease. However, in few of the examples has suppression been directly attributable to specific fungal antagonists. In spite of the lack of direct evidence that fungi are responsible for natural occurrence of disease suppression, many of the reported antagonists are fungi and their potential role in the establish-

ment of effective biological control measures is considerable. Among recently reported examples are *Trichoderma* spp. and *Gliocladium* spp. against *Sclerotium* spp., *Sclerotinia* spp., *Rhizoctonia solani* and *Pythium* spp.; *Sporidesmium sclerotivorum* and *Goniothyrium minitans* against *Sclerotinia* spp. and *Sclerotium cepivorum*; *Laetisaria arvalis* against *Pythium* spp. and *R. solani*; and *Chaetomium globosum* against *Fusarium* spp. and *Pythium* spp. Factors that affect maximum biocontrol potential include soil environmental conditions, media for production of inoculum, selection and genetic improvement of biocontrol isolates and combination of biocontrol agents with other control methods.

A83

BIOLOGICAL CONTROL OF NEMATODES. Brian Kerry, Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, England.

Although many organisms feed on nematodes we know little about their biology or role in regulating numbers of nematodes in soil. There are few useful techniques for quantitative study. Three methods have been used to investigate the effects of antagonists (parasites and predators) on nematode populations: Direct observation to estimate numbers of naturally parasitized nematodes, increasing or decreasing the activity of antagonists already in the soil and introducing antagonists into soil where they are few or absent. Results of these approaches will be discussed. Most work has concentrated on the nematophagous fungi, one of which is used commercially against some nematode pests in France. In N. Europe two endoparasitic fungi, *Nematophthora gynophila* and *Verticillium chlamyosporium* diminish cereal cyst-nematode (*Heterodera avenae*) populations to levels that scarcely affect yield even when cereals are grown continuously. These fungi attack a number of important cyst nematode pests and so methods for their exploitation will be discussed.

A84

RELATION OF BACTERIZATION TO CROP YIELD AND DISEASE CONTROL. T.V. Suslow, Advanced Genetic Sciences, PO Box 3266, Berkeley CA 94703.

The application of selected strains of bacteria to soil, seed, or propagative plant material (bacterization) has been shown to enhance crop growth and reduce disease incidence. Yield increases generally occur in the absence of known pathological stress. In contrast, biological control by bacterization commonly delays symptom development (alters the disease progress curve) but has only rarely been reported to increase growth or yield. Strains of *P. fluorescens-putida*, previously determined to cause growth promotion were evaluated for their ability to control damping-off diseases of sugar beet, tomato, and cotton in greenhouse and field trials. Results indicate that bacteria selected for growth-promoting ability may not be as effective in biological control as those isolated for disease control potential directly. Recently, inherent population density and distribution of *Pseudomonas* on roots, inoculum concentration and irrigation practices were shown to strongly influence colonization of bacteria applied to seed. Experimental strategies must be developed to maximize the benefits of each system and reduce limitations to successful bacterization.

A85

IPM: AN OVERVIEW. Ivan J. Thomason, Dept. of Nematology, Univ. of California, Riverside, Riverside, CA 92521.

Plant Pathology requires integration of many facets of biology. However, it is not integrated pest management (IPM) as some would claim. In the control of some diseases IPM principles and tactics have been successfully applied. Much recent research in plant pathology has, of necessity, been reductionist in nature. IPM however, requires certain plant pathologists to look at crop production systems, and integrate information from many disciplines into management. Advancements in this area are dependent on cooperative multidisciplinary approaches including, plant science, entomology, soil science, systems science, mathematics, and computer science. This has resulted in skepticism from "traditional" pathologists. IPM and systems analysis provide tools to focus aspects of plant pathological research, and can lead to improved instruction for practitioners of plant health.

A86

THE TRANSITION FROM INTEGRATED PEST MANAGEMENT (IPM) TO INTEGRATED CROP MANAGEMENT (ICM): TEACHING. Blanche C. Haning, Plant Pathology Dept., North Carolina State Univ., Raleigh 27650.

The transition from IPM to ICM is as critical today as the introduction of IPM courses/curricula was to the discipline of crop protection a decade ago. Today, students are intuitively recep-

tive to the merits of the holistic approach and management perspective represented by the IPM concept: that crops are the focus and end-point of IPM activity, and that the caliber of crop management can determine the extent of pest problems. Instructional emphasis now must be on ICM including thought and research that encompass agroecosystem design based in the principles of IPM. Although this emphasis can be made at various educational levels, its success depends proportionally on profoundness of understanding crop and pest biology, ecology, population dynamics, soils, agricultural sociology, systems science, management strategies and tactics, monitoring techniques and thresholds, economics, mathematics and computer science. It generally requires interdisciplinary instruction and could be maximized in curricula specifically designed for career ICM specialists.

A87

RESEARCH IN INTEGRATED PEST MANAGEMENT. D. R. MacKenzie, Department of Plant Pathology, 205 Buckhout Laboratory, The Pennsylvania State University, University Park, PA 16802

One desired attribute of Integrated Pest Management (IPM) is the complementation of pest management activities towards some final goal. Although easily stated, the design of experiments to research these relationships often entails multi-factored experiments unsuited to traditional field plot research methods. Further complications come from weather changing through the growing season and from year to year. For this reason there is a growing dependence on computer simulation and modeling in attempts to better understand how the components of a disease management strategy might be expected to operate. Systems science (in opposition to reductionist methodology) has contributed to a better understanding of the complexities of designing experiments more appropriate to IPM investigations. The growing awareness for yield loss information has led to the development of economic decision models, scouting methods and action thresholds that are so necessary for implementing IPM programs.

A88

INTEGRATED PEST MANAGEMENT OR INTEGRATED CROP MANAGEMENT? Barry J. Jacobsen, Department of Plant Pathology, University of Illinois, 1102 S. Goodwin Ave., Urbana, IL 61801.

Crop producers do business in a complex economic and political environment. Management decisions are made primarily for economic reasons. Integrated Pest Management (IPM) has provided crop producers many of the tools to make ecologically and economically sound crop protection decisions. However, the producer needs more than crop protection decision aids. Needed are the unification of all production factors including; crop selection, cultivar selection, tillage, fertility, crop protection, handling, and marketing. These factors should be unified into an Integrated Crop Management (ICM) Program which provides for long-term sustained productivity, high profits, and ecologically sound consequences. Since plant pathologists have used integrated crop management which includes varietal selection, rotation, tillage, fertility, exclusion and pesticides for many years we should be in the vanguard of agriculturalists pressing not for just IPM but ICM. Basic economics, the finite resource of productive land, and an increasing population are "driving" the evolution from IPM to ICM.

A89

INDUSTRY VIEWPOINT OF THE TRANSITION FROM IPM TO INTEGRATED CROP MANAGEMENT. H. V. Morton. CIBA-GEIGY Corporation, P. O. Box 18300, Greensboro, NC 27419.

With the concerns for the environment, erosion, pest resistance and return on investment to the grower, we are seeing many changes in crop management practices. Among the major issues that will have an impact are: conservation tillage, irrigation practices, application of extremely low rates of third generation pesticides and the opportunities in agricultural practices for biotechnology.

A90

CONSULTING. Earle S. Raun, L. N. Leininger, Daryl Monasmith. Pest Management Consulting, Inc., 4743 Meredeth, Lincoln, NE 68506

Consultant firms in the IPM field began integrating pest management in the practical world of crop production in the 60s (South) and 70s (cornbelt). About the same time, independent Agronomic specialists began consulting. Largely trained in one field,

each soon realized the need for expertise in other disciplines. Future consulting firms will employ specialists trained in complementary areas of expertise devoted to practical agriculture. Team oriented, reward systems will relate to income, rather than publication. Academic institutions need to recognize that practical knowledge is utilizable without supporting it with the scientific detail on which it is based. A suggested curriculum would include: Bachelor's level--written and verbal communications (salesmanship), general courses in crops and soils, and pest biology and identification, related to the geographic region of the institution. Graduate level--practical specialization in agronomic sciences or in crop protection (perhaps leading to degree Crop Doctor). Two season internship required.

A91

BIOLOGICAL DISEASE MANAGEMENT OF THE TURFGRASS ECOSYSTEM. P. F. Colbaugh, Texas Agricultural Experiment Station, Texas A&M University Research and Extension Center at Dallas, Dallas, Tx. 75252.

Microbiological suppression by saprophytic bacteria on turfgrass debris is an important constraint to disease initiation by facultative fungal pathogens. The ability of bacterial saprophytes to rapidly colonize dying plant parts as well as produce inhibitory substances for growth of other microorganisms is strongly suppressive to most fungal pathogens. Availability of moisture is a critical factor influencing populations and disease suppressive activities of saprophytic bacteria on plant debris. Turfgrass management practices or environmental relationships favoring cyclical patterns of wetting and drying of turf debris encourage saprophytic growth activities of dormant pathogen propagules in the absence of biological suppression. Cultivar selection, mowing height, irrigation practices and fertility levels are important cultural factors influencing conidial production and disease initiation by facultative fungal pathogens on turfgrass debris.

A92

HERBICIDAL SIDE EFFECTS ON DISEASE DEVELOPMENT. Clinton F. Hodges, Dept. of Horticulture, Iowa State University, Ames, IA 50011.

Postemergence herbicides (2,4-D, 2,4,5-TP, MCPP, dicamba) influence the severity of Drechslera sorokiniana leaf spot on Poa pratensis. Exposure of herbicide-tolerant P. pratensis to spray or soil applied herbicides at 10^{-12} , 10^{-9} , 10^{-6} , and $10^{-3}M$ primarily stimulate disease. Disease increases on progressively older leaves and the auxin-analog herbicides seem to enhance senescence processes in older leaves, predisposing them to more severe attack. Disease is further enhanced on older leaves and decreased on younger leaves by herbicide combinations. This response may be related to potential auxin effects on senescence processes in young and old leaf tissue. The herbicides decrease total sugars, have little effect on amino acids, and increase ethylene content of leaf tissue; these factors may effect pathogenesis. The potential field response of leaf spot to fall applied herbicides is probably influenced by photoperiod.

A93

MULTI-DISEASE RESISTANCE IN ST. AUGUSTINEGRASS, R. W. Toler and M. P. Grisham, Department of Plant Sciences, Texas A&M University, College Station, TX 77843.

In commercial production, St. Augustinegrass is vegetatively propagated. Combined resistance to the St. Augustine decline strain of panicum mosaic virus (PMV-SAD) and the southern chinch bug (CB) was identified and released in the cultivar Floratam in 1971. Since Floratam is infertile, gamma irradiation of nodes was used to improve disease resistance and agronomic characteristics. Mutants that possessed SAD and CB resistance were subjected to downy mildew, gray leaf spot, and the brown patch pathogens. Selections were made with combined resistance to the fungal pathogens. Floratam mutants 6, 7, and 8 were resistant to all four pathogens tested as well as to the chinch bug.

A94

FORECASTING DISEASE DEVELOPMENT THROUGH THE USE OF COMPUTER PREDICTION MODELS. T.K. Danneberger and J.M. Vargas, Jr. Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824

Fungicides are the primary means of plant protection in turf.

Increased awareness by turfgrass researchers and managers of environmental hazards and fungicide costs has resulted in development of disease forecast models. Forecasting disease development will result in more efficient fungicide application strategies. A prediction model for anthracnose (Colletotrichum graminicola), based on the environmental parameters of average daily temperature and hours of continuous leaf wetness, accurately forecasted anthracnose development with 88% accuracy. Other models have been proposed for dollar spot (Sclerotinia homoeocarpa) and Pythium blight (Pythium spp.). These forecast models are complex, but the widespread addition of computers to the golf course business simplifies their use and allows on-site disease forecasting.

A95

CHALLENGES FOR APS IN INTERNATIONAL COOPERATION. Jose Amador, 2401 East Highway 83, Weslaco, Texas 78596.

The American Phytopathological Society has an enviable record of international cooperation. From its very beginning, international programs have been an integral part of the Society and its members have made significant contributions throughout the world. But we should always strive for more and better ways to cooperate and work together as citizens of nations whose borders are coming closer and closer in an age of fast technology. In this symposium, we search for new ideas and challenges that can motivate and excite all of us to think of better ways in which we can use our profession to make this a world in which there will be a minimum of losses due to the ravages of plant diseases of resources needed for food, fiber, and shelter. Let us all work together, and make our International Cooperation programs more effective in reaching these goals.

A96

CHALLENGES IN GLOBAL PROGRAMS; Raoul A. Robinson, Simon Fraser University, Burnaby, B.C., V5A 1S6, Canada.

Possibly the most pressing of our many global problems concerns international phytosanitation; the movement of host germplasm without concomitant movement of pathogens. Tropical crop introduction and improvement programs, as well as genetic conservation programs, are severely restricted or completely stalled because of phytosanitary dangers. Industrial nations possess sophisticated post-entry quarantines and can look after themselves; but Third World countries require assistance. There is great need for intermediate tropical plant quarantines, located in temperate countries where an accidental escape of a tropical pathogen is not dangerous. Such stations would act as goodwill intermediaries to ensure that germplasm exchange between tropical countries is safe. A proposal for such a tropical quarantine in Canada is described.

A97

ENDOWED FOUNDATIONS AS A MODEL.- E.J. Wellhausen - Londres 40, 101 - 06600, Mexico, D. F., Mexico

By year 2000 three fourths of all people in the world will be living in the tropics. Acceleration of food production within the region is extremely urgent. Progress has been excellent where soil, water and climatic conditions are favorable but very sparse on agricultural lands with problem soils, vagaries of weather and ravages of plant diseases, weeds and other pests. Approximately 75 per cent of all agriculture falls into this category. If needs are to be met, a sharper focus will be needed on the development of more stable, disease resistant, high yielding cultivars and agronomic practices better adapted to unfavorable environments. Opportunities are unlimited. Identification of stable disease resistance in native plants and its incorporation into a new set of high yielding crop plants better adapted to unfavorable environments, presents a new challenge to plant pathologists and breeders. The endowed foundations as a model for promoting this type of collaborations will be emphasized.

A98

THE INTERNATIONAL AGRICULTURAL CENTRE AS A MODEL Albert H. Haak, Wageningen, The Netherlands

Wageningen, the centre of agricultural science in the Netherlands, is the home of the Agricultural University and a large number of agricultural research institutes, of the Ministry of Agriculture. The University is engaged in teaching and fundamental research, the research institutes in applied research and advisory work. There is a concentration of

knowledge and experience relating to tropical as well as temperate agriculture. IAC was established in 1951 to deal with matters relating to agriculture in developing countries; its main tasks are project appraisal, the execution of projects, evaluation and training. Using the expertise available in University departments and the research institutes, IAC has become the centre for foreign-auspices of the Ministry of Agriculture, the University, the research institutes, the advisory services, etc. Visit programs are drawn up for policy-makers and visitors work schedules for research workers and scientists. IAC's own training programs are refresher courses (average three months) at a post-graduate level to provide in-service training for mid-career people; the emphasis is on training of people from developing countries. The many links built up all over the world guarantee a truly international approach to agricultural matters in Wageningen.

A99

CHALLENGES FOR THE UNIVERSITIES IN INTERNATIONAL COOPERATION. David E. Schlegel, College of Natural Resources, University of California, Berkeley CA 94720. The role of the Universities in International Agricultural Programs has long been unclear. Some institutions have provided long term support for such efforts while others have left international activities to the whims of individual faculty members. Current attitudes within the states have not been conducive to the strengthening of the role of State Universities in international programs as there is the general feeling that such programs are a federal responsibility. It is likely that any major new initiative by the Universities will have to have strong federal support to be successful. AID's efforts to develop memoranda of understanding with various universities and the proposal for joint career programs are all in recognition of this need, however some of the programs proposed by AID are not compatible with the operating policy of most institutions. The dimensions of the need for qualified specialists are enormous and it is unlikely that current programs are adequate. A fuller recognition of the roles and limitations of both the Federal Government and the Universities is required.

A100

CHALLENGES FOR STUDENT PROGRAMS. J. B. Sinclair, Dept. of Plant Path., Univ. Illinois, 1102 S. Goodwin Ave., Urbana, IL 61801.

Our international scientific friends are some of the best ambassadors of goodwill for the USA and APS. The international student is a special resource to the profession and we need to give them the courtesy and consideration of a guest and the training to meet their individual as well as their country's needs; including research, leadership and teaching. The international student comes with interesting experiences and insights that can help our programs. Fellow US graduate students and faculty can gain from this interaction. International students should give reports in addition to their research reports at regional and national meetings. Some APS committees, like the International Cooperation, should have international student representation. To serve international students, APS should have a reduced membership fee for the student, after they leave the US and/or a one-time substantially reduced cost for APS publications. Domestic students interested in a career overseas could profit from doing a portion of their Ph.D. thesis research overseas with former students as co-advisors, with financial support from APS.

A102

GENETICS OF VIRUSES. Lous van Vloten-Doting, Dept. of Biochemistry, University of Leiden, P.O. Box 9505, 2300 RA Leiden, The Netherlands

The genome of the majority of plant viruses consists of single stranded RNA(s). No recombination has been demonstrated for this type of plant viruses. Genetic variation can take place by mutation, and in case of viruses with a multipartite genome by reassortment of genome parts (yielding pseudorecombinants). The high mutation rate of RNA viruses, which is manifest after host shift, may be responsible for accumulation of additional mutations in mutant isolates. The genome of tobravirus, nepovirus, and comovirus consists of two, that of hordeivirus, bromovirus, and cucumovirus (inclusive alfalfa mosaic virus) of three RNAs. Viable pseudorecombinants can be constructed between different strains of one virus or between viruses of the same group. The combined results of studies with pseudorecombinants and conditional lethal mutants have permitted the localization of several functions. The relative position of the virus coded functions: *RNA replication, transport to neighbouring cells and capsid protein* are similar in all viruses studied upto now.

A103

GENETICS OF PHYTOPATHOGENIC BACTERIA. A.K. Chatterjee and T.C. Currier, Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

During the past decade considerable progress has occurred in genetic research of the phytopathogenic species of *Agrobacterium*, *Erwinia*, and *Pseudomonas*. A number of genes including some that determine plant pathogenicity have been located using recombinational genetics or physical techniques. Transposons have been used in the polarized transfer of chromosomal genes by conjugation, in the isolation of mutants that are avirulent or defective in biosynthetic and catabolic pathways, and in the determination of plasmid-specified phenotypes. Plasmids have been associated with plant pathogenicity in *A. tumefaciens*, *A. rhizogenes*, and *P. savastanoi*. Investigations on the organization and expression of genes and gene products have been facilitated by cloning of several plasmid and chromosomal genes. These developments have produced a better understanding of some factors that control plant pathogenicity. The genetic tools are now available to perform critical studies on the mechanisms underlying plant:bacterial interactions.

A104

GENETICS OF NEMATODE PARASITES OF PLANTS. A. C. Triantaphyllou, Department of Genetics, North Carolina State University, Raleigh, N. C. 27650

Available information about the parasitic capabilities of sedentary, plant-parasitic nematodes relates to: a) The genetic basis of parasitism, b) The genetic mechanisms of resistance overcoming, and c) The possible effect of stabilizing selection on the genetic structure of field populations in the absence of a resistant host. Genes for parasitism have been identified in some amphimictic nematodes (*Globodera* and *Heterodera* species), and the genetic basis of parasitism has been demonstrated in some parthenogenetic *Meloidogyne* species. Circumstantial evidence points to similar genetic factors responsible for parasitism of *Ditylenchus*, *Pratylenchus*, *Radopholus*, *Rotylenchulus*, *Tylenchulus*, and possibly others. Gradual increases in parasitic capability through selection on resistant hosts have been encountered in *Meloidogyne* and *Heterodera* species, but the genetic nature of such adaptations is not clearly understood. Similarly, the limited information about the effect of stabilizing selection is inconclusive.

A105

GENETICS OF PARASITISM IN PLANT PATHOGENIC FUNGI. Neil A. Anderson, Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

At least five areas in plant pathology benefit from genetical studies on parasitism in the fungi. 1) Applied plant pathology - plant breeding programs are beneficiaries in that new resistance genes are identified and made available to scientists around the world. 2) Basic information is developed on the genetics of host-parasite interactions. This genetic information has been the basis for 3) epidemiological and 4) population genetic studies. 5) Genetic studies are the foundation for molecular biology which will be used to determine the nature and interaction of gene products for host resistance and fungal alleles for virulence and avirulence.

A106

IMPROVING THE QUALITY OF EPIDEMIOLOGICAL DATA: 1. DESCRIBING AND QUANTIFYING HOST PROPERTIES. D. I. Rouse, Dept. of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

Since disease is defined as physiological and/or morphological abnormality the measurement of disease severity requires the ability to quantitatively determine the degree of physiological and/or morphological abnormality of plants inflicted by a disease-causing agent. Epidemiological data is collected on the basis of visual signs or symptoms of disease without regard to the direct relationship these signs or symptoms have to the "actual" degree of disease expressed in terms of physiological abnormality. The quality of epidemiological data would be enhanced by a better understanding of the relationship between visual disease ratings and physiological plant stress. This requires the ability to quantify abnormal changes in host properties as a function of both visual disease and time. Research that attempts to link epidemic models with plant growth models may provide a means of understanding the dynamic relationship between disease and visual disease ratings.

A107

IMPROVING THE QUALITY OF EPIDEMIOLOGICAL DATA: DESCRIBING AND QUANTIFYING FOLIAR PATHOGENS. R.D. Shrum, Plant Disease Research Laboratory, USDA-ARS, P.O. Box 1209, Frederick, MD 21701.

Various phases of plant pathology fall under the foliar pathogen/epidemiology umbrella: 1) Detection and monitoring; 2) etiology and disease dynamics; 3) damage appraisals; and 4) development and evaluation of management systems. Others can be named. In each of these areas the value of epidemiological data can be improved in various ways: 1) more data; 2) better acuity; 3) modernized measurement objectives, and 4) more meaningful applications. These can be viewed from distinct yet complementary perspectives: one is the desire to develop more precise and more detailed information; the other to more completely apply available information. Preplanning the etiologic research effort so it coordinates with advisory activities will be stressed. Ultimately the quality of epidemiologic data will be measured by whether or not the data with its improved precision leads to new understandings of population and ecosystem responses. Examples will show how steady state data for foliar pathogens can be used in dynamic field interpretations.

A108

DESCRIBING AND QUANTIFYING SOILBORNE PATHOGENS. K. R. Barker, Department of Plant Pathology, N. C. State University, Raleigh, NC 27650.

Major advances in describing and quantifying soilborne plant-parasitic nematodes and fungi have been made in recent years. Characterization of spatial and temporal distribution patterns has provided a basis for more reliable sampling techniques. New and improved population-assay methods include partially automated elutriation combined with centrifugation for nematodes or with selective media for certain fungi. NaOCl-acid fuchsin staining methods have proven useful for quantifying fungi and nematodes in plant tissues. In addition to numerous selective media and other techniques, ELISA has promise in identifying and quantifying soilborne bacteria and possibly fungi and nematodes. This improved characterization of soilborne pathogens should facilitate increased precision in predicting and assessing associated crop losses.

A109

DESCRIBING AND QUANTIFYING DISEASE PROPERTIES. R.D. Berger, Dept. of Plant Pathology, Univ. of Florida, Gainesville 32611

Properties of disease are quantified for use in epidemiological models and crop management decisions. With the current demand for more reliability, the accuracy of measuring disease intensity and plant responses must be improved several-fold. For example, plant breeders in the past could use coarse estimates of disease intensity to rank cultivars, but such assessments are unsatisfactory for model development. Some advances in disease estimation have been made in the past decade, primarily with the use of improved disease scales, measuring devices, and sensors. In the future, instead of the intermittent estimates by human observers that are strewn with their unintentional errors and biases, the crop may be monitored continuously and nondiscriminately with a computer-assisted array of sensors (multispectral, temperature, light intensity, leaf wetness, radiation), spore samplers, porometers, gas analyzers, and other instruments. Healthy crop growth, and contrarily, the loss of foliage and the sapping of plant vigor by pathogens will be precisely quantified by researchers using modern electronics.

A110

DESCRIBING AND QUANTIFYING ENVIRONMENTAL PROPERTIES. Stella M. Coakley. NCAR, P.O. Box 3000, Boulder, CO 80307.

Environmental data are collected at both macroclimatic and microclimatic levels and the problems of collecting and utilizing each type of data will be discussed. There have been major improvements in the instrumentation and technology available to collect, store, and transmit environmental data with the ultimate limit being the monetary resources of a project. However, the value of the data will depend on the standardization and accuracy of the measured variables, as well as on the capability of the system for on-site processing and transmission of the data to the user. Environmental variables important to the epidemiology of a disease must be identified in order to ensure they are collected. Collection of microclimatic data should always be preceded by knowing how the data will be used in order to allow the selection of adequately accurate measuring devices and the use of appropriate sampling intervals. Available instruments for data collection will be discussed in respect to their accuracy and other limitations.

A111

HANDLING DISEASE DATA. J.C. Zadoks, Laboratory of Phytopathology, Binnenhaven 9, 6709 PD Wageningen, the Netherlands.

Disease data exist in many kinds which all have in common great intrinsic variability. Increasing the accuracy of measurement, if possible, is not the way to get around that variability. It has to be met by various methods such as data compaction, decreasing the accuracy of measurement, or adapting the statistical analysis. Longitudinal analysis is far more powerful than transversal analysis. To find guidance for any specific research project, the objectives of the project must be specified clearly: parameter estimation (precision?, purpose?) or significance testing (level?), or both. Cardinal measures (e.g. disease incidence) and ordinal measures (e.g. infection type) should be distinguished, but both can be handled by parametric and non-parametric statistical methods. Accuracy of the desired output, statistical design, working definitions, methods used, and input of materials and labor are all chained together, the disease data often being the weakest link of the chain. As labor is a limiting factor, sequential procedures should be envisaged.

A112

ABIOTIC CONSTRAINTS TO PLANT HEALTH: INTRODUCTION. R. J. Cook, USDA-ARS, Pullman, Wash. 99164.

The response of plants to abiotic stresses ranges between characteristic and relatively easy to diagnose symptoms, to hidden or "subclinical" effects that are no less important. Tissues may malfunction or the plant may die prematurely as the direct consequence of severe stress, e.g., freezing temperatures, a caliche layer that cannot be penetrated by roots, an acute nutrient deficiency or excess, or high ozone. The preferred term is "abiotic disease" since a "nonparasitic disease" can be caused by a microorganism that is a pathogen but not a parasite. Milder forms of stress such as low plant water potentials, a pressure pan at the depth of tillage, certain nutrient deficiencies, and chilling injury are important in their own right, but are most important when combined with parasites that become aggressive pathogens when their host is predisposed. The trend toward high-intensity crop management with shorter crop rotations and less tillage has helped reduce damage from some biotic pathogens, but is resulting in greater damage from others because of the subtle stresses that accompany such crop management.

A113

SOIL COMPACTION, pH, AND SOIL WATER DYNAMICS IN RELATION TO ROOT DISEASE. R. R. Allmaras, J. M. Kraft, D. E. Miller and D. W. Burke, USDA-ARS; Pendleton, OR 97801, and Prosser, WA 99350.

Soil compaction and associated changes in soil-water regime have improved the abiotic environment for Pythium ultimum propagules in the plow layer and Fusarium solani f. sp. pisi propagules in the subsoil. Both pathogens attack the roots of peas (Pisum sativum L.). Fertilizer-induced decreases of soil pH and organic matter declines may interact with compaction to exacerbate the adverse soil-water regime. Recently buried crop residues above the compacted layers can also affect the disease expression. An understanding of these environments, root development, and the root-disease complex requires that abiotic factors in field-soil layers as thin as 2 cm be examined as deep as 70 cm, and frequently enough to characterize seasonal changes. Root disease-soil relations in peas and beans (Phaseolus vulgaris L.) will be compared.

A114

NUTRIENT IMBALANCES AND PLANT HEALTH. André Läuchli, Department of Land, Air and Water Resources, University of California, Davis, CA 95616.

Nutrient imbalances affecting plant health can be caused by mineral deficiencies and mineral toxicities. Toxicities are due to salinity or heavy metal ions. Interactions between ions can also lead to mineral disorders. Interactions occur when ions form chemical bonds or between ions with chemical properties sufficiently similar to compete for sites of adsorption, uptake, transport and function. Examples are P deficiency in plants induced by P-fixing soils, acid soils giving rise to complex interactions between Ca, Al and P, and saline soils causing plants to suffer from salt toxicity and interactions between salt and nutrient ions. More research is needed on mechanisms of pathological mineral metabolism and on selection and breeding of crops tolerant of mineral deficiency conditions and resistant to salinity and heavy metals.

A115

PHYSICAL AND BIOLOGICAL ACCUMULATION OF TRACE ELEMENTS BY VEGETATION. Robert W. Elias, U.S. Environmental Protection Agency, Environmental Criteria Assessment Office, MD-52, Research Triangle Park, NC 27713.

In typical terrestrial ecosystems otherwise unpolluted by man, non-nutrient trace metals from atmospheric particles accumulate on vegetation surfaces, in soil organic matter, and in the roots of plants. These regions of accumulation can be seen as barriers to the uptake of toxic metals, a strategy that protects the plant by presenting a purified nutrient medium to the physiologically sensitive photosynthetic tissue. At natural background concentrations of atmospheric metals, this biogeochemical system efficiently partitions nutrient and non-nutrient metals among soil, plants, and subsequent components of the grazing and detrital food chains. Recent data on the stable isotopes of lead show how atmospheric metals from anthropogenic sources can significantly override these protective mechanisms.

A116

CHILLING ANAEROBIOISIS AND pH STRESS EFFECT ON ROOT SOLUTE LOSS AND DISEASE INCIDENCE. M.N. Christiansen, Plant Physiology Institute, Agricultural Research Center, USDA-S&E-ARS, Beltsville, Maryland 20705

Chilling, O₂ deficiency or low pH induces loss of organic substances from seedling roots. Root exudates include sugars, amino acids, protein and most other entities common to root cells. The loss of substances stems directly from stress-induced physical and chemical membrane perturbations. The quantity and duration of stress experienced by plants have a linear effect on level of root exudation; which in turn can be directly related to severity of certain diseases such as Rhizoctonia solani and Verticillium albo-atrum.

A117

ASSESSING DISEASE AND WEATHER EFFECTS IN LARGE AREA CROP PRODUCTION FORECASTING. D. A. Holt, Head, Department of Agronomy, University of Illinois, Urbana, IL 61801.

Federal and state agencies, private firms, and individuals provide crop forecasts that strongly influence commodity prices. Forecast information is usually generated by mail survey, official and unofficial observations and measurements, and statistical/mathematical models driven primarily by weather information. We developed a simulation approach to production forecasting based on the idea that the total solar energy that could be fixed in economic biomass is reduced by several factors, including weather and disease. This situation is depicted by the expression $P = Kf_1f_2f_3 \dots f_n$, where P is production, K is total energy, and the f_i are dimensionless factors. In practice, the factors are grouped into some that are evaluated daily for each county by complex submodels, surveys, or remote sensing and one, maximum yield (M), that is evaluated using historical production and other input data and a simple, but very useful, manipulation of the basic equation.

A118

DEVELOPMENT OF EXTENSION EDUCATION SYSTEMS IN PLANT PATHOLOGY. Malcolm C. Shurtleff, Department of Plant Pathology, University of Illinois, Urbana, IL 61801.

Extension programs have progressed from talks and demonstrations on farm trains, at county fairs, farmer's institutes and winter short courses (with preserved specimens, painted wall charts, and lantern slides) to modern educational programs using every known teaching medium and method. Up to the 1950's, most extension plant pathologists were generalists. Today's specialist is a teacher/applied researcher who is people-oriented with training in all plant sciences, epidemiology, integrated control strategies, diagnosis, statistics, and other crop protection disciplines. Extension teaching aids have progressed from literature written on an elementary level to color "fact" sheets and circulars and computer printouts on disease diagnosis, epidemiology, and control written at both the elementary and college levels. This is necessary because of the changing sophistication of clientele. Extension's audience has moved from agrarian to encompass all of today's society. Extension's motto, however, still remains: "Helping others to help themselves."

A119

IMPLEMENTATION OF SUCCESSFUL INTEGRATED PEST MANAGEMENT

PROGRAMS. G. W. Bird, Coordinator, Office of Integrated Pest Management Programs, Michigan State University, East Lansing, MI 48824

Integrated pest management (IPM) is an important part of most human-managed systems. IPM programs usually include the collection and delivery of biological and environmental information, design and use of pest management procedures, and evaluation of their impact on the system and associated environment (Flint, M.L., and R. van den Bosch 1981, in Introduction to Integrated Pest Management, Plenum Press, N.Y. 240 pp). The Cooperative Extension Service (CES) has an important role to play in IPM through general client education, "Communication of Innovations" (Rogers, E.M., and F. F. Shoemaker, 1971, The Free Press, N.Y., 476 pp.), and development of "Strategies for Planned Change", (Zaltman, G., and R. Duncan, 1977, John Wiley & Sons, N.Y., 404 pp.). The objective of this presentation is to describe a philosophy for CES IPM education programs in relation to the basic principles of effective change agency and appropriate communication of innovations.

A121

PESTICIDE EDUCATION TRAINING PROGRAMS RESULTING FROM 1972 FEDERAL LEGISLATION. John H. Wilson, Jr., Department of Horticultural Science, North Carolina State University, 51 Kilgore Hall, Raleigh, N. C. 27607

A 1972 amendment to the Federal Insecticide, Fungicide, Rodenticide Act of 1947 produced substantial increases in the quantity and quality of pesticide education programs. The new law required certification involving training and/or testing of both private and commercial applicators of restricted-use pesticides. Many states enacted even tougher standards including dealer licensing and licensing of certain users applying non-restricted use pesticides. The Cooperative Extension Service conducted training programs for over 1.5 million private and .5 million commercial pesticide applicators to fulfill certification and recertification requirements. The Environmental Protection Agency expended over \$12,263,000 in pass-through funds. States spent over \$19,489,000 from their own resources to develop and conduct training programs. Plant pathologists, entomologists, weed scientists and other agricultural scientists provided technical help for these programs.

A122

COUNTY PLANT CLINICS IN FLORIDA AND NORTH CAROLINA. G. W. Simone and C. W. Averre, Plant Pathology Dept., L.F.A.S., Univ. of Florida, Gainesville, FL 32611 and Plant Pathology Dept., North Carolina State Univ., Raleigh, N.C. 27650

Since 1978, county-level plant pest diagnosis has been evaluated in FL and N.C. Goals included faster and expanded diagnostic service to clientele and enhanced county extension agent profile. In Florida, 25 counties received a compound microscope, case and supplies costing ca. \$440 for the diagnosis of plant diseases. Training consisted of two one-day workshops, office visits, phone assistance and verification of county diagnoses by the State Clinic staff. Agents mastered identification of key vegetable diseases in their counties. North Carolina established 14 integrated Pilot Plant Clinics to diagnose common diseases, disorders, and pests. Each clinic cost ca. \$1000 and included: books (\$145), dissecting microscope (\$221), compound microscope (\$220), pH meter (\$134), dissolved soluble salts meter (\$125), cabinet (\$110), and supplies (\$43). Training included a 2-day workshop followed by ca. 2 county visits by plant pathologists and entomologists. These clinics were successfully used by 60% of the county agents in and out-of-office.

A123

FUTURE OUTLOOK FOR EXTENSION PLANT PATHOLOGY C. Wendell Horne Texas Agricultural Extension Service, College Station, TX 77843

Extension plant pathology has a bright future. All indications are that plant producers will continue to need knowledge readily for application and proven effective in meeting disease control needs. Extension as an educational process assumes that growers can and will adopt needed information when properly assembled and appropriately presented. The interdependence between discovery and delivery is abundantly clear. Only with discovery is delivery possible, and only with delivery is discovery needed. The American Phytopathological Society is actively pursuing balanced promotion of both aspects as evidenced by the publication of basic and applied journals. State programs seem to prosper most where separate and identifiable units of extension and research exist and both function to meet common goals. The future is there for the taking, but it must be taken. I am confident that we will responsibly evaluate society's needs and diligently work to discover and deliver those concepts that best serve its needs.

A124

POTENTIAL DISEASE PROBLEMS FOR U.S. AGRICULTURE: SOYBEAN RUST. W. M. Dowler and K. R. Bromfield. Plant Disease Research Laboratory, USDA-ARS, P. O. Box 1209, Frederick, MD 21701.

Soybean rust, caused by the fungus *Phakopsora pachyrhizi* Sydow, has not been reported from the United States, but ignoring the possibility of its entry and establishment would be imprudent. Studies of the rust in containment facilities at Frederick, MD indicate that climatic conditions are favorable for rust development throughout most of the U.S. Current U.S. cultivars are susceptible to Asian isolates of the pathogen. A key factor determining severity of disease development would be a suitable source of early inoculum, i.e., whether the rust can overwinter locally or whether inoculum enters annually from regions further south. Cooperative studies with scientists at the Asian Vegetable Research and Development Center in Taiwan have shown that field losses of 30-50% can occur when a suitable host-pathogen-environment interaction is present. A few sources of specific resistance have been identified. Significant differences in virulence between isolates from Asia and those from Puerto Rico and Brazil have been demonstrated.

A125

KARNAL BUNT OF WHEAT. J. A. Hoffmann, USDA-ARS Crops Research Laboratory, Utah State University, Logan, UT 84322

The presence of Karnal bunt (partial bunt), caused by *Tilletia indica*, in Mexico poses a serious threat to U.S. wheat production and marketing. Recently, the disease has caused significant losses in the Yaqui and Mayo Valleys of Mexico, and its incidence and spread has increased alarmingly in India and neighboring countries. Information on the biology of the causal organism and disease epidemiology is seriously deficient. Cultivars vary in susceptibility, but apparently none are immune. Control measures have not been developed. Present knowledge indicates that infection is promoted by cool temperature, high relative humidity, and abundant rainfall during wheat anthesis. This suggests that the disease could become established in the summer rainfall and irrigated wheat areas of the U.S. Current APHIS regulations require that all wheat and triticale seed from Mexico be treated with PCNB fungicide before entering the U.S.

A126

POTENTIAL DISEASE PROBLEMS: LATE WILT OF MAIZE. H.L. Warren, USDA, ARS, Dept. Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Cephalosporium maydis Samra and Sabet causes late wilt of maize. The disease is presently confined to Egypt and India. Studies have been conducted to determine a) resistance of maize inbreds and varieties to the pathogen, 2) the mechanism of survival of the pathogen in soil and plant debris, and 3) the mode of infection and means of distribution. Symptoms on infected plants appear about the time of anthesis and rapid wilt occurs which usually lead to premature senescence and severe yield loss. Seed infection is common from severely infected plants, however, the percentage of infected seed is usually low. Thus, infected seed may serve as a means of spread. The temperature for infection is 27 to 35 C with an optimum of 30 C. Optimum moisture conditions for maize growth also is optimum for disease development. Some conditions for disease development in both countries are similar while others are not. This indicates the potential for variability within the pathogen and development of the disease in other areas.

A127

CITRUS BACTERIAL CANKER DISEASE. E. L. Civerolo, USDA, Beltsville, MD 20705

Citrus bacterial canker disease affects most commercially important citrus varieties in major citrus-growing areas of the world. CBCD was eradicated from the United States. Concern about the reintroduction of the pathogen into the United States is based on the importation of citrus fruit from Japan where CBCD is endemic, the epidemic nature of CBCD in South America, and the recent recognition of an apparently new form of CBCD in Mexico. At least three forms of CBCD are recognized. Since pathogenic specialization among CBCD-associated bacteria is not clearly understood, the causal agents of all forms of CBCD are presumed to be pathogenic variants of *Xanthomonas campestris* pv. *citri*. CBCD eradication programs have been generally successful in restricting pathogen spread. Integrated systems of compatible cultural and phytosanitary practices are effective means of CBCD management in areas where the disease is endemic. CBCD diagnosis, management, eradication and quarantine activi-

ties, as well as precise pathogen identification, require a better understanding of genetic diversity in the nomenclature.

A128

Sugarcane rust and smut. L. H. Purdy and A. T. Trese, Plant Pathology Dept., University of Florida, Gainesville, FL 32611.

Sugarcane rust (*Puccinia melanocephala*) was found in Florida in March 1979, whereas sugarcane smut (*Ustilago scitaminea*) was first observed in June 1978. Both diseases appeared subsequently in Louisiana and Texas, and rust has been found in Mississippi. It is highly probable that rust uredospores and smut teliospores were carried by wind to Florida from infected sugarcane in Jamaica or Cuba. It is a remote possibility that smut might have been brought to Florida in sugarcane that entered the country illegally, or inadvertently by imported labor. Quarantines for legal importation of sugarcane are quite adequate to prevent accidental introduction of rust or smut. Rust has spread rapidly and susceptible cultivars have been removed from production. In contrast, smut incidence is increasing in certain cultivars and will probably continue to do so. Cultivars that were most susceptible to smut have been removed. Losses to rust in the cultivar B 4362 that was grown throughout the Caribbean region amounted to several million tonnes of canes. Although smut has been less dramatic, the potential loss might be similar.

A129

SORGHUM DOWNY MILDEW. Richard A. Frederiksen, Dept. of Plant Sciences, Texas A&M Univ., College Station, TX 77843

Sorghum downy mildew (*Peronosclerospora sorghi*) is one of the tropical downy mildews that has spread to most of the major maize or sorghum growing regions of the world. Its appearance in North America during the 1960's was considered as a threat to the sorghum and maize belts. While the pathogen spread to many states, economically damaging levels of the disease remained localized to the Gulf Coast region of Texas. The initial control strategy included both cultural and host resistance, which essentially eliminated losses within the endemic areas. Variation in pathogenicity prompted further research on the deployment of host resistance with integrated control. Metalaxyl labeled as a seed dressing in 1983 has further reduced potential losses by sorghum downy mildew. While periodic monitoring for variability in the pathogen and its distribution are needed, cultural and genetic controls appear to have eliminated sorghum downy mildew as a threatening disease of maize and sorghum in the USA.

A130

NEW EXOTIC VIRUS AND VIRUSLIKE DISEASES OF U.S. MAIZE. D. T. Gordon. Dept. of Plant Pathology. The Ohio State University, OARDC, Wooster, OH 44691.

Recently, several exotic virus and viruslike diseases of maize (*Zea mays*), that cause major crop loss in Latin America and The Caribbean, have been identified in the USA, mostly in southernmost regions. They are corn stunt (CS), maize bushy stunt, maize mosaic, maize rayado fino, and maize stripe (MStp). The pathogens presumably were introduced into the USA by their leaf- or plant-hopper vectors. Only MStp and CS have caused U.S. crop loss. Their spread into the U.S. Corn Belt is not anticipated. Maize chlorotic mottle virus (MCMV), a major pathogen in Peru, has caused crop losses in Kansas and Nebraska in joint infections with MDMV-A or -B to produce corn lethal necrosis. This disease has the potential to spread eastward in the Corn Belt. Introduction of MCMV into the USA was by unknown means. Maize white line mosaic virus, a minor soilborne virus in France and Italy, has caused occasional crop loss in the northern and northeastern USA. Its means of introduction into the USA and its vector are unknown.

A131

GOLDEN NEMATODE OF POTATOES. B. B. Brodie, USDA, ARS, Dept. of Plant Pathology, Cornell University, Ithaca, NY 14853.

The golden nematode (GN), *Globodera rostochiensis*, is undoubtedly the most important nematode threat to the US potato industry. Potato cyst-nematodes (PCN), *G. rostochiensis* and *G. pallida*, originated in the Andes of South America and have spread to virtually everywhere that potatoes are grown, as one or both species have been reported from 48 countries. Yield losses in countries with general infestations of PCN are 9% or more; the potential for losses is greatest in countries where average

yields are greatest, such as the USA. Although several races (pathotypes) of both species exist, only one race (R₁A) of *G. rostralis* occurs in the USA. Good resistance to this race is available and if all potatoes grown in the USA contained this resistance, spread would be restricted and the threat of GN eliminated. Current research focuses on managing GN densities at levels where spread does not occur. If GN is to be contained and its threat eliminated, such management must be eventually applied to all potato acreage of the USA.

A132

RECOMBINANT DNA TECHNOLOGY FOR FUNGAL PATHOGENS. O. C. Yoder, Cornell Univ., Dept. Plant Pathology, Ithaca, NY 14853.

It is now possible to extend to fungal plant pathogens the molecular biological concepts and methodologies that are currently used with *E. coli* and yeast, provided that the fungus in question is sufficiently well-developed. The essential elements include protocols for preparation of high quality fungal DNA and for production and regeneration of protoplasts in large quantities, a mechanism for *in vivo* genetic recombination, appropriate mutants, a cloned gene that is selectable in the fungus, and a library of fungal genomic DNA fragments in a yeast/*E. coli* shuttle vector. All of these tools are now available for *Cochliobolus heterostrophus*, a pathogen of corn. Most of the *Cochliobolus* methodologies are also suitable for *Nectria haematococca*, a pathogen of pea. It is therefore theoretically possible to isolate by complementation any *Cochliobolus* or *Nectria* gene for which there is a defined mutant allele.

A133

PSEUDOMONAS. Dallice Mills, Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331

The genetic determinants which control the interaction of a parasite with its host plant reside in both the host and the parasite. The identification of the gene products and a determination of their role in either compatible or incompatible interactions will undoubtedly provide a basis for the development of new approaches in the control of plant disease. Recombinant DNA technologies provide the tools essential for the identification, isolation and characterization of avirulence and virulence genes among the phytopathogenic pseudomonads. Presently, these technologies are being used to construct genomic libraries, analyze biochemical and genetic properties of plasmids and to develop systems for random transposon- and site-directed mutagenesis. These new approaches are enhancing our understanding of the basic genetics of these organisms and the factors important for disease production. The utilization of these technologies and the progress towards this end with selected phytopathogenic *Pseudomonas* spp. will be discussed.

A134

VIRUS MODIFICATION. Robert J. Shepherd and S. D. Daubert. Dept. of Plant Pathology, Univ. of Calif., Davis, CA 95616.

Approaches will be described for mutagenesis of DNA and RNA plant viruses. The advantage of molecular cloning for use in producing site-specific mutations will be emphasized. Such mutations in viral genomes have led to the identification and modification of functions governing disease expression and virus transmission, as will be illustrated with mutants of cauliflower mosaic virus. An understanding of basic disease inducing mechanisms will be useful in the design of defective-interfering satellite viruses and of attenuated virus strains useful for cross-protection, as well as for other strategies for disease control.

A135

MICROBIAL SYSTEMS AND VECTOR DESIGN. C. I. Kado, Department of Plant Pathology, University of California, Davis, CA 95616.

Gene vectors useful in cloning foreign DNA may be designed to shuttle genes between microorganisms and plants. These vectors are usually in the form of a plasmid because they are easiest to manipulate *in vitro*. Plasmids can be inserted directly into plant protoplasts by transfection. Vectors with replication origins for autonomous replication are constructed using the origins of replication of broad host range plasmids such as pSa and a DNA plant virus such as cauliflower mosaic virus. The vector also carries the integration sequences of the Ti plasmid of *Agrobacterium tumefaciens*. The latter sequences contain a kanamycin resistance cartridge in which a gene can

be inserted in the unique XcyI site and selected for by insertional inactivation. Stable but transient maintenance is required for the integration of the foreign gene into the plant genome. This is accomplished by the above pTi integration segments and replication origin. Expression of the inserted gene results from insertion near a strong constitutive promoter.

A136

GENETICALLY ENGINEERED AGENTS FOR CROWN GALL FIELD CONTROL. S.K. Farrand, J.E. Slota, J.-S. Shim and A. Kerr. Stritch School of Medicine, Maywood, Illinois 60153 and Waite Agricultural Research Institute, Glen Osmond, South Australia.

Field control of crown gall by *Agrobacterium radiobacter* strain 84 is mediated through the production of a highly specific, plasmid-encoded bacteriocin, agrocin 84. Unfortunately field control may lose its effectiveness through the emergence of pathogenic *A. tumefaciens* strains resistant to the agrocin. In addition, some pathogenic strain are innately resistant to agrocin 84. To approach this problem we have used transposon mutagenesis and recombinant DNA deletion analysis to map critical functions on pAgK84, the agrocinogenic plasmid. These include agrocin production and immunity and conjugal transfer. To approach the problem of developing resistance, we have isolated a nonconjugal agrocin-superproducing plasmid variant and are using recombinant DNA and marker exchange techniques to construct a derivative incompatible with *Agrobacterium* Ti plasmids. The problem of innate resistance is being approached by introducing the engineered pAgK84 into an *Agrobacterium* isolate which produces another agrocin with complementary species specificity.

A137

ESTABLISHING THE PRACTICAL SIGNIFICANCE OF SEED-BORNE PATHOGENS. R. H. Morrison. Northrup King Company, P. O. Box 1406, Woodland, CA 95695.

The criteria for establishing the practical significance of a seed-borne pathogen may vary. Criteria for quarantine may not be the same as those involving seed yield and quality, and these may differ further from those where seed infestation can result in a substantial risk of disease development in the resulting crop. In establishing the practical significance of a seed-borne pathogen it is important to determine the type and degree of association with seed, and the consequences of this association for pathogen transport, effects on seed yield and quality, and the potential for disease development in the subsequent crop. Seed assays should be directed towards establishing realistic infestation thresholds which can be related to both short and long term consequences of pathogen transport and/or transmission. Consideration should also be given to the importance of seed-borne inoculum compared with other sources of inoculum in areas where the pathogen is established.

A138

FUTURE TRENDS IN DETECTION METHODOLOGY FOR SEEDBORNE PATHOGENS: FUNGI W.J.Rennie Official Seed Testing Station for Scotland, Department of Agriculture and Fisheries for Scotland, Agricultural Scientific Services, East Craigs, Edinburgh EH12 8NJ

Incubation tests, in which fungal growth on individual seeds or symptom expression on developing seedlings is the basis for identification, are widely used in seed pathology. Standard methods have been modified to facilitate detection of specific pathogens, often at low infection levels. Future trends may be towards the increased use of selective media and biochemical tests.

A139

FUTURE TRENDS IN THE DETECTION OF SEEDBORNE BACTERIA. N. W. Schaad. Dept. Plant, Soil and Ent., Univ. of Idaho, Moscow, ID 83843

Today most seedborne bacteria are detected by rapid, sensitive, and inexpensive laboratory tests. Such tests avoid the disadvantages of growing-on test which include 1) low pathogen transmission, 2) poor or misleading expression of symptoms, 3) high operation costs, and 4) extensive time. In England, extracts of beans are plated onto King's medium B and nutrient agar for recovery of *Pseudomonas syringae* pv *phaseolicola* (PP) and *Xanthomonas campestris* pv *phaseoli* (XP), respectively. The isolated bacteria can be identified by serology and/or phage sensitivity. We are using semi-selective agar media for isolation and immunofluorescence (IF) for identification of several different pathogens. In France and

The Netherlands, *Corynebacterium michiganense* and PP, are tested by IF of bacteria in 18 to 24 hr seed soakings. In Michigan, bean seeds are soaked in a semi-selective liquid medium for recovering XP. In the future, identification of bacterial plant pathogens will most likely be based on IF using monoclonal antibodies.

A140

FUTURE TRENDS IN DETECTION METHODOLOGY FOR SEED-BORNE PATHOGENS: VIRUSES. T.W. Carroll, Department of Plant Pathology, Montana State University, Bozeman, MT 59717.

In the near future, more sensitive serological methods probably will permit most advances in detection methodology for seed-borne viruses. These methods will not only allow seed workers to rapidly detect low concentrations of specific viruses selectively within seed preparations, but they will also make possible the broad diagnosis of all of the important serotypes of the specific viruses encountered in seed. Ideally these methods will also be somewhat simple and inexpensive relative to the amount of seed that can be tested per unit sampled. Improved forms of ISEM (immunosorbent electron microscope tests), ELISA (enzyme-linked immunosorbent assays), and SPRIA (solid-phase radioimmunoassays), will comprise the bulk of the new serological methods.

A141

DETECTION OF MEANINGFUL THRESHOLD LEVELS OF SEED-BORNE PATHOGENS: J. Jørgensen, State Seed Testing Station, Skovbrynet 20, DK-2800 Lyngby, Denmark.

A threshold level for a seed-borne infection indicates the degree of infection that may be tolerated before a specific action must be taken. A first step in detection of a meaningful threshold value is to describe the relationship between laboratory test results and primary infections in the field. This may be complicated due to variation in pathogenicity, host resistance, soil and climatical conditions and due to sampling errors. A second step is to evaluate the importance of the inoculum brought with seed. Information is needed on epidemiology, mainly on alternative sources of inoculum and on yield reduction due to disease under the current conditions in the region concerned. A tentative threshold value is fixed and tried in practice under intensive survey of the disease situation in the field and on levels of infection of the new seed crop. Permanent observations are required as changes in pathogenicity, host resistance and other factors may necessitate adjustment of the threshold value.

A142

IMPACT OF SEEDBORNE PATHOGENS ON INTRANATIONAL AND INTERNATIONAL MOVEMENT OF SEEDS. Hasib S. Humaydan. Joseph Harris Co., Inc., 3670 Buffalo Road, Rochester, N. Y. 14624. Plant germ plasm collection, increase, maintenance and redistribution is now becoming a global endeavor, transcending political and geographical boundaries. Parallel to this endeavor is cultivar development, by private and public institutions around the world. In a number of instances, the activities and services of institutions scattered over 4 continents are required for producing the final commodity of commerce i.e. the seed. Naturally, this system provides an efficient mechanism for the introduction and/or spread of many potentially seed-borne plant pathogens. To circumvent this threat, local, national, and international agencies have to be aware of the danger, and scientific information relating to the detection and control of seedborne pathogens should be made available to anyone involved in the intranational and international movement of seed. In this regard, it should be noted that there is a dire need for the development of sensitive techniques for the detection and/or control of many seedborne plant pathogens.

A143

INTRODUCTION - PURPOSE AND TYPES OF MODELS. F.G.W. Jones, Rothamsted Experimental Station, Harpenden, Herts, England AL5 2JQ.

Models vary in objectives and complexity. All are simplifications and none should be objects of belief. The simplest relate two events in a descriptive way; either there is a logical connexion (the second event occurs or does not according to the status of the first) or there is a quantitative relationship involving one or more parameters (e.g. a linear or complex regression). Relationships may be purely descriptive fits to data, or may be derived from properties of the system. The second presupposes knowledge which can be submitted to systems analysis. Complex models combine a number of relationships and

require a range of appropriate input parameters which may be supplied initially or called as the model is run. Models may be deterministic, stochastic or mixed. From the first, there is only one outcome whereas the second may output results that are strikingly different. Policy models produce long-term projections. Others are concerned with specific pest or disease problems within districts, localities or individual fields.

A144

MODELING SPATIAL RELATIONSHIPS. H. Ferris. Dept. of Nematology, Univ. of California, Riverside, CA 92521. Most organisms exhibit aggregative tendencies mediated by food distribution and feeding behavior, reproductive behavior, and survival strategies. One of several statistical descriptions for aggregated populations, the negative binomial, is characterized by population mean and index of dispersion. The magnitude of these parameters dictates precision associated with sampling intensity. Another useful dispersion index, the exponent relating variance to mean in aggregated populations, is provided by Taylor's power law. Dispersion parameters in soil organisms vary with depth, season, and length of infestation establishment. Multiple-core composite soil samples of aggregated populations are equivalent to determining the mean of a skewed distribution. This may be intuitively unsatisfying as the frequency of observations on either side of the mean is unbalanced. Simulation studies indicate such techniques slightly over-estimate population densities, and result in conservative management decisions in medium-to-low damage situations. Knowledge of spatial distribution of soil organisms, and associated precision of monitoring techniques, allows cost-effectiveness analysis of these techniques in pest management programs.

A145

MODELING DISEASE COMPONENTS. C. Lee Campbell, Department of Plant Pathology, North Carolina State University, Raleigh 27650.

Quantitative description of disease components is essential in developing and understanding management strategies for plant diseases. Infection period, incubation period, latent period, sporulation rate, infectious period and dispersal gradient have been emphasized as significant components of disease development in foliar pathosystems. Analogous components can be quantified in root pathosystems for given propagule types. In pathosystems involving viruses or mycoplasma-like organisms and vectors, latent period in host and/or vector, retention time (vector), acquisition efficiency and inoculation efficiency are essential components amenable to modeling. Similar problems are encountered irrespective of pathosystem in determining precise onset and duration of specific disease components. Difficulties also exist in identifying the appropriate statistical distribution and most meaningful quantitative descriptors for components of disease.

A146

MODELING DISEASE AS A FUNCTION OF ENVIRONMENT. G. Shaner, Dept. Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907

The effect of weather on disease progress is imprecisely known for most plant diseases. Regression models are used, with variable success, to relate weather factors to disease progress. Mean temperature and total precipitation, often used in regression models, can conceal important variation. The frequency and duration of moisture is more important for disease progress than is amount of rain. Temperature during the moist period may have more effect on disease progress than daily mean temperature. Means can obscure minima or maxima outside the developmental range of a pathogen, but such extremes must be considered in relating environment to disease. Deterministic and stochastic modeling by means of computer simulation can deal effectively with problems posed by regression models. A drawback to simulation modeling is that the required weather data (often hourly) are difficult to obtain and are non-existent for large areas of crop production. Such necessary detail often precludes the use of such models for disease forecasting.

A147

MODELING VECTOR/PATHOGEN RELATIONSHIPS AND RESULTING PLANT DISEASE EPIDEMICS. L. V. Madden, Department of Plant Pathology, The Ohio State University, OARDC, Wooster, OH 44691.

Insects transmit at least 288 viruses and 45 mollicutes, yet there is little modeling of vector/pathogen interactions and resulting epidemics. This is partly due to these vector species rarely being important pests per se. However, plant virologists

have begun to apply methodologies of Vanderplank and others to these systems. Epidemic models must consider the effects of environment, host resistance, and pathogen virulence on latent and infectious periods in the host, and virus replication. Also considered are: latent and infectious periods in the vector(s), probabilities of virus acquisition and infection of the insect, and probability of host infection per length of inoculation access period. Modeling of insect population dynamics--survival, fecundity, and developmental time--also enhance our understanding of the resulting epidemics. Complicating factors include pathogen transmission by multiple species within the same field and, the not uncommon situation, by vectors not colonizing the host with the epidemic.

A148

SURVEY METHODS FOR DISEASES OF FIELD CROPS. P.S. Teng. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Surveys of field crops a) detect new, exotic diseases and b) quantify endemic diseases. Detection surveys emphasize extensive coverage (many fields) while quantification surveys require intensive sampling (within-field). Criteria for estimating disease differ with survey objectives - a presence/absence attribute may be sufficient for detection; percent incidence/severity is needed for crop loss assessment. The efficiency of processing disease data is related to method of data recording - paper/pencil method, tape recordings, grid-paper/digitizer, portable microprocessors - microprocessors give the shortest "turnaround" time, but provide high risk of data loss. Computers are increasingly used to provide on-line disease status reports via remote terminals, thereby enabling timely use of the information for pest management decisions. A U.S. national survey system is being developed to link many state surveys via a main computer and provide weekly pest summaries by region.

A149

SURVEY METHODS FOR DISEASES OF VEGETABLE CROPS. Claude E. Thomas. USDA, ARS, SR, MAA, U. S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC 29407.

Variations in the survey methods employed for diseases of vegetable crops are attributable to the diversities in crops, production practices, and geography. Methods currently used range from roadside observations to sophisticated remote sensing techniques and are based on random, area, stratified, or purposive sampling procedures. The choice of method is governed by both the purpose of the survey and the availability of resources. Where disease incidence does not equate with intensity, disease intensity is usually assessed visually using the Horsfall-Barratt or similar systems or through the use of standardized disease assessment keys. In vegetable crops surveys are conducted to: assess general disease incidence, provide estimates of losses, monitor shifts in pathogen populations, refine management activities, support regulatory functions, or complement other research activities.

A150

DISEASE SURVEY METHODS FOR NURSERY CROPS. D. M. Benson, Dept. of Plant Pathology, N. C. State University, Raleigh 27650.

A method for surveying ornamental nurseries on a statewide basis was developed to determine the incidence of Phytophthora root rot of azalea. Azalea nurseries were identified from lists of certified nurseries and statewide inventories of plant materials. Each identified nursery was verified by local county agents. Nurseries were stratified east-west and north-south in the state prior to systematically selecting those to be surveyed. Sample size at each nursery was predetermined based on a 2% standard error using a 10% disease loss estimate. Nurseries were surveyed after the total azalea populations were determined by systematically collecting root samples, recording plant identification, time required, and travel mileage for cost estimates. Samples were assayed on selective medium in the lab, and the percent infection was calculated and statistically compared. The value of the survey results was limited by the nonuniformity of conditions from nursery to nursery.

A151

SURVEY METHODS FOR DISEASES OF FRUIT CROPS. Calvin L. Schoulties, Florida Department of Agriculture & Consumer Services, Division of Plant Industry, P. O. Box 1269, Gainesville, FL 32602.

Florida's 850,000 acre citrus industry is constantly threatened by diseases that could result from the introduction of patho-

gens through citrus imports, by travellers carrying citrus, and by new citrus germplasm. Each year 20% of the commercial acreage of citrus, dooryard citrus throughout the State, and citrus seedling nurseries, are systematically surveyed for new diseases. Surveyors are trained to recognize common diseases, and thereby they distinguish the uncommon and submit them for diagnosis. Further, they are trained to recognize certain threatening exotic diseases such as citrus canker, Xanthomonas campestris pv. citri. The risk of having new and widespread diseases in citrus is minimized by intensifying inspections at and near major ports of entry where pathogens are likely to be introduced and by having a quarantine and tissue culture facility to safely allow the entry and release of new citrus germplasm.

A152

SURVEY METHODS FOR DISEASES OF FOREST TREES. R. Lewis, Jr., USFS, Southern Hardwoods Laboratory, Box 227, Stoneville, MS 38776.

Surveys to show incidence and distribution of diseases in natural forests, plantations, and urban environments may be comprehensive or specific with respect to injury, causal agent, geographical area or forest type. Comprehensive surveys show the incidence and amount of losses from all diseases i.e. wilts, root rots, cankers and decays within areas ranging from individual forests to entire states and regions. Disease specific surveys are concerned with only one problem i.e. oak wilt (Ceratocystis fagacearum) in oaks (Quercus spp.) within a defined area. The survey method used in any situation should provide sufficient data for analysis and satisfy the primary objectives.

A153

INFLUENCE OF WATER POTENTIAL AND TEMPERATURE ON GROWTH OF BOTRYTIS ALLII ON AGAR AND ON DRIED ONION LEAVES. S.C. Alderman and M.L. Lacy. Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

A highly significant interaction between temperature and water potential was evident in growth of Botrytis allii, causal agent of onion neck rot. Growth in prune extract-lactose-yeast extract medium (PLY), osmotically adjusted with KCl, NaCl, sucrose, or PEG 8000 was optimal at 20 or 25 C, at -5 to -15 bars water potential, but was reduced at 30 C. However, growth was optimal at 30 C, at -35 to -45 bars, but was reduced at 20 or 25 C. At potentials less than -50 bars, growth was similar at all three temperatures. Growth was halted at -95 to -100 bars. Growth of B. allii in dried onion leaves, adjusted to various water potentials over salt solution, in sealed chambers, was similar to those mentioned above on PLY medium at corresponding potentials and temperatures. Dry weights of B. allii grown in PLY broth corresponded to growth on solid PLY medium at corresponding potentials.

A154

AN INTEGRATED SCREENING PROCEDURE FOR BREEDING BEANS RESISTANT TO BACTERIAL BROWN SPOT (PSEUDOMONAS SYRINGAE). S. H. Antonius and D. J. Hagedorn, Dept. of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

Four screening procedures available for characterization of host reaction to P. syringae have noteworthy advantages and disadvantages which make each suitable for a particular role in a breeding program. The seedling procedure is rapid but better suited to later generation testing. Greenhouse screening offers the most accurate means for distinguishing among different reaction levels but is time-consuming and requires extensive greenhouse space. The detached pod test offers a relatively poor means of differentiating between high and modest levels of resistance. In the field disease pressure is often highly variable. An integrated screening program is recommended which maximizes response to selection while minimizing the time and space required for a thorough test. In this scheme the weight of the program rests upon the seedling and detached pod tests.

A155

EVALUATING PEPPERS, COWPEAS, SWEET POTATOES AND TOMATOES FOR RESISTANCE TO SOUTHERN BLIGHT INCITED BY SCLEROTIUM ROLFESII SACC. P. D. Dukes, R. L. Fery, Alfred Jones, USDA, ARS, SR, MAA, U. S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC 29407 and M. G. Hamilton, Clemson University, Edisto Agricultural Experiment Station, Blackville, SC 29817. Procedures were developed for evaluating peppers, cowpeas,

sweet potatoes and tomatoes for resistance to southern blight (SB). This disease causes significant losses to these vegetable crops each year. Methods for mass production, standardization and storage of *S. rolfsii* sclerotia were refined, and procedures were developed for rapidly inoculating field plantings. These procedures were shown to be efficient and practical for use in plant breeding programs. Results of field tests suggest there is significant genetic variability in peppers, cowpeas and sweet potatoes for SB resistance; several accessions of peppers and cowpeas exhibited promising levels of resistance. Results of field and greenhouse tests indicate that various ages of pepper plants can be evaluated for resistance.

A156

EVALUATION OF CELERY CULTIVARS AND LINES FOR FUSARIUM YELLOWS RESISTANCE IN MICHIGAN. W.H. Elmer & M.L. Lacy, Dept. of Botany & Plant Pathology, Mich. State Univ., E. Lansing, MI 48824-1312

Thirty cultivars and lines of celery, including seven interspecific crosses of celery X parsley (CXP), were evaluated for resistance to Fusarium yellows (*F. oxysporum* f. sp. *apii* race 2) under field conditions in naturally infested soil and in the greenhouse using a colonized wheat straw soil infestation technique. Fresh or dry weights of the foliar portions were determined and disease ratings were made based on the percent vascular discoloration in the crown region. Cultivars Summer Pascal, Tall Utah 52-70 HK and Tendercrisp were rated as moderately resistant and were highest in fresh weights. Grande, Tall Utah 52-75 and Golden Spartan were considered moderately susceptible. All other commercial cultivars, including Florida 683, the most widely grown cultivar in Michigan, were rated as highly susceptible. Several lines of CXP possessed resistance in segregating progeny which were saved for breeding purposes. Similar levels of relative resistance were observed in both greenhouse and field.

A157

CULTURAL CONTROL OF RACE 3 FUSARIUM WILT OF TOMATO. John Paul Jones and S. S. Woitz. Plant Pathologist and Plant Physiologist, respectively. Univ. of Fla., IFAS, Agr. Res. & Ed. Ctr., Bradenton, FL 33508.

The effects of soil pH and various nutritional regimes on the development of Fusarium wilt of tomato incited by *F. oxysporum* f. sp. *lycopersici* race 3 were determined. The pH of virgin Myakka fine sand was adjusted with hydrated lime; fritted minor elements and Fe, Mn and Zn sulfates added; and liquid fertilizers of N-P-K-Mg were applied thrice weekly. Two $\text{NO}_3:\text{NH}_4\text{-N}$ ratios were used: 80:20 and 20:80. Soil dilution plates were prepared with Komada agar. Disease incidence decreased with increasing soil pH (75, 62 and 38% at pH 4.5, 6.5 and 7.5). Ammonia-N encouraged disease development compared to $\text{NO}_3\text{-N}$ (71% vs. 47%). Micronutrients had no effect. Soil pH of 7.5 + $\text{NO}_3\text{-N}$ reduced disease incidence to 32% compared to 89% for pH 4.5 + $\text{NH}_4\text{-N}$. Numbers of Fusarium colonies recovered from the soil increased with decreasing soil pH. Nitrogen source did not affect the number of colonies recovered.

A158

SCREENING SNAP BEANS FOR RESISTANCE TO SOYBEAN CYST NEMATODE. T.A. Melton, B.J. Jacobsen, and G.R. Noel, Department of Plant Pathology, University of Illinois, Urbana, IL 61801.

Twenty-three snap bean (*Phaseolus vulgaris*) cultivars were screened for resistance in a greenhouse to races 3 and 4 of soybean cyst nematode (*Heterodera glycines*) using naturally infested soil. A randomized complete block design with five replicates was used for each race and the experiment was conducted twice. Means of the white females were separated using Fischer's LSD. Eight snap bean cultivars were equally suitable hosts ($p < .10$) as Williams 79 soybean for race 3 based on white females per root system and per gram of dried root. Three snap bean cultivars were better hosts than Williams 79 for race 4 ($p < .10$). Snap bean WI 36 was classified resistant to both races because reproduction was lower ($p < .05$) and less than 10% of the most susceptible snap bean or soybean cultivars. Additionally, reproduction on WI 36 was not different ($p < .05$) than soybean cv. Fayette (resistant to races 3 and 4) for either race.

A159

FACTORS AFFECTING SURVIVAL OF *PHYTOPHTHORA INFESTANS* IN SEEDS EXTRACTED FROM INFECTED TOMATO FRUITS. V. G. Vartanian and R. M. Endo, Department of Plant Pathology, University of

California, Riverside, CA 92521.

Seeds were extracted from healthy and blight-affected tomatoes collected from two field-grown cultivars, processed as in a commercial operation, and the seeds plated on a selective medium. The pathogen usually was isolated (93%) from discolored, freshly extracted, wet seeds but not from discolored seeds that were dried in an oven (29.5 - 37.5 C for 6 hr) or air dried for 72 hr following extraction. Fermentation for 24 hr eliminated the fungus from discolored seeds of cv 7718 but not of cv 1025. Treatment of discolored seeds with either NaOCl (0.5% for 5 min) or HCl (pH 1.6, for 25 min) significantly reduced the frequency of *P. infestans* isolation. In discolored seeds, hyphae were observed in the remnants of the funiculus, on the seed coat, and in the spaces between the embryo and the endosperm and between the endosperm and the seed coat. These results confirm the generalization by Neergaard that Oomycetous fungi are rarely seed borne because of an intolerance of the hyphae to desiccation.

A160

DEVELOPMENT OF DISEASE MANAGEMENT SYSTEMS FOR IPM OF LETTUCE AND CABBAGE IN HAWAII. J. J. Cho and W. C. Mitchell, Department of Plant Pathology, (P. O. Box 269, Kula, HI 96790) and Department of Entomology, University of Hawaii, Honolulu, HI 96822. The major diseases affecting cabbage and lettuce have been identified during the initial phase of IPM development. Emphasis has been directed at 1) identification of diseases of lettuce and cabbage; 2) defining parameters favorable for disease outbreaks to develop predictive models; 3) develop economic threshold levels for crop losses, and 4) identify feasible means of disease control. Pesticide trials have been directed at establishing effective application levels and developing optimal timing for maximal disease control. Bottom rot of lettuce caused by *Rhizoctonia solani* was effectively controlled with iprodione, thiophanate methyl, and benomyl. Subsequent trials indicated the critical period for bottom rot disease development occurred about two weeks from crop maturity with effective control achieved with one or two iprodione applications starting at that critical period. Weekly applications of Streptomycin sulfate and copper hydroxide were effective in reducing bacterial leaf spot of lettuce caused by a complex of bacteria.

A161

SURVIVAL OF INOCULUM OF THE ENTOMOPATHOGENIC FUNGUS, *BEAUVERIA BASSIANA*, AS INFLUENCED BY FUNGICIDES. R. Loria, S. Galaini, and D. W. Roberts. Dept. Plant Pathology and Long Island Horticultural Research Laboratory, Cornell Univ., Riverhead, NY 11901; Dept of Entomology, Cornell Univ., Ithaca, NY 14853; and Insect Pathology Resource Center, Boyce Thompson Inst., Tower Rd. Cornell Univ., Ithaca, NY 14853

Four fungicides used commercially for control of foliar diseases of potato were evaluated *in vitro* and under field conditions for effects on survival of spores of *Beauveria bassiana* (Balsamo), a pathogen of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). Mancozeb, the most detrimental of the fungicides, substantially reduced survival in both laboratory and field studies. Chlorothalonil and metalaxyl had no detrimental effects on survival of spores in any of the tests conducted, while metiram was intermediate in its fungicidal effects on *B. bassiana*. These data suggest that metalaxyl and chlorothalonil are appropriate fungicides to use in an integrated pest management program which includes *B. bassiana* for Colorado potato beetle control.

A162

INFLUENCE OF *PRATYLENCHUS HEXINCISUS* AND *COLLETOTRICHUM GRAMINICOLA* ON GROWTH AND DISEASE SEVERITY IN MAIZE. R. L. Nicholson, F. P. DeGennaro, and G. B. Bergeson. Dept. of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907.

Colletotrichum graminicola but not *Pratylenchus hexincisus* significantly reduced extended leaf height and stalk circumference of the anthracnose susceptible maize hybrid Mol7_{Ht} X B73_{Ht}. Disease severity was significantly increased in plants grown in the presence of the nematode. Plants grown in the presence of the nematode or inoculated with *C. graminicola* at 13, 35, or 55 days after planting also exhibited a significant increase in senescence over controls. Furthermore, the presence of both nematode and fungus resulted in an even greater rate of senescence. Dry root weight but not foliage weight was significantly reduced by the nematode. In contrast, inoculation with the fungus resulted in significant decreases in both dry root and foliage weights.

A163

ALFALFA IPM IN WYOMING. J. Keith Waldron and Larry E. Gholson. Dept. of Plant Sci., Univ. of Wyo., P.O. Box 3354, Univ. Sta., Laramie, WY 82071.

A pilot integrated pest management (IPM) program was initiated on irrigated alfalfa in Fremont County, Wyoming. Results of surveys conducted in 1982 indicated greater losses due to diseases and weeds than insects. Stand losses primarily attributed to phytophthora root rot, alfalfa stem nematode and an unidentified crown rot complex were conservatively estimated at 5-25%. Accurate identification of diseases will provide information for better disease management, in part through use of resistant varieties and improved irrigation management. Weeds were a secondary problem throughout the production area, invading fields thinned by diseases. Dodder was found in 5% of the acreage and will require close management to prevent further spread. Where alfalfa weevil was a problem, early detection and control increased grower earnings \$50/acre compared to traditional methods that applied control measures after damage was visible. Less than 50% of fields infested with the pea aphid required treatment. Recommendations not to spray saved growers an additional \$6/acre. Wyo. Ag. Exp. Sta. SA 1196.

A164

IDENTIFICATION AND CHARACTERIZATION OF A VIRUS IN SWEET POTATO FOUND IN SOUTHEAST ZAIRE, CENTRAL AFRICA. T. A. Acham, B. Lockhart and E. Banitari. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Three isolates of viruses (ZSPV₁, ₂ and ₃) in sweet potatoes, that caused chlorotic spots and mosaic were obtained from Southeast Zaire. The isolates were readily sap-transmissible to members of the Convolvulaceae and non-persistently transmitted by *Myzus persicae* to *Ipomoea nil* 'Scarlet O'Hara' or *Quamoclit sloteri* 'Cardinal Climber'. All isolates caused systemic infection in *Chenopodium quinoa* which was previously reported to be a local lesion host for sweet potato feathery mottle virus (SPFMV). Antiserum prepared for ZSPV₂ reacted specifically in agar double diffusion assays with all three isolates. A heterologous reaction occurred between the antiserum produced to ZSPV₂ and SPFMV common strain (SPFMV-C) and SPFMV russet crack strain (SPFMV-RC). On the basis of symptoms, mechanical transmission, particle morphology, a common vector and serology, the isolates of ZSPV appear to be related to a strain of SPFMV described in the United States.

A165

APHID TRANSMISSIBILITY OF FIVE STRAINS OF PEANUT MOTTLE VIRUS. D. C. Bays and S. A. Tolin, Department of Plant Pathology & Physiology, Virginia Polytechnic Institute & State University, Blacksburg, Virginia. 24061.

Five strains of peanut mottle virus (PMV) induce differential responses on selected cultivars of soybean (*Glycine max*) but are serologically similar and are equally productive in 'Little Marvel' pea (*Pisum sativum*) and 'Lee 68' soybean. The transmission efficiency of the PMV strains by the green peach aphid (*Myzus persicae*) was determined by counting infected test plants following natural feeding by aphids exposed to virus-infected source plants. Transmission efficiency from pea source plants to pea test plants was 11-36% and varied with strain. Pea to soybean and soybean to soybean transmission was 5-29% and 20-58%, respectively. The overall transmission efficiency of strains V74S/473, V74S/10B-1 and V79S/38-2 was significantly lower than that of V79S/20 and V79S/33. Thus, based on aphid transmission efficiency, the strains could be classified into 2 groups.

A166

EVIDENCE FOR TWO MODES OF RETENTION OF MAIZE DWARF MOSAIC VIRUS BY SCHIZAPHIS GRAMINUM. P. H. Berger, R. W. Toler, Department of Plant Sciences, and K. F. Harris, Department of Entomology, Texas A&M University, College Station, TX 77843.

The rate of loss of infectivity of maize dwarf mosaic virus (MDMV), strain A, was determined after 1, 3, 10, 17, and 30 min acquisition times. As acquisition time increases, the rate of loss of infectivity decreases. Nonlinear regression methods indicated that two separate rates of loss functions were present, suggesting that the mechanisms of transmission (carryover) were different, depending on acquisition time. Serial transmission experiments, using 1 and 30 min acquisition times, indicated that there was no difference in the amount of virus acquired by these two populations of vectors. These data suggest that stylet-borne contamination,

as well as ingestion-egestion of MDMV, occur and are dependent on the acquisition time.

A167

CELL WALL AND MITOCHONDRIAL LESIONS IN P2 SENSITIVE USTILAGO MAYDIS STRAIN PRODUCED BY TOXIN FROM THE VIRUS-CONTAINING USTILAGO MAYDIS STRAIN P4. S.E. Bouillet, J.D. Schoknecht, and R.F. Bozarth. Department of Life Sciences, Indiana State University, Terre Haute, IN 47809

Virus-containing cells of the P4 strain of *Ustilago maydis* produce a toxin which kills sensitive cells of the P2 strain. The toxin, a 10,000 dalton polypeptide, was purified and applied to a cell suspension of sensitive P2 cells. Scanning and transmission electron microscopy of P2 cells fixed within 10 minutes of exposure to the toxin revealed a series of morphological and physiological lesions. Immediately following binding of the toxin to the cell, changes in surface morphology were evident and there was a ballooning out of the cell wall to produce a round structure resembling a spore. This was followed by changes in the normal stacked arrangement of mitochondrial cristae. At the same time respiration increased dramatically and then terminated.

A168

OCCURRENCE OF COTTON LEAF CRUMPLE ASSOCIATED WITH SEVERE WHITEFLY INFESTATIONS IN ARIZONA. J.K. Brown, G.D. Butler, Jr., and M.R. Nelson. Dept. of Plant Pathology, Univ. of AZ, Tucson AZ 85721 and W. Cotton Research Lab-USDA, Phoenix, AZ 85040

Cotton leaf crumple (CLC) was identified as the major cotton disease associated with infestations of *Bemisia tabaci* in AZ during 1981-82. Identification was based on semi-persistent transmission by *B. tabaci*, host range, symptomatology and apparent lack of seed or sap transmissibility. The host range, reportedly confined to the Malvaceae, now includes other families. Observed differences in symptom severity under field conditions are related to host age and site of inoculation (cotyledon vs. true leaf). Adult whitefly populations were monitored by sticky trap and vacuum collections at 14 AZ locations from Jan-Sept, 1982. Adults overwintered on weeds and were detected in melon and cotton fields in March and July, respectively. Whitefly populations were highest in cotton planted adjacent to melons. Populations in cotton increased exponentially in mid-July, followed by a decline in Sept. In 1982, the first CLC symptoms in planted cotton appeared in Sept on flush growth.

A169

COMPARISONS OF CUCUMOVIRUSES AND THEIR SATELLITES. J. C. Carrington, and T. J. Morris, Department of Plant Pathology, University of California, Berkeley, CA 94720, and W. O. Dawson, Department of Plant Pathology, University of California, Riverside, CA 92521.

Two cowpea cucumoviruses were compared to several cucumber mosaic (CMV) and peanut stunt virus (PSV) strains with respect to single-stranded (ss) and replicative-form (RF) nucleic acids, serological relatedness, host range, and responses to 2 satellite RNAs. Both cowpea strains (CV and Cow) were similar to established CMV strains based on ssRNA electrophoretic profiles and strong serological affinity as determined by indirect ELISA. They resembled PSV strain 74-23, however, on the basis of RF accumulation, host range, and moderate serological cross reactivity. A satellite associated with strain CV induced bright yellow chlorosis on infected cowpeas. Satellite-free, CV-infected cowpeas showed no such chlorosis. When this satellite was inoculated with strain Cow onto cowpea, a moderate attenuation of symptoms was observed instead of bright chlorosis. Further, these respective syndromes could be induced if either strain was inoculated with another satellite from a distinct CMV isolate.

A170

POTENTIAL USE OF REMOTE SENSING IN DELIMITING AREAS OF VIRUS INFECTION IN VINEYARDS AND BLUEBERRY FIELDS IN MICHIGAN. A.M. Childress-Roberts and D.C. Ramsdell, Department of Botany and Plant Pathology, and D. Lusch, Center for Remote Sensing, Michigan State University, East Lansing, MI 48824.

Remote sensing techniques were used to detect virus infection in highbush blueberry and 'Concord' grapevines. Blueberry shoestring virus (BBSV), blueberry leaf mottle virus (BBLMV), and peach rosette mosaic virus (PRMV) of grape were assessed during the 1981 and 1982 growing seasons. Spectral reflectances of plant canopies were recorded at high (305 m) and low (2 m) altitudes using color, black/white infrared (IR) and color infrared (CIR) photographs at various phenological stages.

Spectral signatures of healthy and virus-infected plants were measured over 256 wavelengths simultaneously, using a spectroradiometer. Ground truth was acquired by indexing individual plants using the ELISA technique. Generally, BBSSV-infected blueberry bushes and PRMV-infected vines exhibited decreased reflectance in the IR region compared to healthy plants, while BBLMV-infected bushes showed increased reflectance.

A171

FACTORS AFFECTING TRANSMISSION OF SOYBEAN DWARF VIRUS AND DEVELOPMENT OF DISEASE IN WAYNE SOYBEAN. Vernon D. Damsteegt and J. M. Snapp, Plant Disease Research Laboratory, USDA-ARS, P. O. Box 1209, Frederick, MD 21701.

Several physical and biological parameters of disease development were examined for soybean dwarf. Acquisition and inoculation access periods were varied from 24-96 hr; 48 hr AAP and 48 hr IAP gave consistently high levels of transmission. The dwarfing strain was distributed throughout all trifoliolates while the yellowing strain was generally restricted to the younger trifoliolates. Alate and apterous forms of aphids were equally efficient in transmission. Studies in environmental chambers indicated a 14-hr light (25-29C) and 10-hr dark (16-19C) regime was most favorable for growth of Wayne soybeans and disease development. Variations in ambient temperature from 18-27C during propagation and inoculation did not affect the subsequent amount of infection. Soybean plants were more susceptible in early growth stages (0 and 1) than in older plants (growth stages 2 and above).

A172

PRODUCTION OF MONOCLONAL ANTIBODIES AGAINST THREE ISOLATES OF BARLEY YELLOW DWARF VIRUS. R. Diaco,¹ R. M. Lister,² D. P. Durand,¹ and J. H. Hill.³ ¹Dept. of Microbiology, Iowa State Univ., Ames, IA 50011. ²Dept. of Botany and Plant Path., Purdue Univ., West Lafayette, IN 47907. ³Dept. of Plant Path., Seed and Weed Sciences, Iowa State Univ., Ames, IA 50011.

Hybridomas secreting monoclonal antibodies against barley yellow dwarf virus were established. Three monoclonal antibody preparations were generated against the MAV isolate (transmitted specifically by *Macrosiphum avenae*), three against RPV (transmitted specifically by *Rhopalosiphum padi*), and ten against PAV (transmitted nonspecifically by both). Results in a competition ELISA indicated the presence of at least two epitopes (antigen binding sites) on the coat protein of PAV. Preliminary experiments using ELISA suggest the presence of a common epitope on all three virus isolates.

A173

VIRUS INCIDENCE AND APHID TRAPPING IN ARROWLEAF CLOVER
M. M. Ellsbury, R. G. Baer and M. R. McLaughlin, USDA-ARS, Crop Science Research Laboratory, Forage Research Unit, P. O. Box 5367, Mississippi State, MS 39762

Groups of arrowleaf clover bait plants grown in the greenhouse were successively exposed 1 week each in the field, held in the greenhouse 3 weeks, then indexed for viruses by enzyme-linked immunosorbent assay. Aphids near the bait plants were trapped in green tile/water pan traps and collected weekly. Numbers of trapped aphids peaked in November, and in mid-March, mid-April and mid-May. Virus infections were first detected in late March and reached a peak in early May, but few infections occurred in November. Bean yellow mosaic virus occurred earliest and most often, but alfalfa mosaic virus, clover yellow vein virus, peanut stunt virus and red clover vein mosaic virus also were found. Differences in dates of first occurrence among viruses were observed. The apparent time lag between periods of peak aphid movement and increased virus incidence, and the differences in dates of first occurrence among the viruses, suggest complex epidemiological relationships.

A174

CHARACTERIZATION OF A FLORIDA ISOLATE OF MAIZE MOSAIC VIRUS.
B. W. Falk and J. H. Tsai. University of Florida, A.R.E.C., Belle Glade, FL, 33430 and A.R.E.C., Ft. Lauderdale, FL, 33314

Maize mosaic virus (MMV) was purified from greenhouse infected corn (*Zea mays* L.) and characterized. Virions were purified using Celite clarification and differential centrifugation. Purified, infectious preparations contained virions of $224 \pm 21.4 \times 67.6 \pm 8.7$ nm. The sedimentation coefficient for MMV was estimated using linear-log sucrose gradients and was found to be ca. 774. SDS-PAGE of purified virion proteins showed three major proteins with estimated molecular weights of 74,600

(74.6 k), 52,600 (52.6 k), and 30,000 (30 k). The 74.6 k protein reacted with Schiff's reagent indicating it is a glycoprotein. Both the 74.6 k and 30 k proteins were solubilized by non-ionic detergent treatment of purified virions, while the 52.6 k protein was still associated with the nucleoprotein. Based on these data MMV is tentatively assigned to the lettuce necrotic yellows sub group of plant rhabdoviruses.

A175

MILD STRAINS OF POTATO VIRUS Y IN SEED POTATOES. C.L. Fei and E.E. Wanttari. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Isolates of potato virus Y (PVY) that caused mild mosaics were obtained from certified seed potatoes and from potato breeding lines. Symptoms in *Nicotiana tabacum* 'White Burley', *N. glutinosa*, chili pepper *Capsicum annuum* 'Anaheim', in three potato cultivars in the greenhouse, assays by agar double diffusion tests and ELISA, electron microscopy, and transmission with *Myzus persicae* indicated that these isolates of PVY were mild potato strains of PVY^o. In field inoculations 'Kennebec' was most resistant or usually developed only latent infections, 'Russet Burbank' developed mild mosaic and 'Norland' developed rugosity, necrosis and abscission of lower leaves and severe stunting. Comparison of mild isolate and common (severe) strain antisera by agar double diffusion assay or ELISA resulted in homologous reactions with either mild or severe PVY isolates.

A176

REACTION OF POTATO CLONES 'IMMUNE' TO POTATO VIRUS Y, TO POTATO VIRUSES A, X, AND TO A WIDE RANGE OF POTATO VIRUS Y STRAINS FROM THE ANDEAN REGION. E.N. Fernandez-Northcote. Universidad Nacional Agraria La Molina - CIP, Apartado 5969, LIMA - PERU.

Selected potato clones, with 'immunity' to potato virus Y (PVY) derived from *Solanum stoloniferum* or *S. andigena* were challenged with strains prevalent in potato fields from the Andean region: Chile, Argentina, Peru and Ecuador. They belonged to the PVY^o, PVY^c and PVY^g group of strains. After grafting the clones as stocks with PVY infected *Nicotiana occidentalis* scions all the selected clones remained 'immune' to a maximum of 20 isolates tested. They did not show symptoms and were not infected as determined by ELISA and backtesting to tobacco White Burley in two tuber generations. All three *S. stoloniferum* derived clones were also 'immune' to PVA and PVX ('immunity' to PVX derived from *S. acaule* and *S. andigena*), but only one out of five *S. andigena* clones was also 'immune' to PVA. All five were also 'immune' to PVX. The reaction of 'immunity' to PVY of the selected clones to the diversity of strains tested indicates the potential stability of resistance to PVY.

A177

BARLEY YELLOW DWARF VIRUSES IN IDAHO WHEAT AND CORN. Robert L. Forster, Univ. of Idaho Res. & Ext. Center, Kimberly, ID 83341, and W. F. Rochow, ARS, U.S. Dept. Agr., Plant Pathology Dept., Cornell Univ., Ithaca, NY 14853

A severe epidemic of barley yellow dwarf (BYD) in 1978 prompted studies to identify luteoviruses present. Samples were tested by enzyme-linked immunosorbent assay (EIA) with four antisera and by aphid transmission tests with four standard vectors to compare the viruses found with five previously characterized BYD viruses (RPV, MAV, PAV, RMV, SGV). Although only 3 to 12 wheat samples were tested each year from 1978-81, luteoviruses similar to SGV were identified each year. Viruses similar to all five previously characterized ones were identified from 12 samples in 1981. Tests were also made only by EIA of symptomless sweet or field corn leaves from 12 fields in 1981. Luteoviruses similar to PAV and RMV were identified in 1 to 11 of 20 samples from each of 8 fields. The four fields in which no virus was detected were all field corn.

A178

ULTRASTRUCTURE OF TRITICUM DURUM VASCULAR BUNDLES OF LEAVES INFECTED WITH AMERICAN WHEAT STRIATE MOSAIC VIRUS. Wayne S. Gardner, Dept. of Plant Science, South Dakota State University, Brookings, SD 57007

Electron microscopy of 'Rugby' durum wheat leaves naturally infected with American wheat striate mosaic virus revealed bacilliform rhabdovirus particles in phloem parenchyma and companion cells and in xylem parenchyma. These small cells also were rich in mitochondria, plastids, oleosomes and polyribosomes. Large clumps of virions occurred in phloem companion cells and parenchyma. Rhabdovirions accumulated in cytoplasmic and nuclear arrays often in masses on opposite ends of nuclei. In xylem

parenchyma, virions were very common in perinuclear regions, and in membrane-bound clumps in cytoplasm and nuclei. Virions were rarely observed in phloem sieve elements or xylem vessels. It is postulated that these large plant viruses are assembled and accumulate between membranes of the nuclear envelope. This would require active synthesis rather than passive movement through nuclear pores.

A179

PERINUCLEAR ASSEMBLY OF AMERICAN WHEAT STRIATE MOSAIC VIRUS IN *TRITICUM DURUM*. Wayne S. Gardner, Dept. of Plant Science, South Dakota State University, Brookings, South Dakota 57007

Leaves of 30-day old 'Rugby' durum wheat plants, which developed symptoms resembling American wheat striate mosaic virus after late-seeding, were embedded, sectioned and examined by electron microscopy. Bacilliform rhabdovirus particles were found in mesophyll and vascular parenchyma cells. Virions accumulated in cytoplasm, nuclear and perinuclear areas. In the cytoplasm or nuclei virions were observed singly or more often aggregated in membrane-bound lacunae. In nuclei, virions were in lacunae which contained either clear, ribosomal or cytoplasmic ground substance. Some of these lacunae contained rhabdovirions which appeared to be budding from the surrounding membrane. Perinuclear virions were the most common aspect of virus accumulation. They formed between layers of the nuclear envelope and bulged into either the nuclear or cytoplasmic regions. Some virions were close to nuclear pores and areas rich in polyribosomes. These large viruses may be assembled in or near nuclear pores.

A180

INTERACTIONS OF *PISUM* GENES *sbm* AND *mo* WITH PEA SEEDBORNE MOSAIC VIRUS (PSBMV): SYMPTOM EXPRESSION AND IMMUNITY TO THREE VARIANT STRAINS. J. J. Goodell and R. O. Hampton, Dept of Bot & Plant Pathology, Oregon State University, Corvallis, OR 97331.

Immunity to the Oregon (Standard) and Yugoslavian isolates of PSBMV was conferred by *Pisum* gene *sbm* in three of 17 *P. sativum* differential accessions. Immunity to the lentil and New Zealand isolates was conferred by gene *mo* which also confers resistance to bean yellow mosaic virus but not to the Standard isolate of PSBMV. Genetic heterogeneity relative to isolate susceptibility and induced symptoms was observed in some accessions. Whole-plant necrosis was induced in five accessions and was isolate-specific. The New Zealand isolate failed to produce whole-plant necrosis in any accession and was generally latent. The lentil isolate was intermediate in severity. Initial results from host range tests of the Standard and Yugoslavian isolates suggested that they were indistinguishable. The range of symptoms observed suggested the influence of modifier genes on the expression of gene *sbm*.

A181

SUBCELLULAR LOCATION OF POTATO SPINDLE TUBER VIROID AND ITS RELATED RNA SPECIES IN INFECTED CELLS. A. Hadidi*, D. E. Cress†, and T. O. Diener*. *Plant Virology Lab., PPI, and †Tissue Culture and Molecular Genetics Lab., PPHI, ARS, U.S. Dept. of Agriculture, Beltsville, MD 20705

Potato spindle tuber viroid (PSTV)-infected cells were separated into nuclear and cytoplasmic fractions. RNAs isolated from these fractions were separated by gel electrophoresis, transferred to diazotized papers and hybridized to cloned ³²P-labeled PSTVcDNA. Nuclear fractions contained unit-length PSTV and oligomeric forms of dsPSTV. A 20,000g supernatant of the postnuclear fraction was centrifuged at 70,000g. The resulting supernatant contained primarily unit-length dsPSTV; the pellet unit-length PSTV. Further analysis of the pellet fraction by density gradient centrifugation and dot hybridization revealed the association of PSTV with cellular constituents. When purified ³²P-labeled PSTV was added to post-nuclear fractions, no labeled PSTV-cellular constituent complexes were formed. Treatment of the complexes with pronase or Triton X-100 released PSTV; thus PSTV in the post-nuclear fraction appears to be bound to protein(s).

A182

IDENTIFICATION OF SEROLOGICAL TYPES OF APPLE MOSAIC, PRUNUS NECROTIC RINGSPOT AND TOBACCO STREAK VIRUSES WITH MONOCLONAL ANTIBODIES. Dr. Edward L. Halk and Judy Franke, American Type Culture Collection, 12301 Parklawn Dr., Rockville, Md., 20852.

A panel of seven monoclonal antibodies specific for either prunus necrotic ringspot (NRSV) apple mosaic (ApMV) or both viruses were used to screen 22 isolates of ApMV or NRSV in indirect ELISA. Virus isolates were from rose, cherry, apple,

plum and birch. Based on their reaction to specific monoclonal antibodies, NRSV isolates can be divided into three serological groupings and ApMV isolates into five serological groupings. In similar tests five tobacco streak (TSV) specific monoclonal antibodies could differentiate TSV into four serological groupings. Tobacco streak isolates used were from white clover, tobacco, soybean (from Brazil) and grapevine. The ability of these antibodies to discriminate antigenic differences between virus isolates should prove useful in taxonomic and epidemiological studies of these plant viruses.

A183

OCCURRENCE OF ASPARAGUS VIRUS II IN MICHIGAN ASPARAGUS FIELDS. A.C. Hartung, T.A. Evans, and C.T. Stephens, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

In a survey of 23 asparagus (*Asparagus officinalis* L.) fields of varying ages and planting stock nurseries, a virus was mechanically transmitted to *Chenopodium quinoa* using sap from young asparagus spears. This survey indicated that infection was widespread. In most fields, in excess of 50% of the plants were infected. The virus was isolated from four out of five planting stock nurseries, but the incidence was lower than in production fields. Using Ouchterlony double diffusion tests, all isolates tested were determined to be serologically identical with asparagus virus II (AV II) described earlier in Washington and Germany. This is the first report of a virus occurring in asparagus in Michigan.

A184

RAPID DETECTION AND PURIFICATION OF WHEAT SPINDLE STREAK MOSAIC VIRUS (WSSMV). K. Z. Haufler and D. W. Fulbright, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Diagnosis of wheat spindle streak mosaic is based primarily on symptom expression, the presence of pinwheel inclusion bodies in leaf mesophyll cells, and sparsely-occurring virions in leaf-dip preparations. WSSMV was readily detected in plants suspected to be infected with this virus when immunosorbent specific electron microscopy (ISEM) was used. Using ISEM, one thousand times more particles were found in crude sap from infected wheat than when conventional transmission electron microscopy was used. Modal length of the particles observed was 1800 nm x 16 nm in diameter. Purified virus was obtained by grinding infected tissue in liquid nitrogen, extraction in 0.06 M Na₂HPO₄-NaH₂PO₄ buffer, pH 7.0, containing 3% Triton X-100, concentration in 1/5th starting volume 30% polyethylene glycol in 0.6 N NaCl and 1/50th starting volume 20% NaCl, and ultracentrifugation through a sucrose-caesium sulfate cushion step gradient. Modal length of the purified particles was 850 nm.

A185

COMPARISON OF TWO VIRAL ISOLATES FROM *KALANCHOE BLOSSFELDIANA*. S. S. Hearon. USDA, ARS, Beltsville, MD 20705

A carlavirus (KV-1) from Rotkappchen, a European kalanchoë cultivar, has been described (Hearon, 1982. Phytopathology 72:838-44). Another flexuous rod isolate (KV-2) has now been obtained from a USA cultivar, Texas Sunset. KV-2 was distinguished from KV-1 in that KV-2 (1) systemically infected *Chenopodium quinoa* and *C. amaranticolor*, local lesion hosts for KV-1, (2) had a particle normal length of 640-670 nm, ca. 30 nm longer than KV-1, (3) induced in *C. quinoa* huge cytoplasmic masses of membrane-like structures and vesicles (some with a granular matrix) as well as fusiform viral aggregates like those induced by KV-1, and (4) was sensitive to 1% Triton X-100 and to chloroform-carbon tetrachloride. KV-2 was extracted from inoculated *C. quinoa* leaves in 0.2 M K₂HPO₄ with 2mM EDTA and 20mM Na₂SO₃, clarified with Freon 112, precipitated with 6% PEG-6000 and centrifuged in 10-40% CsCl density gradients. KV-1 and -2 were closely related (SDI<3), but distinct, serologically. They had similar buoyant densities (1.31 and 1.30 g/cc, respectively) and capsid proteins of 34,000 daltons MW in SDS-PAGE.

A186

CHARACTERIZATION OF TWO LUTEOVIRUSES. Adrianna D. Hewings and Cleora J. D'Arcy. Department of Plant Pathology, University of Illinois, 1102 S. Goodwin Ave., Urbana, IL 61801.

A legume isolate of beet western yellows virus (BWV) and a vector-nonspecific isolate of barley yellow dwarf virus (BYDV) were characterized. Purified preparations of BYDV had a single

UV-absorbing band; BWYV preparations had two bands. The top component (TC) of BWYV had maximum absorbance at 276 nm, an $S_{20,W}$ of 62, buoyant densities of 1.31 in CsCl and 1.28 in Cs_2SO_4 , and was not infectious. No nucleic acid was detected in TC. BWYV (lower band) had an $S_{20,W}$ of 116 and buoyant densities of 1.42 in CsCl and 1.36 in Cs_2SO_4 . BYDV had an $S_{20,W}$ of 105 and buoyant densities of 1.41 in CsCl and 1.35 in Cs_2SO_4 . The Mrs of the major proteins of BWYV and BYDV were 24,500 and 22,200, respectively. The relative molecular weights of the undenatured RNA species of both viruses were approximately 1.85×10^6 .

A187

RESISTANCE TO SOUTHERN BEAN MOSAIC VIRUS IN COWPEA PLANT INTRODUCTION 186465. H. A. Hobbs, C. W. Kuhn, Dept. of Plant Pathology, Univ. of Georgia, Athens, GA 30602; B. B. Brantley, Dept. of Horticulture, Georgia Station, Experiment, GA 30212.

Inheritance of resistance in cowpea to southern bean mosaic virus was studied by analyzing virus accumulation and symptoms. Susceptible California Blackeye was crossed with resistant PI 186465. California Blackeye reacts with severe symptoms and accumulates 1,000-2,000 μ g of virus/g of leaf tissue. Symptomless PI 186465 becomes infected but accumulates less than 1 μ g/g. F₁ plants reacted with moderate symptoms and accumulated 200-300 μ g/g, suggesting partial dominance of resistance. The F₂ population segregated 3:1 for symptoms : symptomless plants. The symptomless plants had less than 1 μ g/g. Plants with symptoms ranged from mild to severe, and virus accumulation ranged from 100-1,500 μ g/g, with a large group of plants in the low to moderate range and a smaller group in the higher levels.

A188

ULTRASTRUCTURE OF CUCURBITA SPP. INFECTED WITH WHITEFLY-TRANSMITTED SQUASH LEAF CURL VIRUS. Lynn L. Hoefert, U. S. Dept. of Agriculture, ARS-WR, P. O. Box 5098, Salinas, CA 93915.

Squash leaf curl is a whitefly-transmitted (*Bemisia* spp.) disorder that bears striking cytological similarities to bean golden mosaic (Kim, Shock, and Goodman, 1978, *Virology* 89:22-23), *Euphorbia* mosaic (Kim and Flores, 1979, *Phytopathology* 69:980-984), and other whitefly-transmitted diseases of the geminivirus type. Electron micrographs of vascular cells in infected leaves show nuclei with masses of small spherical particles (<20 nm) that occur singly, in pairs, in groups, and in strands. Fibrillar rings appear in nuclei that may or may not contain viruslike particles. Vascular parenchyma cells show a unique type of cytoplasmic vesiculation that is not found in cells infected with other viruses of known vascular affinities. Nuclear changes occur in phloem, xylem, and border parenchyma cells. The disease provokes rapid phloem degeneration which may account for the rapid expression of external symptoms.

A189

INDIGENOUS WILD HOSTS OF THE SOLANUM APICAL LEAF CURLING VIRUS (SALCV) INFECTING POTATO IN THE PERUVIAN JUNGLE. W. J. Hooker and L. F. Salazar, International Potato Center, Apartado 5969, Lima, Peru.

SALCV has recently been identified as a new virus which infects potato in the jungle of eastern Peru. The virus is composed of 3 isometric particles each 17 nm in diameter arranged in a straight chain forming a particle c. 17×52 nm. Symptoms resemble those of exceptionally severe current season PLRV infection or those of mycoplasma infections such as purple top wilt. Wild hosts serving as reservoirs of the virus have been identified in *Solanum basendopogon*, *Nicandra physalodes*, and *Physalis peruviana*. Symptoms include distortion of young leaves, yellowing of small veins in young leaves, and general chlorosis of interveinal tissues of apical leaves. From these naturally infected wild plants the virus was similar to isolates from potato in: symptoms produced in potato, *Datura tatula*, and tomato; in reaction to SALCV antiserum in ELISA serology; and by presence of typical particles when viewed in SALCV antiserum sensitized grids in electron microscopy.

A190

ULTRASTRUCTURE OF CHENOPODIUM LEAVES INFECTED BY LETTUCE INFECTIOUS YELLOWS VIRUS. Margaret S. Houk and Lynn L. Hoefert, U. S. Dept. of Agriculture, ARS-WR, P. O. Box 5098, Salinas, CA 93915.

The newly discovered lettuce infectious yellows virus (LIYV) is a flexuous rod virus known to be transmitted by whiteflies (*Bemisia* spp.). Particles similar in size and shape to

isolated LIYV (Duffus, et al. 1982. *Phytopathology* 72:963) are present in the vascular parenchyma and sieve elements from diseased leaves of infected *Chenopodium* plants. In parenchyma cells, bundles of viral particles are often associated with amorphous clumps of electron dense material and with clusters of vesicles which are often enclosed within a common membrane. The vesicles average 60 nm in diameter and are filled with a filamentous material. Several other inclusions prevalent in virus-infected material are also described. The ultrastructure of the virus and associated structures closely resembles published accounts of closteroviruses such as beet yellows virus and beet yellow stunt virus. LIYV is, however, unique because of its whitefly vector and its wide range of host plants (Duffus & Flock. 1982. *Calif. Agric.* 36:4).

A191

ISOLATIONS OF HYBRIDOMAS SECRETING ANTIBODIES REACTIVE TO RPV AND MAV ISOLATES OF BARLEY YELLOW DWARF VIRUS AND CARNATION ETCHED RING VIRUS. H.T. Hsu, J. Aebig, W.F. Rochow and R.H. Lawson. American Type Culture Collection, Rockville, Md.; Cornell University, Ithaca, NY; and Beltsville Agricultural Research Center, USDA, Beltsville, Md.

Fusions of NS1 mouse plasmacytoma cells with splenocytes obtained from BALB/c mice individually immunized with RPV and MAV isolates of barley yellow dwarf virus (BYDV) and carnation etched ring virus (CERV) resulted in the production of antibody-secreting hybridomas. Three hybrid cell lines were selected for CERV. With BYDV, five were selected for RPV and eight were selected for MAV. Single cell clonings were made under limiting dilutions in conditioned medium, RPMI-1640 supplemented with 15% fetal bovine serum and 1 mM Na-pyruvate, in which mouse fibroblasts (L929) had been cultured for 24 hr. Injections of selected hybridoma clones into BALB/c mice resulted in the production of antibody rich ascites. Two MAV hybrid clones, MAV9E9 (IgM) and MAV14C11 (IgG1), secreted antibodies that also bind to RPV in the initial tests of BYDV hybrid cell lines.

A192

TRANSLATION OF SOIL-BORNE WHEAT MOSAIC VIRUS RNAs IN RABBIT RETICULOCYTE LYSATE. Yau-Heiu Hsu and M.K. Brakke, Dept. of Plant Pathology, Univ. of Nebraska, Lincoln, NE 68583-0722.

Soil-borne wheat mosaic virus RNAs were purified from wild type virions (281 and 138 nm long) and two deletion mutants (one 281 and 110 nm long, the other, 281 and 92 nm long). Each RNA species, designated by relative lengths as 1.0, 0.5, 0.4 and 0.35L, was translated in rabbit reticulocyte lysate. Molecular weights of products of 1.0L RNA ranged from about 200K to 20.5K. None was precipitated with antiserum against virions. The major products of 0.5L RNA had Mr. of 87K, 70K, 49K, 25K, 19.5K and all were immunoprecipitable. The 0.4L RNA gave 54K, 49K, 25K and 19.5K products, and 0.35L RNA gave 49K, 25K and 19.5K products. The maximum size of the translation product was proportional to the size of the RNA. Viral coat protein, Mr 19,500, was the predominant product coded by 0.35, 0.4, and 0.5 L RNAs. The results indicated that the viral coat protein gene is located at 5' end of 0.5L RNA and the deletion may occur near the 3' end of 0.5L RNA to give 0.4 or 0.35L RNA.

A193

INVESTIGATION OF SOIL-BORNE WHEAT MOSAIC VIRUS IN NEBRASKA. Yau-Heiu Hsu and M.K. Brakke, Dept. of Plant Pathology, Univ. of Nebraska, Lincoln, NE 68583-0722.

Soil-borne wheat mosaic viruses from infected wheat from 6 fields were compared by peptide mapping of the viral coat protein and by the frequency and pattern of deletion mutants. Viruses from all 6 fields gave the same peptide patterns after cleavage with cyanogen bromide, hydroxylamine and formic acid followed by electrophoresis on 8-25% polyacrylamide gels. Similar peptide patterns were also obtained from deletion mutants and wild type virus. The deletion is not in the coat protein gene. At the time of collection and 1 month after transplantation, each of 5 plants from each of the 6 fields had only wild type virus, but at 4 months all plants had deletion mutants. The pattern of mutants was different for each plant. There was no significant difference in frequency of mutation in virus from field-to-field.

A194

OCCURRENCE AND SPREAD OF BARLEY YELLOW DWARF VIRUS IN INDIANA. D. Clement, R.M. Lister & J.E. Foster. Dept. of Botany & Plant Pathology & USDA, ARS, Purdue Univ., West Lafayette, IN 47907.

During 1981 and 1982 sets of 116 pots, each containing 5-10 plants of Clintland 64 oats, were exposed weekly in wheat and grass plots at the Purdue Agronomy Farm. Aphid occurrence (mainly *Rhopalosiphum padi*) on the oats indicated population peaks in spring and fall with a further small peak in late summer. ELISA estimates of barley yellow dwarf virus infections in the oats (PAV- and RPV-type isolates) followed roughly the same trends. Up to 50% and 25% of pots exposed in 1981 and 1982, respectively, had infected plants. About 80% of wheat plants sampled in the plots in June 1981 and 1982, and 20% of plants sampled in March 1982, were infected. Aphid populations on field cereals built up in late summer and fall, with large populations developing on corn. Infection was detected in 1.5% and 5% of corn plants sampled in October 1981 and 1982, respectively. Throughout, most virus isolates were of the PAV type, as were those from cereals sampled elsewhere in Indiana in both years.

A195

PROTEINS IN MDMV INFECTED SORGHUM. S. G. Jensen and B. Long Davidson. USDA-ARS, University of Nebraska, Lincoln 68583.

The proteins of healthy or maize dwarf mosaic virus infected sorghum were extracted and separated by polyacrylamide gel electrophoresis. Changing environmental conditions resulted in an alteration of symptom expression but no major protein changes were noted. A protein of about 60Kd was found only in infected tissue but it was not serologically related to virus coat protein (42Kd) by electro blot technique. Coat proteins of different strains of MDMV did not differ in migration but the 60Kd protein of different strains did vary.

A196

RAPID DETECTION OF SUNBLOTCH VIROID RNA AND VIRUS-LIKE DOUBLE-STRANDED RNA IN MULTIPLE AVOCADO SAMPLES. Ramon L. Jordan, J. A. Heick, J. A. Dodds and H. D. Ohr. Department of Plant Pathology, University of California, Riverside, CA 92521.

Sunblotch viroid RNA and viral double-stranded (ds) RNA from single 0.5 g samples of avocado leaves are detected as follows. Tissue is powdered in liquid N₂, extracted in 1.2 ml 0.1 M Tris, 0.2 M NaCl, 0.002 M EDTA pH 6.8 (2 x STE) containing 3% SDS, 0.5% mercaptoethanol, 3 mg/ml bentonite, then emulsified in 0.6 ml phenol, 0.6 ml chloroform:pentanol (24:1) and centrifuged. All subsequent steps are done in microfuge tubes. Viral dsRNA is recovered by adding 0.05 g cellulose powder (CF-11) to the supernatant, adjusted to 16.5% ethanol. The dsRNA is eluted from washed powder with STE and precipitated with ethanol. The nucleic acids which remain after removal of dsRNA contain viroid RNA and are precipitated with ethanol. The viroid and dsRNA enriched pellets are resuspended and analyzed separately by electrophoresis on mini 6% polyacrylamide gels. Results have been obtained from approximately 1000 samples from commercial, university and foundation block sources.

A197

LOCATION OF PRUNE DWARF AND PRUNUS NECROTIC RINGSPOT VIRUSES IN SWEET CHERRY POLLEN AND FRUIT. R.D. Kelley and H.R. Cameron, Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331.

Intact prune dwarf virus (PDV) infected sweet cherry pollen was heavily coated with latex spheres conjugated to PDV antiserum in scanning electron microscope examination. Virus-like particles were observed in the cytoplasm of PDV infected pollen using transmission electron microscopy (TEM). Decreasing levels of antigen were detected by ELISA in the buffer from successive washings of intact PDV infected pollen. Spheres conjugated to Prunus necrotic ringspot virus (PNRSV) antiserum did not coat PNRSV infected pollen, and particles were not seen in TEM samples of PNRSV infected or in healthy pollen. A low level of antigen was detected only in the buffer from the first wash of intact PNRSV infected pollen. However, high antigen levels were detected when the washed pollen samples, either PNRSV or PDV infected, were subsequently ground in buffer. Virus distribution within fruits was different for each virus, and was determined by which parent was the source of infection.

A198

COMPARISON OF THE CYTOPATHIC EFFECTS INDUCED BY DIFFERENT ISOLATES OF THE COWPEA SEVERE MOSAIC VIRUS IN MONARCH COWPEA. E. W. Kitajima, K. S. Kim and J. P. Fulton, Dept. Biol. Cell., Univ. Brasilia, 70910 Brasilia, DF, Brazil and Dept. Plant Pathology, Univ. Arkansas, Fayetteville, AR 72701.

Nine isolates of the cowpea severe mosaic virus from the U. S. and several Latin American countries varied in their pathological and serological properties. Monarch cowpea reacted to the isolates with different types of local lesions and varied severity of systemic infection. The major cytopathic effects which are common for comoviruses such as cell wall protrusions, virus particles in rows in tubules, cytoplasmic fibrous inclusions, and occasional intranuclear membranous elaborations were all induced by these isolates with slight variations. The most pronounced and consistent difference between isolates which may be significant enough to be of diagnostic value were the cytoplasmic fibrous inclusions, which were considerably larger and more frequent in cells infected with isolates I and II from Brazil.

A199

DASHEEN MOSAIC VIRUS IN CHINESE EVERGREEN PLANTS IN CALIFORNIA. W. Kositratanang, L. G. Meathers, and D. J. Gumpf. Department of Plant pathology, University of California, Riverside, CA 92521.

Chinese evergreen plants (*Aglaonema commutatum*) from a nursery in California were tested to determine the cause of mild stunting, chlorosis, leaf distortion and mosaic. Long flexuous rods (750 nm X 13 nm) were detected in leaf dip and partially purified preparations of diseased tissue. Sap inoculation from diseased *A. commutatum* tissue to *Philodendron selloum* seedlings (6-7 leaf stage) caused systemic vein chlorosis followed by severe mosaic and deformation of young leaves 2-3 weeks after inoculation. The virus was tentatively identified as dasheen mosaic virus on the basis of host range, virus particle morphology (Zettler, F. W., et al., *Phytopathology* 60:983-987), and reaction with dasheen mosaic virus antiserum (kindly supplied by F. W. Zettler, Univ. of Florida) in immuno-double diffusion and immunosorbent electron microscopy tests. Preliminary surveys indicate that dasheen mosaic virus is not widespread in cultivars of *A. commutatum* in California.

A200

THE COAT PROTEIN OF WHEAT STREAK MOSAIC VIRUS, Leslie C. Lane and Rose Skopp, Dept. of Plant Path., Univ. of Nebr., Lincoln, NE 68583-0722.

Wheat streak mosaic virus (WSMV) rapidly isolated from field samples of wheat or corn contains a protein weighing 45 Kd or 29 Kd or often a mixture of these two as well as intermediate components. Protein of WSMV purified from wheat or corn growth at constant temperatures ranging from 20-30° C was similarly variable. WSMV containing predominantly 45 Kd protein could be obtained by selecting a sucrose gradient centrifugation zone from virus isolated from young leaves of greenhouse-grown wheat. The 45 Kd protein form of WSMV can be converted *in vitro* by treating the virion with any of several proteases to a 27 Kd form which sediments slower than the 45 Kd form. A similar conversion likely occurs *in vivo*. This conversion could be a step in natural uncoating of the nucleic acid or could function in reutilizing amino acids from the virion protein.

A201

ISOLATION AND CULTURE OF CALLUS AND PROTOPLASTS OF TANIERS (*XANTHOSOMAS* spp.) IN PUERTO RICO. Lii-Jang Liu, Evelyn Rosa Márquez, M. Licha and María L. Biscochea, Agricultural Experiment Station, College of Agricultural Sciences, University of Puerto Rico, Mayaguez Campus, Mayaguez, Puerto Rico 00708.

More than 8,000 plantlets were obtained from callus culture of taniers. The results obtained from replicated field experiments indicated that the average weight of corn per plant from the apparently mosaic virus disease free group was 11.75 Kg, almost double to the amount (6.02 kg) produced by the diseased group. Protoplasts of taniers were isolated through the use of Japanese enzymes, cellulase and macerozyme. The yield of viable protoplasts was approximately 80-95%. The problem of calcium oxalate crystals was overcome. The number of protoplasts was high enough to obtain regeneration. Protoplast elongation and division were observed.

A202

A VIROID-LIKE RNA ASSOCIATED WITH A STUNTING SYNDROME IN CARNATIONS. S.A. Lommel and T.J. Morris, Department of Plant Pathology, University of California, Berkeley, CA 94720.

A low molecular weight, viroid-like RNA was identified in commercial carnation plants exhibiting a leaf curl and stunt syndrome. It was

transmissible to seedling carnations producing a grassy-like appearance within 3-6 months, but all plants were also infected with carnation mottle virus (CaMoV). Circularity of the purified viroid-like RNA was established by electrophoresis under denaturing conditions and an estimated molecular weight of 80-85,000 was determined. Infectivity of purified, viroid-like RNA, in the absence of CaMoV infection, has yet to be confirmed. Consequently, distinguishing between a viroid or virusoid etiology has yet to be accomplished.

A203

PRODUCTION AND CHARACTERIZATION OF MONOCLONAL ANTIBODIES SPECIFIC TO POTATO LEAF ROLL VIRUS. R.R. Martin and R. Stace-Smith, Agriculture Canada, Research Station, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2

Three hybridoma clones that secrete antibody specific for potato leaf roll virus (PLRV) were produced by somatic cell fusion between mouse myeloma cell line P3X63AG8.653 and spleen cells from BALB/c mice immunized with PLRV. Ascites fluid from clones 399E, 371A and 372E have titers of 10^4 , 10^7 , and 10^8 , respectively, in an indirect ELISA using leaf sap from PLRV infected potato and a goat anti-mouse peroxidase conjugate. Clones 371A and 372E produce antibodies of the subclass IgG1 and clone 399E produces antibodies of subclass IgG2a as determined by elution properties from a protein A affinity column. None of the monoclonal antibodies reacted with beet western yellows virus in ELISA tests.

A204

MECHANISMS OF SOYBEAN MOSAIC VIRUS TRANSMISSION THROUGH SOYBEAN SEED. J. J. Mataka, Cleora J. D'Arcy, and R. M. Goodman. Dept. of Plant Pathology, University of Ill., Urbana, Ill. 61801

In studies with two soybean mosaic virus strains (G1, G2) in two high (Midwest and PI 181.549) and two low (Mukden and Merit) incidence seed-transmitting soybean lines, a generally uniform percentage of embryos infected with G1 or G2 occurred in each line over the course of reproductive development. A larger average percentage of embryos infected with G1 or G2 was present in Midwest (25%) and PI 181.549 (20%) than in Mukden (2%) and Merit (1%). Transmission rate of G1 or G2 through progeny seed paralleled the percentage of embryos infected in each line. Electron microscopic studies of the immature Midwest embryos showed virus-like rods and often cytoplasmic inclusion bodies present near the epicotyl tip in each of four embryos assaying positive for G2, but absent in the same area of six G2-negative embryos. Attempts to infect excised healthy immature Midwest or Merit embryos with G2 through several inoculation techniques were unsuccessful.

A205

VIRUSES OF FORAGE LEGUMES IN THE SOUTHEASTERN UNITED STATES. M. R. McLaughlin, USDA-ARS, Department of Plant Pathology and Weed Science, P. O. Drawer PG, Mississippi State, MS 39762.

Bait plants of alfalfa, *Medicago sativa*, and six clover species (alsike, *Trifolium hybridum*; arrowleaf, *T. vesiculosum*; crimson, *T. incarnatum*; red, *T. pratense*; subterranean, *T. subterraneanum*; and white, *T. repens*) were planted each year and indexed for viruses in 11 southeastern states in 1978-80 by cooperators in Southern Regional Research Project S-127, Forage Legume Viruses. Bean yellow mosaic virus (BYMV), peanut stunt virus (PSV) and clover yellow vein virus (CYVV) occurred in 13%, 10% and 9%, respectively, of over 2000 plants tested. Alfalfa mosaic virus, red clover vein mosaic virus and white clover mosaic virus occurred in 4%, 2% and 2%, respectively. The distribution of infections among bait plant species was: alsike 27%, white 27%, red 13%, arrowleaf 10%, crimson 9%, subterranean 9% and alfalfa 5%. BYMV occurred most often in alsike (29% of alsike plants tested) and red (15%), PSV in white (26%), and CYVV in alsike (19%) and white (15%). Mixed infections occurred in 16% of the infected plants.

A206

INHERITANCE OF RESISTANCE TO MAIZE DWARF MOSAIC VIRUS. M. A. Mikel, Cleora J. D'Arcy, A. M. Rhodes and R. E. Ford. Department of Plant Pathology, University of Illinois, 1102 S. Goodwin Avenue, Urbana, IL 61801.

Resistance to maize dwarf mosaic virus (MDMV) was incorporated into sugary (su) maize from starchy maize. F1 progeny of su x Pa405 were 97% (829/857 total), su x B68 61% (113/186), su x Oh1EP 69% (73/106), su x Ga209 0% (0/48), and su x T232 0% (0/48) resistant. Three years of data show that F2 segregates

of su x Pa405 fit a 45R:19S ratio of a three gene model where one gene must be present with either of the other two. The testcross segregates fit a 3R:5S ratio for the same three gene model. In one year's data, F2 segregates of su x B68 fit a 27R:37S ratio of a three gene model where all three genes must be present for MDMV resistance. Testcross segregates in the same year fit a 1R:7S ratio of the same three gene model. With inbreeding and selection of resistant plants from two-way (su x Pa405), three-way (su x (su x Pa405)F1), and delayed three-way crosses (su x (su x Pa405)FX) we have obtained homozygously resistant sugary corn lines.

A207

ANTI-VIRAL CHEMOTHERAPY OF THE SEED-BORNE VIRUS, BARLEY STRIPE MOSAIC VIRUS. R. V. Miller¹, T. W. Carroll², and D. C. Sands², 1. Dept. of Plant Pathology, North Carolina State Univ., Raleigh, NC 27607 and 2. Dept. of Plant Pathology, Montana State Univ., Bozeman, MT 59717.

Seed-borne viruses, particularly embryo-infecting viruses, present a unique opportunity for studying anti-viral chemotherapy. A chemotherapeutic test system was developed using barley stripe mosaic virus. Compounds to be tested were dissolved in DMSO and distilled water. Seeds, normally producing 65 percent symptomatic seedlings were allowed to imbibe the solution for 24 hours and planted into sterile soil. Nineteen compounds statistically reduced viral symptom development 5 to 50 percent as compared to controls. Three percent of asymptomatic plants treated with one compound contained viral antigen as determined using the ELISA technique. None of the asymptomatic control plants contained viral antigen.

A208

EFFECTS OF ULTRAVIOLET (UV) IRRADIATION ON TOBACCO MOSAIC VIRUS (TMV)-INDUCED GREEN ISLANDS IN SYSTEMIC TOBACCO. A. MITRA and M. CHESSIN, Department of Botany, University of Montana, Missoula, MT 59812.

Two lower leaves of *Nicotiana tabacum* var. Wisc. 38(2 months old) were inoculated with TMV ($20 \mu\text{g ml}^{-1}$) and kept in the growth chamber until green islands were developed in upper leaves which were then exposed to various doses of UV (85% at 253.7 nm) followed by 24 hours dark treatment to prevent photoreactivation. Seven days after irradiation leaves were harvested, green island tissue and nongreen tissue were separated and clarified extracts were inoculated on half-leaves of *N. glutinosa*. Virus titers were determined by comparing lesion numbers with known concentrations of TMV on opposite half-leaves. The green island tissues had less virus than nongreen control tissues. UV irradiation increases virus titer in green island tissues presumably by breaking down the resistance mechanism. 3.74×10^4 ergs cm^{-2} was the optimum UV dose to suppress the resistance mechanism, both higher and lower doses were less effective. The decrease of virus titer at higher doses were probably due to a combination of damage to host metabolic machinery and direct virus inactivation.

A209

SEASONAL DIFFERENCES IN POPULATIONS OF VIRULIFEROUS ILLINOIA PEPPERI, THE APHID VECTOR OF BLUEBERRY SHOESTRING VIRUS. K.M. Morimoto and D.C. Ramsdell, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Aphids were sampled weekly from mature BBSSV-infected highbush blueberry plants and surrounding healthy potted blueberry "trap" plants. Aphids were also collected weekly from yellow pan traps within the field and outside the field to a distance of 300 m. All aphids were tested for viruliferousness by radioimmunoassay. The percentage of viruliferous apterous aphids on blueberry plants ranged from 0 - 15% throughout the season, while that of viruliferous alate aphids was highest (80%) in late May then declined to 0% in July. Of the aphids caught in yellow pan traps within the field, 34 of 315 were viruliferous. Few aphids were trapped outside the field and only one was viruliferous. A substantial proportion of both apterous and alate *I. pepperi* are viruliferous and move readily within the field; however, the importance of long distance spread of BBSSV by its vector is not known.

A210

ISOLATION OF VIROID AND VIROID-LIKE RNA FROM PLANT TISSUE. T. J. Morris, Department of Plant Pathology, University of California, Berkeley, CA 94720.

Procedures for identification of plant viroids were compared for potato

spindle tuber, citrus exocortis, chrysanthemum stunt and avocado sunblotch diseases. Published procedures proved suitable for detection of the viroid for which they were developed but were generally ineffective for other viroid diseases. A procedure was developed for the isolation of a viroid containing fraction of nucleic acid from diverse types of plant hosts. Identification of low molecular weight circular RNA in such extracts was simplified by initial separation of the RNA species in 6% polyacrylamide gels followed by a second dimension separation in a denaturing gel. Application of these procedures for the identification of new viroid-like diseases will be described.

A211

A NEW POTYVIRUS ASSOCIATED WITH A SEVERE DISEASE OF CANTALOUPE (*Cucumis melo*) IN SOUTHERN CALIFORNIA. S. T. Nameth, J. A. Dodds and A. O. Paulus. Department of Plant Pathology, University of California, Riverside, CA 92521 and A. Kishaba, U.S.D.A. Boyden Laboratory, Riverside, CA 92521.

A severe disease affected cantaloupe production in some fields in the spring, 1982, in Imperial County. The virus was transmitted by mechanical inoculation and by *Myzus persicae*. Symptoms in cantaloupe in the field and in the greenhouse included stunting, foliar mosaic and blistering, and fruit deformation. Symptoms were much more severe than those caused by watermelon mosaic virus-2 (WMV-2), the most common cucurbit virus. The virus infected *Luffa acutangula*, but did not infect *Phaseolus vulgaris* c.v. Black Turtle (like WMV-1). It induced local lesions in *Chenopodium amaranticolor* (like WMV-2). Purified virus particles were long flexuous rods (750 nm x 15 nm). A homologous antiserum was prepared which reacted with the virus and with an agent common in diseased cucurbit samples from Egypt, but did not react with WMV-1 and WMV-2. Results indicate a new cucurbit potyvirus previously unreported in the USA.

A212

RELATIONSHIP OF A WATERMELON MOSAIC VIRUS FROM EGYPT (WMV-E) TO WMV-1 AND WMV-2. M. F. Ouf and H. A. Scott, Dept. of Plant Pathology, Univ. of Minia, Minia, Egypt and Dept. of Plant Pathology, University of Arkansas, Fayetteville, AR 72701

A watermelon mosaic virus isolate (WMV-E) from infected squash growing near Minia, Egypt was propagated in pumpkin, *Cucurbita pepo* L. 'Small Sugar', and purified utilizing the technique of Purcifull and Hiebert for WMV-2 (Phytopathology 69:112-116, 1979). Symptoms produced by WMV-E were similar to those produced by WMV-1 (ATCC PV23) in 10 varieties of squash and one variety each of pumpkin, watermelon, and cucumber. It infected *Luffa acutangula* Roxb., as does WMV-1, but failed to infect *Nicotiana benthamiana* Domin. and *Pisum sativum* L. 'Alaska' which are susceptible to WMV-2 (ATCC PV27). Reciprocal SDS-immunodiffusion tests with WMV-E antiserum utilizing SDS-treated extracts of infected Early Prolific Straightneck squash resulted in cross reactions and spur formation between WMV-E, WMV-1, and WMV-2. Antisera specific for WMV-1 or WMV-2, however, showed no serological relationships among the three isolates.

A213

MOLECULAR CLONING OF COMPLEMENTARY DNA SEQUENCES OF CITRUS TRISTEZA VIRUS (CTV) RNA. A. Rosner, Irit Ginzburg & M. Bar Joseph Virus Laboratory, Volcani Center, Bet Dagan 50-250, and Dept. of Neurobiology, Weizmann Institute, Rehovot, Israel.

Complementary DNA to citrus tristeza virus (CTV) genomic RNA sequences were synthesized 'in vitro', converted to double stranded cDNA and inserted into the pBR322 plasmid of *E. coli*. Clones harboring viral sequences were detected by colony hybridization with a ³²P labelled viral RNA probe. Hybridization patterns to northern blots of viral RNA indicated the presence of three types of clones (I) clones hybridizing with a distinct narrow band (II) clones hybridizing with a broader band and (III) clones hybridizing with several distinct bands. All the clones positively hybridized with the full length viral genomic RNA. Similar patterns were obtained respectively when these clones were hybridized to purified ds RNA from CTV infected plants. The origin of variation among the CTV clones is discussed.

A214

ALFALFA MOSAIC VIRUS PROTEIN SYNTHESIS IN INFECTED ALFALFA PROTOPLASTS. D. A. Samac, S. E. Nelson, L. S. Loesch-Fries Agrigenetics Advanced Research Laboratory, Madison, Wisconsin, 53716

Alfalfa protoplasts were infected with alfalfa mosaic virus RNA by using a polyethylene glycol procedure. After infec-

tion, nearly all of the protoplasts were viable and approximately 50% were routinely infected. All four virus RNAs were easily detected by labeling with [³H]uridine. However, it was necessary to UV-irradiate the protoplasts prior to inoculation in order to detect virus proteins. As early as 5 hrs after inoculation, [³⁵S]met-labeled 3a protein was detected. At 10 hrs after inoculation, proteins corresponding to all four *in vitro* translation products were detected; pulse labeling indicated that at 20 hrs after infection these proteins were still being synthesized.

A215

ELECTRON MICROSCOPY OF VIRION RNAs OF SOUTHERN BEAN MOSAIC VIRUS. O.P. Sehgal, K.G. Murti and C.H. Hsu. Department of Plant Pathology, Univ. of Missouri, Columbia, MO 65211 and Virology Divn. St. Jude Children's Research Hospital, Memphis, TN 38101.

Electron microscopy of denatured SBMV RNA shows the presence of two main linear components, 0.80 ± 0.17 μm (genomic RNA, 25S) and 0.31 ± 0.08 μm (subgenomic RNAs). Using Qβ RNA as a marker (1.00 μm, mol. wt. 1.64 x 10⁶), the calculated mol. wts. for SBMV genomic and subgenomic RNAs are, 0.51 x 10⁶ and 1.31 x 10⁶, respectively. Nondenatured RNA from heat-inactivated SBMV measures 1.0 ± 0.20 μm (mol. wt. 1.64 x 10⁶, 32S) and is poorly-infectious. Upon denaturation, the 32S RNA yields components of lengths typical for the 25S and subgenomic RNAs with a full restoration of the infectivity. The lowly-infectious nature of RNA from inactivated SBMV appears to be due to an intimate noncovalent association between a genomic and a subgenomic RNA.

A216

THE ASSOCIATION OF b-PROTEINS WITH VIRAL INDUCED NECROSIS IN *NICOTIANA SYLVESTRIS*. J. L. Sherwood, Dept. of Plant Pathology, Oklahoma State University, Stillwater, OK 74078.

The production of b-proteins has been associated with virus induced necrosis to subsequent viral inoculations (Phytopath Z. 102:277). Necrotic lesion producing strains of TMV, e.g. TMV-P, produce lesions in dark green areas but not light green areas of the mosaic leaves of *Nicotiana glauca* systemically infected with common TMV (TMV-C). RNA of TMV-P or turnip mosaic virus (TuMV) can produce necrotic lesions in both light and dark green areas of the leaves. TMV-P, TMV-P RNA and TuMV produce necrotic lesions in healthy plants. TMV-C infected and healthy *N. glauca* were inoculated with TMV-P, TMV-P RNA or TuMV; proteins extracted and electrophoresed in 10% polyacrylamide gels. TMV-P induced b-proteins in healthy and dark green areas, and TMV-P RNA or TuMV induced b-proteins in healthy, light and dark green areas. b-proteins were not found in unchallenged healthy, light green, or dark green areas. It is concluded that b-proteins are a result of necrosis and not associated with viral induced protection.

A217

BARLEY YELLOW DWARF VIRUS CONTENT AS AN INDEX OF SYMPTOMATIC RESISTANCE IN CEREALS. M. Skaria, R.M. Lister, J.E. Foster and G.E. Shaner, Purdue University and USDA, SEA, W.Lafayette, IN. 47907.

Enzyme linked immunosorbent assay (ELISA) was used to quantify three isolates ("PAV", "MAV", or "RPV") of barley yellow dwarf virus (BYDV) in extracts from cereal cultivars grown in growth chamber or field. Symptomatically "resistant"(R) and "susceptible"(S) pairs of wheat, oats and barley (Abe, S and Elmo, R; Clintland 64, S and Porter, R; California Mariout, S and CM 67, R; respectively), as selected in plant breeding trials, were inoculated in separate experiments with the isolates. With PAV, the S oat and barley contained significantly more virus than the corresponding R cultivars, but the R and S wheats contained the same amount of virus. With MAV, the S oat contained significantly more virus than the R oats, while the S wheat and barley contained only slightly more. With RPV, the S wheat contained more virus initially, and the oat and barley pairs did not differ. Thus, some symptomatic resistance to BYDV can be associated with reduced virus multiplication, but both effects are strain specific. Growth chamber results seem valid for field conditions.

A218

EFFECT OF WITHIN-ROW PLANT DENSITY ON INCIDENCE OF THREE APHID TRANSMITTED VIRUSES AND YIELD OF SNAP BEANS. J. R. Stavely, R. W. Harris, and C. A. Thomas, USDA, ARS, BARC-W, Beltsville, MD 20705

Phaseolus vulgaris 'Eagle' was seeded in 64 rows, 10m long, 1m apart, and perpendicular to a white clover border. Seedlings

were thinned to average 3, 5, 10, or 15cm between plants in four replicate four row plots in a randomized complete block design. Random symptomless and all symptomatic plants in a typical meter from one central row of each of the 16 four row plots were assayed by ELISA 10 weeks after seeding. Peanut stunt, clover yellow vein, and/or bean yellow mosaic virus infected 24% of all plants in a 6:3:1 ratio. Close spacing significantly decreased the percentage of infected plants and increased pod yield per meter from 60% and 12.9g in the 15cm plots to 12% and 46g in the 3cm plots. The number of infected plants per meter was constant, but the actual number of plants per meter increased with closer spacing. Close within-row spacing is apparently an effective method for reducing the impact of these viruses on yield.

A219

SPREAD OF CARNATION MOTTLE VIRUS IN CARNATIONS. D. C. Stenger, R. D. Raabe, and T. J. Morris, Department of Plant Pathology, University of California, Berkeley, CA 94720.

Carnation Mottle Virus (CaMoV) persists within commercial carnation production in California at the grower level despite indexing programs at the propagator level. Analysis by indirect ELISA detected significant temporal spread of CaMoV within newly planted clean stock in a commercial greenhouse. Observations of the spatial spread of CaMoV suggests transmission occurs during cultural practices involving wounding. Transmission studies determined CaMoV is effectively transmitted via contaminated cutting tools. Quantification of CaMoV concentrations in host tissues by sandwich ELISA indicate the virus is present in varying concentrations in leaf, stem, root, and flower tissues. Our observations indicate control of CaMoV may be accomplished at the grower level by completely removing infected plants from entire greenhouses prior to replanting with clean stock. Implementation of sanitation measures to disinfect hands and cutting tools when moving from one greenhouse to another would reduce the likelihood of re-introduction of CaMoV into the new crop.

A220

SEROLOGICAL STUDIES OF SOBEMOVIRUS ANTIGENS. J.H. Tremaine and W.P. Ronald, Research Station, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C., V6T 1X2.

Rabbit polyclonal antisera against the bean and cowpea strains of southern bean mosaic virus (SBMV-B and SBMV-C), sowbane mosaic virus (SoMV), and turnip rosette virus (TRoSV) were used in indirect ELISA experiments in which the plates were coated with the viruses in the form of virion, swollen virion and dissociated virion (protein). All antisera reacted well with all three forms of their homologous virus antigen and some cross reactions between all virus antigens were detected. Eleven mouse monoclonal antibody cultures reacted with SBMV-B in ELISA tests but cross reactions with SoMV or TRoSV antigens were not detected. Gel diffusion serological tests were positive with only three of the monoclonal antibodies and these reacted only with virion antigens. All three reacted with SBMV-B and two additional bean strains; none reacted with the Ghana cowpea strain; and only one reacted with SBMV-C.

A221

RESULTS OF EXPERIMENTS ON THE PURIFICATION OF POTATO VIRUS Y. L. Yang, B. Reddick, and S. A. Slack, Dept. of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

The purification procedure adopted was essentially as described by Baum and Barnett (Phytopathology 71:859). Nicotiana tabacum 'Burley 21' leaves harvested ≥ 30 days post-inoculation consistently yielded 18-22 mg PVY/kg tissue (mean $A_{260/280} = 1.24$). If only systemically infected leaves rather than systemic + inoculated leaves were used in purifications, the mg virus/kg tissue recovered was 35% higher. Further, virus yields doubled when fresh-harvested rather than pre-cooled (4C, 18 hr) tissue was used. Higher virus yields and cleaner preparations were obtained with 4% PEG (MW 8000) than with 6 or 8% PEG. The Cs_2SO_4 equilibrium density gradients improved virus yields about 3x over sucrose density gradients. Final virus preparations were kept in 0.5 M potassium phosphate, pH 7.2, and 1.0 M urea at 4C. Urea removal resulted in virus aggregation.

A222

CROSS PROTECTION AS A POSSIBLE MEANS FOR CONTROL OF PAPAYA RINGSPOOT VIRUS. S.-D. Yeh and D. Gonsalves, Plant Pathology, Cornell University, NYS Agr. Exp. Station, Geneva, NY 14456

Papaya ringspot virus (PRV), a potyvirus, causes a destructive

disease of papaya throughout the tropics and subtropics. Cross protection may be the best means of control because of lack of resistance in Carica papaya L. and a restrictive host range of PRV. Efforts to select naturally occurring mild strains of PRV were not successful. In an attempt to induce mild strains, crude sap from PRV-infected squash was treated with nitrous acid and used to inoculate Chenopodium quinoa. A mild mutant, PRV HA 5-1, was obtained from one of 663 single-lesion isolations. Papaya seedlings inoculated with this mild strain remained symptomless or showed mild mottling with no reduction in plant size. Under greenhouse condition, papaya seedlings were infected with PRV HA 5-1 and mechanically challenged with a severe PRV strain 5, 17, 26, 35, and 56 days after initial inoculation. One month later, cross protection was observed in 0, 79, 93, 93, and 100% of the seedlings, respectively.

A223

BIOLOGICAL ACTIVITY OF A PREFORMED PLANT VIRUS INHIBITOR FROM DATURA STRAMONIUM L. A. Zipf and M. Chessin, Dept. of Botany, U. of Montana, Missoula, Montana 59812.

Inhibitors of plant viruses can affect establishment or multiplication. Inhibitors of establishment decrease lesion number while inhibitors of multiplication decrease lesion size and have an inhibitory effect when applied 5-12 hrs after virus inoculation. A partially purified preformed inhibitor isolated from Datura stramonium L. appears to be an inhibitor of virus establishment exclusively. Assayed on Pinto Bean against TMV, it can give up to 100% inhibition of lesion number when mixed with TMV at a concentration of 20ug/ml. The inhibitor has no effect on lesion size. If applied before inoculation with TMV it gives over 90% inhibition of lesion number. When applied after inoculation with TMV no inhibition of lesion number or size results. Detaching leaves after treatment gave no increase in lesion number, indicating that an increase in microlesions is not responsible for the decrease in visible lesion number. Experiments are being done to test the inhibitor as an inducer of systemic resistance, as an inhibitor of other plant viruses and in other test hosts including D. stramonium itself.

A224

A CULTURE SYSTEM FOR PATHOLOGICAL STUDIES OF SUBMERGED AQUATIC PLANTS. J. P. Hoffmann, K. M. Kutchera, J. A. Colman, and J. H. Andrews, Dept. of Plant Pathology, University of Wisconsin, Madison, WI 53706.

To avoid artificial characteristics of flask culture, an aseptically biphasic system was designed for Eurasian watermilfoil, Myriophyllum spicatum L. Twenty- and 40-liter aquaria contained undergravel filters, air lift pumps, 50-watt heaters, and plexiglass lids. The system was sterilized in 70% ethanol and assembled aseptically. Aeration was at 0.4 L \cdot min $^{-1}$ and ranges of temperature and light were from 15 to 35°C and 30 to 250 $\mu E \cdot m^{-2} \cdot s^{-1}$, respectively. Plant shoots were rooted separately in 160 ml cups containing 60 g of artificial sediment approximating natural marl and providing 90% of the N and P. Plants were immersed in a mineral salts medium with levels of N and P comparable to lake concentrations. The maximum relative growth rate, 0.14 mg \cdot mg $^{-1} \cdot day^{-1}$, occurred at 22°C and 250 $\mu E \cdot m^{-2} \cdot s^{-1}$, comparable to unrooted shoots grown in an enriched medium. At 27°C, the peak photosynthetic rate, 14 mg O $_2$ ·g dry wt $^{-1} \cdot h^{-1}$, was similar to that of field plants.

A225

WILD RICE YIELD REDUCTIONS ASSOCIATED WITH FOUR FUNGAL BROWN SPOT EPIDEMICS. Clint L. Kohls and James A. Percich, Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Four fungal brown spot epidemics of wild rice (Zizania aquatica L.) were created in experimental plots at four different stages of host development by artificial inoculation with Bipolaris oryzae. Non-disease controls were maintained by the timely application of Mancozeb (Dithane M-45). The plots were 2.13 x 3.05 m, with the treatments being arranged in a randomized complete block with five replicates. Disease severity on the uppermost, second and third leaves was recorded in each experimental plot four times during the season. Inner plots, 1.22 x 2.13 m, were hand harvested, dried, dehulled, graded and weighed. Yield reductions in plots inoculated at boot, heading, one-quarter grain fill and milk growth stages of disease initiation were 67, 56, 32 and 0%, respectively as compared to the non-disease control. Multiple regression analysis of disease severity ratings from the uppermost, second and third leaves during the late milk stage accounted for 87% of the variation in yields.

A226

OVERESTIMATION OF YIELD LOSS DUE TO PATCHY FIELD DISTRIBUTION OF *MELOIDOGYNE INCOGNITA*. J. P. Noe and K. R. Barker, Department of Plant Pathology, North Carolina State University, Box 5397, Raleigh, NC 27650.

M. incognita has a patchy field distribution, resulting in frequency counts which can be described by the negative binomial distribution (NB). The NB is positively skewed, which means that most of the probability density is below the mean value. This leads to overestimation of yield loss due to *M. incognita* when mean density is used as the only indicator variable. The NB is defined by the mean, and k parameter. A coefficient of overestimation (CO) was computed for combinations of mean density and k-values selected as typical of pre-plant *M. incognita* populations. The CO ranged from 20 percent for a mean of 50 and k of 0.5, to only 2 percent for a mean of 1000 and k of 4.0. A least-squares model was derived to predict k-values from mean population density of *M. incognita*. The CO for typical pre-plant densities was 10-15 percent of the predicted yield loss.

A228

EFFECTS OF BACTERIAL BLIGHT ON SOYBEAN YIELD. E. W. Park and S. M. Lim. Department of Plant Pathology, University of Illinois at Urbana-Champaign, Urbana, IL 61801.

The relationship between bacterial blight (*Pseudomonas syringae* pv. *glycinea*) severity and yield of two soybean cultivars, Wells II and Williams 79, was studied in 1981 and 1982. Soybean plants were inoculated at five different growth stages. Disease severity increased significantly for two weeks post inoculation when plants were inoculated earlier than R3 stage. By midseason, rapid plant growth reduced disease severity. Disease severity at R6 stage in 1981 ranged 0-36% and 0-29%, and in 1982, 0-8% and 0-4% for Wells II and Williams 79, respectively. Yield and 300-seed weight of Wells II were significantly different between treatments in 1981 but only 300-seed weight was different in 1982. Disease severity at R6 stage of Wells II was negatively correlated with yield in 1981 ($r = -.39^*$) and with 300-seed weight in both years ($r = -.53^{**}$, 1981, and $r = -.39^*$, 1982). Yield and 300-seed weight of Williams 79 were not significantly different between treatments in both years.

A229

A YIELD LOSS MODEL FOR CYLINDROCLADIUM BLACK ROT OF PEANUTS. J. K. Pataky and M. K. Beute. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650.

Yield loss due to *Cylindrocladium* black rot (CBR) was estimated for two advanced generation CBR-resistant breeding lines and two virginia-type peanut cultivars evaluated in 10 field trials in 1980, 1981 and 1982. A critical-point model explained CBR-yield relationships when yield was expressed as the percentage of the maximum yield at a location. Critical-point models for Florigiant, NC 8C and NC 18229 were: $Y = 98.8 - 72.7 X$, ($r^2 = 0.84$); $Y = 100.2 - 74.5 X$, ($r^2 = 0.79$); and, $Y = 98.3 - 66.6 X$, ($r^2 = 0.57$); respectively, where $Y = \% \text{ maximum yield}$ and $X = \text{proportion CBR incidence 1 wk before digging}$. In trials where CBR epidemics developed naturally, mean proportion CBR incidence 1 wk before digging ranged from 0.21 to 0.74, 0.17 to 0.53 and 0.13 to 0.33 and mean predicted yield loss ranged from 15 to 53%, 13 to 40% and 9 to 22% for Florigiant, NC 8C and NC 18229, respectively. A single model was not applicable over locations for NC 18016 which appeared to be less agronomically stable than the other lines evaluated in this study.

A230

THE RELATIONSHIP BETWEEN YIELD AND BROWN STEM ROT IN SOYBEANS. Scott A. Sebastian, and Cecil D. Nickell, W307 Turner Hall, Urbana, IL 61801.

Field tests were conducted in 1982 to determine the relationship between yield and reaction to *Phialophora gregata* (Pg), the cause of brown stem rot (BSR). These tests included 25 maturity group III and 20 maturity group IV soybean genotypes. The same genotypes were also screened for resistance to Pg in the greenhouse. BSR ratings included counts of nodes showing leaf and stem symptoms in both field plots and greenhouse pots. Visual ratings of leaf symptoms in field plots were also recorded. In fields where BSR was a problem, leaf and stem ratings (node counts) were highly correlated to yield. Greenhouse ratings were good predictors of field results. Visual leaf ratings of field plots were slightly less correlated to yield than were stem symptoms. However, since visual ratings require much less time and labor than splitting stems

and counting nodes, the visual ratings may be a valuable selection tool.

A230A

EFFECT OF WINTER WHEAT POWDERY MILDEW ON YIELD. M. G. Anderson. Agriculture Canada Research Station, Kentville, Nova Scotia, Canada B4N 1J5

Various levels of wheat powdery mildew (*Erysiphe graminis* f. sp. *tritici*) were obtained by fungicide application. The results suggest a threshold level of mildew is required to reduce wheat grain yield under Nova Scotian weather conditions.

A231

DEUTEROMYCETES ASSOCIATED WITH FOLIAR AND POD SPOT DISEASES OF CARDAMOM IN GUATEMALA. Colette M-S. Beaupré, Plant Science Dept. SDSU, Brookings, SD 57007, and J.E. Dimitman, Biological Sciences California State Polytechnic Univ., Pomona, CA 51768.

A portion (186 isolates) of a Deuteromycete collection taken June, 1978-June, 1980 from foliar and pod spots of cardamom, *Elettaria cardamomum* (L)Maton (Zingiberaceae) grown commercially in the south coastal highlands of Guatemala contained: *Fusarium oxysporum*, an unidentified member of Sphaeropsidales, *Colletotrichum* sp., *Ascochyta* sp., *F. roseum*, *Acremonium* sp., an unidentified bulbil-forming genus, *Gliocladium vermoeseni*, *F. solani*, *Alternaria* sp., and *Gliocladium roseum*. These were 39, 17, 13, 9, 7, 7, 4, 3, 1, 0.5, and 0.5% of this portion of the collection respectively. The balance of the collection (*Chorda*, *Phoma*, *Phyllosticta*, *Cercospora* and other Imperfecti genera) was lost. No correlation was found with respect to specific symptoms, collection sites, or time of year. Generally, the taxa were distributed equally on pod and leaf spots. Though Koch's postulates were not completed, *F. solani*, *Colletotrichum* sp., *Ascochyta* sp. and *Alternaria* sp. could be pathogens.

A232

ORGANISMS ASSOCIATED WITH ROOT ROT OF LENTILS. M.K. Bhalla and C. Nozzolillo. Dept. of Biology, University of Ottawa, Ottawa, Ont. K1N 6N5; and E.F. Schneider, Chemistry and Biology Research Institute, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Field experiments were conducted in Ottawa in 1980 and 1981 to identify organisms most frequently associated with root rot of lentils. *Fusarium oxysporum* was the organism most frequently isolated. *F. solani*, *F. equiseti*, *Microdochium bolleyi*, *Acremonium strictum*, *F. melanochlorum*, and an *Acremonium* sp. were also recovered in order of decreasing frequency. All isolates caused root discoloration and foliar chlorosis in seedlings maintained in aseptic culture and significant reductions in yield when plants were grown in pasteurized soil. Simultaneous inoculation of seedlings with the most virulent isolates of *F. oxysporum* and *F. solani* resulted in less severe symptoms than if plants were inoculated with *F. oxysporum* alone. Comparative studies with Washington and Colombian lentil isolates indicated that our isolate of *F. oxysporum* was the most virulent and was similar to a Colombian isolate in terms of taxonomic characteristics and pathogenicity to lentils.

A233

ANASTOMOSIS GROUPS AND PATHOGENICITY OF ISOLATES OF RHIZOCTONIA SOLANI FROM BRAZIL. H. A. Bolkan and Wilma R. C. Ribeiro, Dept. de Biologia Vegetal, Universidade de Brasilia, Brasilia DF, 70910 - Brazil.

Of the 122 isolates of *Rhizoctonia solani* from various plant species found in 10 states of Brazil five belonged to AG1, 27 to AG2, 13 to AG3, and 59 to AG4. Eight isolates did not anastomose with any of the tester strains or among themselves. AG2 was the predominant group found in the state of Amazonas and all isolates were from leaves of rubber, cabbage or radish. AG3 was isolated only from sclerotia found on potato tubers cultivated in the Federal District and Sao Paulo. AG1 was obtained from bean and cucumber leaves cultivated in Amazonas. AG4 was isolated from various host plants and with the exception of Amazonas was found in all states surveyed. Pathogenicity and virulence of the isolates studied differed widely among AGs, but no within each AG group. Most isolates of AG1 and AG4 were highly virulent on leaves of bean and cowpea, but weakly to moderately virulent on soybean leaves. AG2 isolates were weakly virulent on bean and cowpea, and avirulent on soybean.

A234

COMPARISON OF PERONOSCLEROSPORA SORCHI FROM DIFFERENT AREAS OF THE WORLD. M.R. Bonde, G.L. Peterson, and N.B. Duck. Plant Dis.

Maize seedlings (2-leaf stage) were inoculated with conidia of isolates of *P. sorghi* from Thailand, India, Brazil, and Texas; placed overnight in dew chambers (20C); incubated in growth chambers 28 days (27C day-18C night); and compared for symptoms. The plants then were moved into dew chambers (20C) to induce sporulation, and mature conidia were collected as they dropped onto water agar containing 1% copper sulphate. Leaf pieces bearing conidiophores were collected, fixed, and examined microscopically as whole-leaf mounts. Conidia of the Thailand isolate were significantly smaller than conidia from other isolates. Only small differences in shape, width, and length of conidiophores existed among isolates. Although only minor morphological differences were noted, consistent differences in symptoms, and dramatic differences in host range and effects of temperature on conidial germination for the Thailand isolate as compared to the others indicate that the pathogen in Thailand may not be *P. sorghi*.

A235

THE TELEOMORPH OF *CRISTULARIELLA MORICOLA*. Molly Niedbalski Cline, Department of Plant Pathology, University of Illinois, Urbana, IL 61801, J. L. Crane and S. D. Cline, Department of Botany and Plant Pathology, Illinois Natural History Survey, Champaign, IL 61820.

The teleomorph of *Cristulariella moricola* (= *C. pyramidalis*) a leaf spotting fungus which attacks numerous woody and annual plants, is described as a new genus and species, *Grovesinia pyramidalis*. It was produced *in vitro* by fertilizing sclerotia of one isolate with a microconidial suspension from another isolate. The teleomorphic-anamorphic connection was confirmed by the production of the pyramidal-shaped conidia on kidney bean (*Phaseolus vulgaris*) after mycelial inoculations from a culture of ascospore origin. *G. pyramidalis* is characteristic of the Sclerotinaceae sensu Whetzel. It develops a tuberoid sclerotium devoid of host tissue, a stipitate apothecium, ellipsoidal ascospores and globose microconidia. This species is segregated into a new genus primarily on the basis of its associated macroconidial state (*Cristulariella moricola*).

A236

ASSOCIATION OF LECTIN BINDING TO FUNGAL CELL WALLS AND RESULTING MORPHOLOGICAL EFFECTS. W. Gade and R. Brambl. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Plant seed lectins, labeled with fluorescein, were observed to bind specifically and reversibly to conidial germ tubes of *Botryodiplodia theobromae* and *Neurospora crassa*. Several effects of this binding were observed microscopically: morphological distortions (such as abnormal branching), lysis, retardation of germination and alterations in the elongation rates. However, binding of certain lectins to the fungal cell walls did not result in any morphological changes. Uniform binding along the germ tube (concanavalin A) was less likely to result in morphological changes than specific binding to the rapidly growing regions such as the apex and branch points (pokeweed mitogen or wheatgerm agglutinin). Furthermore, lectins with similar binding specificity did not always result in similar changes; *B. theobromae* germ tubes were highly branched and lysed after 7 h incubation with pokeweed mitogen, but were almost unaffected by wheatgerm agglutinin or concanavalin A although all three lectins bound well to the germ tubes.

A237

DIFFERENTIAL DISEASE REACTION OF COTTON CULTIVARS TO THE FUSARIUM WILT FUNGUS - ROOT-KNOT NEMATODE COMPLEX. R. H. Garber, A. H. Hyer and E. C. Jorgenson, USDA, ARS, U.S. Cotton Research Station, Shafter, CA 93263.

Cotton cultivars selected for higher tolerance to root-knot nematodes perform better than commercial 'Acala' varieties from California when grown in Fusarium wilt problem soils. The disease tolerance of four strains with high nematode tolerance was compared to four commercial 'Acala' varieties. Two of the 'Acalas' have moderate tolerance and two more recently released varieties have high tolerance to Verticillium wilt. Compared to the 'Acalas', the nematode-tolerant strains were taller, had fewer root galls, fewer Fusarium wilt symptoms and higher yields. Of the four 'Acala' varieties the two with the most Verticillium tolerance had the most tolerance to Fusarium wilt. Although the four 'Acalas' were equal in nematode susceptibility, the two with highest disease tolerance also had the fewest propagules of *Fusarium oxysporum* per g of petiole tissue. In contrast, although the four nematode-tolerant cultivars all had high disease tolerance, only two had low propagule numbers.

A238

SHEATH BLIGHT OF RICE IN CALIFORNIA. P. S. Gunnell and R. K. Webster. Department of Plant Pathology, University of California, Davis, CA 95616.

Rhizoctonia oryzae-sativae (Saw.) Mordue, a binucleate *Rhizoctonia* sp., has been identified as the causal agent of a sheath blight disease of rice in California. The fungus attacks leaf sheaths producing circular lesions with pale centers and distinct brown margins. Leaves of diseased sheaths are usually killed, turning uniformly yellow. Numerous globose to cylindrical, brown sclerotia are visible in diseased tissue. Preliminary studies have shown short statured CA rice varieties to be consistently more affected by the disease than tall varieties. Evidence suggests that this differential disease response is due to differences in microclimatic conditions between tall and short varieties in the field, and to differences in cultural practices employed in growing tall and short varieties. The disease is extremely similar in symptomatology to sheath blight of rice caused by *R. solani* Kuhn.

A239

A STUDY OF A POSSIBLE INTERACTION BETWEEN *DIAPORTHE PHASEOLORUM* VAR. *CAULIVORA* AND *PHYTOPHTHORA MEGASPERMA* VAR. *GLYCINEA*. P. M. Higley and H. Tachibana. Dept. of Plant Pathology, Seed and Weed Science, Iowa State Univ., and USDA-ARS, Ames, IA 50011

Frequent isolations of *Diaporthe phaseolorum* var. *caulivora* (Dpc) from soybeans in which *Phytophthora megasperma* var. *glycinea* (Pmg) was known to be a problem suggested a possible interaction between the two pathogens. To test this, Dpc-susceptible soybean cultivar 'Pike' was grown in the greenhouse in soils known to be conducive and to be suppressive to Pmg. The soils were infested separately with Dpc, Pmg race 1, and a mixture of both pathogens. All inocula were grown on sterile whole oats. Stand counts taken 4-wks after emergence showed significant differences in stands between the two soils, but not between the infestation treatments within a soil type. After emergence, significantly more plants died in soils infested with Dpc and the Dpc-Pmg mixture than in soils with Pmg alone. These results suggest that the Pmg-suppressive soil is also suppressive to Dpc, that there is no synergism between Dpc and Pmg, and that Dpc can be a virulent pathogen in *Phytophthora* problem soils.

A240

RELATION OF VEGETATIVE BUD DEVELOPMENT AND SOME CHEMICAL CONSTITUENTS OF APPLE ROOTSTOCKS TO *PHYTOPHTHORA CACTORUM* SUSCEPTIBILITY. W. J. Janisiewicz and R. P. Covey, Washington State University Tree Fruit Research Center, Wenatchee, WA 98801.

Four apple rootstocks were tested *in vitro* for susceptibility to *Phytophthora cactorum* throughout the year. MM 106 was most susceptible followed in order by M 26, M 7 and M 9. Susceptibility increased rapidly after bud break and was greatest two weeks later, except for M 26 which was most susceptible in July. Increase in tissue susceptibility paralleled an increase in stimulation of *P. cactorum* grown on PDA amended with vacuum extracted sap. Resistance to *P. cactorum* *in vitro* did not follow changes in concentration of phloridzin in bark and sap. Greenhouse studies support field results indicating that phloridzin is not responsible for resistance to *P. cactorum*. Zeatin riboside (ZR) concentration in the bark was highest in the resistant stage and decreased sharply as susceptibility increased, but it did not increase again with increased resistance. If ZR is involved in the resistance to *P. cactorum*, it would be only early in the season when its concentration is high.

A241

SUGARCANE RUST: THE COMPONENTS OF THE EPIDEMIC AND THEIR USEFULNESS IN DISEASE FORECASTING IN PUERTO RICO. Lii-Jang Liu, Agricultural Experiment Station, College of Agricultural Sciences, University of Puerto Rico, Mayaguez Campus, Mayaguez, Puerto Rico 00708.

The ideal rainfall for rust infection was found to be 5-6 inches per month. Drought or excess rainfall decreases percent of leaf infection by *Puccinia melanocephala*. The optimum temperature for leaf infection was 75°F. Increase in temperatures reduces percent of leaf infection. The optimum age for rust infection was found to be at 2 months. The percent of leaf infection decreases when the cane becomes older. An equation for forecasting rust incidence at a given planting date (Gran cultura) using the traditional multiple regression method was developed. With this equation, the incidence of rust for a given variety at a given planting season can be predicted.

A242

VARIATION IN DEGREE OF RUST RESISTANCE AMONG PLANTLETS DERIVED FROM CALLUS CULTURES OF SUGARCANE IN PUERTO RICO. Lii-Jang Liu, Evelyn Rosa Márquez and María L. Biascochea, Agricultural Experiment Station, College of Agricultural Sciences, University of Puerto Rico, Mayaguez Campus, Mayaguez, Puerto Rico 00708.

A total of 2,489 plantlets of sugarcane were obtained from callus cultures of sugarcane varieties CP 57-603, CO 798, PR 64-2705, and B 4362. In a preliminary inoculation trial, variation in degree of rust resistance among the plantlets was observed. Six plantlets derived from callus cultures of the variety B 4362 appeared resistant to the rust (*Puccinia melanocephala*). Sugarcane protoplasts were isolated using Japanese enzymes, cellulase and macerozyme. However, the numbers of protoplasts were rather low. Efforts are now being made to improve the techniques of protoplast isolation.

A243

EVIDENCE FOR A PHOTOCONVERTIBLE PRECURSOR TO THE PATHOTOXIN CERCOSPORIN. S. S. Martin, E. G. Ruppel, and M. P. Steinkamp, USDA Crops Research Laboratory, Colorado State University, Fort Collins, CO 80525.

Cercospora beticola isolate C-1 grown on malt extract agar in darkness did not produce the red pathotoxin cercosporin but instead accumulated a yellow, highly fluorescing substance ("Compound X"). Even weak illumination led to the disappearance of Compound X and the appearance of cercosporin, suggesting that Compound X might be a cercosporin precursor. However, another *C. beticola* isolate (IPV-F573) that *in vivo* rarely produces cercosporin also accumulated Compound X in darkness; traces of the compound were detected in light-grown cultures, but no cercosporin was detected. If Compound X is a precursor to cercosporin, in this isolate its transformation could be blocked, and it may instead be converted to some other product. Compound X and CBT, a yellow pathotoxin also produced by *C. beticola*, are easily distinguished by their fluorescence spectra.

A244

FUNGAL PATHOGENS OF *CANNABIS SATIVA* IN CENTRAL ILLINOIS. John M. McPartland, Dept. of Plant Pathology, University of Illinois, Urbana, IL 61801.

Cannabis sativa was introduced into central Illinois for hemp production and became naturalized by 1852. In a brief survey of both wild plants and illicit field plantings in central Illinois during 1981 and 1982, five fungal pathogens were identified: *Fusarium oxysporium* f. sp. *cannabis*, *Septoria cannabis*, and *Macrophomina phaseolina* have previously been recorded in the literature on *C. sativa*. An isolate of *Phomopsis cannabina* restricted to foliar lesions (previously reported exclusively from stem lesions) and an unreported *Acrosporium* stage of a powdery mildew are also described. *Alternaria tenuis*, previously reported as a blight pathogen of *C. sativa* in central Illinois, was only found as a saprophyte on senescent flowers and other necrotic tissue in the present survey. [Acknowledgements extended to Capt. M. Yodice of the M.P.P.D. for assistance in obtaining samples of *C. sativa*.]

A245

THE DIFFERENTIATION OF *ENDOTHIA PARASITICA* FROM *E. GYROSA* BY POLYACRYLAMIDE VERTICAL SLAB GEL ELECTROPHORESIS. J. A. Micales and R. J. Stipes. Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, VA 24061.

The biochemical differentiation of *Endothia parasitica* from *E. gyrosa* by tube gel electrophoresis has been recently reported. Vertical slab gel electrophoresis, considered to be a superior technique, was used to verify the separation of these species. Soluble proteins of 32 and 22 vouchered, single-conidium isolates of *E. parasitica* and *E. gyrosa*, respectively, were extracted from lyophilized mycelia. Protein concentrations were determined by the Bradford assay; approximately 80 µg of protein from each isolate were used for electrophoresis. The electrophoretic system was nondissociating and discontinuous with a 12% acrylamide (pH 8.8) separating gel and a 3.9% acrylamide (pH 6.8) stacking gel. The protein patterns of *E. parasitica* isolates were clearly dissimilar to those of *E. gyrosa* despite some intraspecific variation. Over 40 proteins could be distinguished for each species. This technique is a reliable means by which to separate these taxa.

A246

INFLUENCE OF LOCAL ENVIRONMENTAL CONDITIONS ON KERNEL DISCOLORATION OF BARLEY. M.R. Miles and R.D. Wilcoxson. Department of Plant Pathology, University of Minnesota, St. Paul, Minnesota 55108.

Kernel discoloration of 30 barley lines associated with species of *Bipolaris*, *Alternaria*, *Fusarium* and *Cladosporium* was evaluated at four Minnesota locations during 1982. Kernels from 20 threshed heads per line were scored; one indicated little discoloration and five severe. Chevron and CI9539 scored 1 or 2 at all locations, whereas Karl, Cebada Capa and CI4974 scored 3, 4 or 5; other barleys were intermediate. Kernels discolored most at Morris and least at St. Paul; Crookston and Rosemount were intermediate. Discoloration was associated with the amount of rain that fell between anthesis and harvest. Rainfall was greatest at Morris, least at St. Paul and Rosemount, and intermediate at Crookston. Discoloration at Rosemount was enhanced by both a late harvest and late rain. A significant cultivar by location interaction occurred; kernel discoloration was greater on some cultivars at Morris and Rosemount than at St. Paul and Crookston.

A247

COMPARATIVE STUDIES WITH TWO *MUCOR* SPECIES CAUSING POSTHARVEST DECAY OF TOMATO FRUIT. H. E. Moline and Joseph Kuti, USDA, ARS, HSI, Horticultural Crops Quality Lab, Beltsville, MD 20705

Growth rates of *Mucor mucedo* and *M. piriformis* were compared on mature-green and red tomato fruit and potato dextrose agar (PDA) at temperatures from 0-40°C. *M. mucedo* grew on green and red tomatoes and PDA at temperatures from 5-30°C with an optimal growth temperature of 20°C. *M. piriformis* grew on all substrates tested at temperatures from 0-20°C with an optimal growth temperature of 15°C. Growth rates of both fungi were greater on red than on green fruit; *M. mucedo* is a more aggressive pathogen than *M. piriformis* and is capable of completely decaying tomatoes within 2-3 days after inoculation. Of a number of fungicides tested, only Guazatine showed measurable fungicidal action against the two fungi, significantly reducing decay on green and red fruit.

A248

OCCURRENCE OF HYPHAE OF *UNCINULA NECATOR* IN BUDS OF GRAPEVINE. R.C. Pearson and W. Gärtel, Dept. of Pl. Path., Cornell Univ., Geneva, NY 14456 and Biologische Bundesanstalt, Institut für Pflanzenschutz im Weinbau, 5550 Bernkastel-Kues, Fed. Rep. Germany, respectively.

Since the late 1800's evidence for survival of *Uncinula necator* (Schw.) Burr. in buds of grapevine has been largely circumstantial, based on field observations and greenhouse studies. Observations using SEM revealed the first direct evidence that hyphae of *U. necator* can reside inside buds. Hyphae with characteristic lobate appressoria were observed on the concave side of bud scales dissected from the interior of green buds on infected shoots. Immunofluorescent techniques, utilizing antisera produced against conidia of *U. necator* and 'indirect' staining with fluorescein isothiocyanate, revealed green fluorescent hyphae at the base of scales in longitudinal sections of green buds. Nonspecific staining of unidentified hyphae in buds suggested further studies on specificity of the technique are required before precise localization of hyphae of *U. necator* within buds can be achieved.

A249

POTATO ROOT TIPS LAPSE INTO MATURITY WHEN INFECTED BY *VERTICILLIUM DAHLIAE*. James W. Perry, Dept. of Botany, University of Wisconsin, Madison, WI 53706.

The structure and development of tissues in potato (*Solanum tuberosum*) root tips colonized by *Verticillium dahliae* was contrasted with those of uninoculated root tips. Within two days of inoculation hyphae had penetrated the rootcap without eliciting any apparent structural response in the rootcap cells. Callose-like deposits were found along the walls of protodermal cells bordering the colonized cap cells. Overall, colonized root tips had lost their meristematic appearance due to increased vacuolation of the cells. In contrast to the normal longitudinal course of primary vascular differentiation, in infested root tips the protoxylem matured in advance of the protophloem. Fifteen days after inoculation the root tips had lapsed into maturity. The endodermis and exodermis extended completely around what was once the apical meristem. Although the xylem had differentiated to within several cell layers of the infested apex, xylem infection had not occurred in this region. Sieve elements in colonized root tips failed to develop sieve-plate pores.

A250

A MATHEMATICAL MODEL OF GROWTH AND REPRODUCTION OF OIDIUM BEGONIAE. James A. Quinn, Rohm and Haas Co., Research Labs, Spring House PA 19477.

A mathematical model predicting growth, sporulation and disease progress was devised from morphological observations of powdery mildew of begonia. The basic formula predicting daily sporulation of first generation colonies is:

$$N_{ds} = x_0 v w z \sum_{n=0}^{t-p} b^n \quad \text{where } t-p \geq 0$$

where x_0 = amount of primary inoculum, v = number of conidia that form sporulating colonies divided by x_0 , w is the mean number of hyphae originating from the mother conidia, z = number of conidia produced daily per daily hyphal growth segment after a latent period p , t = time since germination and b = the number of new branches formed per daily hyphal growth segment plus one for extension of existing hyphae. Verification of the model and more complicated equations will be presented.

A251

PEACH TREE PRUNING TIMES IN RELATION TO SUSCEPTIBILITY AND SPREAD OF BOTRYOSPHERA DOTHIDEA. C. C. Reilly and W. R. Okie, USDA-ARS, Southeastern Fruit and Tree Nut Research Laboratory, P. O. Box 87, Byron, GA 31008.

Summer versus spring pruning of peach orchards was studied to determine length of time tree wounds were susceptible to invasion by B. dothidea. Spore trapping was conducted in a commercial orchard heavily infested with fungal gummosis. Conidia of B. dothidea were detected from 3 June through 13 October with new gumming first detected in early June. Pruning wounds made on March 1 were highly susceptible to B. dothidea for up to 1 wk as indicated by visual gumming ratings and reisolation rates. Pruning wounds from summer pruned trees (August 15) were less susceptible to invasion and colonization by B. dothidea. The only significant reisolation occurred from wounds inoculated at 0 and 3 days after pruning. A Benlate, captan mix protected pruning wounds from invasion by B. dothidea during summer pruning.

A252

INFECTION OF PINEAPPLE INFLORESCENCES BY PENICILLIUM FUNICULOSUM AND FUSARIUM MONILIFORME UNDER CONTROLLED ENVIRONMENTAL CONDITIONS. K. G. Rohrbach and G. Taniguchi, Department of Plant Pathology, University of Hawaii, Honolulu, Hawaii 96822.

Pineapple crowns of cultivar 53-116 (susceptible to Penicillium funiculosum) and 58-474 (susceptible to Fusarium moniliforme) were grown under greenhouse conditions (26°C day/22°C night) at the Southeastern Plant Environmental Laboratory, N.C.S.U., Raleigh, N.C. Plants inoculated with P. funiculosum were subjected to 4 different temperature regimes (22°C day/14°C night, 22°C day/18°C night, 22°C day/22°C night and 30°C day/22°C night) from 6 to 12 weeks postflower induction or for 5 day intervals at 22°/14°C when inflorescences were at 1.25 cm open heart, 2.4 cm open heart, mid to late cone, and, late cone to early flower. Maximum infections as indicated by unopened flowers and interfruit corking, leathery pocket and fruitlet core rot (FCR) fruit symptoms occurred at 22°C day/14°C night temperatures. Plants inoculated with F. moniliforme and subjected to the 4 temperature regimes showed greatest FCR at 22°C day/18°C night.

A253

MYCOCHROME SYSTEM AND CONIDIOGENESIS IN ALTERNARIA CICHORII. D. J. Vakalounakis and C. Christias, Dept. of Biology, Nuclear Research Center "Democritos", Aghia Paraskevi, Attikis, Greece.

Irradiation from 310-420 nm (BLB) inhibited the maturation of conidiophores and the formation of conidia in Alternaria cichorii. The higher the temperature (>25°C) the greater the inhibition. This inhibition of sporulation was caused by the blue wavelengths of light in BLB irradiation. The inhibition was reversed by continuous incubation under BLB in a temperature-dependent response, but not under blue light (360-530 nm) alone. This blue light suppression of conidial development could be reversed if NUV irradiation (310-400 nm) was applied immediately after blue light. The effects of these two kinds of light were reversible and the final response depended on the kind of light last received. This repeated reversibility of the effects of NUV and blue light suggests that the photo-receptor "mycochrome" may be responsible for the effect of light on conidial development.

A254

A NEW STEM CANKER DISEASE OF SUNFLOWER. B. L. Watters, L. J. Herr, and P. E. Lipps. Department of Plant Pathology, The Ohio State University, OARDC, Wooster, OH 44691.

A stem canker disease of oilseed sunflower was found in Ohio in August 1980. Cankers originated at petiole bases and were brown to black, later turning ash-grey. Leaf symptoms were unilateral and characterized by interveinal bronzing. A Phomopsis-Diaporthe sp. was consistently isolated from stem tissue and pycnidial ooze. Pycnidia contained single-celled alpha conidia and/or filiform beta conidia. Long-necked perithecia from overwintered stems contained clavate asci with eight two-celled ascospores. Koch's postulates were fulfilled, verifying the pathogenicity of the isolated organism. Mature, reproductive plants were affected by the disease, whereas young plants were not. Yield loss in the field was due to premature death and lodging of plants.

A255

Blue lupine is a host for Colletotrichum trifolii and C. fragariae. Ronald E. Welty. USDA ARS, Dept. Botany and Plant Pathology, Oregon State University, Corvallis 97331.

The host range for some anthracnose-inducing fungi is wide. For example, Colletotrichum acutatum f. sp. pinus from 4 species of pine infects blue lupine (Lupinus angustifolius), and vice versa; likewise C. acutatum also induces a fruit rot of strawberry. To test the pathogenicity of 2 other Colletotrichum spp., blue lupine was inoculated separately (1×10^6 conidia/ml) in the greenhouse with races 1 or 2 of C. trifolii from alfalfa, and 3 isolates of C. fragariae from strawberries grown in North Carolina, Louisiana, or Florida. Using a disease severity index of 1-5, blue lupine was highly susceptible to the two races of C. trifolii (DSI 4.3 and 4.9, respectively) and to the three isolates of C. fragariae (DSI 4.5-4.9). When the same isolates of C. fragariae were inoculated into alfalfa cvs. Saranac AR and Arc, DSI ranged from 1.1 to 1.8. It was concluded that the host range of C. trifolii and C. fragariae should be extended to include blue lupine.

A256

DISPLACEMENT OF CALCIUM FROM SUSPENSION-CULTURED GLYCINE MAX CELLS IN RELATION TO THE EFFECT OF CHITOSAN ON MEMBRANE PERMEABILITY. D.H. Young and H. Kauss. Dept. of Plant Pathology, University of Wisconsin, Madison, WI 53706 and Fachbereich Biologie der Universität, D-6750 Kaiserslautern, Germany.

Treatment of Glycine max cells labeled with ^{45}Ca with chitosan, a polycation with a possible regulatory role in host-fungal interactions, caused a rapid release of Ca from the cells. This appeared to be correlated temporally with binding of chitosan to the cells, but not with the chitosan-induced leakage of total electrolytes. Other polycations, polyamines and polyanions, which can act as chelating agents, also released Ca, however only the polycations greatly increased membrane permeability. Poly-L-lysines of differing mol wt caused a similar release of Ca but their ability to increase membrane permeability decreased with decreasing size. The results suggest that the effect of chitosan and other polycations on permeability is not the direct result of Ca displacement from the cell wall and/or plasma membrane, but is due to cross-linking of surface components.

A257

EFFICACY OF A STEROL-INHIBITING FUNGICIDE IN RELATION TO TIME OF APPLICATION AGAINST APPLE POWDERY MILDEW. L. P. Berkett, K. D. Hickey and H. Cole, Jr. Dept. of Plant Pathology, The Pennsylvania State University, University Park, PA 16802.

The effectiveness of triadimefon (75 mg a.i./L.) in the management of apple powdery mildew, Podosphaera leucotricha (Ell. & Everh.) Salm., was evaluated in an orchard of 'Rome Beauty' trees during 1980, 1981 and 1982. The experiment utilized a randomized complete block design with 5-6 single tree replicates. Trees were sprayed at specific periods during the growing season ranging from the 'Tight Cluster' phenological stage through the 'Fourth Cover'. Disease incidence was assessed on 10-15 shoots per tree. The 'Bloom', 'Petal Fall' and 'First Cover' applications were found to be the most effective in reducing incidence. Weather conditions and the number of primary infection sites per tree had a significant effect on the optimal timing of applications. It was determined that 2 properly timed sprays could be as effective as 4 applications at lower levels of initial inoculum.

A258

POPULATION DYNAMICS OF SOIL MICROFLORA AFFECTED BY SOIL APPLICATION OF FUNGICIDES AND INSECTICIDES. V. S. Bisht and R. S. Singh, Dept. of Plant Pathology, G. B. Pant University of Agriculture and Technology, Pantnagar, U. P., India.

Four fungicides : Bavistin, Brestan, Demosan and Vitavax and two insecticides : Furadan and Temik were added to soil at 1.0 g a.i./kg and incubated for 21 days at 25±2°C. Selective media were used to recover fungi, bacteria, Actinomycetes, *Fusarium* spp. hyphal propagules and conidia. Brestan and Vitavax reduced the fungal recovery below the control (no chemical treatment). All treatments showed a higher recovery of bacteria within 24 hrs., after which the populations were equal to the control. Brestan and Vitavax inhibited Actinomycetes. *Fusarium* spp. recovered from hyphal propagules and conidia were reduced by Brestan and Vitavax, but *Fusarium* spp. recovery from hyphal propagules increased with Bavistin and Demosan (300 and 600 colonies/g soil, respectively, compared to 162.5 for control). Furadan and Temik showed no differences at the end of 21 days.

A259

EFFECT OF LIME APPLICATION TO ACID SOIL ON INCIDENCE OF CEPHALOSPORIUM STRIPE IN WINTER WHEAT. W.W. Bockus, Department of Plant Pathology, Kansas State University, Manhattan, KS 66506.

Cephalosporium stripe (Cs) of winter wheat is caused by the soilborne fungus *Cephalosporium gramineum* (Cg). It was first detected in Kansas in 1972 and has since increased in severity to become one of the leading causes of reduced yields in the continuous wheat cropping area. In this area, 22 of 30 fields sampled had soil pH readings of less than 5.5 in the top 15 cm of soil. These low values were possibly due to continual applications of nitrogen fertilizers. A study was established in a field naturally infested with Cg to determine the effect of lime (5000 lbs/ac of 50% effective calcium carbonate) application on Cs incidence. Lime treatment (soil pH=6.5) significantly reduced Cs incidence from 36.2% to 22.0% when compared with unlimed plots which remained at pH=4.7. Thus, it appears that gradually declining soil pHs in the continuous wheat growing area of Kansas may have contributed to the fairly recent appearance and increase of Cs disease.

A260

EFFECT OF TEMPERATURE ON CONTROL OF SEEDLING DISEASE ON SPRING WHEAT GROWN FROM SCABBY SEED. G. W. Buchenau & M. D. Yahnke, Dept. of Plant Science, SDSU, Brookings, South Dakota 57007

Cleaned seed of MPV-2 spring wheat from a scabby crop was treated with fungicides, rolled in rag-dolls, and buried in cylinders of soil in temperature tanks maintained at 5 degree intervals between 10 C and 30 C. Germination was not greatly affected by temperature or seed treatment, but coleoptile rot, negligible at 10 C, increased sharply with temperature to 25 C. Benlate T reduced disease at all temperatures, but Vitavax 200 was not effective at 20 C or 25 C. These results suggest that seed treatment of scabby seed will be of marginal benefit in South Dakota spring wheat planted at low soil temperatures, but may be very beneficial on winter wheat which is commonly planted in soil at 15-20 C. Vitavax 200 may not provide adequate control in winter wheat seeded early into warm soil.

A261

EFFECTS OF ACIDIC RAIN ON THE RETENTION OF FUNGICIDES ON LEAF SURFACES. E. J. Butterfield and J. Troiano, Boyce Thompson Institute, Ithaca, NY 14853.

Rainfall is recognized to be a significant factor in removal of pesticides from leaf surfaces. The effects of rainfall intensity and duration on removal of pesticide deposits have been modeled but the effects of elevated concentrations of H⁺, SO₄⁼ and NO₃⁻ in rain have not been described. Primary leaves of snap bean were treated with several fungicides and were subjected to simulated rain at a pH of 5.6, 4.6, 3.8 or 3.0. Increasing the acidity of simulated rain increased the rate of fungicide loss for triphenyltin hydroxide, chlorothalonil, benomyl and thiabendazole. The loss of fungicide at each pH could be modeled by an exponential decay function of the form $y = \beta_0 e^{-\beta_1 x}$, where y was the amount of fungicide retained, β_0 was the initial fungicide deposit, β_1 was the decay function and x was the amount of rainfall. A first order relationship between β_1 and acidity, measured as the concentrations of H⁺, was observed with TPTH. The relationship between acidity and β_1 can be used to predict the effect of acid rain episodes on the retention of foliar fungicides.

A262

DISTRIBUTION OF ¹⁴C-METALAXYL IN PLANTS FOLLOWING UPTAKE BY ROOTS. Lori M. Carris and P. R. Bristow, West. Wash. Res. & Ext. Ctr., Wash. State Univ., Puyallup, WA 98371.

In young cabbage, red raspberry and strawberry plants ¹⁴C-metalaxyl was readily taken up by roots and translocated to the above ground parts of the plants. Accumulation of radioactivity was greatest in the margins of mature leaves. After 8 days potted red raspberry plants contained nearly 2% of the ¹⁴C-metalaxyl drenched onto the surface of the soil; strawberry plants took up almost 5% of the applied fungicide. Translocation into cotyledons and leaves of cabbage decreased when transpiration rate was lowered by wrapping those plant parts in either clear plastic or aluminum foil. Pairs of separately potted stolon-connected strawberry runner plants were used as donor-receptor units. Application of ¹⁴C-metalaxyl to the soil of the donor resulted in lateral translocation of radioactivity to all parts of the receptor. Withholding water from the receptor or removing the leaves of the donor increased lateral translocation which suggests that fungicide uptake is directly related to water uptake rates.

A263

SENSITIVITY OF BARLEY POWDERY MILDEW TO TRIADIMENOL IN THE U.K. Janice Clark, Jenny Butters and D.W. Hollomon, Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, U.K.

Fungicides which inhibit ergosterol biosynthesis are widely used to control barley powdery mildew (*Erysiphe graminis* f.sp. hordei) in the U.K. The sensitivity of mildew to one of these fungicides, triadimenol, has been monitored for several years, using both laboratory assays and greenhouse tests. Some decline in sensitivity has occurred since 1980, although field performance remains generally satisfactory and no confirmed cases of resistance have been reported. This reduced sensitivity to triadimenol is associated with lower sensitivity to other fungicides which inhibit 14C-demethylation in ergosterol biosynthesis, but not to morpholine fungicides which act at a later step. Sensitivity to triadimenol and the hydroxypyrimidine fungicide, ethirimol are often inversely related, whilst tests with differential barley cultivars have revealed links between triadimenol sensitivity and certain pathogen virulence genes. Factors likely to influence the relative fitness of less sensitive isolates will also be examined.

A264

EFFECT OF CALCIUM ON CELL WALL INTEGRITY AND DECAY OF 'GOLDEN DELICIOUS' APPLES. W. S. Conway and C. E. Sams, Hort. Crops Quality Lab, HSI, ARS, S&E, USDA, Beltsville, MD 20705

'Golden Delicious' apples were pressure infiltrated (68.95 kPa) with 0, 2, 4, 6, or 8% solutions of CaCl₂. After 4 months storage (0 C) the fruit were removed and one lot was wound inoculated with *Penicillium expansum*. Another similarly treated lot was macerated, placed in petri dishes, autoclaved and seeded with fungal mycelium. Dehydrated PDA was amended with CaCl₂ to a rate approximately 3X the amount the fungus encounters in the fruit, and also seeded with fungal mycelium. Fruit were analyzed for calcium content and water soluble polyuronide, which is an indicator of cell wall breakdown. Decay reduction, increase in tissue calcium content and decrease in water soluble polyuronide were most evident in fruit infiltrated with higher levels of CaCl₂. After 7 days, fungal growth on agar plates amended with CaCl₂, or on macerated apple tissue was not retarded as calcium concentration increased. These results imply that the reduction of decay is partially due to calcium's role in maintaining cell wall integrity of the fruit in storage.

A265

EFFECT OF BACILLUS SUBTILIS ON FUNGI ASSOCIATED WITH SOYBEANS. M. A. Cubeta and J. B. Sinclair, Dept. of Plant Path., Univ. Illinois, 1102 S. Goodwin Ave., Urbana, IL 61801.

Isolates of *Bacillus subtilis* were tested for antagonism to 26 fungi associated with soybeans. In dual cultures on potato-dextrose agar (PDA) and soil-extract agar, zones of inhibition developed between 25 of the fungi, including spp. of *Phomopsis*, *Cercospora*, and *Colletotrichum*. Autoclaved culture filtrates of *B. subtilis* grown for 24 to 48 hrs. at 28°C and 37°C and mixed with PDA inhibited radial growth of *Phomopsis* spp. at 5, 10, and 20% v/v. Suspensions of *B. subtilis* applied as a seed treatment significantly reduced *Phomopsis* stem infection in the field, but not in the greenhouse or growth chamber studies. However,

germination and seedling vigor were significantly below controls. Suspensions sprayed on plants in growth chambers and in the field showed no reduction in *Phomopsis* spp. on inoculated plants.

A266

CONTROL OF POWDERY MILDEW (*PODOSPHAERA LEUCOTRICHA*) [Ell. et. ev.] Salm) OF APPLE ON FRUIT, FOLIAGE AND TERMINAL BUDS. Robert H. Daines, Darrell Weber, Eileen Bunderson and Teryl Roper, Dept. of Botany, Brigham Young University, Provo, Utah 84602.

Powdery mildew fruit infections of apple occur during the pink stage of blossom development, and can be prevented by the use of an effective fungicide. Vanguard was the most effective one tested, with wettable sulfur, Dinocap, and Benomyl following in that order. Vanguard may have been the most effective against the mycelium from germinated spores. The effectiveness of these fungicides in preventing foliage infections and open and dead terminal buds was in the same order. The most important applications for the protection of the foliage were pink petal fall and first cover. While additional cover sprays generally reduced the incidence of foliage mildew in Sept. it often required 2 or 3 applications to produce statistical significance. In Sept. the 5 to 9 oldest leaves on a terminal were free of visible mildew even though in June many of these leaves were found to exhibit powdery mildew.

A267

PESTICIDE REGISTRATIONS FOR "MINOR" USES. J.E. Elson, W.L. Biehn, IR-4 Project, Cook College, Rutgers University, New Brunswick, NJ 08903

Interregional Research Project No. 4 (IR-4) is a coordinating effort to provide research guidance in obtaining requisite data to register pesticides for minor or special uses. Since 1975 IR-4 has received 562 pesticide/commodity requests for disease or nematode control in food crops. IR-4 has 46 fungicide/nematicide food use projects underway and an additional 95 are eligible for research. Currently 46 petitions for fungicides and nematicides are under review at manufacturers or at the Environmental Protection Agency (EPA). Since 1975, 24 IR-4 researched fungicide/nematicide uses were cleared by EPA. Since its initiation in 1977 the IR-4 Ornamentals Program has received over 3000 different requests for disease and nematode control on ornamentals. IR-4 has contributed data in support of 621 ornamental registrations involving 11 fungicides and two nematicides. Presently there are 653 ornamental requests for disease and nematode control that are eligible for research.

A268

DERMAL EXPOSURE TO CAPTAN AND PROTECTION AFFORDED BY TWO TYPES OF SPRAY SUITS WHILE HAND SPRAYING A CHRYSANTHEMUM FLOWER CROP. A. W. Engelhard¹, S. E. Snowden¹, W. E. Wheeler², G. D. Stratton² and R. N. Hackler². Univ. of Fla., IFAS, Bradenton¹ 33508 and Gainesville² 32611.

Captan fungicide was sprayed at 150 psi on a chrysanthemum flower crop by an operator using a hand-held spray boom. Deposition of fungicide was monitored on 6 locations (left arm, right arm, chest, back, left leg, right leg) on the outside and the inside surface of the spray suits during each of 6 spray periods. Also, spray suits made of 2 different materials were compared for spray penetration. One was made of Gore-Tex[®] laminate, a light-weight material that generally is impervious to water but "breathes", and the other of a 65-35 cotton polyester material. Significantly greater deposition of captan occurred on the left and right leg patches than on the other 4 locations when the totals were compared over 6 spray days and both suits. The overall percent penetration values for the two suits were low and not significant (Gore-Tex 1.5% and cotton-polyester 1.8%) indicating similar levels of protection.

A269

CHANGES IN THE EFFECTIVENESS OF IPRODIONE FOR THE CONTROL OF ALLIUM WHITE ROT. A.R. ENTWISTLE. National Vegetable Research Station, Wellesbourne, Warwick, CV35 9EF, UK.

Iprodione (Rovral 50% w.p.; May & Baker plc) applied as seed and stem base treatments (total rate 3 kg a.i./ha) failed to control white rot in routine screening field tests in 1982. Different batches of iprodione, tested by the manufacturer, gave similar results. *S. cepivorum* isolated from diseased onion tissue did not differ from parent isolates in its in

vitro response to iprodione. Control was partially restored when iprodione was tested on land with no history of previous useage with that fungicide. Vinclozolin and meclozolin, fungicides with related molecular structure to iprodione, consistently controlled white rot.

A270

EFFECT OF MECLOZOLIN AND VINCLOZOLIN ON ALLIUM WHITE ROT. A.R. Entwistle, National Vegetable Research Station, Wellesbourne, Warwick CV35 9EF, UK.

Meclozolin (BAS 4360F 50% w.p.; BASF plc) applied to seed (50 and 25 g a.i./kg) or to the seed furrow at planting (0.05 and 0.025 g a.i./m row) and followed 4 weeks later by a stem base treatment of 0.05 or 0.025 g a.i./m row (total rate 1.5 kg meclozolin/ha) reduced white rot incidence from 100% to 6% or less in salad (green) onions sown in April 1982. When applied as a stem base treatment 2 months after sowing, to plants grown from untreated seed, established infections were controlled whereas all untreated plants were killed. Vinclozolin (Ronilan 50% w.p.; BASF plc) applied as a seed treatment at 50 g a.i./kg followed 2 months later by a stem base treatment of 0.025 g a.i./m row (total rate 2.25 kg vinclozolin/ha) to salad onions sown in August 1981, reduced white rot incidence the following June from 100% to 4%. Stem base treatments applied to plants grown from untreated seed were less effective.

A271

EFFECT OF SPRAY VOLUME AND SPRAY PRESSURE WITH MANCOZEB FUNGICIDE ON PEANUT LEAFSPOT AND YIELDS. T. A. Kucharek and R. P. Cromwell, Depts. of Plant Pathology and Agricultural Engineering, University of Florida, Gainesville, FL 32611, and J. Riabov, Diamond Shamrock, Hockessin, Delaware 19707.

Spray volume (SV) and spray pressure (SP) combinations were inconsistent for the control of peanut leafspot (PL) caused by *Cercospora arachidicola* and *Cercosporidium personatum*. Differential between SV-SP combinations was best related to rainfall parameters rather than specific SV-SP parameters. Using mancozeb fungicide at a constant rate/test, in three years of field testing, highest volume sprays (467.5 l/h) performed best when rainfall was lowest. Lower volume (93.5 - 233.8 l/h) sprays were better than higher volume sprays when rainfall amounts were highest. Considering all three tests a lower SV was better for PL control and peanut yields. SP exerted a negligible influence on PL control. In all three tests, unsprayed plots incurred at least 85% defoliation from PL. Yields of unsprayed plots were always statistically lower than those in sprayed plots.

A272

EFFECTS OF CHEMICAL CONTROL OF PASMO DISEASE (*MYCOSPHAERELLA LINORUM*) OF FLAX (*LINUM USITATISSIMUM*) ON FLOWERING AND YIELD COMPONENTS. M. W. Ferguson, C. L. Lay, & P. D. Evenson, Plant Science Department, South Dakota State Univ. Brookings, SD 57007

The largest yield losses occur when PasmO infected flax is flowering during conditions optimum for fungal infection. Single applications of Benlate 50W and Dithane M-45 were applied to an early 'Wishek' and late 'Dufferin' variety at either prebloom, fullbloom or postbloom. Daily flower counts were taken and the stems rated for disease at harvest. Both compounds significantly (0.05) reduced disease while use of Benlate 50W significantly (0.05) increased yield. Other yield parameters were not significant. Cumulative flower data for each plot were fitted to a logistic curve. Total flowers (TF), day of maximum flowering (MF) maximum rate of flowering (S) and period where most flowering occurred (MP) was derived from the logistic equation. Yield was positively correlated with seed weight and (MF) and negatively with seeds per boll and infection.

A273

BIO-Y: A NEW, SIMPLIFIED ONE-HOUR FUNGICIDE BIOASSAY USEFUL FOR CALIBRATING SPRAYERS. W. E. MacHardy, Dept. of Botany and Plant Pathology, Univ. of New Hampshire, Durham, 03824.

BIO-Y is an inexpensive, quick, easily-performed bioassay designed for use by scientists and non-scientists, including growers. It is a manometric assay that relates CO₂ production by baker's yeast, *Saccharomyces cerevisiae*, to fungicide residue. BIO-Y offers several advantages over other bioassay procedures: no culturing, sterilization, laboratory facilities, or prior laboratory training are required. In 1982 BIO-Y was used to check the calibration of sprayers used by apple growers. Plastic strips placed in the upper, middle, and lower portions of the canopy of

five trees were sprayed with a test fungicide, Captan 50 WP. The strips were then assayed, and within an hour the distribution of captan in the tree canopy, expressed as $\mu\text{g}/\text{cm}^2$ of leaf surface, was determined. If the residue differed from prescribed tolerances, adjustments in spraying were made and the test repeated until the fungicide residue was within acceptable limits. The procedure is adaptable to most crops and sprayers, and other test fungicides can be used.

A274

INTEGRATED CONTROL OF YAM TUBER DECAY IN PUERTO RICO. J. S. Mignucci, M. Santiago and J. Green. Depts. of Crop Protection and Horticulture, Univ. of P. R., RUM, Mayaguez, P. R.

We have estimated that 40% of harvested yam (*Dioscorea* spp.) tubers are lost due to mechanical damage and subsequent storage decay. Even with healthy yams, 50% reduction in field emergence of tuber-pieces is common. Fungi associated with tuber decay include *Penicillium* spp., *Fusarium* spp., *Rhizoctonia* sp., *Sclerotium rolfsii* and a *Sclerotium*-like mycelial basidiomycete. Fungicides (thiabendazole and captafol) when applied as seed-piece dip before storage or before planting effectively reduced tuber decay and resulted in higher emergence and survival in the field. Increased yield correlated with increased emergence for both pre-storage and pre-plant treatments of seed pieces. *D. alata* cv. Florido and whole tubers had less rapid decay compared to *D. rotundata* cv. Habanero and seed pieces, respectively. Seed and variety selection and use of pre-storage and pre-plant fungicide treatments are some of the practices which need to be integrated to control yam tuber decay.

A275

SOIL SOLARIZATION IN ARIZONA. J.D. Mihail and S.M. Alcorn. Dept. of Plant Pathology, Univ. of Arizona, Tucson, AZ, 85721.

The effect of soil solarization on natural and/or artificially established populations of *Macrophomina phaseolina* and *Sclerotium rolfsii* was examined using 51 μm clear polyethylene tarp for 2, 4 or 6 weeks during spring, summer and fall tests. In one summer trial, the maximum temperatures achieved were 54, 45, 40C, which were 7-8C higher than the control plots at 1, 15, and 30 cm depths respectively; *M. phaseolina* populations were never eliminated under tarps. During a summer trial, complete control of *S. rolfsii* was attained to 15 cm after 4 wk, while during the fall trial, the fungus was controlled only at the 1-cm depth after 2 wk. Following three of the trials, *Euphorbia lathyris* was planted in tarped and control plots. The incidence of mortality associated with *M. phaseolina* in the tarped plots was never lower than the control plots.

A276

FUNGICIDES APPLIED SINGLY AND IN COMBINATION FOR CONTROL OF EARLY BLIGHT OF CELERY IN FLORIDA. D. F. Myers, University of Florida, Agricultural Research and Education Center, Belle Glade FL 33430.

Tilt 3.6 E (CGA-64250, 0.066 l/ha), Bravo 6F (Chlorothalonil, 0.29 l/ha), and Manzate 200 (254 g ai/ha) were applied singly and in combination with Kocide 101 (254 g ai/ha) 13 times at weekly intervals to 'Fla 683' celery to control early blight (*Cercospora apii*). Under severe blight conditions, Tilt combined with Kocide gave the highest market wt per plant (445 g) and the lowest final disease ($y = 0.38$) as compared to the non-sprayed control (117 g and $y = 0.85$). Tilt alone (395 g and $y = 0.38$), or combined with Kocide at one-half the recommended rates (368 g and $y = 0.38$) gave similar disease severity but lower market wt. A combination of Tilt and Kocide, where applications of each chemical were alternated weekly, gave a lower market wt (354 g) and higher final disease severity ($y = 0.63$) than the better Tilt treatments. All treatments containing Tilt were generally superior to comparable Bravo and Manzate treatments.

A277

FIELD CONTROL OF POSTHARVEST BODY AND STEM-END ROTS OF PAPAYA. W.T. Nishijima and J.T. Nagata, Hawaii Agric. Exp. Stn., Univ. of Hawaii, Hilo, HI 96720.

A field test was installed to determine the role of sanitation and fungicide spray frequency on the incidence of papaya body (BR) and stem-end rots (SER) after 2 weeks of storage at 10 C and ripening at room temperature for 4-5 days. Sanitation consisted of petiole and leaf pruning once every 2 months and fungicide sprays were with mancozeb at 3.36 kg/ha at 14 and 28

day intervals. The test showed that: (a) there were no significant differences in BR and SER as a result of 14 and 28 day spray intervals with and without sanitation; (b) field control measures were ineffective in controlling SER, but hot-water treatment (48 C for 20 min.) reduced SER from about 40% to about 4%; and (c) field sprays were effective in reducing BR from 70% of fruits before spraying to 5% after 12 weeks and 0% after 19 weeks.

A278

CONTROL OF SCLEROTINIA BLIGHT OF PEANUT WITH FUNGICIDES. P. M. Phipps, Tidewater Res. Ctr., VPI&SU, Suffolk, VA 23437.

Fungicide sprays were applied ca Jul 14, Aug 10 and Sep 8 to replicated plots of Florigiant peanut in 1981 and 1982. Spray nozzles (one 8008LP/row) delivered 335 $\mu\text{l}/\text{ha}$. Initial outbreaks of Sclerotinia blight, caused by *Sclerotinia minor*, were noted on Jul 28 and Jul 7 in 1981 and 1982, respectively. Vinclozolin at 0.84 kg/ha and iprodione at 1.12 kg/ha suppressed disease incidence by 79 and 62% in 1981, and 57 and 20% in 1982, respectively. One spray of dicloran at 3.36 kg/ha followed by two sprays at 2.52 kg/ha suppressed disease incidence by 2% in 1981 and 26% in 1982. Two applications with a 10G formulation of PCNB at 5.6 kg/ha ca Jul 14 and Aug 10 were more efficacious than similar treatments with sprays of a 75W formulation, and resulted in 44 and 29% suppression of disease incidence in 1981 and 1982, respectively. Yield increases were as follows: vinclozolin, 1936 and 1293 kg/ha; iprodione, 2011 and 829 kg/ha; dicloran, 718 and 791 kg/ha; PCNB, 1460 and 941 kg/ha in 1981 and 1982, respectively. Untreated plots yielded 3513 kg/ha in 1981 and 3140 kg/ha in 1982.

A279

SCREENING SEED-PROTECTANT FUNGICIDES FOR CONTROL OF SEEDLING DISEASES IN RICE. G. K. Podila and M. C. Rush, Dept. Plant Path. & Crop Physiol., La. Agric. Expt. Sta., La. State Univ. Agric. Ctr., Baton Rouge, LA 70803.

Seed-protectant fungicides were screened in the field under conditions simulating drill- and water-seeding. During the testing period 1979 through 1982 Dithane M-45, Difolatan 4 Fl, Vitavax R (200), Kocide SD, Orthocide 4 Fl, Terra Coat ZN2055, Gustafson 42-S, Captan 30DD, Zinc Omadine, Ridomil, and Captan 80 wp were outstanding. Dithane M-45 wettable powder and flowable formulations consistently produced high stand increases under all planting and water management systems. A laboratory test for screening seed-protectants for rice was developed. Treated seeds were exposed to a complex of the fungi *Achlya klebsiana*, *A. conspicua*, *Pythium dissotocum*, and *P. spinosum*. Primary shoot length and percentage germination after 3 weeks were positively, significantly correlated with field results.

A280

EFFECT OF SOME FUNGICIDAL DRENCHES ON PYTHIUM INOCULUM LEVELS IN A SOIL MIX IN CONTAINERS. R. D. Raabe, Department of Plant Pathology, University of California, Berkeley, CA 94720.

Inoculum of *Pythium irregulare* and *P. debaryanum* was grown on autoclaved millet seed and added to a soil mix of half sand and half peat. Poinsettia plants were then transplanted into this mix and fungicide drenches were applied three times at monthly intervals. After 9 weeks, plants were rated as to disease development and samples were taken from the bottoms of pots to determine the numbers of propagules per gram of soil mix. Disease control was not necessarily correlated with the number of fungus propagules remaining in the soil mix. Fungicides used included etridiazole, fenaminosulf, propamocarb, fosetyl-al and metalaxyl. Of these, only the latter greatly reduced the level of fungus propagules.

A281

RELATIVE EFFICACY OF METALAXYL SEED AND SOIL TREATMENTS FOR CONTROL OF PHYTOPHTHORA ROOT ROT OF SOYBEAN. A.F. Schmitthenner. The Ohio State University, OARDC, Wooster, OH 44691.

Metalaxyl soil treatments (1.12 kg/ha) significantly increased stands of susceptible, nontolerant soybean cultivars in Phytophthora infested soil in six of nine tests and yields in all tests over a 4-year period over the control. Yield increases varied 4.8 to 19.7 Q/ha for a mean of 12.2 Q/ha. The same soil treatment increased stands of a susceptible, tolerant cultivar in four of nine tests and yields in six tests. Yield increases varied from 3.0 to 16.4 Q/ha and averaged 10.0 Q/ha. Yields of the nontolerant cultivars were lower than the tolerant cultivars in six of nine tests. Metalaxyl seed treatment (.31 g/kg seed) in-

creased stands of the nontolerant cultivar in five of eight tests and yields in seven tests. Seed treatment increased stands of the tolerant cultivar in three tests and yields in five tests. Mean yield response to seed treatment was 5.6 Q/ha compared to 10.6 Q/ha for the soil treatment. Metalaxyl increased yields of a multi-race resistant cultivar in three tests, and decreased yields in three tests.

A282

EFFECT OF CHEMICAL CONTROL AND USE OF PARTIAL RESISTANCE ON STEM ROT CAUSED BY *SCLEROTIUM ROLFSSII* ON PEANUT. B. B. Shew and M. K. Beute, Dept. of Plant Pathology, North Carolina State University, Raleigh, NC 27650.

Effectiveness of PCNB, carboxin, oxycarboxin, CGA 64250, and OAC 3890 in control of Southern stem rot was evaluated on peanut lines NC 8C, NC Ac 18016, and Florigiant in NC during 1980-1982. NC Ac 18016 had fewest lesions but inferior quality and yield in all three years. Effects of fungicides and partial resistance on disease incidence and yield were additive. Incidence of disease and rankings of fungicide efficacy differed as environment varied over years. Disease was most severe in 1980, a dry season, and least in 1982, a moist season. In 1980, fewer lesions occurred in plots treated with carboxin or PCNB than untreated plots for all peanut lines. Oxycarboxin was the most effective fungicide on all peanut lines in 1981. None of the fungicide treatments in 1982 reduced disease severity. The insecticide chlorpyrifos applied alone or in combination with fungicides in 1982 did not affect lesion number.

A283

CULTURAL CHARACTERISTICS AND COMPETITIVE ABILITY OF CITRUS GREEN MOLD (*Penicillium digitatum* Sacc.) RESISTANT TO THE FUNGICIDE Sec-Butylamine. J.L. Smilanick and J.W. Eckert, Dept. of Plant Pathology, University of California, Riverside CA 92521.

Penicillium digitatum isolates resistant to sec-butylamine (SBA) were obtained by UV irradiation or field collection. Resistant isolates could not be controlled by standard SBA treatments. The ED₅₀ on PDA was 1000-3000 µg/ml and 50-75 µg/ml for resistant and sensitive isolates, respectively. The growth of both isolates in culture or untreated fruit were similar. The competitive ability of resistant isolates was tested by inoculating surface-sterilized lemons with 1:1 mixtures of resistant and sensitive spores. Spores collected from the decayed fruit were characterized as to the proportion of resistant spores and inoculated into sound lemons. In 27 resistant:sensitive pairs, composed from 9 resistant and 6 sensitive isolates followed for four generations, the proportion of resistant spores increased in 19, decreased in 5, and did not change in 3 pairs. These results suggest that the mutation for SBA resistance is not accompanied by a decrease in the vigor of this pathogen.

A284

ENDODAN SHOWS PROMISE FOR THE CONTROL OF TOMATO EARLY BLIGHT (*ALTERNARIA SOLANI*). Demetrios J. Vakalounakis, Plant Protection Institute, Heraklion, Crete, Greece.

Endodan, a new alkylenebisdithiocarbamate fungicide (ethyl-enethiuram monosulfide 50%), was compared with other fungicides for the control of early blight of tomato, caused by *Alternaria solani*, in greenhouse potted plant trials and in laboratory tests. In the slide germination test, endodan and dichlofluanid inhibited spore germination of *A. solani* at 8 µg/ml while other fungicides tested were less effective. In the poison food test, endodan inhibited mycelial growth at 100 µg/ml while iprodione at 10 µg/ml. In the greenhouse potted plant experiments, endodan gave the best protection followed by dichlofluanid, chlorothalonil, mancozeb and maneb. In the potted plant experiments endodan had an ED₉₅ = 357 µg/ml that was lower than those of all the other tested fungicides.

A285

EFFECT OF BAYTAN, IMAZALIL AND NUARIMOL SEED TREATMENT ON COMMON ROOT ROT (*COCHLIOBOLUS SATIVUS*), SUBCROWN INTERNODE LENGTH, AND COLEOPTILE-NODE-TILLERING IN SPRING WHEAT. P. R. Verma and F. S. Sedun, Res. Stn., Agr. Can., Saskatoon, Sask., Canada S7N 0X2

The effect of seed treatment with baytan at 0.175 and 0.3, imazalil at 0.15 and 0.2, and nuarimol at 0.1 and 0.15 g a.i./kg seed on subcrown internode length, occurrence of coleoptile-node-tillers (CNT) and common root rot severity was studied in two spring wheat cultivars at three locations in Saskatchewan. Plants from fungicide-treated seed of both cultivars had significantly shorter subcrown internodes and usually more CNTs

than those in the nontreated checks. Further, the proportion of CNTs that produced fertile heads of grain was significantly higher in plants from treated than nontreated seed. All treatments considerably reduced the intensity of common root rot that was assessed on each of three sampling dates. A slight, though nonsignificant increase in yield was associated with the treatments.

A286

SELECTIVE CONTROL OF VARIOUS FOLIAR PATHOGENS IN WHEAT USING FUNGICIDES. F. E. Wright, J. W. Verser, R. D. Gipson, Agricultural Research, P.O. Box 2340, State University, AR 72467.

Five foliar fungicides and two combinations were used to determine disease control in wheat (cultivar 'Rosen'). Five foliar and/or spike diseases were observed. All fungicides and combinations exhibited a differential of control. Benomyl 50WP controlled Fusarium scab better than the other diseases. Bayleton 50WP controlled 100% of the leaf rust and significantly reduced Fusarium scab and the other diseases. Tilt 3.6 EC significantly reduced leaf rust and Fusarium scab but was less effective on the *Septoria* spp. All treatments reduced disease significantly compared to the control. Partial control was achieved on a broad spectrum of pathogens. Specific fungi were controlled depending on material used. Monitoring diseases and inoculum present in the field was essential to obtain maximum efficiency for selective control of diseases using foliar fungicides.

A287

ELECTROSTATIC FORCES AND THE MECHANISM OF ACTIVE SPORE DISCHARGE IN BASIDIOMYCETES. G. C. Adams, Jr. and C. M. Leach, Oregon State University, Corvallis, OR 97331.

Previously, C. M. Leach discovered that certain surfaces (eg. leaves, gills, agar media) have appreciable electrostatic charges in still air of 100% relative humidity (RH). These charges dissipate when the air is moved >0.4 m/sec. Commonly at night in nature, air movement is often at zero with RH near saturation. As spores of most Basidiomycetes are discharged at night, we hypothesize that the mechanism of spore discharge is repulsive forces between like-charged spore and basidium. Gills of *Agaricus* and exposed basidia of *Thanatephorus* and *Sistotrema*, in agar culture, discharged spores in air velocities of 0-1.7 m/sec and at low and high RH. Spore discharge rates were constant for 6-8 hr in saturated air moving at 1.7 m/sec. Low RH caused spore discharge to gradually decrease, then stop. Infra-red light, 1 min at 250 µEm⁻² sec⁻¹, stopped spore discharge. Sporulation recurred following approximately 2 hr of darkness. These results suggest that an electrostatic mechanism is not involved in ballistospore discharge.

A288

INFLUENCE OF INTERRUPTED DEW PERIOD ON LESION PRODUCTION IN ONION BY *BOTRYTIS SQUAMOSA*. S.C. Alderman and M.L. Lacy, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

One-month-old onion plants sprouted from bulbs were inoculated with 2.5 mg dry *Botrytis squamosa* conidia in a 61 cm diam X 71 cm settling tower. Plants were incubated in a dew chamber at 20 C for 2, 4, 6, 8, 10, 12, or 24 hr, followed by 2 hr without dew in a 20 C growth chamber at 65% RH, then were moved back to the dew chamber for the remainder of the 24 hr incubation period. Uninoculated controls remained in the dew chamber for 24 hr. Fewest lesions occurred when the 2 hr interruption followed 4 or 6 hr in the dew chamber. Other plants were given 6 hr of dew, which was interrupted for 20, 40, 60, 80, or 100 min, then plants were returned to the dew chamber for 18 hr. As interruption duration increased, lesion numbers decreased. Conidial germination began after 2 hr in the dew chamber, and increased with periods of continuous dew up to 24 hr.

A289

CORRELATION OF GERMINATION RATES OF *USTILAGO HORDEI* TELIOSPORES WITH DISEASE INCIDENCE. B. J. Christ and C. O. Person, Department of Botany, University of British Columbia, Vancouver B. C. V6T 2B1.

One of 3 populations (pop.) of *Ustilago hordei*, which were undergoing selection on 2 barley cultivars, was observed to differ in germination rate and percent infection as compared to the other 2 pop. The objective of these experiments was to determine if there was a significant difference in germination among the 3 pop. Teliospores were placed on agar plates and examined for germination every 5 hrs. The optimal temperature

was 22°C. Germination rates within pop. were similar on PDA, Complete and Minimal medium, where after 10 hrs pop. I, II and III on average had 61%, 6% and 52% basidiospore formation, respectively. I, II and III gave 32%, 2% and 30% infection, respectively, on the cultivar Trebi. The results of germination directly correlates with the amount of disease produced, therefore, germination may be a component of aggressiveness in U. hordei.

A290

EFFECT OF LIGHT ON THE REACTION OF SORGHUM TO *Peronosclerospora sorghi*. J. Craig and R. A. Frederiksen, USDA/ARS, Plant Sciences Dept., Texas A&M University and Plant Sciences Dept., Texas A&M University, College Station, TX 77843, respectively.

The downy mildew resistant sorghum hybrid Tx 399 x Tx 430 was used to study the effect of light intensity on the reaction of sorghum to *Peronosclerospora sorghi*. Sorghum seedlings were inoculated with conidia of *P. sorghi* and grown in environmental chambers at 25C and high and low light intensities. The high light treatment consisted of an illumination period of 14 hr per day with a light intensity in the 400-700 nm range of 920 microwatts/cm². The low light treatment was an illumination period of 10 hr per day with a light intensity in the 400-700 nm range of 309 microwatts/cm². Plants in the low light treatment were changed to high light 10 days after inoculation. The incidence of downy mildew at 21 days after inoculation was 14% in the high light treatment and 45% in the low light treatment. The difference between disease incidences was highly significant (P=0.01).

A291

COMPARISON OF TWO METHODS OF ESTIMATING POPULATIONS OF PLANT PATHOGENIC BACTERIA ON LEAVES. C. A. Jasalavich and L. Sequeira, Plant Pathology, University of Wisconsin, Madison, WI 53706

To reduce the amount of labor involved in estimating bacterial populations in large numbers of leaves the plate-dilution frequency assay (Harris, R.F. and L.E. Sommers. 1968. Appl. Microbiol. 16:330-334) was compared with the standard dilution method. Leaves of 3-4 wk old cucumber and soybean plants were spray-inoculated with suspensions (10⁶ CFU/ml) of a streptomycin resistant strain of *Pseudomonas syringae* pv. *lachrymans* or *P. syringae* pv. *glycinea*. Both homologous and heterologous combinations were tested. After inoculation each leaf was ground in a mortar and pestle with 1 g sterile sand and 25 mls sterile phosphate buffer. This grinding method was previously shown to have a high efficiency of recovery of bacteria from leaves. For each leaf homogenate 5 separate tenfold dilution series were made and plated on King's B with 500 ug streptomycin/ml by the dilution plating method or the plate-dilution frequency assay. The dilution plating method gave more accurate and reliable estimates of bacterial populations than the plate-dilution frequency assay.

A292

SPORULATION OF *PSEUDOPERONOSPORA HUMULI* IN HOP YARDS. D. A. Johnson. IAREC, Prosser, WA 99350-0030.

The effects of night temperature and relative humidity on sporangial production of *Pseudoperonospora humuli* on hop shoots systemically infected with downy mildew were studied. During the spring of 1981 and 1982, non-sporulating downy mildew infected shoots were labeled in hop yards, collected the next morning, and sporangia which formed overnight were counted. Temperature (T) and relative humidity (RH) were recorded by hygrothermographs in weather shelters 15 cm above the ground at the edge of hop yards. Sporulation was generally inhibited when either the night T was below 5°C or the night RH was below 70%. Quantity of sporangia was positively correlated with minimum T, nightly mean T (2400-0600 hrs) and hours (2100-0600 hrs) of RH > 80%. Multiple regression analysis with minimum nightly T x hours of RH > 80% at night, and nightly mean T as independent variables accounted for 83% of the variation for production of sporangia/cm² of lower leaf surface. Data acquired will be used in a mildew forecasting system.

A293

SURVIVAL OF *MUCOR PIRIFORMIS* IN SOIL. T. J. Michailides and J. M. Ogawa. Department of Plant Pathology, University of California, Davis, CA 95616.

Ninety-five to 100% of surviving propagules (SP) of *Mucor piriformis* (California isolate CA, and Chile isolate CH) were sporangiospores. Chlamydospore-like structures were observed in mycelium but no colonies originated from these structures.

On inoculated peaches buried 5 cm below the surface of a sandy soil, CA survived for more than a year, CH for 8 months. In a clay soil, CA and CH survived longer than a year. After one year the SP of CA were 10 times greater than SP of CH. Dilution plates of monthly soil samples showed a decline in SP. The initial rate of decline in SP was exponential for 1 to 1½ mo with an average half-life (t_½) of 20-25 days. The t_½ for both isolates in the following three-month period was at least 3 times greater than the t_½ of the initial decline; the t_½ of isolate CA was generally longer than that of CH. Controlled laboratory studies also showed CA surviving longer than CH in non-sterile soil.

A294

SPATIAL STATISTICS AS A TOOL TO COMPARE THE DISTRIBUTION OF *VERTICILLIUM DAHLIAE* IN THE SOIL TO THAT OF DISEASED PLANTS IN A COMMERCIAL POTATO FIELD. P.C. Nicot (#), D.I. Rouse (#), and B.S. Yandell (*), Depts. Plant Pathology (#), and Horticulture and Statistics (*), Univ. of Wisconsin, Madison, WI 53706.

A soil sample and a plant sample were taken from each of 250 sites located on 10 regular grid patterns (5x5) in a commercial potato field. The inoculum density (ID) of *Verticillium dahliae* was assessed in the soil samples and the plants were rated for disease. Presence of a significant spatial autocorrelation was tested, the autocorrelation function was computed, and trend surfaces were built for each data set. In an attempt to relate soil inoculum density to disease, the results of the above computations were compared for ID and disease data in each grid. Regression analysis (disease vs ID) was performed and the residuals were examined for spatial autocorrelation in each grid. Using the same procedure, an attempt was made to relate yield of individual plants to ID in the soil.

A295

YIELD-LOSS DETERMINATION IN THE BARLEY-SPOT BLOTCH SYSTEM USING VISUAL AND REMOTELY SENSED DISEASE ASSESSMENT SCHEMES. F. W. Nutter, Jr. and V. D. Pederson. Department of Plant Pathology, North Dakota State University. Fargo, ND 58105

Spot blotch (*Cochliobolus sativus*) epidemics of different intensities were generated in barley field plots to quantify the relationship between disease severity (DS) and loss in yield. Disease severity was recorded on 'Larker' (susceptible) and 'Dickson' (resistant) barley by visual assessment (using standard area diagrams) and by using a hand-held, multispectral radiometer. The spectral quality of sunlight reflected from barley canopies was recorded for wavelengths 0.5 to 0.9 µm. The disease proportion of the upper three leaves of 'Larker' were negatively correlated with % reflectance in the 0.75 to 0.90 µm range (P<0.01) whereas significant negative correlations for 'Dickson' occurred only with the flag minus 2 leaf. Significant yield losses occurred only with Larker and yield was positively correlated with reflectance in the 0.75 to 0.90 µm range (P<0.01). Objective remote sensing methods may provide reliable estimates of yield losses in barley due to spot blotch.

A296

COMPONENTS OF RESISTANCE FOR TOMATO EARLY BLIGHT. D.J. O'Leary and P.B. Shoemaker, Department of Plant Pathology, North Carolina State University, Raleigh 27650

Components of resistance (latent period (LP), lesion expansion rate (LER), sporulation rate (SR) and capacity (SC), and infection efficiency (IE) for four tomato breeding lines resistant to *Alternaria solani* and susceptible cultivar Flora-Dade were compared in the field and greenhouse. LP, LER, SR, and SC were determined by placing 10 µl droplets of a conidial suspension (10,000/ml) on leaflets. Lesions were measured and conidia harvested daily for 2 wk after inoculation. IE among lines were compared by spraying leaflets with a conidial suspension (10,000/ml) and counting lesions. LP differences were not significant. A significantly faster LER, higher SR and SC, and a greater IE were found for Flora-Dade than for the four resistant lines. IE for a line from *Lycopersicon hirsutum* x *L. esculentum* was significantly greater than the other breeding lines. SR was significantly slower for Campbell 1943 (1.2 conidia/mm²/day) than for a line from Campbell 1943 x STEP 625 (2.3 conidia/mm²/day).

A297

GEOGRAPHICAL DISTRIBUTION OF BENOMYL RESISTANT STRAINS OF *Cercospora beticola* Sacc. IN MINNESOTA AND NORTH DAKOTA. J.A. Percich and M.W. Hotchkiss. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Isolates of *Cercospora beticola* on sugar beet from 37 of 50 locations surveyed in 16 counties throughout the sugar beet production areas of Minnesota and North Dakota were resistant to at least 5 µg/ml benomyl (Benlate) in vitro. At 8 locations all isolates were resistant to benomyl, while at 29 other locations 3.3 to 95.8% of the total strains isolated were resistant. The benomyl-resistant strains of *C. beticola* were also cross-resistant to both thiabendazole (Mertect) and thiophanate methyl (Topsin-M) at 100 µg/ml. Isolates of *C. beticola* were not found to be resistant to triphenyl tin hydroxide (Du-Ter) at 10 µg/ml in vitro.

A298

FORECASTING AND CONTROL OF POTATO EARLY BLIGHT, CAUSED BY *Alternaria solani*, IN WISCONSIN. J.W. Pscheidt & W.R. Stevenson, Dept. of Plant Pathology, Univ. of Wis., Madison, WI 53706.

Methods were evaluated for timing chlorothalonil sprays (0.88 kg/ha) on 'Russet Burbank' potatoes for early blight control and for the detection of airborne *A. solani* spores in Wisconsin from 1980-1982. FAST, a forecaster of *A. solani* on tomato, accurately predicted the first major rise in airborne spore concentrations. A total of 35 severity values (Madden, L. et al, Phytopathology 68:1354-1358) occurred 5-7 days in advance of a significant rise in airborne spores during each year of evaluation. A total of 300 physiological time units or P-DAYS (Sands, P.J. et al, Field Crops Research 2:309-331) occurred 7 days prior to this rise in spores in all three years. Spray schedules generated from both methods used 2-3 fewer sprays than the conventional schedule (weekly sprays started when plants are 20-25 cm tall) for similar early blight control. Prediction methods that use weather vane spore trap data or growing degree day summation (base 7.2°C) from planting or emergence were not consistently effective each year of evaluation. The weather vane spore traps did not accurately reflect airborne spore concentrations as detected by the rotorod sampler due to poor trapping efficiency.

A299

WETTING AND TEMPERATURE REQUIREMENTS FOR SCAB INFECTION OF APPLE FRUIT AT DIFFERENT STAGES OF DEVELOPMENT. W.F.S. Schwabe and A.L. Jones, Fruit and Fruit Technology Research Institute, Stellenbosch, South Africa and Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312, respectively.

Potted apple trees with fruit in various stages of development were inoculated with conidia of *Venturia inaequalis* and exposed to different temperatures and durations of wetting. After incubation, scab development on the fruit was recorded. Wetting and temperature requirements for infection increased with increasing age of the fruit. At high inoculum levels, fruit showed light infection at infection indices (hours of wetting x mean temperature C) of >120, 240, 375, 470, 535, and 560 when they were inoculated 1, 5, 10, 15, 20, and 25 wk, respectively, after full bloom. The light infection curve was linearized with a square root transformation of fruit age ($r^2=0.95$). When wetting periods were adjusted for the effect of age, a multiple regression model relating hours of fruit wetness and temperature to infection was developed.

A300

COMPUTERIZED SYSTEM FOR EARLY WARNING OF CERCOSPORA LEAF SPOT OF SUGAR BEET IN MINNESOTA AND NORTH DAKOTA. W. W. Shane and P. S. Teng, Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

An information exchange system was developed on the University of Minnesota mainframe computer to speed communication among university, sugar factory, and private industry personnel regarding timely control of *Cercospora* leaf spot. Any person with a remote terminal and modem could easily access or add to 'SUGNEWS', a computer-stored, user-contribution pest alert newfile. Another newfile, 'SUGDATA', contained university weekly field survey data which provided a concise overview of regional disease progress. A third component, 'MAILBOX', allowed users to submit private messages retrievable only by specified individuals. The effectiveness of the system was demonstrated in 1982 when *Cercospora* leaf spot was detected in indicator plots and warnings were made available in 'SUGNEWS' 10 to 12 days before the disease was found in commercial fields.

A301

SAMPLING FOR ALFALFA LEAF SPOT DISEASES. W. Thal and C. Lee Campbell, Department of Plant Pathology, North Carolina State University, Raleigh 27650.

Samples were taken to investigate spatial pattern of alfalfa leaf spot for development of optimal sampling strategies within

a field. One objective was to estimate the most efficient quadrat size for use in future studies. Grids of 16x16 or 8x8 contiguous 1x1 m quadrats were subsampled at a rate of 3 stems/quadrat. Two lower and 2 upper leaves/stem were rated for leaf spot severity. Contiguous quadrats were successively grouped and mean squares were obtained for each level of grouping for use in estimating Smith's 'b'. This value gives a measure of correlation between adjacent quadrats and can be used in estimating optimum quadrat size. Values obtained for 'b' averaged about 0.3. A linear cost function was constructed consisting of a fixed cost per quadrat, K_1 , and a cost depending on quadrat size, K_2 . Optimum quadrat size was estimated by the formula $X_{opt} = b * K_1 / (1 - b) * K_2$, depending on the relation between fixed and variable costs and the spatial correlation between disease levels.

A302

INFLUENCE OF MOISTURE, TEMPERATURE, HARVEST TIME AND WIND ON THE SPREAD AND INCIDENCE OF CUCUMBER ANTHRACNOSE. D. C. Thompson and S. F. Jenkins, N. C. State University, Raleigh 27650.

The spread and incidence of anthracnose caused by *Colletotrichum lagenarium* from inoculated, greenhouse-grown plants of *Cucumis sativus* cv Calypso to healthy plants under field conditions was determined during 1982. The approximate number of conidia present on lesions of infected plants was determined before a dispersal event. Rainfall, irrigation, temperature, relative humidity, leaf wetness and wind direction and speed were monitored to determine their effect on lesion formation. Overhead irrigation in the afternoon (16-20 h) resulted in greater numbers of lesions than irrigation in the morning (7-11 h). Increasing the amount of irrigation from 1 to 3 cm resulted in additional lesions at both times. Rainfall increased the number of lesions, but the extent of lesion production was influenced by amount of rainfall, wind direction and speed. Morning harvesting following dew deposition resulted in more lesions than afternoon harvesting on the same day. Irrigation or rainfall had a greater influence on disease severity than harvesting alone.

A303

RUST OF ALFALFA AS A MODEL PATHOSYSTEM TO EXAMINE SEQUENTIAL EPIDEMICS. M. van Nuffelen and R.D. Berger, Department of Plant Pathology, University of Florida, Gainesville 32611

Epidemiological experiments on carry-over inoculum in most perennial crops require many yrs to test hypotheses because only one epidemic occurs per yr. Three to eight cuttings of alfalfa (*Medicago sativa*) are made each yr, and because sequential epidemics in each regrowth can be evaluated, the perennating study can be compressed into a few seasons. Severity of rust (*Uromyces striatus*) was followed in the regrowth of alfalfa after each of three cuttings in a 0.1 ha field experiment. Total leaf area per plant increased linearly after each cutting at 10 to 12 cm²/day. Rust increased exponentially on the regrowth after the first two cuttings at logistic rates of 0.12-0.13, which was ca twice the rate in the non-cut control plants. Proportions (y) of rust infected leaf area were maximum prior to the second (y=0.3) and third (y=0.35) cuttings. The number of airborne urediniospores monitored by intermittent trapping was reflective of the rust intensity. High daytime temp (>32C), which occurred after the third cutting, drastically slowed rust progress to near zero

A304

EFFECT OF CERCOSPORA SOJINA AND PHOMOPSIS SPP. ON SOYBEAN SEED QUALITY AND YIELD. V. S. Bisht and J. B. Sinclair, Dept. of Plant Pathology, University of Illinois at Urbana-Champaign, Urbana, Illinois. 61801.

Two cultivars, Corsoy-79 (Cor) susc. and Wells (W) resis. to *Cercospora sojina* Race 10A (C) but equally susc. to *Phomopsis* spp. (P), were inoculated with C or P alone or in combination (CP) in field plots, in 1981 and 1982. Check (Ck) plots were non-inoculated. In 1981, yield, 1000-seed wt. (TSW) and % seed germination (on PDA) were higher in the control. In 1982, there were no differences in yield and TSW, but % germination was lower in P-inoculated plots. Brown stem rot was higher in 1982 and was correlated to yield ($r=-0.42$) and TSW ($r=-0.50$). Frog-eye leaf spot (FLS) caused by C, was more in Cor and greater in 1981. FLS was higher in C-inoculated plots in both years and correlated with yield ($r=-0.56$) and TSW ($r=-0.50$). C isolated from C-inoc. plots was higher. Also, P recovery from seeds and stem pieces of P-inoc. plots was higher. Seed germination was lowest in CP, intermediate for C & P alone and highest in Ck. C and P act independently and have an additive effect.

A305

ENVIRONMENTAL INTERACTION OF INTERNAL INCIDENCE OF FUNGI IN CORN KERNELS. O.H. Calvert, A.S. Foudin, H.C. Minor, and G.F. Krause. Dept. of Plant Pathology; USDA, APHIS, P.P.Q.; & Dept. of Agronomy, Univ. of Missouri-Columbia, 65211, respectively.

Corn kernels from four hybrids, grown with and without irrigation at both Columbia and Portageville, Missouri in 1982 were examined for internal fungi. Triplicate 100-kernel samples of sound, intact seed, were surface sterilized in Clorox solution for 10 min, placed on potato-sucrose agar, and incubated in the dark for 5 d at 28 C. The predominant fungal species encountered was Fusarium moniliforme. At Columbia in corn grown under overhead irrigation, the number of kernels with F. moniliforme was twice that in kernels of corn grown without irrigation (55.2/100 seed vs 27.8). At Portageville the difference was not as great (77.5 colonies vs 63.6). The incidence of other fungi from kernels averaged around 10 colonies per 100 seed except that kernels from corn grown without irrigation at Portageville averaged 5.4 colonies per 100 seed.

A306

A COMPARISON OF METHODS FOR DETECTION OF DRECHSLERA GRAMINEA IN BARLEY SEED. T. R. Gordon and R. K. Webster. Department of Plant Pathology, University of California, Davis, CA 95616.

Ten seed lots of barley were examined for the presence of D. graminea, cause of barley stripe; five were known to be infested with D. graminea and five were believed free of infestation. The level of D. graminea infestation was estimated by each of the following methods: plating seed on barley leaf pieces set on water agar and identifying infested seed by the growth and sporulation of D. graminea; growing out seed under greenhouse conditions conducive to disease development and rating plants for the occurrence of barley stripe; and by quantifying the concentration of ergosterol extracted from surface sterilized seed incubated from three to five days. Infestation levels measured by plating seed, and the concentration of ergosterol in extracts from incubated seed were both highly correlated with the incidence of barley stripe in greenhouse grown plants. Infestation levels as low as 1% could be detected by all three methods. Detection based on the concentration of extractable ergosterol gave results in the shortest period of time.

A307

RELIABILITY OF 'DOME' TEST AS AN ASSAY FOR BEAN BLIGHT PATHOGENS. L. K. Lahman and N. W. Schaad. Dept. Plant, Soils and Ent., University of Idaho, Moscow, ID 83843.

The 'Dome' Test, developed in North Dakota, was used to assay 7 bean seedlots for Pseudomonas syringae pv. syringae, P. syringae pv. phaseolicola and Xanthomonas campestris pv. phaseoli. The seedlots were previously identified as being infected with these pathogens by 'Dome' testing at another laboratory. Of the bacteria isolated from watersoaked lesions on plants in the 7 seedlots, 22 were fluorescent on King's Medium B and 66 yellow on YDC. All 22 fluorescent bacteria were positive for manitol, sorbitol, and lactate and negative for hypersensitivity, indicating they were not P. phaseolicola or P. syringae. Although strain C-199 of P. phaseolicola produced typical halo blight lesions and strain C-203 of P. syringae produced typical brown spot lesions, the 22 'Dome' strains failed to produce typical symptoms. Of the 66 yellow strains, none were typical of Xanthomonas and all failed to infect beans. These results suggest that the 'Dome' test should not be used as a routine assay for certification of bacteria blight-free bean seeds.

A308

FIELD AND LABORATORY EFFECTS UPON INTERNAL EPIPHYTIC CONTAMINATION AND DETECTION IN DRY BEAN SEED. D.E. Legard and H.F. Schwartz, Department of Botany & Plant Pathology, Colorado State University, Fort Collins, Colorado 80523.

An internal bean bacterial infusion test (IBBIT) was developed to evaluate certified dry bean seed lots produced in western Colorado during 1981 and 1982. These and other seed lots originating in different production regions were tested for internal epiphytic bacterial contamination. IBBIT was derived from the North Dakota Dome Test and designed to detect prevalent bacterial pathogens in Colorado bean growing areas. Special emphasis was placed on the detection of the halo blight bacterium, Pseudomonas syringae pv. phaseolicola. Field factors including seed source, bactericide treatment, cropping history, and other cultural practices were investigated to determine their effects upon epiphytic contamination of certified bean seed lots. Laboratory factors including incubation temperature, surface sterili-

zation, and infusion procedures were also investigated to determine their effects upon detection of seed-borne bacteria.

A309

TREATMENTS FOR CONTROL OF SEED-BORNE XANTHOMONAS CAMPESTRIS PV. CAMPESTRIS IN BRASSICA OLERACEA. T. R. Schultz and R. L. Gabrielson. Washington State University West. Wash. Res. and Ext. Ctr., Puyallup, WA 98371

Two compounds proved effective as bactericides against the crucifer black rot pathogen Xanthomonas campestris pv. campestris. Calcium hypochlorite [$Ca(OCl)_2$] and HPMTS (2-hydroxypropylmethanethiosulfonate, Buckman Laboratories) controlled this pathogen in one artificially and two naturally infected seed lots of Brassica oleracea. Both compounds were applied as slurries using approximately 20 g (a.i.) $Ca(OCl)_2$ and 2.5 g (a.i.) HPMTS per kg of seed. Treatment containers were left sealed overnight (12 h). Artificially inoculated seed were assayed for the pathogen by directly plating seed onto SX agar. Naturally infected seed were assayed by liquid plating the seed washate onto SX agar. In both assays, no colonies of X. campestris pv. campestris were observed after seven days incubation at 30°C. Germination of artificially inoculated seed was unaffected by either treatment when compared to untreated seed using standard AOSA germination procedures.

A310

FACTORS INFLUENCING THE UPTAKE OF DIPHENYLAMINE (DPA) ON APPLES. S. Lee, A. Carag, H. Kaplan. Pennwalt Corporation, 1713 S. California Ave., Monrovia, California 91016

Diphenylamine is widely used on apples after harvest to prevent a physiological storage disorder known as scald. The product is marketed as an emulsifiable concentrate and a wettable powder and typically applied by drenching with bath solutions containing diphenylamine along with certain fungicides and often with calcium chloride added. This paper describes the results of a series of experiments aimed at elucidating the influence certain application parameters on the residue found on treated apples. Included in the investigation were core temperature, bath solution temperature, variety of apple, DPA concentration, additive surfactants, calcium chloride, and alternative product formulations. All factors studied did effect residue levels, with the exception of calcium chloride and the surfactant additives. Only extremes of temperature had an influence.

A311

FUNGI CAUSING REDUCED GERMINATION OF SORGHUM PI'S IN GEORGIA. Grover Sowell, Jr., USDA, ARS, Southern Regional Plant Introduction Station, Experiment, GA 30212

Approximately 700 samples of sorghum seed of plant introductions (PI's) grown at Experiment were germinated on moist blotters under 12 hours of fluorescent light per day for one wk. Ten of the PI's germinated poorly (<17%) and Fusarium moniliformae grew from most of the seed of these. Seed of RTX2536 inoculated at 50% bloom with Fusarium moniliformae and incubated for 48 hrs in a moist chamber failed to germinate. All PI's with <17% germination were dipped in 70% ethanol and treated with 0.5% NaOCl for 5 min. This treatment increased germination to 35-100% except for PI 246697. Curvularia geniculata, C. lunata, C. intermedia, Helminthosporium spicifera, and H. turcicum were isolated from a few seed of many PI's. They reduced germination of seed from inoculated plants to 0-16%. Helminthosporium rostratum was isolated but was not pathogenic. Colletotrichum graminicola was isolated and its pathogenicity was not tested.

A312

PINK SEED IN DURUM WHEAT. R. W. Stack⁽¹⁾, M. P. McMullen⁽²⁾, J. D. Miller⁽³⁾ and V. L. Youngs⁽⁴⁾. ¹, 2, Dept. of Plant Pathology, 3, USDA-ARS, Plant Pathology, 4 USDA-ARS Cereal Technology, North Dakota State Univ., Fargo, ND 58105.

Kernel color is an important quality factor in grading of durum wheat (Triticum turgidum L.). In some recent years, samples of durum showed 1 to 6% of kernels which had distinctly pink coloration. Many of the pink discolored kernels were fully plump and vitreous. Previous attempts to isolate known pathogens from pink durum kernels were unsuccessful, and the problem had been considered physiological. Pink durum kernels were surface sterilized and plated on agar. After 2-3 days, bacterial colonies developed which showed a fuchsia-pink coloration diffusing through the agar. When wheat heads were inoculated with bacterial suspensions, pink kernels, similar to

those found naturally, were formed. Non-inoculated heads on the same plants bore normal grain. The pink diffusate-producing bacterium was re-isolated from pink kernels in inoculated heads thus completing Koch's Postulates.

A313

LONG-TERM STORAGE OF SOYBEAN SEEDS IN OIL. P. N. Thapliyal, T. M. Zinnen and J. B. Sinclair. Dept. of Plant Path., Univ. of Illinois at Urbana-Champaign, 1102 S. Goodwin, Urbana, IL 61801.

Cumberland seeds were stored in an open beaker or under soybean oil for 108 weeks at 28±2°C. Seed samples were drawn at 2 wks. and periodically thereafter. Oil-treated seeds were washed 3 times with 95% ethanol and half of the untreated seeds were washed or not washed with ethanol. All seed samples were surface sterilized with 10% Clorox, rinsed with sterile water and plated on PDA plates with 5 seeds/plate. After 5 days at 25°C, germination and occurrence of microflora were recorded. There was no significant difference between treatments up to 50 wks.; between 54 and 68 wks. germination was equal to or higher than the control. After 68 weeks germination and seedling vigor was significantly higher than the control. Microflora recovery was low and thus no differences could be detected.

A314

SEED-BORNE MICROFLORA IN WHEAT AS AFFECTED BY FOLIAR FUNGICIDE APPLICATION. F. E. Wright, Agricultural Research, P.O. Box 2340, State University, AR 72467.

Six foliar fungicide treatments were applied to various wheat (cultivar 'Rosen') plots at two growth stages (10.0 and 10.5 Feek's scale). Seed-borne microflora isolated from seed of the treated plants varied in amount with the treatment. The fungicide treatments significantly reduced the numbers of pathogens isolated from the seed compared to the non-sprayed control. Microflora isolated from seed were; *Alternaria* spp., *Epicoccum* spp., *Penicillium* spp., *Aspergillus* spp., *Nigrospora* spp., *Fusarium culmorum*, *Septoria nodorum* and *Drechslera sativum*. The protectant fungicides resulted in a greater number of pathogens isolated from the seed compared to the systemic materials. The non-sprayed control resulted in a greater number of pathogens isolated from or in the seed. *Fusarium graminearum* infected 10%, *Septoria nodorum* 6%, *Drechslera sativum* 5%, and *Fusarium culmorum* .5% of the seed from the non-sprayed control.

A315

POTATO BLACKLEG IN PROGENY PLANTINGS FROM DISEASED AND SYMPTOMLESS PARENT PLANTS. J.D. Apple and M.L. Powelson, Dept of Bot & Pl Path, OSU, Corvallis, OR

Stems and tubers from potato hills with and without blackleg symptoms were sampled in seed fields of the cultivars Norgold Russet (NR) and Russet Burbank (RB). Presence of *Erwinia carotovora* subsp. *carotovora* (Ecc) and *E. carotovora* subsp. *atroseptica* (Eca), causal agents of blackleg, was determined in symptomatic stems. In NR and RB seed fields, 27.9 and 60.9%, respectively, of the isolates from parent plants with blackleg symptoms were Ecc. In corresponding non-symptomatic plants, 53.0 and 30.8% of the isolates were Ecc. The tubers were stored and planted the following spring at one location. Progeny plants were monitored for disease symptoms and the presence of Eca or Ecc. The percentage of plants with typical blackleg symptoms 108 days after planting NR tubers originating from plants with or without symptoms was 66.6 and 63.5%, respectively. The corresponding blackleg percentage in RB were 6.6 and 6.3%. Ecc composed 100 and 86.6% of the isolates from a sample of NR progeny from healthy and blackleg parents, respectively. In RB progeny, the corresponding Ecc recoveries were 89.5 and 100%, respectively. Less than 15% of the isolates from all diseased progeny plants were Eca. These results suggest that the presence of blackleg symptoms in parent plants may not be a valid indicator of disease incidence in progeny plants when Ecc is the predominant pathogen. The soil and water should be considered as an important inoculum source of Ecc.

A316

CHEMICAL CONTROL OF BACTERIAL SOFT ROT OF POTATOES. J. A. Bartz and A. Kelman. Univ. of Florida, Gainesville, FL 32611 and Univ. of Wisconsin, Madison, WI 53706.

A bactericide, CGA 78039 (7-chloro-6-fluoro-1,4-dihydro-4-oxo-3-quinolinecarboxylic acid), effectively controlled bacterial soft rot in cured as well as freshly bruised tubers. Russet Burbank tubers were inoculated by immersion in suspensions of *Erwinia carotovora* pv *carotovora* (5 X 10⁶ CFU/ml), treated, and incubated in a continuous aqueous mist for 4 days at 20 C. Reduction in surface area decay (SAD) of up to 96% resulted from immersion of inoculated tubers in CGA 78039 at 16 to 1000 ppm a.i. for 2 sec to 20 min. At the highest dosage short exposures provided as much control as long exposures.

Populations of pectolytic *Erwinia* in the peel were reduced five fold but were not eliminated within 2 hr by treatment with 500 ppm CGA for 5 min. Immersion in 1000 ppm Cl₂ led to a similar reduction, but the SAD in the CGA treatment was five-fold lower than in the Cl₂ treatment. Control of bacterial soft rot provided by immersion of tubers in 1000 ppm CGA for 5 min was equal to that provided by a similar exposure to 1.05% NaOCl.

A317

SUGAR COMPOSITION AND SEROLOGICAL PROPERTIES OF THE LIPOPOLYSACCHARIDE (LPS) OF *PSEUDOMONAS SOLANACEARUM*. J. J. BRADSHAW-ROUSE, E. BARLOW, AND L. SEQUEIRA, Dept. of Plant Pathology, Univ. of Wisconsin, Madison WI 53706

The sugar composition of the lipopolysaccharide of 13 strains of *P. solanacearum*: Race 1 (K60, B1, and PPS14), Race 2 (J8301, J8346, J8375, J8391), Race 3 (72, 73, 80, 81, and 276), and Race 4 (M5) was analysed by gas chromatography of alditol acetate derivatives. The LPS of nine strains contained rhamnose, xylose, glucose, heptose and glucosamine and appears to have a complete O-antigen portion. Four strains (B1, 72, 73, and 276) contained the same monosaccharides except xylose and appeared to lack the O-antigen portion of LPS. There were no host- or race- specific differences in the LPS of *P. solanacearum*. Antiserum from strain 81 (Race 3) LPS, however, cross reacted with whole cells of the Race 3 strains, 80 and 276, but not with K60 or B1. Thus, subtle differences may exist in the structure of the LPS of *P. solanacearum* that cannot be detected by sugar composition analysis alone.

A318

Infection and Movement of Endophytic Bacteria in Sugarbeet Plants. W. M. Bugbee, USDA, ARS, Department of Plant Pathology, North Dakota State University, Fargo, North Dakota 58105.

Sugarbeet plants were penetrated and systemically colonized with *Pseudomonas fluorescens* and *Corynebacterium* sp. isolated from sugarbeet roots and a *P. syringae* strain isolated from leaf lesions. Mutant strains of the bacteria were induced to grow on nutrient agar (NA) supplemented with 50 µg/ml of rifampicin, 1000 µg/ml streptomycin sulfate, and 100 µg/ml of mercuric chloride. The mutant strains were inoculated on flowering sugarbeet plants and recovered from ethanol-flamed seeds but not from flamed seedlings. Mutants were recovered from homogenates of ethanol-flamed roots, hypocotyls, petioles and leaves of healthy plants grown in pasteurized soil that contained the resistant bacteria. The pathogenic *P. syringae* reisolated from healthy plants caused leaf lesions when inoculated on to sugarbeet leaves. These results suggest that both saprophytic and pathogenic bacteria penetrated sugarbeet roots and moved upward.

A319

SEROLOGICAL IDENTIFICATION OF SEVERAL XYLEM-LIMITED BACTERIA (XLB). C. J. Chang and N. W. Schaad. Dept. Plant Pathology, University of Georgia, Georgia Experiment Station, Experiment, GA 30212.

Serological relatedness among 24 strains of xylem-limited bacteria (XLB) [11 strains of Pierce's disease bacteria (PDB), 5 of phony peach (PPB), 5 of plum leaf scald (PLB), 2 of periwinkle wilt (PWB), and 1 of elm leaf scorch (ELB)] were determined by Ouchterlony double-diffusion agar tests of a membrane protein complex (MPC) and crude ribosome preparation from whole cells. Antisera to MPC of PDB, PPB and PLB produced a major precipitin band whereas antisera to crude ribosome of PDB and PPB produced three precipitin bands when reacted against homologous MPC and crude ribosome preparations, respectively. Reactions of partial identity (spur) occurred between PDB and each of PPB, PLB, PWB; between PPB and each of PDB, and ELB. Reactions of non-identity occurred between PPB and PDB when crude ribosome antisera were used. Different XLB were serologically distinguishable if antisera of MPC or crude ribosome preparation were used.

A320

TRANSMISSION OF PECAN BUNCH AGENT FROM PECAN TO PERIWINKLE BY DODDER. C. J. Chang¹, N. W. Schaad¹, P. F. Bertrand², and T. R. Gottwald³. ¹Dept. Plant Pathology, University of Georgia, Georgia Station, Experiment, GA 30212; ²Cooperative Extension Service, RDC, Tifton, GA 31793; and ³USDA Southeastern Fruit and Tree Nut Lab., Byron, GA 31008.

The mycoplasma-like organism (MLO) associated with pecan bunch disease has been transmitted from pecan to periwinkle by dodder (*Cuscuta campestris*). The structures observed by electron

microscopy in infected periwinkle were morphologically and ultrastructurally identical to those in bunched pecan. About 2-4 year old bunched pecan seedlings dug from a nursery orchard at Thomas County, Georgia were planted in the greenhouse and used as the MLO inoculum. Dodder, established on healthy periwinkle, was allowed to attach to bunched pecan seedlings; 7-8 weeks after establishment it was allowed to attach to healthy periwinkles. Periwinkle infected with pecan bunch MLO developed bunch-top symptoms which are distinct from those induced by aster yellows MLO. Flowers appeared to be aborted. No bunch-top symptoms developed on periwinkle used as controls.

A321

ISOLATION OF BACTERIA FROM OAK TREES SHOWING LEAF SCORCH SYMPTOMS. C. J. Chang and J. T. Walker. Dept. Plant Pathology, University of Georgia, Georgia Experiment Station, Experiment, GA 30212.

Scorch symptoms have developed on the leaves of three red oak trees (*Quercus rubra* L.) in early July every year over the past ten years. Symptoms begin as marginal chlorosis on the outer and uppermost leaves, sometimes in scattered locations. By early August leaves throughout the crown are affected. The chlorotic tissue soon becomes necrotic with a red band 2-3 cm from the leaf margins separating the green and brown areas. Tissue remains intact and leaves remain attached to stems. Dieback of twigs and limbs occurs; new leaves appear along the larger branches. Fastidious xylem-limited bacteria (XLB) were successfully cultured in CS 20 agar medium and their colonies became visible (50X) after 10-14 days. The average size of this bacterium was 0.4-0.75 x 1.05-3.5 μ m. All triple-cloned isolates were Gram negative and immunofluorescent positive against antiserum to phony peach bacterium. No XLB colonies developed from sap of symptomless trees.

A322

APPROACHES TO BIOLOGICAL CONTROL OF ICE NUCLEATION-ACTIVE BACTERIA ON DECIDUOUS FRUIT TREES. Y. S. Cody, D. C. Gross, E. L. Proebsting, Jr* and R. A. Spotts**. Wash. St. Univ., Pullman, WA 99164; *Irr. Agr. Res. Ext. Ctr., Prosser, WA 99350; and **Mid-Columbia Expt. Sta., Hood River, OR 97301.

Epiphytic bacteria, present at high populations ($>10^5$ /g) during the peak frost injury period in Pacific Northwest (PNW) fruit tree orchards, were tested for their ability to colonize buds and flowers, and antagonize growth of ice nucleation-active (INA) *Pseudomonas syringae* (the only source of bacterial ice nuclei found in PNW orchards). Antagonists were initially screened on King's B medium for inhibition of *P. syringae*, and then in the greenhouse for the ability to colonize plant surfaces and inhibit INA bacterial growth. Field application of 10^7 cells/ml at the tight blossom cluster and first bloom stages resulted in good tree colonization by most potential antagonists (10^6 /g, $>80\%$ of the total bacterial population). A ten-fold reduction of INA bacteria was observed following treatment with the best antagonist. Most potential antagonists did not persist as long in orchards as did INA *P. syringae*.

A323

ATTACHMENT OF WILD-TYPE AND CELLULOSE-MINUS STRAINS OF AGROBACTERIUM TUMEFACIENS TO TOBACCO MESOPHYLL AND TISSUE CULTURE CELLS. M. C. Deasey and A. G. Matthyse. Department of Biology, University of North Carolina, Chapel Hill, N.C. 27514

Two strains of *A. tumefaciens* with different abilities to make cellulose were injected into tobacco leaves. A cork borer was used to remove disks from the leaves at timed intervals, over a 24 hour period. The disks were prepared for scanning electron microscopy and were critical-point dried. Leaf epidermis was removed before the disks were sputter-coated. Cells of both strains attached to tobacco mesophyll cell walls. Strain A₆, which is known to produce cellulose fibrils during binding to suspension culture cells, produces a small number of fibrils. Strain Ce₂ produces none at all. Production of bacterial fibrils in tobacco leaves, callus, and suspension culture cells will be compared.

A324

PRODUCTION OF NATURALLY INFECTED, ROOTED, PEACH CUTTINGS FOR STUDYING X-DISEASE. Sharon M. Douglas and Saul Rich. The Connecticut Agricultural Experiment Station, Box 1106, New Haven, CT 06504.

Semi-hardwood, leafy, terminal cuttings from healthy and East-

ern X-diseased 'Washington' and 'Loring' peach trees (*Prunus persica* (L.) Batch) produced well-rooted cuttings after 30 days. Cuttings taken in late August 1982 were wounded, IBA treated, planted in vermiculite, and misted intermittently in either a glass or hoop house. Parent trees were visually rated for X-disease severity using the following scale: 0= 0%; 1= 10%; 2= 50%; 3= 90%; 4= 100%. Rooting was significantly better for healthy than X-diseased cuttings. Percentage rooting and rooting rate were not affected by cultivar. Similarly, cutting diameter was not influenced by X-disease severity of parent tree or cultivar. Mycoplasma-like organisms in phloem of glutaraldehyde-fixed sections of newly formed roots were detected with the fluorochrome DAPI (4'-6-diamidino-2-phenylindole). The use of rooted cuttings permits year-round study of X-diseased peach tissue.

A325

PREVENTION OF SOYBEAN BACTERIAL TAN SPOT BY CUPRIC HYDROXIDE. J. M. Dunleavy, Agricultural Research Service, USDA, 417 Bessey Hall, Iowa State University, Ames, IA 50011.

A field test to determine if cupric hydroxide (77% a.i.) would control *Corynebacterium flaccumfaciens*, the tan spot bacterium, was conducted using three susceptible cultivars (Wayne, Cutler 71, and Clark 63). The experimental design was a randomized block with six replications. Each cultivar was grown in three row plots, 3 M long, and the center row was harvested for yield. A spray containing cupric hydroxide (2g/liter) was applied to plants weekly from June 15 until plant maturity. Plants in some rows were inoculated as seedlings. Treatments were: Plants inoculated and sprayed, inoculated and unsprayed, uninoculated and unsprayed, and uninoculated and sprayed. Cupric hydroxide was effective as a protectant in uninoculated-sprayed rows from which yields were significantly greater (0.5% level) than yields from rows receiving all other treatments. However, it failed to eradicate the disease in inoculated-sprayed rows.

A326

SEROLOGICAL DETECTION OF SPIROPLASMA CITRI BY THE LATEX AGGLUTINATION TEST. J. Fletcher, J. A. Leath, and S. A. Slack. Dept. of Plant Pathology, Univ. of Illinois, Urbana, IL 61801; and Dept. of Plant Pathology, Univ. of Wisconsin, Madison, WI 53706.

The latex agglutination test was adapted for the detection of the mollicute *Spiroplasma citri*, causal agent of citrus stubborn and horseradish brittle root diseases. In blind tests, the pathogen was correctly detected in infected turnip petioles, in leaf samples of healthy bean, aster, Jimson weed, and the weed *Macroptilium lathyroides* to which cultured spiroplasma had been added, and in beet leafhoppers (*Circulifer tenellus*, a vector of *S. citri*) which had fed on infected turnip plants. Corresponding controls were negative in each case. Sample preparation was enhanced by grinding with an electric tissue homogenizer and centrifuging at approximately 9000 x g for 3 min. The minimum detection level for *S. citri* was 10^7 cells/ml.

A327

TRANSMISSION ELECTRON MICROSCOPE OBSERVATIONS OF VIRUS-LIKE PARTICLES FROM A HORSERADISH ISOLATE OF *Spiroplasma citri*. K.M. Franklin and H.J. Wilson, Department of Biological Sciences Box 311, University of Alabama in Huntsville, Huntsville, AL 35899.

Spiroplasma citri is the causative agent of Brittleroot disease of horseradish. Cultures of BR6-3X, a triply cloned horseradish isolate of *S. citri*, were prepared for transmission electron microscopy: a concentrated suspension of cells was applied to formvar coated grids and negatively stained with phosphotungstic acid or ammonium molybdate, or cells were fixed with gluteraldehyde, stained with uranyl acetate, embedded in EPON, and thin sections post-stained with lead citrate. Examination of both fresh mount and embedded spiroplasmas revealed virus-like particles measuring 40-50 nm in width, with visible short tails 12-20 nm in length. These particles are consistent with physical descriptions of the SVC3 group of viruses infecting spiroplasmas.

A328

HYPERSENSITIVITY IN COWPEA INDUCED BY DIFFERENT STRAINS OF XANTHOMONAS CAMPESTRIS PV. VIGNICOLA. R. D. Gitaitis, Dept. of Plant Pathology, University of Georgia, Tifton, GA, S. M. McCarter, Dept. of Plant Pathology, University of Georgia,

Athens, GA, and E. L. Styer, Vet. Diagnostic Lab, Tifton, GA.

A normal hypersensitive response (HR) induced by strain XVG 80-4 of *Xanthomonas campestris* pv. *vignicola* and an atypical form of HR caused by strain XVG 81-30 were examined in cowpea. When the two bacterial strains were inoculated into primary leaves either simultaneously or one following the other at various time intervals up to 24 h, the normal HR was the predominant reaction. However, once the atypical HR was expressed fully, it prevented the normal HR from occurring. The various interactions were examined by light and electron microscopy. Effects of temperature upon the reactions also were studied.

A329

BACTERIAL WILT, *PSEUDOMONAS SOLANACEARUM* RESISTANCE IN PEPPER AND EGGPLANT LINES. R.W. Goth, Vegetable Lab, ARS, USDA, Beltsville, MD. K.V. Peter, Kerala Agricultural University, Kerala, India. R.E. Webb, Leader, Vegetable Lab, ARS, USDA, Beltsville, Maryland 20705.

Pepper and eggplant cultivars from the U.S. and India were evaluated for their reactions to 8 race 1 isolates and 1 race 3 isolate of *Pseudomonas solanacearum*. The Indian pepper cultivar KAU Cluster was resistant to 4 of the race 1 isolates and race 3 isolate; cultivar White Khandari was resistant to 6 of the race 1 isolates and cultivar Pant C-1 was resistant to 3 race 1 isolates and the race 3 isolate. The U.S. cultivar Duoky was susceptible to all race 1 isolates and race 3 isolate. These results indicate that the pepper lines KAU Cluster, White Khandari and Pant C-1 and the eggplant line SM-6 maybe sources of germplasm for resistance to *P. solanacearum* and could be used for germplasm enhancement.

A330

EFFECTS OF ICE NUCLEATION-ACTIVE BACTERIA ON SUPERCOOLING AND FROST RESISTANCE OF DECIDUOUS FRUIT TREE FLORAL BUDS. D. C. Gross and E. L. Proebsting, Jr.* Wash. St. Univ., Pullman, WA 99164; *Irr. Agr. Res. Ctr., Prosser, WA 99350.

Cold hardiness of developing floral buds of deciduous fruit trees is contingent on the amount of supercooling and the inherent tolerance of ice formation. Ice nuclei limit supercooling and, thus, influence the degree of frost injury to floral buds. Only two sources of ice nuclei occur in association with fruit trees in the Pacific Northwest: ice nucleation-active (INA) *Pseudomonas syringae* and nonviable ice nuclei associated with woody tissue. Peach buds inoculated (10^5 - 10^6 cfu/g) with an INA bacterium (3×10^2 cells/ -5°C nucleus) were ice nucleated about 1.5°C higher than buds without INA bacteria. However, attachment of floral buds to 12.5 cm stem segments decreased supercooling to the same extent as inoculated buds. Nucleation at higher temperatures enhanced survival prior to bloom. Following bloom, ice nucleation resulted in severe injury whether ice emanated from INA bacteria or woody tissue. Thus, the presence of INA bacteria in orchards had little effect on supercooling and frost resistance.

A331

DISPERSAL OF *XANTHOMONAS PHASEOLI* VAR. *SOJENSIS* IN A SOYBEAN CANOPY. D. E. Groth and E. J. Braun, Dept. of Plant Pathology, Seed and Weed Sciences, Iowa State University, Ames, IA 50011.

Dispersal of the bacterial pustule pathogen was studied on soybean hill plots planted 0.76 m apart. A central hill of susceptible plants was inoculated with a rifampin-resistant mutant of *Xanthomonas phaseoli* var. *sojensis* (Xps), and leaflets from surrounding hills at various distances and directions from the central hill were sampled over time and assayed for external populations of Xps. The pathogen was dispersed equally in all directions and at the same rate (0.1 m/day) in plots of resistant and susceptible soybeans. Populations on resistant and susceptible varieties were not significantly different ($P=0.05$) during the first 3 weeks after inoculation. At 35 days after inoculation, when peak populations were detected, external Xps populations were 40-fold higher on the susceptible plants. All resistant plants remained disease free throughout the season. Deposition of airborne Xps on agar plates at canopy height was 1.4×10^3 CFU/m²/hr 30 minutes after a rainfall of 2.3 cm and 96 CFU/m²/hr under dry, sunny conditions

A332

THE INFLUENCE OF MOTILITY ON EPIPHYTIC SURVIVAL AND ICE NUCLEUS PRODUCTION BY *PSEUDOMONAS SYRINGAE*. D. M.

Haefele, and S. E. Lindow, Department of Plant Pathology, University of California, Berkeley, CA 94720.

Corn seedlings were coinoculated with equal numbers of either motile ice nucleation active *Pseudomonas syringae* strain 31R1 or a motile revertant and a non-motile mutant of 31R1. Mean populations of the motile parent strain and motile revertant isolated after 7 days of intermittent moist incubation did not differ significantly (2.3 and 1.8 log CFU/g fresh wt. respectively). In both mixtures the mean population of the non-motile mutant was significantly lower than the motile strains (0.35 and 0.41 log CFU/g fresh wt. respectively). Mean populations of the motile parental strain, motile revertant and non-motile mutant 7 days after individual inoculations on bean primary leaves did not differ significantly (4.9, 5.2, and 5.1 log CFU/g fresh wt. respectively). However, the non-motile mutant produced fewer ice nuclei active at -5°C than the parental strain or the motile revertant strain (3.0, 3.3, and 3.5 log ice nuclei/g fresh wt. respectively). In vitro nucleation frequencies for all strains were identical.

A333

BACTERIAL DESCRIPTION BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY Valerie N. Hall, D.C. Sands, and E.H. Abbott*, Departments of Plant Pathology and Chemistry*, Montana State University, Bozeman, MT 59717.

Nmr spectroscopy affords a technique of describing intact organisms in a non-destructive manner. This system has been used to examine the plant pathogen *Xanthomonas campestris*. Carbon-13 natural abundance spectra of the cells within the pathovar X.c. *translucens* showed many common resonances but varied slightly from isolate to isolate. To shorten the time (8 hours) needed for data accumulation when using natural abundance carbon - 13, a method of isotope enrichment was designed. Uniformly labeled glucose was added to the minimal growing medium. Trials were run to detect the optimum time for incorporation of the label, and comparisons of enriched isolates of X.c. *translucens* were made.

A334

ENZYMATIC DEGRADATION OF *PSEUDOMONAS SOLANACEARUM* LIPOPOLYSACCHARIDE BY BACTERIOPHAGES TE-1 AND SE-1. C.A. Hendrick, Dept. of Pl. Path., Univ. of Neb., Lincoln, NE 68583, W. Sweet and L. Sequeira, Dept. of Pl. Path., Univ. of Wisconsin, Madison, WI 53706.

Bacteriophages of *Pseudomonas solanacearum* were isolated from soil and plant material. Two of the phage isolates, (TE-1 and SE-1) were found to have the ability to degrade lipopolysaccharide (LPS) enzymatically. Phage-mediated degradation of LPS from the wild-type strain K60 was measured by a reducing sugar assay and by solubilization of label from ¹⁴C-labelled LPS; the reaction was dependent on temperature and phage concentration. Phage-treated LPS had an altered banding pattern when separated by electrophoresis on SDS-polyacrylamide gels. Low mol wt oligosaccharides produced by phage hydrolysis were separated from phage-treated LPS by gel filtration. Gas-liquid chromatography showed that the sugar composition of the purified oligosaccharides was identical to that of the O-antigen region of K60 LPS (i.e., rhamnose, xylose and NAc-glucosamine in a 4:1:1 ratio).

A335

BACTERIAL STEM BLIGHT OF ADZUKI BEANS. B.W. Kennedy and R. Denny, University of Minnesota, Department of Plant Pathology, St. Paul, MN 55108.

A devastating bacterial disease limits production of Adzuki bean (*Phaseolus angularis*) in Minnesota. Water-soaking and cracking of stems are the prominent field symptoms and the final expression is lodging and death of plants. A bacterium producing white colonies can be isolated from diseased tissues and produces symptoms in the greenhouse similar to those observed in the field. In both field and greenhouse infections, an abundance of exudate is produced and lesions are readily invaded by saprophytes, frequently making isolation difficult. The bacterium is pathogenic on several other beans in the genus *Phaseolus* in the greenhouse. The pathogen is Gram negative, levan positive, oxidase negative, aerobic, arginine dihydrolase negative, and produces weak fluorescence on King medium B. We have classified the bacterium in the genus *Pseudomonas* and noted that it differs from *P. syringae* pv. *phaseolicola* in important physiological characteristics, including growth on Betaine HCl, inositol, trigonelline, and mannitol.

A336

BACTERIAL BLIGHT OF *Philadelphus* spp. B.W. Kennedy, J.D. Froyd, and R.L. Bowden. University of Minnesota, Department of Plant Pathology, St. Paul, MN 55108.

A leaf and twig blight of Mock Orange has been observed frequently in Minnesota during the last 15 years. It is characterized by typical angular leafspots that occur following spring rains; leafspots are first water-soaked in appearance but turn brown within 2-3 days. Young shoots are also blighted and produce "shepherds' crook". The causal bacterium is a Gram negative motile rod with polar flagella; it is oxidase negative, arginine dihydrolase negative, levan positive, negative for potato soft rot, and produces white colonies and a green fluorescent pigment on King medium B. We conclude that the bacterium is *Pseudomonas syringae* pv *syringae* on the basis of physiological tests made on eight isolates. Two groups were distinguished on the basis of differential reactions on utilization of D-tartrate, L-lactate, D-erythritol and D-sorbitol as well as syringomycin production, esculin hydrolysis and production of tyrosinase.

A337

Motility of *Erwinia herbicola*. M.J. Klopmeier and S.M. Ries. Dept. of Plant Pathology, University of Illinois at Urbana-Champaign, 1102 S. Goodwin, Urbana, IL 61801.

Growth temperatures of 29 to 31 C are optimum for motility of *Erwinia herbicola* (strain 112Y-courtesy of S.V. Beer) cells determined by capillary assay. Electron micrographs indicate normal flagella at growth temperatures of 18 to 31 C and short, stubby flagella at 33 C. The optimum pH for motility in the motility medium is pH 7 and the optimum EDTA concentration is 10^{-2} to 10^{-3} M. The addition of dulcitol or mannitol to the motility medium does not enhance motility, whereas glucose significantly inhibits flagellar movement. *Erwinia herbicola* is attracted chemotactically to Jonathan apple nectar extract by capillary assay.

A338

KINETICS OF CHANGES IN ICE NUCLEATION ACTIVITY OF *PSEUDOMONAS SYRINGAE* FOLLOWING TEMPERATURE SHIFTS. S.E. Lindow, Department of Plant Pathology, University of California, Berkeley, CA 94720.

The -5 C but not the -9 C ice nucleation activity of intact *Pseudomonas syringae* cells suspended in solutions of rifampicin, chloramphenicol, KCN or water increased up to 1000 fold when cells harvested at growth temperatures above 24 C were incubated at temperatures below 24 C. Maximum rates of increase of -5 C ice nuclei occurred within 8 min of temperature shift. Rates of increase in ice nuclei decreased linearly in Arrhenius plots with increasing and decreasing incubation temperature from 24 C. An apparent reaction order of 1.21 for the activation of *P. syringae* ice nuclei was calculated. Ice nuclei active at -5 C decreased in first order reactions when intact *P. syringae* cells were shifted to incubation temperatures above 26 C. The rate of decrease of ice nuclei increased logarithmically with increasing incubation temperature and with decreasing growth temperature between 24 C or with increasing concentration of 2-phenylethanol at either 27 C or 33 C. The results suggest that -5 C bacterial ice nuclei are not expressed well in fluid membrane lipids.

A339

A STRAIN OF *XANTHOMONAS CAMPESTRIS* PATHOGENIC TO APPLE IN TISSUE CULTURE. J. L. Maas, M. M. Finney, E. L. Civerolo. USDA, Beltsville, MD 20705

A yellow gram-negative bacterium was isolated from apple ('Redchief') in tissue culture (TC). The original budwood came from a nursery in Washington and the buds were taken directly to TC. Buds in TC became necrotic, involving leaf tips or whole apical growing tips. A bacterial mass developed in the medium at the base of the growing buds. The bacterium was consistently isolated from necrotic tissue. Based on diagnostic tests the bacterium was identified as *Xanthomonas campestris*. Koch's postulates were performed, indicating *X. campestris* to be the causal agent. EM examination showed the bacteria to be clustered in and around leaf stomata, but absent in vascular tissue. Preliminary greenhouse tests indicate pathogenicity to apple, but not to tomato, tobacco, cassava, peach or grape.

A340

MULTIPLICATION OF *PHYTOMONAS DAVIDI* IN THE LEAFHOPPER *EUSCELIDIUS VARIEGATUS*. R.E. McCoy and P.G. Murkham,

University of Florida, Fort Lauderdale, FL 33314, USA and John Innes Institute, Norwich NR4 7UH, UK. The unflagellated protozoan *Phytomonas davidi* (ATCC 30287) multiplied to titres of 5×10^8 cells/cc hemolymph in *Euscelidius variegatus* injected with 10^5 protozoal cells/cc insect saline. Peak titers occurred ca 1 week after injection and injected insects had an increased mortality rate. Protozoal cells occurred in salivary glands of insects with hemolymph titers $\geq 10^7$ cells/cc. *P. davidi* cells suspended in 5% sucrose fed to insects through a membrane appeared in honeydew within 3 hr of the onset of feeding. Honeydew contained 10^4 - 10^5 cells/cc 18 hr after feeding and up to 3×10^6 cells/cc one week after feeding in 33% of fed insects. At least one gut-infected insect became systemically infected. *E. variegatus* is not a natural vector of *P. davidi*; this investigation was undertaken to determine the infectivity of *P. davidi* to a phloem feeding insect.

A341

CELL SURFACE HYDROPHOBICITY OF MUCCOID AND NON-MUCCOID STRAINS OF *PSEUDOMONAS SOLANACEARUM*. James L. McEvoy and Arun K. Chatterjee. Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

Cell surface hydrophobicity of the well-characterized *P. solanacearum* strains K60 (mucoid, virulent, wild type) and B1 (non-mucoid, avirulent mutant of K60) was examined using hydrophobic-interaction chromatography on octyl- and phenyl-sepharose gels, adherence to hydrocarbons (xylene, decane, hexadecane), and agglutination in ammonium sulfate solutions. B1 cells, grown on various media, significantly adhered to xylene and to the hydrophobic gels, while the K60 cells, grown under similar conditions, did not. Agglutination of the B1 cells occurred at 0.05 M $(\text{NH}_4)_2\text{SO}_4$, while agglutination of the K60 cells was not observed even with 2 M solutions. These results suggest that the B1 strain is hydrophobic and that the capsule external to the outer membrane masks the hydrophobicity of the K60 cells.

A342

SUSCEPTIBILITY OF POTATO CULTIVARS TO ERWINIA SOFT ROT. R. G. McGuire and A. Kelman, Department of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

Tubers of nine potato cultivars were harvested from plants grown on both silt loam and fine sandy loam soils and tested for susceptibility to infection by *Erwinia carotovora* pv. *atroseptica* (Eca), resistance to maceration by *Erwinia*'s pectic enzymes, and calcium content. Percent surface area of tubers decayed was determined following inoculation and incubation in a mist chamber. Butte, Russet Burbank, and Norgold Russet were consistently most resistant on both types of soils, Rhinered, Superior, and Red La Soda were intermediate, whereas Norland, Norchip, and Belchip were most susceptible. When injected into tubers which were maintained under anaerobic conditions, a partially purified pectic enzyme preparation of Eca caused twice as much rot in Norland and Belchip as in Butte and Russet Burbank. Between cultivars, the increased susceptibility of tubers to maceration, caused either by Eca or pectic enzymes, was correlated with the reduced calcium content of medullar tissue.

A343

BACTERIAL ANTAGONISM TOWARDS THREE FUNGI PRODUCING SCLEROTIA. J.D. Mihail and S.M. Alcorn. Dept. of Plant Pathology, Univ. of Arizona, Tucson, AZ, 85721.

Seven strains of *Pseudomonas fluorescens* and one of *Serratia marcescens* were antagonistic to *Macrophomina phaseolina*, *Verticillium dahliae* and *Sclerotium rolfsii* in culture. Some isolates of *P. fluorescens* greatly reduced or eliminated the formation of sclerotia. Diameters of *M. phaseolina* sclerotia formed in the presence of antagonists and in pure culture were compared; antagonists caused 25-54% reduction in sclerotial diameter. Two bacterial isolates delayed the formation of sclerotia by 2-3 days compared to unchallenged *M. phaseolina* cultures while still permitting hyphal growth. The same two strains caused a 9-day-delay in sclerotium formation by *V. dahliae*. The ability of these bacteria to delay or eliminate sclerotial formation while still permitting hyphal growth is a potentially useful method for studying the hyphal and sclerotial phases of fungal development.

A344

EFFECT OF CONTINUOUS DARK ON ULTRASTRUCTURAL INTERACTIONS OF *XANTHOMONAS CAMPESTRIS* PV. *MALVACEARUM* WITH BACTERIAL BLIGHT-IMMUNE IM 216 AND -SUSCEPTIBLE AC 44 COTTON LINES (GROWN IN DARK AS COMPARED WITH A LIGHT-DARK CYCLE.) A. Morgham, P. Richardson, M. Essenberg, Oklahoma State University, Stillwater, Oklahoma 74078.

Inoculations with 6×10^8 bacteria/ml were made into the fourth or fifth leaf of six-week-old plants. Immediately after inoculation half of the plants were placed in continuous dark. Control plants remained in a 14 hr light/10 hr dark cycle. In the dark, bacteria multiplied in both Ac 44 and Im 216 to levels typical of susceptible Ac 44 in the light/dark cycle. However, ultrastructural interactions in Im 216 in the dark resembled those in the light/dark cycle. In Ac 44 in the dark ultrastructural interactions resembled those previously seen in the light/dark cycle in lines of intermediate resistance, i.e. bacteria were enveloped by 4 hr after inoculation, but were ruptured within 2 days. Plasma membrane, cytoplasm and chloroplast degeneration occurred earlier than is usually seen in Ac 44 in the light/dark cycle.

A345

A NEW BACTERIAL LEAF SPOT DISEASE OF SOUTHERN MAGNOLIA IN ALABAMA. J. M. Mullen and G. S. Cobb. Auburn University, Alabama 36849.

A new leaf spot disease on southern magnolia (*Magnolia grandiflora*) has been observed in 2 locations in southern Alabama. Lesions on the foliage began as small, dark brown specks. On newly unfolding leaves, specks enlarged and coalesced until 1/3-2/3 of the leaf area was affected with dark brown necrotic lesions. On expanding foliage, the initial lesions developed into dark brown spots (5-10 mm diameter) surrounded by a yellow halo. As the lesions dried, shot holes appeared. On mature foliage, leaf spots did not advance beyond the initial speck stage. A gram-negative, rod-shaped bacterium was repeatedly isolated from diseased tissue. Biochemical tests indicated that this organism is a fluorescent *Pseudomonas* sp. which does not resemble the common pathogens in this genus. Pathogenicity tests conducted on southern magnolia produced symptoms identical to those originally observed. The bacterium was repeatedly isolated from inoculated plants.

A346

FIELD SURVIVAL OF *PSEUDOMONAS SYRINGAE* PV. *GLYCINEA*. E. W. Park and S. M. Lim. Department of Plant Pathology, University of Illinois at Urbana-Champaign, Urbana, IL 61801.

The population of *P. syringae* pv. *glycinea* (PSG) was monitored for the ability to overwinter in Urbana, IL from Nov., 1981 to April, 1982. Severely infected leaves from greenhouse grown soybean seedlings infected with a streptomycin-rifampicin resistant mutant of PSG were placed in mesh bags and positioned at 10, 20, and 30 cm below ground levels and on the surface. PSG populations were estimated monthly from the number of PSG colonies growing on King's B medium containing streptomycin 100 ppm, rifampicin 50 ppm, and cycloheximide 60 ppm. PSG populations below ground declined at about the same rate regardless of depth. PSG population on the surface was significantly higher than those from below ground throughout the winter. About 10^3 cfu/100 cc soil were detected on the surface during March but were non-detectable by April. The bacterium could not be detected from below ground after February. Preliminary results indicates that soil temperature and moisture are important for survival of PSG.

A347

COMPARISON OF PHYTOALEXIN CONCENTRATIONS NEAR SITES OF BACTERIAL INFECTION IN LEAVES OF RESISTANT AND IMMUNE COTTON. M. Pierce, E.C. Cover and M. Essenberg. Department of Biochemistry, Oklahoma State University, Stillwater, OK 74078.

Concentrations of fluorescent phytoalexins lacinilene C (LC) and lacinilene C 7-methyl ether (LCM) in leaf cells adjacent to colonies of *Xanthomonas campestris* pv. *malvacearum* were calculated from results of fluorescence microscopy and methanol-water extractions. Cotton lines used were Im 216, which has immunity to bacterial blight, and resistant OK 1.2, which was derived from Im 216. Race 3 of pv. *malvacearum* multiplied to 6-fold higher populations in leaves of OK 1.2 than in those of Im 216. Completely inhibitory concentrations of LC in an average of 3.1 leaf cells per bacterial colony were calculated for OK 1.2 on the day bacterial growth ceased. Five- to tenfold lower amounts of phytoalexins were extracted from Im 216, despite its immunity. Host cells became fluorescent faster in Im 216 than in OK 1.2, but only partially

inhibitory concentrations of LC and LCM were calculated for those cells in Im 216 at the time bacterial growth ceased.

A348

A DIRECT SEEDLING TEST FOR SELECTING ANTAGONISTIC BACTERIA. P. S. Randhawa and N. W. Schaad. Dept. Pl., Soil and Ent. Sci. Univ. Idaho, Moscow, ID 83843

A technique for recovering antagonistic bacteria was developed using germinating seeds. A bioassay chamber was constructed using a square Petri dish (100 x 15 mm) divided by a 6-mm glass rod into compartments of 89 x 28 mm and 89 x 56 mm, respectively. The lower, smaller chamber is filled with an agar medium. A sterile glass platform (75 x 15 mm) with an attached absorbent paper pouch is placed in the upper chamber adjacent and parallel to the glass rod. The distance between the pouch and glass rod is 5 mm. Seeds treated with seed washings, soil, or specific bacteria are germinated for 24 hrs and placed into the pouches soaked with sterile water. Pathogenic bacteria can be added to the emerging roots to determine antagonism. The chamber is incubated vertically and bacterial growth observed around the root on the agar medium after 5 days. We have used the test for determining the ability of possible antagonists to survive on roots and/or inhibit several seedborne plant pathogenic bacteria.

A349

CHARACTERIZATION OF THE BACTERIUM CAUSING BACTERIAL WILT OF TORONTO CREEPING BENTGRASS. D. L. Roberts, J. M. Vargas, Jr., D. W. Fulbright, and K. K. Baker, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Pathogenic bacterial isolates from diseased *Agrostis palustris* Huds. cv. Toronto from several midwestern states were identical in standard physiological, morphological and serological assays. The bentgrass bacterium exhibited the following characteristics: rod-shape 0.3-0.5 by 1.0-1.5 μ m, Gram(-), oxidase(-), catalase(+), obligate aerobe, H_2S production, starch hydrolysis utilization of casein, gelatin liquefaction and growth at 36 C but not at 41 C. The bentgrass bacterium exhibited bright yellow pigmentation and copious slime was produced on yeast extract-dextrose-calcium carbonate agar. These characteristics resembled those for the genus *Xanthomonas* although Ouchterlony gel double diffusion tests suggested no serological relationship between the bentgrass bacterium and several known *Xanthomonas campestris* pathovars.

A350

A MEDIUM SELECTIVE FOR AGROBACTERIUM TUMEFACIENS BIOTYPE 3. M. A. Roy and M. Sasser, University of DE, Newark, DE 19711.

Agrobacterium tumefaciens biotype 3, the causal agent of crown gall of grape, typically will not grow on media selective for biotypes 1 or 2. A medium reasonably selective for biotype 3 isolates has been designed and tested. With adonitol as the carbon source, it includes tetrazolium, boric acid and several antibiotics. Growth of diverse isolates of all 3 biotypes from the US, USSR, Hungary and Greece as well as isolates of *A. rubi*, *A. radiobacter*, *A. rhizogenes*, *Rhizobium* and 4 other genera was assayed on our medium and 3 others (New-Kerr's, Schroth's and PDA). Biotype 3 colonies on our medium are whitish, mucoid and convex, while the few contaminant colonies are flat, red and thus easily distinguishable. Recovery of known additions to pasteurized and non-pasteurized soils and isolations from plant material and native soils have been performed.

A351

STRAIN VARIATION OF *CORYNEBACTERIUM MICHIGANENSE* SUBSPECIES *NEBRASKENSE* WITHIN ONE FIELD. Mary Smidt, Bharati Joshi, Carol Hendrick, Anne K. Vidaver, Dept. of Plant Pathology, Univ. of Nebraska, Lincoln, NE 68583-0722.

Forty-four strains of *C. michiganense* subsp. *nebraskense* were recovered from popcorn residue and live popcorn plants in one field in Nebraska during 1982. The variability among these isolates was assessed on the basis of color and morphology of cultures on solid media, growth rate, bacteriocin production and sensitivity, phage sensitivity and relative virulence. Strains which could be distinguished from each other on these bases were used to extract cellular proteins. Salt extracted proteins were subjected to SDS-polyacrylamide electrophoresis and the profiles of polypeptides compared. Plasmid DNA was also isolated, subjected to SDS-agarose electrophoresis and plasmid profiles were compared. At least 10 different variants have been identified.

Differences were found not only between strains from widely separated areas of the 46 hectare field, but also between strains from within the same 0.03 hectare plot.

A352

SEROLOGICAL COMPARISON OF FOUR ANTIGENS FOR IDENTIFICATION OF *XANTHOMONAS CAMPESTRIS* PV *CAMPESTRIS*. N. Thaveechai and N. W. Schaad, Dept. Pl., Soil and Ent., Univ. Idaho, Moscow, ID 83843

Four antigens (formaldehyde fixed cells, glutaraldehyde fixed cells, trichloroacetic acid (TCA) extracts, and ribosomal extracts) were compared by agar double diffusion for identification of *Xanthomonas campestris* pv *campestris* (XC). Antiserum (AS) to each of the preparations resulted in a single major band and one to three minor bands of precipitin when reacted against homologous purified cell extracts. The major precipitin, however, was considerably sharper and stronger in AS to ribosomes. Using the major precipitin of AS to ribosomes, 25 strains of XC were typed (separated) into four serovars. Twenty-nine other bacteria, including 13 strains of five other pathovars of XC, 12 other species, and four unidentified bacteria from crucifer seeds, were tested by agar diffusion with AS to the four serovars. Three strains of *X. vesicatoria* and one strain of *X. translucans* cross-reacted. All other bacteria failed to react. These results suggest that the same major species specific antigen is present in both TCS and ribosomal extracts of cells and in fixed cells of XC.

A353

VARIATIONS IN RESPONSE OF 24 PAPAYA VARIETIES INFECTED WITH BACTERIAL CANKER. Robert Webb, C.V.I. Ag. Exp. Stn., St. Croix, U.S.V.I. 00850.

Bacterial canker of papaya (BC), caused by an Erwinia like species, is a facet of a disease syndrome known as St. Croix Decline. The disease is characterized by oily, systemic lesions on the leaves and trunks of affected trees. Tree collapse usually occurs following the observation of trunk lesions. Evaluations of various commercial and wild papaya varieties for resistance to BC have shown a wide variation in response to infection. Bacterial suspensions of 10^5 cfu/ml were applied to 1 month old seedlings and incubated for 24 hrs. at 100% RH. Symptom evaluations were made at 2 and 4 weeks. None of the varieties screened were completely resistant to infection, however, distinct differences were observed in the number, type and severity of leaf and trunk lesions. A non-commercial variety from Barbados displayed a significant tolerance to infection by eliciting an HR type response to leaf infections.

A354

CHANGES IN COTTON ROOT DENSITY AND FUNGAL COLONIZATION OF COTTON ROOTS BY MODIFYING THE SOIL MICROFLORA WITH SELECTIVE FUNGICIDES. G. L. Andersen and O. C. Huisman, Department of Plant Pathology, University of California, Berkeley, CA 94720.

Two field plots in the San Joaquin Valley were treated with five different fungicides (benomyl, PCNB, metalaxyl, ethazole, vinclozolin), each selective for a different portion of the soil microflora. In addition, methyl bromide fumigation was used. Throughout the season, cotton root length density (RLD) and fungal colonization on the roots were evaluated for each of the treatments. The final yield of cotton lint was taken at the end of the season. Treatment with metalaxyl increased RLD of both total and living roots. It also increased the rate (colonies/100 cm) of fungal colonies from roots plated out on a semi-selective medium and increased cotton lint yield. Benomyl and methyl bromide fumigation decreased cotton yield and live RLD. The effect of the fungicides on RLD and yield appears to be caused by inhibition or promotion of root colonizing fungi in the soil. A *Pythium* sp. is strongly implicated in these effects.

A355

MEASUREMENT OF TRIFLURALIN EFFECTS ON A PINTO BEAN-FUSARIUM DISEASE SYNDROME. Cynthia Baretta and Jack Altman, Botany & Plant Pathology Dept., Colorado State University, Ft. Collins, CO 80523

A disease index rating (DIR) was developed to evaluate a herbicide-Fusarium-interaction on dry beans. Trifluralin (a, a, a-trifluoro-2, 6-dinitro-N, N-dipropyl-p-toluidine) incorporated into soil at 2.5 ppm (field rate) and 2x and 3x increased the DIR when compared to infested, non-herbicide treated soil. Soil infested with *Fusarium solani* f. sp. *phaseoli* and treated with a Trifluralin formulation blank showed no DIR increase. The DIR (modified after Beebe et al,

1981) includes a measurement of lesion size and depth of penetration, and should provide a more precise evaluation for the herbicide-disease interaction in the Pinto bean-Fusarium complex.

A356

EFFECT OF POTASSIUM FERTILIZATION AND CHLORIDE ION ON PHYTOPHTHORA ROT OF SOYBEANS. C. H. Canaday and A. F. Schmitthenner, Dept. of Plant Pathology, The Ohio State University, OARDC, Wooster, OH 44691.

Field soils naturally infested with *Phytophthora megasperma* f. sp. *glycinea* were used to study the effects of potassium fertilizers and chloride salts on *Phytophthora* rot of soybeans in growth chamber experiments. KCl at 150 to 200 ppm K (wt K:wt dry soil) significantly increased disease losses and significantly reduced plant height compared to untreated controls, while K_2SO_4 and KNO_3 at similar rates did not. Comparison of KCl and K_2SO_4 at 300 ppm K on different soil types revealed significant disease increases only with KCl. When KCl, K_2SO_4 , K_2HPO_4 , and KH_2PO_4 were compared at 400 ppm K, only KCl significantly increased disease. $MgCl_2$, NaCl, NH_4Cl , CsCl, and other chloride salts all significantly increased disease losses at rates of 150 to 300 ppm Cl. It was concluded that the disease increases with KCl fertilization were due in large part to the presence of the chloride ion.

A357

EFFECT OF TILLAGE PRACTICES ON FUSARIUM BLIGHT OF SOYBEAN. R. B. Carroll and S. Leath, Dept. of Plant Science, Univ. of Delaware, Newark, DE 19711.

A 4-yr study of Fusarium blight on soybean under conventional tillage vs no-tillage and wheat vs barley cover crops was completed in 1981. Plots of 'Essex' and 'Williams' soybeans were established in the exact location each year at Georgetown, DE in a field with endemic *Fusarium oxysporum* inoculum. Extensive isolations were made from root and stem tissues and rhizosphere throughout each season utilizing selective culture media. *F. oxysporum* was recovered most often from plants under no-tillage-wheat treatments ($P=0.01$). Rhizosphere populations of *F. oxysporum* were significantly greater from no-tillage plants than those grown with conventional tillage. Twenty of 22 isolates tested were pathogenic to 'Essex' soybean and were able to colonize and survive in roots of wheat and barley in greenhouse inoculation tests.

A358

PYTHIUM SPP. PATHOGENIC TO PACIFIC NORTHWEST WHEAT AND THE INFLUENCE OF TILLAGE PRACTICES ON THEIR POPULATIONS. C. Chamswarng and R. J. Cook, Dept. of Plant Path., Washington State University, Pullman, WA 99164.

At least four *Pythium* spp. or s. spp. cause root disease on Pacific Northwest wheat: *P. aristosporum*, *P. ultimum* var. *ultimum*, *P. ultimum* var. *sporangiferum*, and *P. torulosum*. The latter were previously unknown in Northwest wheat-field soils. This is the first report of *P. ultimum* var. *sporangiferum* as a pathogen of wheat. Dilution-plate counts of the total *Pythium* population in soil samples collected at four times between Sept. 1981 and Nov. 1982 in a tillage experiment revealed significantly ($P = 0.05$) higher populations in the minimum-tilled plots (crop residue left near the soil surface) than in the mold-board-plowed plots. The *Pythium* populations in direct-drilled (no till) plots were intermediate between those in minimum-tilled and plowed plots. This pattern held for all sampling dates. Populations were higher in samples collected in Dec-Nov than in June-Sept. *Pythium ultimum* (vars. *ultimum* and *sporangiferum* combined) was dominant.

A359

EFFECT OF LONG-TERM CONTINUOUS CROPPING OF SPRING WHEAT ON PATHOGENICITY OF *HELMINTHOSPORIUM SATIVUM*. H. El-Mashaar and R. W. Stack, North Dakota State Univ., Fargo, ND 58105.

Repeated planting of the same crop often results in an increase of inoculum of soil-borne plant pathogens, but little is known of the effect on pathogenicity in the pathogen population. In the 1890's H. L. Bolley established a continuous wheat plot which has been planted to spring wheat ever since. We collected *Helminthosporium sativum* from symptomatic wheat plants from Bolley's plot (98 isolates) and from grain fields in the surrounding area (44 isolates). Relative pathogenicity of isolates was tested in replicated greenhouse trials using wheat plants

scored for disease six weeks after inoculation. Isolates from Bolley's continuous wheat plot were more pathogenic on average than isolates from commercial fields. The variances of the two populations were not different. Long term continuous cropping to wheat appears to shift the population of *H. sativum* toward more aggressive types, although many less pathogenic types also remain. No 'super-pathogenic' isolates of *H. sativum* were observed.

A360

EPIDEMIOLOGY AND MANAGEMENT OF FUSARIUM BASAL ROT AND PINK ROOT OF ONIONS. K.L. Everts and H.F. Schwartz, Dept. of Botany and Plant Pathology, Colorado State Univ., Fort Collins, CO 80523.

Fusarium basal rot (*Fusarium oxysporum* f. sp. *cepae*) and Pink Root (*Pyrenochaeta terrestris*) are wide-spread problems of onions in Colorado. A wide variation in inoculum potential of both pathogens was detected by serial dilution plating of soil. Onion varieties and fungicides were evaluated for their effectiveness in reducing infection by either pathogen. Interactions between these pathogens and the seedcorn maggot and other factors such as mechanical damage to roots were also evaluated. Fusarium basal rot disease incidence increased from 30% without to 40% with maggots and to 50% when wounding occurred in infested soil. Maggots alone did not cause a high incidence of bulb rot in non-Fusarium infested soil. A similar study showed that Fusarium basal rot increased three-fold in the presence of *P. terrestris*. These results suggest that high priority must be given to developing a management program that would be effective against the Fusarium pathogen and the other factors that contribute to its incidence.

A361

SPATIAL PATTERN OF PHYTOPHTHORA PARASITICA VAR. NICOTIANAE IN INFESTED TOBACCO FIELD SOIL. D. M. Ferrin and D. J. Mitchell, Dept. Plant Pathology, Univ. Florida, Gainesville, FL 32611.

The horizontal component of the inoculum pattern of *P. parasitica* var. *nicotianae* in infested tobacco field soil was evaluated as a function of depth at time of planting. Soil samples were taken at several depth increments (i) along transects across randomly chosen plots and (ii) from randomly chosen transects across a single plot. Propagules of the pathogen were enumerated by plating soil suspensions onto a medium selective for *Phytophthora* spp. All data sets were best described by the negative binomial distribution which indicated aggregation of inoculum. For depth increments of 0-10 and 10-20 cm, K-values for the field were 0.41 and 0.12, respectively. Within a single plot K-values were 0.98, 0.72 and 0.22 for depth increments of 0-10, 10-20 and 20-30 cm, respectively. Furthermore, K-values obtained for pooled depth increments of 0-10, 0-20 and 0-30 cm within this plot differed only slightly. This indicated a high degree of aggregation of inoculum both within the field and the plot, and aggregation increased with depth.

A362

EFFECTS OF SOIL SOURCE, SOIL MOISTURE, SEED QUALITY AND SEED TREATMENT ON SOYBEAN EMERGENCE IN THE GREENHOUSE. R. S. Ferriss, R. E. Stuckey and M. R. Siegel. Department of Plant Pathology, University of Kentucky, Lexington, Ky 40546

High and low quality seed, treated with carboxin-thiram or untreated, were planted in soils collected from four Kentucky soybean fields. The soils were adjusted at planting to three moisture levels [0 bars (high), -0.1 to -0.4 bars (medium) and -1 to -3 bars (low)]. In general, differences in emergence among seedlots, seed treatments and soils were greatest at high and least at medium moisture. Emergence was significantly greater from high than low quality seed regardless of soil source, soil moisture or seed treatment. Seed treatment increased emergence from low quality seed in all soils at all moisture levels, but increased emergence from high quality seed only at the high moisture level. Differences in emergence between soils occurred at high and low, but not medium, moisture. Emergence from the same seed in a field test under relatively dry conditions correlated best with greenhouse emergence in the same soil at low moisture.

A363

DETECTION OF VERTICILLIUM DAHLIAE IN HOST TISSUE BY USE OF AN INDIRECT ENZYME-LINKED IMMUNOHISTOCHEMICAL ASSAY. J. S. Gerik, S. A. Lommel, and O. C. Huisman, Department of Plant Pathology, University of California, Berkeley, CA 94720.

Hyphae of *Verticillium dahliae* were detected in root tissue using rabbit

antisera prepared against a soluble protein extract of *V. dahliae*. The reaction of rabbit antibody to *V. dahliae* hyphae was detected with an alkaline phosphatase anti-rabbit IgG conjugant and localized by enzymatic hydrolysis of the substrate, naphthol-as-phosphate. The product of this reaction was coupled to a diazonium salt which yielded an insoluble, colored precipitate which stained the fungal hyphae. The hyphae were readily observed on and in the root cortex of the host using a dissecting microscope. This technique allows for rapidly determining the presence and location of *V. dahliae* in the root systems of plants and can be applicable to other fungal species for which a specific antiserum can be produced. Data will be presented on the specificity and sensitivity of the assay.

A364

ECOLOGY OF FUSARIUM MONILIFORME AND OTHER FUSARIA IN CULTIVATED FIELD SOILS IN COLORADO. R. L. Gilbertson, E. G. Ruppel, and W. M. Brown. Dept. of Botany & Plant Pathology, Colorado State University, and USDA, ARS, Fort Collins, CO 80523.

Fusarium spp. population densities (PDs) in soils from a four-crop rotational study and a continuous corn-variable tillage regime study were determined by a soil dilution plate method. Organic debris also was recovered from soil and assayed for fusaria. *Fusarium moniliforme* (Fm) PDs were determined in rhizosphere soils (RS) from crops, certain weeds, and corn plants with stalk rot. Highest Fm PDs were found in corn soils, with lower PDs in barley soil, and lowest PDs in bean and sugarbeet soil. Soil with continuous corn had greatest Fm PDs, and a conventional tillage regime had greater Fm PDs than two reduced tillage regimes. RS from corn, barley and grass weeds had high PDs of Fm, whereas RS from bean and sugarbeet had low PDs. Fm PDs were high in RS from corn plants with stalk rot caused by Fm. *F. roseum* var. *graminearum* rarely was detected in soils by the dilution plate method, but was isolated from organic debris.

A365

SCLEROTINIA WILT OF SUNFLOWER: THE EFFECT OF INOCULUM DENSITY ON DISEASE INCIDENCE. R. C. Holley and B. Nelson, Dept. Plant Pathology, North Dakota State University, Fargo, ND 58105.

Field experiments were established at eight sites in eastern North Dakota, on land naturally infested with *Sclerotinia sclerotiorum*, to study the effects of inoculum density on the incidence of sunflower wilt. Sunflower (hybrid 894) plots of 15, 20, 25 and 30 thousand plants/acre were established and replicated at each site. Inoculum densities (populations of sclerotia) were determined in the upper 16.5 cm of soil. Disease incidence was recorded at weekly intervals throughout the season. Results indicated a relationship between inoculum density and disease incidence. At inoculum levels of 1.5, 2.3, 2.6, 5.7, 11.8, 13.1, 18.0 and 20.0 sclerotia/10 kg soil there was 13, 32, 42, 54, 83, 60, 70 and 66% wilt respectively, in plots with 20,000 plants/acre. Disease incidence was not significantly different between plant populations. Disease progress was similar at all sites, with approximately 70% of disease development following anthesis. The results indicated that low inoculum densities (less than 1 sclerotium/kg soil) can result in considerable wilt.

A366

MORE INTENSE MICROBIAL COMPETITION FOR EPHEMERAL CARBON SOURCES MAY OPERATE IN FUSARIUM-SUPPRESSIVE SOILS. S.F. Hwang, R.J. Cook, and W.A. Haglund, Dept. Pl. Path., WSU, Pullman, WA 99164.

Suppressiveness of soil to chlamydospore germination of *Fusarium oxysporum* f. sp. *pisii* was partially overcome (increased from 10 to 55%) by adding 4X the glucose (3.2mg C/g soil) required for 90% germination in conducive soil. Significantly more carbon (C) as CO₂ was evolved from suppressive than conducive soil during 24 hr after glucose had been added to provide 0.8mg C/g soil, and 2X and 4X glucose produced incremental increase in the amount of CO₂ evolved from suppressive but not conducive soil. This suggests that the capacity for glucose consumption is greater in suppressive than conducive soil. The initial respiratory response of the microbiota was delayed 20-24 hr in suppressive soil by adding 1000ppm novobiocin with the glucose, and 68% chlamydospore germination occurred with glucose at only 0.8mg C/g soil. Chlamydospore germination may be poor in suppressive soil, in part because of insufficient carbon; the total microbiota activated by added glucose may be larger in suppressive than in conducive soil, may respond more rapidly, or both.

A367

INFLUENCE OF SOIL ON POPULATION-DISEASE RELATIONSHIPS OF RHIZOCTONIA SOLANI. R.S. Kinsbursky and A.R. Weinhold,

Department of Plant Pathology, University of California, Berkeley, CA 94720.

A soil survey was conducted to determine the influence of soil on population-disease relationships of *Rhizoctonia solani*. Seventeen soils collected from the San Joaquin and Sacramento valleys were infested with various inoculum levels of *R. solani*. Radish seeds were planted in 2 cm deep soil columns contained in 5.5 cm diam. brass rings. Water potential was adjusted to -0.15 bars in a pressure plate extractor. Soils were then placed in a growth chamber at 27 C, and incidence of infection readings was determined after 3 days. Infection data was transformed to account for multiple infections. There was a linear relationship between mean number of infections per plant vs. inoculum density, significant at $P = 0.01$, for all soils except those without significant infection at the inoculum levels tested. Soils were compared using a reference soil which was arbitrarily given an infection rating of 100. Infection levels ranged in a continuum from 5-135% of the reference soil value. This demonstrates that soil had a significant influence on population-disease relationships of *R. solani*.

A368

PSEUDOMONAS SYRINGAE PV. LACHRYMANS SURVIVAL WITH CUCUMBER ROOTS. Curt Leben, Department of Plant Pathology, The Ohio State Univ., OARDC, Wooster, OH 44691.

Leaf-spotting pathogenic bacteria have been isolated from roots many times. The question asked was: if the cucumber pathogen, *Ps1*, was washed from leaf spots into soil, where would it survive? In three greenhouse tests, cucumber seeds were planted in autoclaved soil in small peat pots. When seedlings emerged, peat pots (one seedling/pot) were set into a nonsterile soil mix (soil, sand, vermiculite) in larger pots. When seedlings had 3-4 leaves, the soil mix around peat pots was saturated once with a *Ps1* suspension (ca 1.3×10^7 colony forming units (cfu)/ml). After 7-8 days, during which pots with plants and control pots with *Ps1* were sprinkler-watered similarly, rhizosphere soil mix carried 7.4×10^4 cfu *Ps1*/g ($n=17$). Damp, well-washed roots from the mix carried 1.3×10^6 cfu/g ($n=17$). In contrast, non-rhizosphere mix (from control pots containing only the mix) carried 810 cfu/g ($n=10$). These results suggest that in watered natural soil *Ps1* survives on and near roots.

A369

EFFECTS OF Cl^- ON THE COLONIZATION OF CROP RESIDUES BY *Pythium ultimum*. F. N. Martin and J. G. Hancock, Department of Plant Pathology, University of California, Berkeley, CA 94720.

As *Pythium ultimum* is a pioneer colonizer, factors which repress early colonization of organic matter will reduce subsequent population increases. We reported previously, and have subsequently confirmed with several years of field data, the existence of soils which did not support the saprophytic development of *P. ultimum* (Low *P. ultimum*, LP) and where $[Cl^-]$ and *Pythium oligandrum* tended to be at higher levels than found in soils which did support *P. ultimum* (HP). Recently we have found when HP soils with low *P. oligandrum* populations were amended with Cl^- to concentrations found in LP soils, organic matter colonization and subsequent population increases of *P. ultimum* were reduced. Reduction in colonization of organic matter was manifested within the first 2 days after soils were amended. In the presence of higher $[Cl^-]$, *P. oligandrum* colonized organic matter sooner (24 hr vs 38 hr) and more extensively (up to 8x increase) than in HP soils not amended with Cl^- . The outset of this colonization coincided with reduced colonization by *P. ultimum*. Frequencies of co-colonization by both fungi were very low.

A370

RELATIVE RESISTANCE OF FOUR DIFFERENT ENGLISH WALNUT ROOTSTOCKS TO PHYTOPHTHORA CITRICOLA. M. E. Matheron and S. M. Mircetich, USDA, ARS, Dept. of Plant Pathology, Univ. of Calif., Davis, 95616.

Phytophthora citricola is causing severe crown rot and death of walnuts in California orchards. Ten 2-month-old seedlings each of *Juglans hindsii* and Paradox (*J. hindsii* x *J. regia*), standard walnut rootstocks, and *J. sieboldiana* and *Pterocarya stenoptera*, potential walnut rootstocks, were planted in soil infested with *P. citricola*. *P. citricola* caused crown rot and death in 10 of 10 *J. hindsii*, crown rot in 2 of 10 *J. sieboldiana* and Paradox, and death in 1 of 10 *J. sieboldiana* seedlings within 3 months. In contrast, *P. stenoptera* seedlings in infested soil developed no crown rot and grew as vigorously as plants in uninfested soil. *J. hindsii*, the most widely used walnut rootstock in California, is apparently highly susceptible to *P. citricola*, while Paradox and *J. sieboldiana* appear resistant and *P. stenoptera* appears highly resistant to the same pathogen.

A371

EFFECTS OF VARIOUS LENGTHS OF SOIL SATURATION ON SEVERITY OF CROWN ROT IN THREE ENGLISH WALNUT ROOTSTOCKS CAUSED BY PHYTOPHTHORA CITRICOLA. M. E. Matheron and S. M. Mircetich, USDA, ARS, Dept. of Plant Pathology, Univ. of Calif., Davis, 95616.

In walnut orchards infested with *Phytophthora citricola*, field observations generally revealed a higher incidence of dead trees on *Juglans hindsii* than on Paradox (*J. hindsii* x *J. regia*) rootstock, especially on well-drained soil. To study length of soil saturation effects on severity of *P. citricola* infection, 2-month-old Paradox, *J. hindsii* and *Pterocarya stenoptera* seedlings were planted in soil artificially infested with *P. citricola* and flooded biweekly for 0, 6, 12, 24 or 48 hr for 3 months. All *J. hindsii* trees grown in infested soil developed severe crown rot and died regardless of length of flooding treatment. None of the Paradox trees died at 0 or 6 hr flooding while 20, 40 and 100% died at 12, 24 and 48 hr flooding treatments, respectively. In infested soil, *P. stenoptera* seedlings developed no crown rot at 0 or 48 hr flooding treatments.

A372

EVALUATION OF METHODS FOR ASSESSING THE INOCULUM DENSITY OF *VERTICILLIUM DAHLIAE* IN FIELD SOIL. P. C. Nicot and D. I. Rouse, Dept. of Plant Pathology, Univ. of Wisconsin, Madison 53706.

Field soils varying in texture and degree of infestation by *Verticillium dahliae* (Vd) were assessed for inoculum density (ID) of the fungus using a dilution plating (DP) (10 g dry soil in 100 ml sterile water; 1 ml aliquots plated on a selective medium), an Anderson sampler (AS), and a wet sieving (WS) (400 mesh fraction collected) method. Accuracy, precision, and ease of use of each method were compared. The DP and AS methods were generally similar in their ability to detect the fungus and gave results up to 2.5 times greater than WS for soils with $ID > 30$ propagules/gram. Results were comparable for all methods at lower ID. Wet sieving was the most precise method and AS displayed the most variability. The DP method was the easiest to perform, WS the most difficult. A cesium chloride flotation method and a bioassay involving *Datura stramonium* gave variable results and were found time-consuming and difficult to implement. Three types of media selective for Vd were compared for best detection of the fungus.

A373

RAPID IDENTIFICATION OF ISOLATES OF RHIZOCTONIA SPP. FROM A FIELD MULTICROPPED WITH RYE AND SOYBEAN UNDER REDUCED-TILLAGE. R.C. Ploetz, and D.J. Mitchell. Univ. Florida, Gainesville, 32611

Rhizoctonia spp. isolates from soil, rye, or soybeans in a multicropping, reduced-tillage experiment were characterized. Isolates initially recovered with Flower's selective medium were transferred to Difco potato dextrose agar for assignment to a morphological type. Pigmentation, density, pattern, and rate of mycelial growth and sclerotium formation were characteristics used for typing these isolates. Isolates of *R. solani* AG-4, *R. zeae*, and four binucleate anastomosis groups could be quickly identified (65-95% accuracy). Culture age was an important factor in making these morphological distinctions; young cultures of AG-4 and two of the binucleate groups resembled one another and often could not be distinguished until after 10-14 days of growth. One of the four binucleate groups anastomosed with Burpee's CAG-4 tester; other binucleate groups from this field did not anastomose with Burpee's or Ogoshi's testers. A fifth binucleate type, comprised of two or more anastomosis groups, could not be differentiated by this technique.

A374

PATHOGENICITY TO RYE AND SOYBEAN BY RHIZOCTONIA SPP. ISOLATES FROM A FIELD MULTICROPPED UNDER REDUCED-TILLAGE. R.C. Ploetz, D.J. Mitchell, and R.N. Gallaher. Univ. of Florida, Gainesville, 32611

Rhizoctonia spp. isolates from soil, rye, or soybeans in a multicropping, reduced-tillage experiment were tested for pathogenicity to "Wrens Arbuzzi" rye and "Bragg" soybeans in greenhouse studies. Isolates of one binucleate anastomosis group and *R. solani* AG-4 were pathogenic to soybean; AG-4 isolates also were pathogenic to rye. Isolates from four other binucleate groups were nonpathogenic. Generally, higher soil populations of all groups were detected at depths of 0-5 cm than at 5-15 cm; these groups were not detected in soil adjacent to the experimental field. Apparently AG-4 exists in this field as a parasite of rye and soybean and as a colonizer of dead plant material; it comprised 45-75% of the total soilborne population of *Rhizoctonia* spp. recovered from this field. Binucleate

groups represent 20-50% of the total; with one exception, they appear to exist in this field as saprophytes in plant debris or nonpathogenic colonists of rye and soybean root systems.

A375

INFLUENCE OF HOST SEEDLING EXUDATES ON GERMINATION OF SCLEROTIA OF *SCLEROTINIA SCLEROTIUM*. S.R. Rimmer and J.G. Menzies, University of Manitoba, Department of Plant Science, Winnipeg, Manitoba, Canada. R3T 2N2

Sclerotia of *Sclerotinia sclerotiorum* usually germinate carpogonically and consequently, most host crops are infected from ascospore inoculum. However, it has been shown that basal stem infections in sunflowers derive from myceliogenic germination of sclerotia (Huang & Dueck 1980 Can. J. Pl. Path. 2:47). We examined the effect of host seedling exudates from corn, sunflowers and rape on the type of germination occurring *in vitro*. Also, we examined the influence of host plants grown in soil in pots on sclerotial germination. Our results indicate that for certain single spore isolates of *S. sclerotiorum*, rape and corn seedling exudates are inhibitory to myceliogenic germination and stimulate carpogenic germination whereas with other isolates the converse is true. Sunflower exudates were not significantly different from water controls. *Sclerotia* influenced by sunflower plants in pots had increased myceliogenic germination and reduced carpogenic germination compared to sclerotia with rape plants in pots.

A376

A METHOD FOR ASSESSING THE ROOT-COLONIZING CAPACITY OF BACTERIA. F.M. Scher, J. S. Ziegler and J. W. Kloeppe, Advanced Genetic Sciences, P. O. Box 1373, Manhattan, KS 66502.

Corn seeds were mixed with bacteria suspended in 1% methyl cellulose (and then shaken with talc) or soaked in a 0.1M MgSO₄-bacterial suspension for 2 hr (no talc). Six cm sand and 5 ml H₂O were placed in 25 X 250 mm test tubes. Sand was overlaid with 2 cm field soil (15% moisture). Treated seeds were added and covered with 2 cm soil; tubes were sealed with parafilm and incubated (14C, 4000 lux). After 3-4 wk, roots in sand were excised, ground and dilution plated on media containing 100 ug/ml rifampicin. Approximately 30% of soil bacteria tested were corn root colonizers (> 10³ cfu/g root). Final root populations were independent of the seed treatment method and inocula levels (between 10²-10⁶ per seed). Bacteria multiplied on roots as indicated by higher root than seed populations. Non-colonizing bacteria tested in a sterile soil system were not recoverable from roots, despite their presence on seed. This assay should be effective in assessing root-colonization capacity of bacteria for many crop systems.

A377

SUPPRESSION OF FUSARIUM YELLOWS OF CELERY BY COMPETITIVE NONPATHOGENIC STRAINS OF FUSARIUM OXYSPORUM. R. W. Schneider, Department of Plant Pathology, University of California, Berkeley 94720.

Root-infecting strains of *Fusarium oxysporum* were selected from areas in which *F. oxysporum* f. sp. *apii* (Foa) has been recovered but disease development is repressed. More than 300 such isolates were screened for ability to competitively exclude Foa in a quantitative root infection assay using an orange mutant of the pathogen. Roots from celery plants growing in the disease-suppressive areas were heavily infected with nonpathogenic strains of *F. oxysporum* that were effective competitors (54% of isolates), while nonpathogenic strains from disease-conducive areas were mostly ineffective (6% of isolates were effective). Several of the most effective strains were evaluated as biological control agents in severe greenhouse tests. Incorporation of 1.0 to 2.0 g ground barley straw inoculum/kg soil of several test strains resulted in almost complete disease control.

A378

INHIBITORY EFFECT OF SIMULATED ACIDIC RAIN ON ROOT INFECTION AND SPORANGIUM PRODUCTION BY *PHYTOPHTHORA CINNAMOMI*. S. R. Shafer, R. I. Bruck, and A. S. Heagle, Dept. of Plant Pathology, N. C. State University, Raleigh, NC 27650.

Pots containing soil and week-old *Lupinus angustifolius* seedlings were flooded with deionized water, infested with *Phytophthora cinnamomi* (Pc) zoospores, and allowed to drain for 15 min. One-hour exposures of simulated rain (2.4 cm) adjusted to pH 5.6, 4.0, 3.2, or 2.4 were then applied. Two days later, root systems were weighed and pressed into Pc-selective agar medium and incubated for 48 hr. Infections were expressed as number of colonies per gram root tissue (CPG). Infection rates decreased with increasing rain acidity [CPG = 1.8 (pH) + 5.4, P < 0.01].

Infected radicle tips (1.0 cm) were enclosed in nylon mesh and buried for 48 hr in soil adjusted to 12-15% moisture with rain solutions. Number of stained sporangia per radicle (SPR) relative to the maximum produced decreased with increasing solution acidity [relative SPR = 0.12 (pH) + 0.20, P < 0.01]. Pc infection and reproduction can be inhibited by acidity levels occurring in ambient rainfall.

A379

EFFECT OF FUNGICIDES IN PHYTOPHTHORA SELECTIVE MEDIA ON GERMINATION AND COLONY FORMATION BY ZOOSPORES OF *PHYTOPHTHORA PARASITICA* VAR. *NICOTIANAE*. H. D. Shew, Dept. of Plant Pathology, N. C. State Univ., Raleigh 27650.

The recovery of single zoospore isolates of *Phytophthora parasitica* var. *nicotianae* (Ppn) is routinely performed on selective agar media containing fungicides and antibiotics. When aliquots of Ppn zoospores were placed on both 5% V-8 agar and selective media, the number of colonies produced on V-8 agar was up to 450% higher than on the selective medium. Tests conducted in well-plates containing 5% V-8 broth plus varying concentrations of the fungicides PCNB and hymexazol indicated that concentrations of PCNB > 20 ppm alone, or all concentrations of PCNB in combination with hymexazol at 20-60 ppm resulted in a small reduction in zoospore germination. However, a high percentage of the germ tubes produced were abnormally short and knobby which may result in reduced colony formation. The use of selective media containing these fungicides may thus result in reduced recovery of Ppn zoospores and selection of single spore isolates tolerant of these fungicides.

A380

INCREASED SOLUBLE MINERAL NUTRIENTS IN SOILS AS RELATED TO INCREASED PLANT GROWTH RESPONSE FOLLOWING SOIL SOLARIZATION. J. J. Stapleton*, J. E. DeVay*, J. Quick†, H. Van Rijckevorsel†, and G. J. DeBoer†, Dept. of Plant Pathology* and Dept. of Land, Air, and Water Resources†, Univ. of Calif., Davis, CA 95616.

Four field soils of different textures were solarized for 6 wk. Maximum soil temperatures during treatment were 44-46 C at 15 cm depth. Following solarization, increased levels (P < 0.05) of NO₃-N and NH₄-N by KCl extraction were found in the 0-15 cm depth range of all soils tested. Increased P (P < 0.05) by 0.5M NaHCO₃ extraction was found in three of the experimental soils, and increased EC, Mg, and Ca (P < 0.05) by H₂O extraction were detected in two of the four soils. Increases in NO₃-N plus NH₄-N were equivalent to 26 kg/ha (+608%) in loamy sand, 60 kg/ha (+137%) in fine sandy loam, 43 kg/ha (+221%) in loam, and 177 kg/ha (+602%) in silty clay soil, as compared to nontreated control soil (0-15 cm depth) of each texture. Increases in plant growth of 32-491% fresh or dry wts. (P < 0.05) were obtained with field or greenhouse-grown pepper and radish plants in each of the solarized soils, as compared to nonsolarized soils.

A381

VARIABILITY IN CABBAGE SEEDLING EMERGENCE. J.G. White, National Vegetable Research Station, Wellesbourne, Warwick, CV35 9EF, UK.

Standard seed tests involving seedling growth rates, mechanical impedance of seedling emergence or leaching of electrolytes from seed sometimes fail to demonstrate large differences in vigour between seedlots. The tests do not take into account the widely differing pathological status of field soils. For example in two soils, one naturally infested with *Pythium irregulare* Buisman and the other with *P. ultimum* Trow., six apparently similar seedlots gave total emergences ranging from 71-87% on the first soil to 37-80% on the second soil. The ranking for emergence was identical for four of the six seedlots. The presence of such fungi may partly account for the variability in emergence of apparently similar brassica seedlots.

A382

FACTORS AFFECTING POPULATIONS OF *MACROPHOMINA PHASEOLINA* IN MISSOURI SOILS. T.D. Wyllie and S.B. McKelvey. Department of Plant Pathology, University of Missouri-Columbia 65211.

Three hundred eighty-five soil samples were collected from commercial soybean fields in 44 counties in northern and southwestern Missouri in the Summer and Fall 1981, and in the Spring 1982 to determine the population of *Macrophomina phaseolina*, the cause of charcoal rot. Correlation and regression analyses were made on soil fertility factors in an effort to explain the observed population densities. Fungal popula-

tions means by season were 15.6, 12.3, and 17.3 sclerotia/g of soil, respectively. Analysis revealed that 31-54% of the variability in pathogen population may be due to soil pH and P and K levels. Crop, crop sequencing, and soil texture account for additional percentages. Higher pathogen levels are observed in soybean monoculture than other systems. Clay soils yield greater numbers of sclerotia than loam or sand.

A383

EFFECT OF GLUCOSE LEVELS ON AMMONIUM PRODUCTION FROM L-ASPARAGINE IN CULTURES OF *BIPOLARIS MAYDIS* RACE T. T. W. Bischoff and M. O. Garraway, Dept. of Plant Pathology, The Ohio State Univ., Columbus, OH 43210 and OARDC, Wooster, OH 44691.

L-asparagine (ASN) and L-aspartate (ASP) were compared as nitrogen sources for ammonium (NH_4^+) production in cultures of *Bipolaris maydis* race T. After 6 days of incubation on a synthetic agar medium containing 10 g/l glucose and 4 g/l ASN NH_4^+ was detected, while on a similar medium containing 4 g/l ASP no NH_4^+ was detected. At 2 g/l the NH_4^+ produced on ASN was significantly higher than at 10 g/l glucose. Also, NH_4^+ was produced on ASP at 2 g/l glucose. To evaluate the contribution of the amide and amino groups of ASN to NH_4^+ production, we substituted butyramide for ASN and gamma-aminobutyrate (GABA) for ASP. With 10 g/l glucose NH_4^+ levels were significantly higher with butyramide than with GABA. In contrast at 2 g/l glucose the NH_4^+ level was higher on GABA than on butyramide. Thus the level of glucose appears to determine whether the amide or amino group is the source of NH_4^+ released from ASN by *B. maydis* race T.

A384

EVIDENCE FOR A DIFFUSIBLE ENDOGENOUS INHIBITOR OF CARPOGENIC GERMINATION IN SCLEROTIA OF *SCLEROTINIA SCLEROTIUM*. W. L. Casale and L. P. Hart, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312

Sclerotia incubated at 15 C in PEG 8000 solutions adjusted to ψ_m of 0, 0.5, 1, 2.25, 3, 4.5 and 8.8 (- bars) had carpogenic germination of 20, 42, 82, 32, 17, 54, 56 and 32%, respectively. Germination in soil adjusted to ψ_m of 0.5, 1, 1.5, 2, 3, 5 and 7 (- bars) was 48, 20, 8, 4, 4, 8 and 4%, respectively. All sclerotia absorbed equal amounts of water at all ψ_m , suggesting the possible involvement of a water soluble inhibitor. When sclerotia were removed from water after 10 days and placed in fresh water or in the concentrated original incubation solution, germination was 30-100% in the former and 0% in the latter. Pre-leached sclerotia incubated in saturated soil germinated 4-5 days earlier than unleached sclerotia, and after 27 days showed 80% germination as compared with 10% for unleached sclerotia. Sclerotia incubated in sterile distilled water that was changed at regular intervals showed 72% germination as compared with no germination of sclerotia in unchanged water.

A385

CASEIN HYDROLYZATE ENHANCES RHIZOMORPH PRODUCTION AND POLYPHENOLOXIDASE ACTIVITY IN *ARMILLARIA MELLEAE*. Garraway, M. O. and D. F. Edwards. Dept. of Plant Pathology, The Ohio State University, Columbus, OH 43210 and OARDC, Wooster, OH 44691.

Growth and rhizomorph production by *A. melleae* were enhanced when casein hydrolyzate (CAS) was substituted for L-asparagine (ASN) in a synthetic agar medium. On ASN media rhizomorphs were produced with a supplement of ethanol (800 $\mu\text{l/l}$) but not with one of guaiacol (200 mg/l). On CAS media abundant rhizomorphs were produced on guaiacol as well as ethanol. Moreover, when guaiacol and ethanol were used simultaneously more rhizomorphs were produced on CAS than on ASN. Polyphenoloxidase (PPO) activity increased, when young undifferentiated thalli were incubated for 72 hr on liquid media supplemented with guaiacol, ethanol or both. In each instance the level of PPO was higher with CAS than with ASN. A supplement of commercial tyrosinase (mushroom PPO) failed to promote rhizomorph growth in synthetic media. Thus, PPO activity appears to be correlated with, but is not the cause of, the growth response of *A. melleae* to casein, guaiacol or ethanol.

A386

LEAF SURFACE ELECTROSTATICS IN THE NATURAL ENVIRONMENT. C. M. Leach Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331.

If active spore discharge by dry-spored foliar fungi involves an electrostatic mechanism as proposed, then it is axiomatic that leaf surfaces become charged. Using a "field mill" to measure electrostatic fields, detached leaves of beans and corn were monitored over a 5 week period (mid-summer) while recording meteor-

ological conditions. Leaves consistently became charged during the daylight hours with increasing charge correlated with humidity and temperature changes. After sunrise there was a gradual increase to a maximum (200-1,500 Vcm^{-1}) during early afternoon. Leaves were usually positively charged during hot, dry weather but on occasions were negative. Rapid loss of charge occurred near sunset as humidity increased and temp. decreased; simultaneously the leaf surface changed from a non-conductor to a conductor. Highest field strengths (ca. 1,500 Vcm^{-1}) occurred on clear sunny days with much lower levels on overcast days. Leaves lacked charges on rainy days and at night. Similar electrostatic patterns were observed for beans, corn, apples, grapes, blackberries, roses, table beets and English laurel.

A387

ELECTROPHORESIS OF RIBOSOMAL PROTEINS AS AN AID IN THE IDENTIFICATION OF *FUSARIUM* SPECIES. J. E. Partridge, Univ. of Nebr., Dept. of Plant Pathology, Lincoln, NE 68583-0722.

Ribosomal proteins of various putative species of *Fusarium* have been found to be reliable indicators of species when analysed on 15% to 25% polyacrylamide gradient electrophoresis slabs in SDS. An extremely high degree of conservation within *Fusarium* species from a global distribution was expressed for majority of plant pathogenic species. However, it would appear that the present species distinction given to some species (e.g. *F. episphaeria*) is too broad to allow the use of the method alone without confirming microscopic examination. This limitation may speak more to the present assemblage of species than to value of ribosomal proteins as aids in identification.

A388

POTASSIUM ION STIMULATES A RISE IN cAMP LEVELS AND STARTS DNA SYNTHESIS IN BEAN RUST GERMLINGS. R. C. Staples and H. C. Hoch, Boyce Thompson Institute, Ithaca, NY 14853; NY State Agricultural Experiment Station, Cornell University, Geneva, NY 14456. The potassium ion is an efficient inducer of differentiation of the bean rust fungus (*Uromyces phaseoli*). Differentiation induced by K^+ can be seen first when the nuclei start to divide. Division begins in the germ tube during the 6th hour of germination. The nuclei in half of the spores have divided by 9.5 h. DNA replication briefly precedes the start of nuclear division. Cyclic AMP levels apparently are closely coordinated with the rate of nuclear division. Treatments with cAMP and its derivatives efficiently induce the start of nuclear division but induce appressoria weakly. The nuclei divide 6 h after treatment with cAMP drugs as they do when stimulated by K^+ . Several inhibitors of cAMP phosphodiesterase induce both nuclear division and infection structures, and they raise the level of cAMP in the spores. We suggest that cAMP is an important element of the controls which start nuclear division and development of infection structures in bean rust uredospore germlings.

A389

CONTACT STIMULI INDUCE WHEAT STEM RUST UREDOSPORE GERMLINGS TO DIFFERENTIATE APPRESSORIA BUT NOT VESICLES. R. C. Staples, H. C. Hoch, and W. K. Wynn, Boyce Thompson Institute, Ithaca, NY 14853; New York State Agricultural Experiment Station, Cornell University, Geneva, NY 14456; University of Georgia, Athens, GA 30602. Wheat stem rust (*Puccinia graminis tritici*) germlings underwent one round of nuclear division (4 nuclei) and formed appressoria abundantly in the grooves of scratched sheets of such materials as polystyrene, polyethylene, or aluminum foil. The infection structures did not develop further. Differentiation also occurred on scratched glass and cellulose, but the frequency of response was low. Complete infection structures (appressorium, peg, vesicle, infection hypha) developed when the germlings were stimulated by heat shock or by acrolein (1.5 nMolar), but the appressoria were not necessarily located in the grooves. These structures had at least 8 nuclei. We concluded that contact stimuli serve to position appressoria over stomata, but that development of the vesicle requires other factors apparently from the host.

A390

SIMULTANEOUS METABOLISM OF THREE ISOFLAVONOID PHYTOALEXINS BY *FUSARIUM*. Y. Zhang and D. A. Smith, Department of Plant Pathology, University of Kentucky, Lexington, Ky, 40546-0091.

Three of the phytoalexins produced by *Phaseolus vulgaris*, phaseollin, kievitone and phaseollinisoflavan, were concurrently metabolized when added to liquid cultures of the bean pathogen, *Fusarium solani* f. sp. *phaseoli*. The products were the known metabolites 1a-hydroxyphaseollone and kievitone hydrate, from phaseollin and kievitone respectively, and a not yet fully char-

acterized compound from phaseollinisoflavan. All three products appeared to be less toxic than their parent compounds. Although the phytoalexins (each at $7.5 \mu\text{g ml}^{-1}$) had all disappeared ca. 30 hr after their introduction to liquid cultures, loss of kievitone was most rapid. Only kievitone was altered when the phytoalexins were added to cell-free filtrates prepared from fungal liquid cultures. Triple metabolism of phaseollin, kievitone and phaseollinisoflavan also occurred when the fungus grew on agar. An ability to accomplish simultaneous detoxification of several host phytoalexins might be important for some pathogens.

A391

SCREENING CANOLA LINES FOR RESISTANCE TO DAMPING-OFF CAUSED BY RHIZOCTONIA SPECIES. S. N. Acharya, J. Dueck, P. R. Verma and R. K. Downey. Res. Stn., Agr. Can., Saskatoon, Sask., Canada S7N 0X2

Two hundred canola (*Brassica napus* L. and *B. campestris* L.) genotypes were screened for resistance to pre-emergence damping-off and to seedling root rot caused by *Rhizoctonia* species. Tests were conducted under a controlled environment which simulated spring soil temperatures in the main canola-growing area of northern Saskatchewan. Percent seedling emergence after 1 week and percent healthy plants after 3 weeks, in soilless mix infested with 35 *Rhizoctonia* isolates (5.7×10^4 viable propagules/L of mix) were the criteria used in evaluating disease reactions. Although none of the genotypes exhibited complete resistance, five *B. napus* and five *B. campestris* genotypes were selected on the basis of their relative resistance. Progenies of the 10 genotypes were more resistant than either Regent (*B. napus*) or Candle (*B. campestris*), the two most commonly grown canola cultivars in Western Canada.

A392

RESISTANCE OF WHEAT TO *Bipolaris sorokiniana*. K.L. Adlakha and S.P. Raychaudhuri. 312, A12 Quaker Church Road, Randolph, N.J. 07869, and C/52 Inderpuri, New Delhi, India.

The inheritance of resistance to *Bipolaris sorokiniana* in wheat was studied in the F_1 and F_2 generations in crosses involving four resistant and four susceptible wheats. The data from the F_1 generation indicated that resistance was dominant. Data from the F_2 generation indicated that resistance was conditioned by two genes in Motia, Line E5895 and Line HD1927, and by one gene in Line DT188. Lesions on resistant cultivars were fewer, smaller and sporulated less than did lesions on susceptible cultivars.

A393

EVALUATION OF SAUERKRAUT CABBAGE FOR RESISTANCE TO XANTHOMONAS CAMPESTRIS PV. CAMPESTRIS AND FUSARIUM OXYSPORUM F.SP. CONGLUTINANS, RACE 1. Paul W. Bosland and Paul H. Williams, Dept. of Plant Pathology, University of Wisconsin-Madison, WI. 53706

Forty entries of cabbage cultivars were tested for resistance to *X. campestris* pv. *campestris*. Five-week-old seedlings grown in the Central Sands area of Wisconsin were inoculated twice, 7 days apart, with isolate PHW 117-2. Resistance was evaluated 44 days after the first inoculation using a 0-9 scale, 0=no symptoms and 9=severe necrosis. All lines were susceptible. Forty-two entries were tested for resistance to *Fusarium oxysporum* f.sp. *conglutinans*, race 1 (PHW 81-2). Five-day-old seedlings were inoculated by dipping roots in a suspension of 1.5×10^4 mycelial fragments and spores. Seedlings were transplanted to washed silica sand and placed in a controlled temp. tank at 24°C with 24 hrs. illumination at $250 \mu\text{Es}^{-1}\text{M}^{-2}$. Plants were watered daily with 0.5X Hoaglands. After 14 days, interaction phenotypes were classified using a 0-9 scale, 0=no symptoms and 9=dead. Variation in susceptibility between and within entries was observed. Yield, head quality, and maturity were evaluated in the field.

A394

INFLUENCE OF LOW TEMPERATURE ON THE EXPRESSION OF SOME *Puccinia recondita:Triticum* CORRESPONDING GENE PAIRS. L. E. Browder and M. G. Eversmeyer, USDA-ARS, Dept. of Plant Pathology, Kansas State University, Manhattan, KS 66506.

Seedlings of *Triticum aestivum* lines Lr1(TC), Lr16(TC), Lr17(TC) and Thatcher (abbrev. TC) were infected with *P. recondita* cultures C3(Lp1Lp16Lp17) and C21(Hp1Hp16Hp17), then exposed to 0, 2, 4, and 8 days at 20 C before transfer to 5 C for the remainder of a 61 day period. Low infection types (IT) occurred on C3/Lr1(TC) at the 2, 4, and 8 day treatments, on C3/Lr17(TC) at the 4 and 8 day treatments, and on C3/Lr16(TC) at the 8 day

treatment. C21 produced high ITs on all lines at all temperature treatments. Development of low ITs expressed at 12 days after infection were partially reversed with time on C3/Lr1(TC) in the 2 day treatment, on C3/Lr17(TC) in the 4 day treatment, and on C3/Lr16(TC) in the 8 day treatment. We conclude that *P. recondita:Triticum* gene pairs Lp1/Lr1, Lp16/Lr16, and Lp17/Lr17 do not function at 5 C. Further, at 20 C Lp1/Lr1 functions during the first 2 days after infection, Lp17/Lr17 between 2 and 4 days after infection, and Lp16/Lr16 between 4 and 8 days after infection.

A395

UREDIOSPORE GERMINATION AND GROWTH OF PUCCINIA RECONDITA IN LEAVES OF RESISTANT AND SUSCEPTIBLE WHEAT CULTIVARS. Kan Fa Chang and Roland F. Line, Dept. of Plant Pathology, Washington State Univ. and ARS, USDA, respectively, Pullman, WA 99164.

Urediospore germination, appressorium formation, and growth of *Puccinia recondita* were studied on 10 spring wheat cultivars (CVS) with different resistances to leaf rust. At 10 C, maximum germination and infection occurred within 12 hrs after inoculated plants were placed in a dew chamber. Urediospore germination and appressorium production were lower on some CVS, but the low germination and appressorium formation were not related to the resistance that is expressed by low infection types. On adult plants of CV Wampum, spore germination and appressorium formation was greater at the base than the tips of the leaves. No significant differences in the rate of fungal growth were observed up to 4 days after inoculation of susceptible and resistant CVS, but subsequent growth was slower in leaves of the most resistant CVS. Thus, *P. recondita* germination and appressorium formation on leaves and growth within leaves may be related to the resistance of the CVS.

A396

COMPARISON OF THE REACTION OF SPRING BARLEY TO COMMON ROOT ROT BETWEEN NORTHWESTERN ALBERTA AND CENTRAL SASKATCHEWAN. L. J. Duczek, Agriculture Canada Research Station, 107 Science Crescent, Saskatoon, Saskatchewan, Canada, S7N 0X2.

The ranking of spring barley cultivars and lines for reaction to common root rot was generally similar at Beaverlodge and Fort Vermilion in northwestern Alberta, and at Saskatoon and Scott in central Saskatchewan, but the level of disease differed between locations. Although disease rating and grain yield loss were not always correlated, increased disease intensity was associated with increased yield loss. Yield loss was related to the reduction in number of heads. Isolations from subcrown internodes from Beaverlodge yielded *Fusarium culmorum* as or more frequently than *Cochliobolus sativus*, while at other locations *C. sativus* was isolated more frequently. There was no difference in pathogenicity between isolates from northwestern Alberta and central Saskatchewan in greenhouse tests. The study shows that selection for common root rot resistance in spring barley could be done at any location in western Canada.

A398

CONTROL OF BROWN STEM ROT (CAUSED BY PHIALOPHORA GREGATA) WITH CONCOMITANT INCREASE IN YIELD BY CONTINUOUS CROPPING OF RESISTANT SOYBEAN. A. H. Epstein, J. D. Hatfield, and H. Tachibana. Dept. of Plant Pathology, Seed and Weed Science, and USDA-ARS, Iowa State Univ., Ames, IA 50011

Brown stem rot (BSR) resistant soybean cultivar 'BSR 301' and susceptible 'Oakland' were grown continuously for 5-yrs on land that initially had 100% plant infection in a susceptible cultivar. BSR incidence (plant infection) and severity (extent of stem browning) decreased after BSR 301 but not with Oakland. The decrease provided BSR levels lower than the resistance of BSR 301. When four susceptible cultivars (Cumberland, Oakland, Williams 79 and Williams 82) were grown on the BSR 301 or low BSR land, disease incidence and severity averaged 50.0 and 19.0 %, respectively, and 74.4 and 36.1% following Oakland. Average yield for the four susceptible cultivar was 10% greater on BSR 301 than on Oakland land. These results were obtained in a year of the highest average rainfall which precluded any moisture stress at the critical stage of pod filling. Thus, the higher yields are attributed to reduction in BSR.

A399

ACCUMULATION OF SOYBEAN ISOFLAVONOIDS AND ISOFLAVONE GLUCOSIDES IN LEAVES INOCULATED WITH A VIRULENT OR AN AVIRULENT STRAIN OF XANTHOMONAS CAMPESTRIS PV. GLYCINES. W. Fett, Eastern Regional Research Center, 600 E. Mermaid Lane, Philadelphia, PA 19118

Bacterial growth and the accumulation of stress metabolite isoflavonoids (glyceollin, daidzein, formononetin, and coumestrol) and isoflavone glucosides (daidzin, ononin, and genestin) in soybean leaves of cvs. Clark (susceptible) and Clark 63 (resistant) inoculated with either an avirulent or a virulent strain of *Xanthomonas campestris* pv. *glycines* (Xcg) were examined each of four days after inoculation. Growth of the avirulent Xcg strain S-9-8 was greatly restricted when compared to that of the virulent Xcg strain XP 175 in either cultivar. However, only the virulent strain induced significant accumulation of stress metabolites. The levels of isoflavonoids and glucosides induced were similar in both cultivars with glyceollin isomers (up to 100 µg/g fr wt) and daidzin (up to 115 µg/g fr wt) accumulating to highest levels.

A400

RESISTANCE TO *PHYTOPHTHORA MEGASPERMA* f.sp. *MEDICAGINIS* IN THE DIPLOID ALFALFA, *MEDICAGO FALCATA* L. M.J. Havey and D.P. Maxwell, Department of Plant Pathology, University of Wisconsin Madison, WI 53706.

Inheritance of resistance to *Phytophthora* root rot was studied in the diploid ($2n=2x=16$) alfalfa species *M. falcata* L. The S_1 families of resistant plants and the F_1 and backcross families of resistant by susceptible plants contained resistant plants. The *M. falcata* resistance is dominant and heritable. Three methods are being attempted to transfer the *M. falcata* resistance from the diploid (2x) to the tetraploid (4x) level: direct doubling by colchicine treatments; 2x-4x crosses using a 4x *M. sativa* plant as the pollen parent, the triploid (3x) progeny are then backcrossed to the 4x parent; and crosses between *M. falcata* and 2x plants derived by haploidization of a resistant 4x *M. sativa* plant, followed by 2x-4x crosses. The latter method should increase the probability of sexual polyploidization, due to unreduced gamete formation in the 2x *M. falcata-sativa* hybrid.

A401

EVALUATION OF RAPID-CYCLING CRUCIFERS FOR RESISTANCE TO SELECTED PATHOGENS. Curtis B. Hill and Paul H. Williams, Department of Plant Pathology, University of Wisconsin, Madison, WI 53706.

Crucifer genetics stocks (CGS), developed for rapid generation time, were evaluated for seedling resistance to selected pathotypes of *Albugo candida* (Ac), *Fusarium oxysporum* f.sp. *conglutinans* (Foc), *Peronospora parasitica* (Pp) and *Plasmodiophora brassicae* (Pb). Tests with Foc were conducted in silica sand, Pb in peat-lite and Ac and Pp in *Teghniculture*TM trays at 24°C under continuous light of 250 µEm⁻²s⁻¹. Nearly all *Brassica campestris* (CGS-1) seedlings were immune or hypersensitive to 2 Pp pathotypes, Ac races 1 and 2 and Foc races 1 and 2 and reactions to Pb race 6 varied widely. Most *B. nigra* (CGS-2) seedlings were immune or hypersensitive to 2 Pp pathotypes, Foc race 1 and Ac race 1, susceptible to Foc race 2 and varied widely to Ac race 2 and Pb race 6. *B. juncea* (CGS-4) seedlings were fully susceptible to Ac race 2 and Pb race 6, mostly resistant to Foc races 1 and 2 and varied in reaction to 2 Pp pathotypes. Other crucifer genetics stocks were tested and selections were made to study the inheritance of resistance.

A402

HISTOLOGY OF *BOTRYOSPHAERIA DOTHIDEA* HYPHAE IN THE XYLEM OF DROUGHT-STRESSED VS. NONSTRESSED *BETULA ALBA* STEMS. John M. McPartland and Donald F. Schoeneweiss, Illinois Natural History Survey, Champaign, Illinois 61820.

Stems of drought-stressed (xylem water potential <-1.2 MPa) and nonstressed (xylem water potential >-0.05 MPa) *B. alba* seedlings were wound-inoculated with an isolate of *B. dothidea* (ATCC # 42212). Hyphal growth was extensive (> 20 mm) in vessel lumens of stressed stems but remained within 5 mm of inoculation points in nonstressed stems. No morphological barriers to hyphal growth were observed in stained sections under the light microscope or SEM. SEM examination of specimens prepared by several methods demonstrated that hyphae were thinner, less branched, deposited less adhesive material, and exhibited a greater frequency of hyphal tip swelling and bursting in nonstressed stems than those predisposed by drought stress.

A403

SENSITIVITY OF TOBACCO PROTOPLASTS AND CELLS TO CULTURE FILTRATES OF *PHYTOPHTHORA PARASITICA* VAR. *NICOTIANAE*. Sally A.

Miller and David A. Evans, DNA Plant Technology Corporation, 2611 Branch Pike, Cinnaminson, NJ 08077.

Protoplasts isolated from tobacco cultivars possessing different levels of quantitatively-inherited resistance to black shank disease were viable 1 hr after treatment with filtrates (diluted 1:2 with protoplast culture medium) from 12-day-old cultures of races 0 and 1 of *Phytophthora parasitica* var. *nicotianae* (Ppn). One day after treatment, 85-90% of the protoplasts from all of the cultivars tested were killed. Resistant and susceptible cultivars were also equally sensitive to more dilute filtrates. Five-day-old tobacco cells were killed by 1:2 dilutions of Ppn filtrates within 24 hr after treatment, but with more dilute filtrates, cultivars with high resistance to Ppn were less sensitive than susceptible cultivars. Cells of the cultivar Coker 319 (low black shank resistance) were more sensitive to culture filtrates from Ppn race 1 than race 0. Protoplast-derived cells may provide a better means of screening resistant cells than freshly isolated protoplasts.

A404

INHERITANCE OF ADULT-PLANT, TEMPERATURE-SENSITIVE RESISTANCE TO STRIPE RUST IN PACIFIC NORTHWEST WHEATS. Gene Milus and Roland F. Line, Dept. of Plant Pathology, Washington State University and ARS, USDA, respectively, Pullman, WA 99164.

Gaines, Nugaines, and Luke winter wheats have durable, high-temperature, adult-plant resistance to Pacific Northwest races of *Puccinia striiformis*. Parental, F_1 , F_2 , and backcross populations from reciprocal crosses between resistant cultivars and crosses with a susceptible line were evaluated in the field. Infection type and rust intensity on each of the 8,000 plants were recorded three times during the season. Intensity data were transformed to area under the disease progress curve (AUDPC). Resistance was recessive with no maternal inheritance. Most gene action for AUDPC was additive. Dominance and epistatic effects were significant in some crosses. Narrow heritability ranged from 25-68%, and the estimated number of resistance genes ranged from two-three in crosses not showing epistasis. Based on infection type, there are at least two resistance genes in each cultivar, but they are not all identical.

A405

THE USE OF SUB-LETHAL DOSAGES OF SYSTEMIC FUNGICIDES TO EVALUATE HOST GENOTYPES FOR RATE-REDUCING RESISTANCE. R. R. Nelson, Department of Plant Pathology, The Pennsylvania State University, University Park, PA 16802.

Evaluating and ranking large numbers of host genotypes as potential sources of rate-reducing resistance can be tedious and time-consuming when conventional methods of evaluating each genotype for several resistance parameters are used. Working with rice blast and stem rust and powdery mildew of wheat, we have devised a relatively simple technique to identify rate-reducing resistance. Leaves of host genotypes are sprayed with varying sub-lethal dosages of the appropriate systemic fungicides 48 hr prior to inoculation with a given pathogen. Host genotypes with the greatest amount of rate-reducing resistance are those that require the least amount of fungicide to bring the amount of disease to zero. Non-treated controls identify and, thus, eliminate lines with race-specific resistance.

A406

DEVELOPMENT OF FROGEYE LEAFSPOT LESIONS ON SOYBEAN LEAVES. D. V. Phillips, Department of Plant Pathology, Georgia Experiment Station, Experiment, GA 30212.

Small lesions or flecks on soybean leaves infected with *Cercospora sojae* Hara are considered a resistant reaction, while large lesions are considered a susceptible reaction. Lehman (J. Agr. Res. 36:811-833) and the Compendium of Soybean Diseases (APS, 1982) describe lesion development as expanding from minute reddish brown spots to larger lesions with light centers and dark borders. Thus, a plant might be rated resistant when lesions are small and susceptible after they enlarge. Time-lapse photography was used to determine lesion development on Bragg soybeans inoculated with *C. sojae* race 5. Final size and shape of lesions was generally discernable on the first day that any part of the lesion was visible. The entire border of large lesions was not always sharply delineated at this time. Small lesions or flecks on resistant plants or together with larger lesions on susceptible plants did not increase in size. No progression of lesion size was observed on over 70 cultivars inoculated with 5 races of *C. sojae*.

A407

TISSUE CULTURE-INDUCED VARIATION IN CELERY FOR FUSARIUM YELLOWS. G. S. Pullman and L. Rappaport, Dept. of Plant Pathology and Vegetable Crops, University of California, Davis, CA 95616.

Celery plants regenerated from Tall Utah 5270R callus suspension cultures were highly variable in their development & expression of Fusarium wilt. After 10 wks in *Fusarium oxysporum* f. sp. *apii* (Race 2) (FOA)-infested soil in the greenhouse, plants were rated on a 0 (no vascular discoloration) to 7 (dead) scale. Regenerated plants obtained ratings from 0 to 7; plants from 5270R seed were rated as 6 or 7. A plant selection system was developed where small regenerated plants were placed on FOA precolonized water agar plus Murashige & Skoog salts. The few plants surviving after one month were transferred to a growth medium containing Benlate, allowed to increase in size, planted in the greenhouse in FOA-infested soil and rated for disease. The percentage of regenerated plants with low (0-3) disease ratings was increased by prescreening on FOA-colonized agar from 5.6% in 180 plants not prescreened to 25.0% in 64 prescreened plants (surviving from approx. 3500). Plants rated 0-2 are currently being tested to determine if disease tolerance/resistance is genetic.

A408

RESISTANCE IN RED KIDNEY BEANS TO WISCONSIN'S BEAN ROOT ROT COMPLEX. R. E. Rand, W. F. Pfender, and D. J. Hagedorn, Dept. of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

Crops of Wisconsin red kidney beans (*Phaseolus vulgaris* L.) are troubled with a root rot incited by *Pythium* spp. and *Aphanomyces euteiches* f. sp. *phaseoli*. In 1980-81 greenhouse (gh) tests, 100 red kidney bean plant introductions (PIs) were assayed for reaction to *Aphanomyces* by dipping roots of 9-day-old seedlings in inoculum of 5×10^3 zoospores/ml and incubating at 24-26°C for 14 days. Seventeen PIs which showed a promising level of resistance were tested in 2 infested fields in 1981 and again in 1982—a commercial field near Menominee, WI, and a highly infested *Aphanomyces* plot at UW Hancock Experimental Farm. Five of the 10 best lines from the gh performed very well, indicating root rot resistance. They are red kidney bean PIs 209488, 313454, 309758, 209492 and 312068.

A409

LEAF RUST RESISTANCE IN AEGILOPS SQUARROSA, ITS TRANSFER AND EXPRESSION IN COMMON WHEAT (*TRITICUM AESTIVUM* L.). W. J. Raupp, L. E. Browder, and B. S. Gill, Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

Fifty-three *Aegilops squarrosa* accessions were tested to *Puccinia recondita* and 24 of these gave a 03C to 23X infection type (IT). Accessions 1691 (09N IT), 1695 (03C IT), and 1649 (09N IT), were hybridized with Wichita (99P IT) and F₁ hybrids obtained using embryo rescue. The 3 F₁ hybrids gave 78X, 99P, and 14C IT respectively. The F₁ plants were backcrossed, selfed and BC₁F₂ seed was obtained. 1691 gave rise to 2 BC₁F₂ lines, the first segregated 78X and 99P IT and the other 67X with chromosome numbers 45-50 and 42 respectively. 1695-derived BC₁F₂ plants were all 99P IT with chromosome numbers of 39-42. 1649, which showed resistance in the F₁ plants, segregated 23X-56X, 78X, and 99P IT with chromosome numbers of 39-42. The lack of, or altered, expression of resistance may have been caused by chromosome loss and/or gene inhibition. These data indicate that it is possible to transfer disease resistance directly from wild species into common wheat.

A410

DETECTION OF RESISTANCE TO POWDERY MILDEW (*ERYSIPHE PISI*) IN *PISUM SATIVUM* ISOLINES. P. W. Reeser, D. J. Hagedorn and D. I. Rouse, Dept. of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

Four pea (*Pisum sativum* L.) isolines, Wisconsin 7101, 7102, 7103 and 7104, resistant to *Erysiphe pisi* DC and their respective susceptible parents, Sprite, Dark Skin Perfection, New Era and New Line Early Perfection, were tested for reaction in a laboratory procedure. Powdery mildew conidia were applied in a liquid carrier to excised leaves through a Schein inoculator to deliver ca 50 conidia/cm². A 1 meter high settling tower facilitated quantitative and uniform conidial application. Conidial germination, appressorium formation, and fungus colony development were determined. In 3 of the isolate pairs, resistance was expressed at conidial germination stage, but more strikingly and uniformly the

appressoria on resistant peas were unable to establish fungus colonies.

A411

VERTICILLIUM GROWTH ON XYLEM SAP FROM ENVIRONMENTALLY STRESSED MAPLE TREES. F. J. Regulski, Jr. and J. L. Peterson, Agr. Res. Ctr. Monticello, Fla. 32344 and N. J. Ag. Exp. Sta., Rutgers University, New Brunswick, N.J. 08903.

Soil around Norway maple trees was treated with high rates of S, K, N, and NaCl. Roots of some trees were also wounded by trenching. Sap taken at dormant, bud-swell, bud-break, and full-leaf stages was used as a growth medium for *V. dahliae*. Data were taken on conidial, microsclerotial and mycelial production. Growth and sporulation increased on sap from control trees peaking at bud-break and declined at the full-leaf stage. Fungal growth was greater on sap from trees treated with S, K, and N. Maximum growth occurred on bud-break and full leaf saps in the S and N treatments. Growth on sap from NaCl and trench treated trees was reduced at all stages. Changes in the tree environment and growth stage altered the ability of maple sap to support fungus growth and sporulation. N.J. Ag. Exp. Sta. No. K-11410-1-83.

A412

A RECURRENT SELECTION POPULATION FOR LEAF RUST RESISTANCE IN BARLEY. Reinhold, M., E. L. Sharp and H. E. Bockelman, Dept. of Plant Pathology, Montana State University, Bozeman, MT 59717.

A male sterile facilitated recurrent selection population (RSP) was used to pyramid resistance genes to barley leaf rust. Manchurian msg and fifteen 6-rowed cultivars representing diverse genoplasm and wide adaptability were chosen as a base population. Resistance sources for leaf rust were identified from the world collection of barley and handcrossed into the base population. During the first cycle the plants were grown in disease nurseries at many locations and only resistant plants were harvested. In the following winter the RSP was grown in isolation. Only seed from male sterile plants was harvested. This cycle was repeated several times. The system is open ended and new resistance sources can be added at any time. Resistance to leaf rust in the RSP increased an average of 10 percent per double cycle. By exposing the population to a wide array of virulence of leaf rust in the different disease nurseries a broad based type of resistance should be obtained.

A413

HEAT SHOCK ENHANCES PEROXIDASE ACTIVITY IN CUCUMBERS AND INDUCES RESISTANCE TO *CLADOSPORIUM CUCUMERINUM*. B.A. Stermer and R. Hammerschmidt, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Immersion of cucumber seedling shoots in a 50 C water bath for 40 seconds resulted in enhanced peroxidase activity and increased resistance to *C. cucumerinum*. Heat shock induced resistance could be demonstrated by inoculating seedlings as soon as 6 hours after treatment and lasted for at least 4 days. Enhanced peroxidase activity in heat shocked seedlings appeared within 24 hours of treatment and was present for at least 5 days. Physiological changes correlated with disease resistance produced by heat shock were similar to changes seen in cucumbers with resistance induced by biological agents. Electrophoresis of soluble peroxidases showed that most of the increase in enzyme activity after heat shock was in the fast-moving anodic isozymes. Increased epidermal lignification in response to fungal penetration was also seen in shocked plants. The data suggest that heat shock and biological agents may induce resistance by similar mechanisms.

A414

RESISTANCE TO *ERYSIPHE GRAMINIS TRITICI*, *PUCCINIA RECONDITA TRITICI*, AND *SEPTORIA NODORUM* IN WILD *TRITICUM* SPP. J. R. Tomerlin, M. A. El-Morshidy, and J. G. Moseman, USDA, ARS, Field Crops Laboratory, PGGI, BARC-W, Beltsville, MD 20705.

Eighty-four *Triticum* accessions, (comprising 23 spp.) were evaluated for resistance to a culture of *P. recondita tritici* (PRT), two composites of *E. graminis tritici* (EGT) cultures, a composite of *S. nodorum* (SN) cultures, and a single virulent culture of SN. The PRT culture and EGT composites possessed most of the virulence genes found in the U.S. Resistance was rated on a scale of 0 (immune) to 9 (susceptible). Rating distributions were bimodal for the PRT culture and both EGT composites; almost normal for the SN composite; and skewed toward susceptibility for the virulent SN culture. Resistance to SN was correlated to

resistance to EGT (r=55). The data suggest that *T. carthlicum* may be a good source of resistance to EGT, *T. monococcum* may be a good source of resistance to PRT and EGT, and *T. timophevi* may be a good source of resistance to all three pathogens. Seven of nine accessions showing resistance to all three pathogens were highly pubescent.

A415

DETERMINATION OF THE RESISTANCE TO ROOT-ROT DISEASE (PHYTO-PHTHORA CAPSICI) ON SOME PEPPER VARIETIES COMMONLY GROWN IN TURKEY. S. Tuzun, O. Yegen, S. Iren, Department of Plant Pathology, University of Kentucky, Lexington, Ky 40546 and Department of Phytopathology, Faculty of Agriculture, University of Ankara, Diskapi, Ankara, Turkey.

The resistance of the ten most commonly cultivated Turkish and nine European and American pepper varieties against *Phytophthora capsici* was tested in the greenhouse. Stems of 1 month-old pepper seedlings were transversely cut above the 7th-8th expanded leaf and inoculated with a disc of mycelium grown on carrot agar. After 18 hr necrosis of the stem became apparent and the length of the necrosis was measured at three day intervals. Twelve days after infection, the length of necrosis on the Turkish variety "Izmit Biberi" was 30-60% that on other varieties. After 3 weeks, necrosis reached soil level and caused plant death in all varieties except "Izmit Biberi". This variety also showed considerable resistance to soil inoculations.

A416

ASSOCIATION OF RESISTANCE TO RHYNCHOSPORIUM SECALIS, PYRENOPHORA TERES AND ERYSIPIHE GRAMINIS IN BARLEY COMPOSITE CROSS II. R. K. Webster and M. A. Saghaimarouf, Department of Plant Pathology, Univ. of Calif., Davis, CA 95616.

Parents, random samples of generations and progenies of 50 randomly chosen plants (50 families) from each of 4 generations (F₈, F₁₃, F₂₃, F₄₅) of barley Composite Cross II were tested for reaction to *P. teres*, *E. graminis* and 4 races of *R. secalis*. Frequency of resistant plants increased from the earliest to the latest generation in all cases with the exception of one race of *R. secalis*. There were significant positive correlations between resistance to races 40, 61, and 74 of *R. secalis* in the parental types and in all 4 generations. Resistance to *P. teres* showed significant positive correlations with 3 races of *R. secalis* in F₂₃ but decreased by F₄₅. Significant correlation between resistance to *R. secalis* and *E. graminis* was not observed in any of the generations. Families derived from later generations carried combinations of multiple resistance not observed among the parents indicating the generation and conservation of germplasm for use in breeding programs.

A417

MULTIPLE INOCULATION OF CUCUMBER (CUCUMIS SATIVUS L.) COTYLEDONS. A. J. Wyszogrodzka and P. H. Williams, Dept. of Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

Optimal conditions for microinoculations of cucumber seedlings with anthracnose (*Colletotrichum orbiculare*), scab (*Cladosporium cucumerinum*), downy mildew (*Pseudoperonospora cubensis*) and angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*) were studied. Interaction phenotypes obtained following inoculation of 2 day post-emergence seedlings grown in vermiculite at 26/21°C, 14 hr photoperiod, light intensity of 250 $\mu\text{E}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, permitted differentiation between resistant and susceptible genotypes of cucumber cultivars GY 14, Wisconsin SMR 18 and Straight 8. Cotyledons were inoculated with 1000 spores of *C. orbiculare*, 50 zoospores of *P. cubensis*, 100 spores of *C. cucumerinum*, each applied in 1 μl of distilled water, and by pricking with a toothpick dipped in a suspension of 2.2×10^7 CFU/ml of *P. syringae* pv. *lachrymans*. Plants were incubated in the dark for 48 hr at 20°C, 100% R.H. Highly localized symptoms developed 6 days after inoculation. This inoculation technique facilitated the study of multiple pathogen interactions.

A418

EFFECT OF VIRUS INFECTION ON THE ACTIVITY OF PROTEASES IN TOBACCO LEAVES. Z. K. Xu and S. J. Sheen, Department of Plant Pathology, University of Kentucky, Lexington, Ky. 40546

Leaf proteases of Samsun and Samsun NN tobacco were prepared from fraction 2 protein and acetone powder. Protease activity, which was stable for 2 hrs at 40°C, was present in fractions with molecular weight greater than 10 kd and remained constant for 2 hours at 40°C. Studies of the effects of protease acti-

vators and inhibitors revealed that thioproteases followed by metalloproteases are the predominant types in tobacco leaf. TMV infection enhanced protease activity significantly in Samsun NN at 22°C. This response was not observed in Samsun NN when infected with TMV at 30°C or with potato virus X at 22°C. At either temperature, infection of Samsun nn with the same viruses did not alter protease activity. A low molecular weight fraction (<10 kd) from virus-infected Samsun NN inhibited papain activity, whereas the corresponding fraction of Samsun increased papain activity.

A419

RESPONSE OF PLANTS TO ACIDIC MIST OR FOG. A. L. Granett, L. J. Ross and E. C. Smith, Statewide Air Pollution Research Center, University of California, Riverside, CA 92521.

Phytotoxicity of acidic mists or fogs similar to rocket engine exhaust was tested by applying hydrochloric acid (HCl) to plants using a device which produces 10 to 1000 μm dia. droplets. Localized burns, appearing ca. 30 min after applications, formed bifacial necrotic lesions within 24 hr. Size of lesions varied with acid conc. All plant species tested were sensitive to single, 10 min episodes of 1% HCl (pH 0.7) acid mists. Significant leaf injury occurred with 0.002% HCl (pH 3.2) for radish, 0.025 (pH 2.0) for zinnia and marigold, 0.012% (pH 2.3) for nasturtium, and 0.1% for pinto bean plants. Above-ground parts and fleshy roots of radish plants exposed to 0.5 and 1% HCl (pH 1.0 and 0.7), respectively, weighed significantly less than controls. Leaves cut from mature lemon trees showed injury when exposed to 0.1% HCl mist whereas lemon flowers, buds, and fruit were injured following exposure to 0.5 or 1% HCl. HCl aerosols caused visible injury on exposed plants raising the possibility that certain naturally-occurring fogs may also be phytotoxic.

A420

IMPACT OF OZONE FUMIGATION ON METABOLITE LEVELS IN CULTIVARS OF SOYBEAN WITH DIFFERING TOLERANCE TO OZONE. J. L. Hess, L. D. Moore and B. I. Chevone, Dept. of Biochem. & Dept. of Plant Path. & Physiol., VPI & SU, Blacksburg, VA 24061.

Soybean cultivars identified as sensitive, Dare (S), and tolerant, Williams (T), were fumigated 4h/d for 4d with 80 ppb O₃ at 28±2°C, 80±5% R.H., and 400 $\mu\text{E}/\text{m}^2$ PAR. Leaf tissue was extracted with 5% trichloroacetic acid and levels of total glutathione and ascorbic acid determined. Although leaf damage was not observed the S cultivar responded within 72-96h with a significant increase in glutathione and a decrease in ascorbate levels. The T cultivar had a significant increase in ascorbate, but no change in glutathione levels. Data are consistent with a response to an elevated flux of electrons through the oxygen reduction pathway which utilizes both ascorbate and glutathione to catalyze hydrogen peroxide reduction. Comparisons with cultivars having intermediate sensitivity to ozone revealed that tolerance was not correlated with the absolute concentration of these metabolites but with the ability of the leaf to metabolize pools of the metabolites.

A421

EFFECTS OF LIGHT, WATER AND POLLUTANT STRESSES ON GROWTH OF YELLOW POPLAR SEEDLINGS. Keith F. Jensen. USDA Forest Service, 359 Main Road, Delaware, Ohio 43015.

One-year-old yellow poplar (*Liriodendron tulipifera* L.) seedlings were grown in outdoor chambers in either full sunlight or under 30% shade cloth. They were watered either daily, twice a week, or once a week. Seedlings from each of these six treatment combinations were exposed to one of four fumigation treatments: control, 0.1 ppm O₃, 0.2 ppm SO₂, or both 0.1 ppm O₃ and 0.2 ppm SO₂. Fumigations ran for 12 hours a day 2 days a week. Ten seedlings were harvested from each of the 24 treatment combinations at 4-wk intervals to construct leaf area, leaf weight, and total seedling weight growth curves. Analysis of covariance showed significant differences among the growth curves for all three variables. Relative growth variables were calculated from the curves. Relative growth rate and relative leaf area growth rate decreased with increased light intensity, increased water stress, and with fumigation treatment in the following order: control, SO₂, O₃, and O₃ plus SO₂.

A422

OZONE AND NaCl SPRAY INDUCE EPIDERMAL CHANGES IN PINE NEEDLES

Charles R. Krause and Aiden M. Townsend, USDA, ARS and Leon S. Dochinger, USDA, USFS, 359 Main Rd., Delaware, OH 43015.

Scanning electron microscopy (SEM) and energy dispersive X-ray

analysis (EDX) were used to determine if epidermal changes could be detected on pine needles, previously exposed to NaCl and ozone (O₃). Ramets of ponderosa pine (*Pinus ponderosa* Law.) and eastern white pine (*Pinus strobus* L.) were exposed to either; clean air + H₂O spray; O₃ + H₂O spray; clean air + NaCl; or O₃ + NaCl. Fumigations were conducted in open-top chambers in 1980 (5pphm for 8 weeks) and in 1982 (30pphm, for 10 weeks). NaCl was applied daily only to needles as a 2% spray in 1981 and as a 20% spray in 1982 for 2 weeks. Needles of both species exposed to clean air + H₂O spray were asymptomatic. O₃ + H₂O spray caused epidermal injury to both species. Clean air and NaCl induced coalesced wax on both species. O₃ + NaCl caused severe wax degradation associated with NaCl accumulation on *P. strobus* but not on *P. ponderosa*.

A423

IMPACT OF OZONE ON GRAIN YIELD OF WINTER WHEAT AND SORGHUM. L. W. Kress and J. E. Miller, RER Division, Argonne National Laboratory, Argonne, IL 60439.

Field-grown plants of three varieties of winter wheat (*Triticum aestivum* L.) and one hybrid of grain sorghum (*Sorghum vulgare* Pers.) were exposed daily to O₃ in open-top chambers. The wheat plants were exposed between 8 May and 2 July 1982 to seasonal 7-hr average (0900-1600 CST) O₃ concentrations of 0.041 ppm (open plots), 0.023 ppm (charcoal-filtered air), and 0.041, 0.068, 0.095, or 0.122 ppm (unfiltered air with O₃ added). While Roland was the highest yielding variety in the filtered-air, it was the most O₃-sensitive, exhibiting a 15% reduction in the 0.041 ppm chamber treatment and a 48% reduction at 0.095 ppm. The respective yields for Abe were +8% and -36%, and for Arthur 71 were +3% and -24%. The sorghum (DeKalb A28+) was exposed between 16 July and 8 October to four O₃ concentrations above an ambient of 0.040 ppm. Yield reductions were slight even at the two highest O₃ treatments (0.102 ppm: 10% and 0.129: 15%).

A424

SENSITIVITY OF PONDEROSA PINE, JEFFREY PINE AND GIANT SEQUOIA SEEDLINGS TO OZONE AND SULFUR DIOXIDE MIXTURES. P. R. Miller, USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507 K. W. Stolte and O. C. Taylor, Statewide Air Pollution Research Center, University of California, Riverside, CA 92521

Two-year-old ponderosa and jeffrey pine and 5-month-old giant sequoia were fumigated in open top chambers 8 hours daily, 6 days per week with ozone (10, 20, 30, and 40 ppm), sulfur dioxide (5, 10, 15, 20 and 25 ppm) and mixtures of ozone plus sulfur dioxide (10+5, 10+10, 10+20, 20+5, 20+10 and 20+20 ppm). After 8 weeks injury was evaluated as the % of total needle surface area with chlorotic mottle or necrosis. Average injury from mixed gases was 2.8, 6.6, and 1.7 times greater than the sum of the injury from single gases for ponderosa pine, jeffrey pine and giant sequoia respectively. Pine was most sensitive to the 20+20 ppm mixture, giant sequoia was most sensitive to 40 ppm ozone. The average injury to the three species was 46 percent from 20 ppm ozone + 5 ppm sulfur dioxide. This illustrates that additive injury may result from ambient pollutant mixtures.

A425

CELL WALL AND PROTOPLAST PEROXIDASE ACTIVITIES IN LEAVES OF TWO HYBRID POPLAR CLONES THAT DIFFER IN SUSCEPTIBILITY TO OZONE INJURY. Roy L. Patton and Michael O. Garraway. USDA Forest Service, 359 Main Road, Delaware, OH 43015 and Dept. of Plant Pathology, The Ohio State University, Columbus, OH 43210.

Twelve-week-old rooted cuttings of clones NE-50 (*Populus maximowiczii* x *P. berolinensis*) and NE-207 (*P. deltoides* x *P. trichocarpa*) were placed in open-topped field chambers with and without 15 ppm ozone. After 2 weeks, leaves at the 15th node of each clone were examined for ozone injury and peroxidase activity (PA). NE-50 had higher total PA and showed larger increases in PA after exposure to ozone than NE-207. NE-50 also exhibited the earliest and most severe injury after exposure to ozone. Separation of total PA into cell wall and protoplasmic fractions revealed that NE-50 had the largest proportion of PA in the protoplasmic fraction, whereas NE-207 had the largest proportion in the cell wall fraction. Ozone did not alter the distributions. Thus, clones of hybrid poplar that differ in sensitivity to ozone appear to differ in total PA and in the proportions of PA in protoplasmic and cell wall fractions.

A426

EFFECTS OF SEQUENTIAL O₃ AND SO₂ EXPOSURE ON NET PHOTOSYNTHESIS AND STOMATAL CONDUCTANCE IN SOYBEAN. Y. S. Yang and B. I.

Chevone, Dept. of Plant Path. & Physiol., VPI & SU, Blacksburg, VA 24061.

Soybean (*Glycine max* (L.) Merr.) cv. Essex plants, 21-24 d old, were exposed to 0.20 µl/l O₃ and/or 0.70 µl/l SO₂. Exposure was administered for 2 h either as single pollutants, simultaneously or in sequential pollutant combinations (SO₂ was added with O₃ at the end of the 1st h during a 2-h O₃ fumigation and vice versa). At the end of a 2-h exposure, O₃ and SO₂ reduced net photosynthetic (Pn) by 9 and 10%, respectively. Exposure of O₃ then O₃+SO₂, SO₂ then SO₂+O₃, and continuous O₃+SO₂ significantly inhibited Pn by 38, 59, and 67%, respectively. A 2-h exposure of O₃ or SO₂ induced a 4 and 6% decrease in stomatal conductance, respectively. Sequential pollutant combinations resulted in less-than-additive effects on stomatal conductance whereas the simultaneous mixture of O₃ and SO₂ resulted in a significant synergistic effect compared to single pollutant exposures.

A427

THE EFFECT OF TRICHODERMA HAMATUM ON THE SPORULATION CAPACITY OF COCHLIOBOLUS SATIVUS LESIONS EXCISED FROM WINTER WHEAT SEEDLING LEAVES. C.L. Biles and J.P. Hill, Dept. Botany & Plant Path., Colorado State University, Fort Collins, Colorado 80523.

Wheat seedlings were sprayed with a sterile water suspension of *Trichoderma hamatum* conidia (1x10⁶/ml) and then with a sterile water suspension of *Cochliobolus sativus* conidia (1x10⁴/ml), at the rate of 0.7ml/plant. Inoculated plants were placed in a dew chamber for 24 hrs and transferred to the greenhouse. Five days later, individual *C. sativus* lesions were excised from live leaves, grouped according to size and placed in petri dishes containing moist filter paper. Sporulation proceeded in the dark at room temperature. Three days later the lesions were transferred to 25 ml test tubes containing 5 ml of 0.05 copper sulfate solution. After agitation, 0.1 ml aliquots of the conidial suspension were placed on 1 by 2 cm strips of water agar and the conidia counted. Sporulation capacity (SC) was calculated as number of conidia per lesion. The SC of lesions obtained from *T. hamatum* treated plants was significantly less than the SC of comparable lesions obtained from untreated plants.

A428

CHLAMYDOSPORE FORMATION BY TRICHODERMA SPP. IN ORGANIC MATTER-AMENDED SOIL. S. D. Cohen, J. A. Lewis, G. C. Papavizas and G. A. Bean. USDA, ARS, Beltsville, MD 20705 and Dept. of Botany, Univ. of Maryland, College Park, MD 20742

Abundant chlamydo-spores of species of *Trichoderma* formed in oats in sterile soils after conidia were added. A benomyl resistant isolate of *T. viride* (T-1-R9) formed 10⁶ chlamydo-spores/g of oats after adding conidia to oat-amended soils (1 x 10⁷ c/g of soil). Conidia added to plant tissues (corn and bean) or soil amended with plant tissue (oats) produced 10-20% of the total chlamydo-spores, indigenous *Trichoderma* species represented another 10%, and the remainder were produced by unidentified fungi. Chlamydo-spore formation of introduced *Trichoderma* isolates on organic matter, observed by fluorescent microscopy, showed that intercalary or terminal chlamydo-spores were formed from conidia in alfalfa and oat tissues. The fact that chlamydo-spores form in plant tissues and organic debris suggests that organic matter is an ecological niche for chlamydo-spore formation and survival in soil.

A429

VIABILITY OF TRICHODERMA HARZIANUM STORED IN FLUID DRILLING GELS AT FOUR TEMPERATURES. Kenneth E. Conway. Department of Plant Pathology, Oklahoma State University, Stillwater, OK 74078.

Fluid drilling of germinated vegetable seeds contained in gels has advantages over dry seeding or using transplants. Incorporation of biological control agents into gel allows for infestation of the rhizosphere at plant. Delays in planting may necessitate storage of gel for several days. Viability of *Trichoderma harzianum* was assessed in three gel products; Laponite 508, Laponite 445, and Polysurf-C at four temperatures (5,16,20 and 25C). *Trichoderma harzianum* was added to each gel at the rate of 1x10⁷ conidia/ml. Initial densities of viable conidia, determined by a most probable numbers technique, ranged from 7.8-13.3x10⁵ conidia/ml in each gel. Gels were incubated in the dark at the four temperatures and densities of viable propagules and gel pH were determined at 0,2,7 and 10 days. No significant changes in numbers of viable propagules were recorded. The pH decreased in the Laponite gels (9.9-8.0) but increased in Polysurf-C (6.5-7.5).

A430

USE OF ANTIBIOTIC RESISTANT MUTANTS FOR TRACKING APPLE PHYLLOPLANE MICROBES IN SITU. D. Cullen and J.H. Andrews, Dept. of Plant Pathology, University of Wisconsin, Madison, WI 53706.

Acriflavine resistant (acr^R) strains of *Aureobasidium pullulans* and *Microspheeropsis olivacea*, rifampicin^R (rif^R) strains of actinomycete A-11 and *Flavobacterium* sp., and a streptomycin^R actinomycete A-13 produced spontaneously or induced (UV, MNNG) were sprayed individually onto apple trees in an orchard. All populations declined precipitiously, except acr^R *M. olivacea*, which was present at $>3 \times 10^4$ colony forming units/g leaf tissue two weeks after application. In separate experiments, benomyl^R strains of *Chaetomium globosum*, *Trichoderma viride*, and *M. olivacea* were sprayed onto apple trees. Spray treatments consisted of single strains, single strains with later benomyl sprays, mixes of parental and ben^R strains, and mixes with later benomyl sprays. Without benomyl, no differences in ben^R and w^R survival were observed. With fungicide, susceptible parents and natural mycoflora rapidly declined, but no enhancement of ben^R populations was measured.

A431

ANTAGONISM OF *VENTURIA INAEQUALIS* (= *SPILOCAEA POMI*) BY *CHAETOMIUM GLOBOSUM*. D. Cullen, J.H. Andrews, and F.M. Berbee, Dept. of Plant Pathology, University of Wisconsin, Madison, WI 53706.

Fifty bacterial and fungal isolates from McIntosh apple leaves were screened in petri plates, agarose-covered slides, and seedling trials for antagonism to *Spilocaea pomi*. A *Chaetomium globosum* strain which produced a heat labile, agar-diffusible toxin, was highly antagonistic in all tests. Toxin sensitivity did not differ among 37 *S. pomi* strains. Cell-free culture extracts and *C. globosum* ascospore suspensions significantly reduced *S. pomi* infection in growth chamber studies. In field trials conducted two consecutive seasons, ascospore suspensions (10^6 /ml) were sprayed on young apple trees at a frequency recommended for commercial fungicides. At intervals during the growing season, scab lesions were counted, and *C. globosum* populations were determined by leaf washing onto selective media. High populations of *C. globosum* persisted (2 weeks) on leaf surfaces. Relative to water controls, *C. globosum* sprays significantly decreased scab severity.

A432

EFFECTS OF SOIL SOLARIZATION AND OF AMENDING SOIL WITH SOYBEAN MEAL ON POPULATIONS OF THREE SOIL-BORNE FUNGI. J. Cummings Zarnstorff, Department of Natural Resources, Madison, WI, 53711 and J. G. Berbee, Department of Plant Pathology, University of Wisconsin, Madison, WI, 53706.

Amending nursery soil with 1 or 2% soybean meal in sealed test tubes greatly reduced after 2-3 weeks, populations of *Rhizoctonia solani* and *Cylindrocladium floridanum*. Amending soil with soybean meal (2 or 4%) increased populations of *Fusarium oxysporum* for 10 days but after 20-30 days decreased populations much below levels in nonamended soil. However, in the nursery, amending tarped soil with 2% soybean meal failed to reduce populations of soil-borne pathogens. Tarping nursery soil at Boscobel, WI with clear 2-mil polyethylene increased soil temperature by 8-15 C to 30 cm, and incorporating 2% soybean meal into plots elevated soil temperatures by an additional 2-3 C. Extrapolation from equations relating air temperature to soil temperature indicated that an air temperature of about 36 C would be required to achieve a temperature of 40 C at a depth of 17 cm in tarped, soybean meal-amended soil.

A433

THE LEVEL OF INDUCED SYSTEMIC RESISTANCE IN CUCUMBER CULTIVARS IS REVEALED BY INCREASING CONCENTRATIONS OF CHALLENGE INOCULUM R. A. Dean and J. Kuć, Department of Plant Pathology, University of Kentucky, Lexington, Ky 40546

Systemic resistance in cucumber was induced by inoculating the first true leaf with spores of *Colletotrichum lagenarium*, race 1. One week later, the second leaf was challenged with either, 10^4 , 10^5 , 10^6 , 10^7 or 2×10^7 spores ml^{-1} . Lesion size and number were consistently smaller on induced plants than on controls for a given concentration of challenge inoculum. Induced resistance was evident at all concentrations of challenge inoculum. The cultivar SMR-58 was more resistant than Marketer and the level of induced resistance was higher in the former. In both, the number and size of lesions on control plants, challenged with 10^5 spores ml^{-1} , were similar to those on induced plants challenged with 10^7 spores ml^{-1} .

A434

ORDINATION ANALYSIS OF THE FUNGI DECOMPOSING SCLEROTIA OF SCLEROTINIA MINOR. M. T. Dunn, Dept. of Botany, Univ. of Maryland, College Park, MD 20742 and R. D. Lumsden, USDA, ARS, BARC, Beltsville, MD 20705

Sclerotia of *Sclerotinia minor* were buried in eight soils in the field. Their survival and the fungi colonizing them were monitored monthly for one year. The numbers of sclerotia decreased rapidly in some plots but not others. Over 60 species (40 genera) of fungi were associated with the sclerotia and were isolated and identified. The frequency of occurrence of the fungi and their association with decline in sclerotial numbers formed the basis for an ordination of the plots using principal components analysis. This method groups associated species together. Fungi characterizing the plot with the greatest decline of sclerotia included a sterile dark mycelial fungus, *Gliocladium virens*, *Chaetomium aureum*, and *Codinaea heteroderae*. These and others of the most frequently occurring isolates were tested for biocontrol ability. An ecological approach is suggested by this method for selection from thousands of isolates those most likely to succeed for biocontrol of disease.

A435

DECREASED PHYTOPHTHORA ROOT ROT OF SOYBEANS FROM SEED TREATED WITH *ACTINOPLANES MISSOURIENSIS* OR *A. UTAHENSIS*. A. B. Filonow and J. L. Lockwood, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Actinoplanes missouriensis and *A. utahensis*, actinomycetous hyperparasites of *Phytophthora megasperma* f. sp. *glycinea* (Pmg) oospores, were tested in the greenhouse for their ability to decrease *Phytophthora* root rot of soybeans. Seed (cv. 'Corsoy') were coated with hyperparasites in 1% carboxymethyl cellulose + 1% soluble starch (w/v in water) and planted in Capac loam soil naturally infested with Pmg or in Capac loam artificially infested with Pmg at 400 oospores/g soil. After one month, stands and root weights of plants from seed treated with either organism were nearly twice those of plants from nontreated seed. Disease severity was also markedly reduced. Aqueous suspensions of the hyperparasites were applied to soil (ca. 5×10^8 CFU/g soil) and incubated for one week. This treatment gave decreased inoculum densities of Pmg, as determined by a soil-dilution, seedling-baiting assay.

A436

EVALUATION OF MICROBIAL AGENTS FOR THE CONTROL OF BLACK ROOT OF SUGARBETS. A. B. Filonow, J. L. Lockwood and C. L. Schneider, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Actinoplanes missouriensis, *A. utahensis*, *Amorphosporangium auranticolor*, *Micromonospora* sp., *Humicola fuscoatra* and *Hyphochytrium catenoides* were evaluated in the greenhouse as biocontrol agents against black root disease (*Aphanomyces cochlidioides*) on sugar beet. Seed (US H20) were coated with test microbes in 1% carboxymethyl cellulose + 1% soluble starch (w/v in water) and were planted in Capac loam soil artificially infested with 50 oospores/g soil or in a naturally-infested soil. *A. utahensis* and *H. fuscoatra* most consistently increased emergence and reduced post-emergence damping-off, sometimes significantly ($P=0.05$), when compared with non-coated controls. *H. fuscoatra* added to infested soil (ca. 1×10^6 conidia/g soil) resulted in a decreased inoculum density of *A. cochlidioides*, as determined by a soil-dilution, seedling-baiting assay. Seed coated with *H. fuscoatra* also gave increased emergence ($P=0.05$) in a naturally infested field.

A437

SURVIVAL OF ASCOSPORES AND CONIDIA OF *TALAROMYCES FLAVUS* IN FIELD SOIL AND PYRAX®. D. R. Fravel, Dept. of Botany, Univ. of Maryland, College Park, MD 20742, G. C. Papavizas, and J. J. Marois, USDA, ARS, Beltsville, MD 20705

Survival of *T. flavus* which suppresses *Verticillium* wilt of eggplant and potato, was studied in laboratory and field experiments. Ascospores of a wild-type isolate of *T. flavus* and benomyl-resistant biotype derived from the wild-type survived better than conidia when stored in Pyrax® (typrhylite) at -5, 5, 15, 25 or 35 C for 150 days, when the experiment was terminated. Optimum survival occurred at 25 C. However, when potato seed-pieces were dusted with the Pyrax® preparations and planted in a field, conidia of both isolates survived better in the rhizosphere than ascospores of the same isolate up to 54 days when the experiment was terminated. Similar results were obtained when the benomyl-resistant biotype alone was added to field soil in the laboratory and

stored at -5, 5, 15, 25 or 30 C for up to 150 days. Survival was best at 5 and 15 C.

A438

BACILLUS LICHENIFORMIS PRODUCES AN INDUCIBLE, WATER-SOLUBLE ANTIBIOTIC(S) AGAINST TAN SPOT OF WHEAT. D. W. Gabriel, Plant Pathology Dept., Oklahoma State Univ., Stillwater, OK 74078.

B. licheniformis (BL), a gram-positive, spore-forming bacterium, is known to protect wheat leaves against tan spot caused by Pyrenophora trichostoma when both organisms are applied concurrently on leaves (Gough, et al, Phytopath 71:876). We evaluated the biocontrol potential of BL cultures, washed cells, and culture filtrates applied at various times before and after inoculation with the pathogen. Several conclusions emerged. First, once the fungus was established on the leaf, our BL treatments delayed disease progress by 2-3 days. Second, BL culture filtrates were almost as effective as cultures with cells. Third, BL treatments lost effectiveness against subsequent inoculations with the fungus in 48 hrs. Finally, we found one BL strain that produces much more antibiotic activity when grown in the presence of the fungus than when grown by itself. This suggests that antibiotic production may be regulated and that strains may be developed for increased antibiotic production.

A439

SURVIVAL OF AMERICAN CHESTNUT TREES: EVALUATION OF BLIGHT RESISTANCE AND VIRULENCE IN ENDOTHIA PARASITICA. G. J. Griffin, F. V. Hebard, R. W. Wendt and J. R. Elkins, Dept. of Plant Pathol. & Physiol., VPI & SU, Blacksburg, VA 24061.

Large (25 to 114 cm DBH), surviving American chestnut trees in the natural range were evaluated from 1978 to 1982 for blight resistance and/or the presence of low-virulence (hypovirulent) strains of E. parasitica. Canker length measurements following inoculation of virulent E. parasitica on grafted scions, seedlings and excised stems indicated that some surviving trees are blight resistant. In situ inoculation trials of virulent E. parasitica on large, surviving trees indicated that superficial canker development also is an important character associated with blight resistance. The incidences of isolates with low virulence in the E. parasitica populations from large, surviving trees and small, stump-sprout trees in Virginia-West Virginia, were 14.9 and 4.3%, respectively, while the incidences of intermediate-virulence strains were 13.2 and 2.6%, respectively. Many American chestnut trees may survive because of the combined effects of blight resistance and low virulence in E. parasitica.

A440

EFFECT OF SOIL MATRIC POTENTIAL ON COLONIZATION OF WHEAT ROOTS BY A PSEUDOMONAS SP. SUPPRESSIVE TO TAKE-ALL. W. J. Howie and R. J. Cook, Dept. Plant Path., Wash. State U., Pullman, WA.

A Pseudomonas sp. suppressive to Gaeumannomyces graminis var. tritici on wheat roots was applied to wheat seed at 6.1×10^6 colony forming units (CFU) per seed and the seed then planted in nonsterile silt loam maintained at -0.01, -0.05, -0.1, -0.3, -0.5, and -0.7 bars matric potential. After 10 days at 16°C, populations of the bacteria on the seed were approximately the same and unchanged for all treatments. The population on the first 1-3 cm of root below the seed at -0.01 and -0.05 bar was only one-tenth that at -0.1 to -0.7 bar (e.g., 1.9×10^4 CFU/cm at -0.05 and 1.8×10^3 CFU/cm root at -0.01 bars). The population on roots 7-9 cm below the seed at -0.01, -0.05, -0.5, and -0.7 bars was only one-tenth that at -0.1 and -0.3 bars (e.g., 1.2×10^3 CFU/cm at -0.3 compared with 1.2×10^6 and 3.3×10^6 CFU at -0.05 and -0.7 bars, respectively. Colonization in soil wetter than -0.05 bars was probably limited by lack of oxygen. Although maximum colonization was at -0.1 to -0.3 bars, colonization probably can occur to about -1 bar matric potential.

A441

BIOLOGICAL CONTROL OF COLLAR ROT CAUSED BY PHYTOPHTHORA CACTORUM. W. J. Janisiewicz and R. P. Covey, Washington State University Tree Fruit Research Center, Wenatchee, WA 98801.

Pseudomonas spp. inhibitory to Phytophthora cactorum were isolated from orchard soil. A method of biological control of collar rot was developed using a siderophore producing Pseudomonas 3A17. When decayed bark was removed from the lesion and the bacterium from King's B medium was applied, spread of the lesion was arrested and callus was formed resulting in healing. In vitro, the bacterium inhibited fungal spread by siderophore production. Extract from soil inoculated with 3A17 was more inhibitory to growth of P. cactorum than extract from noninoculated soil.

Iron chloride soil amendment stimulated the reproduction of 3A17, but extract from this soil was not more inhibitory to the growth of P. cactorum than those from noninoculated soils. Soils differed greatly in their ability to retain siderophore.

A442

EFFECT OF SPHACELOTHECA HOLCI INFECTION ON MORPHOLOGY AND COMPETITIVENESS OF SORGHUM HALEPENSE. C. L. Massion and S. E. Lindow, Department of Plant Pathology, University of California, Berkeley, CA 94720.

Teliospores of Sphacelotheca holci-infected Johnson grass (Sorghum halepense) systemically with high frequency through wounds in stems of mature plants in greenhouse inoculations (up to 62% infection). No infection of two varieties of Sorghum vulgare and one variety of Sorghum sudanense was obtained in greenhouse tests. The height of field-grown smutted S. halepense was significantly less than healthy plants (99.2 cm vs 152.4 cm, respectively). The aboveground biomass and lateral rhizome expansion was also significantly lower in field-grown smutted plants compared to healthy plants (270 g/plant vs 591 g/plant) and (6300 cm² vs 20,000 cm²), respectively. The aboveground biomass of smutted S. halepense grown in the greenhouse with Zea mays was significantly lower than healthy plants (7.3 g/plant and 12.3 g/plant, respectively) and both were significantly lower than comparable plants grown without Z. mays competition. A similar interaction of stress due to S. holci infection and plant competition on rhizome extension of S. halepense was measured.

A443

BIOLOGICAL CONTROL OF SCLEROTINIA WILT OF SUNFLOWER BY TALAROMYCES FLAVUS. D.L. McLaren and S.R. Rimmer, Dept. of Plant Science, Univ. of Manitoba, Winnipeg, Manitoba R3T 2N2, and H.C. Huang, Agric. Canada Res. Stat., Lethbridge, Alberta T1J 4B1. The interaction between Sclerotinia sclerotiorum and Talaromyces flavus was examined. Greenhouse trials indicated that T. flavus was capable of destroying sclerotia of S. sclerotiorum. Sclerotinia wilt of sunflower was reduced in treatments where T. flavus was used. Results at two locations showed that T. flavus was also effective in the field. When T. flavus inoculum was buried with sclerotia the number of sclerotia recovered was reduced. Recovered sclerotia, infected or killed by T. flavus, were greater in treated than in untreated plots. T. flavus reduced sclerotinia wilt when added to the soil. At one location the percentage of disease in the T. flavus-treated plots was 3.8% compared to 47.2% in the control. Yields of treated compared with untreated plots were 2870 kg/ha and 2350 kg/ha respectively. Similar results occurred at the second location. The percentage disease in treated plots was 26.6% compared with 81.4% in untreated plots. Yields of treated compared to untreated plots were 2140 kg/ha and 1430 kg/ha respectively.

A444

EFFECT OF COMPOST MATURITY ON THE INDUCTION OF SUPPRESSION TO RHIZOCTONIA DAMPING-OFF OF RADISH BY TRICHODERMA HARZIANUM. E. B. Nelson, G. A. Kuter and H. A. J. Hoitink, Department of Plant Pathology, The Ohio State Univ., OARDC, Wooster, OH 44691.

Induction of suppression of Rhizoctonia damping-off by Trichoderma harzianum was examined in container media amended with batches of composted hardwood bark (CHB) that differed in stage of decomposition. Although T. harzianum induced high levels of suppression in media amended with mature (44-wk-old) CHB heated to 60 C for 5 days, it had no significant effect in media amended with heated fresh bark (FB) or with heated green (3 wk or 6-wk-old) CHB. Rapid decline in the number of viable Rhizoctonia solani propagules was associated with disease suppression in mature CHB. However, disease suppression could not be correlated with development of high populations of T. harzianum. Populations of T. harzianum increased in media amended with all ages of CHB yet high levels of suppression were found only in the media amended with mature CHB. These results suggest that intrinsic properties of the composts, and not simply abundance of T. hamatum were critical for suppression.

A445

PUCCINIA CARDUORUM, A POTENTIAL BIOCONTROL AGENT OF MUSK THISTLE. D.J. Politis and W.L. Bruckart, Plant Disease Research Laboratory, USDA-ARS, P.O. Box 1209, Frederick, MD 21701.

Isolates of P. carduorum from Eurasia have been evaluated for potential use in biocontrol of musk thistle (Carduus nutans). Under greenhouse conditions, plants 4-6 weeks old were highly susceptible to P. carduorum. Leaves of inoculated plants developed pustules 7-8 days after inoculation, and became chlorotic

within 12-14 days. Infected leaves usually died within 20 days after inoculation. Maximum number of pustules developed with dew periods of 12-16 hr at 17 or 20.5C. Good infection occurred from 11.5-24C with 8 or more hr dew and some infection developed at 7.5C and with as little as 4 hr dew. No infection occurred at temperatures of 27C and above. *C. nutans* plants inoculated 3 and 4 times at weekly intervals had lighter root systems (fresh and dry weights) than plants inoculated only once or twice. These results indicate that *P. carduorum* can infect musk thistle under conditions of dew and temperature common in North America.

A446

CONTROL OF BROWN ROT WITH A *BACILLUS* BACTERIUM. P. L. Pusey and C. L. Wilson, USDA-ARS, Southeastern Fruit and Tree Nut Research Station, Kearneysville, WV 25430.

A *Bacillus* species (B-3) originally isolated from colonies contaminating laboratory cultures was shown to inhibit *Monilinia fructicola* in culture and greatly reduce brown rot when applied to stone fruits. Peaches, nectarines, apricots, and plums were wounded, treated with bacterial suspensions as a spray or dip, dried, then spray-inoculated with a spore suspension of the fungus. B-3 concentrations of 10^6 or greater viable cells per ml were effective at temperatures ranging from 5 to 30 C. Both wounded and non-wounded fruit were protected even when inoculation with fungal spores was delayed for 1 week following treatment. B-3 culture filtrate protected fruit against brown rot better than did thoroughly washed B-3 cells suspended in water, although it did not protect as well as did cells resuspended in diluted filtrate. B-3 and/or its antibiotic may have potential use in the postharvest control of brown rot.

A447

PEACH BARK FUNGAL MICROFLORA IN WESTERN COLORADO, Steven D. Savage, Colorado State University, OMRC, 3168 B $\frac{1}{2}$ Road, Grand Junction, CO 81503

Isolations were made by bark washing and from plating of surface sterilized bark pieces of two peach cultivars near Grand Junction, Colorado. More than 500 isolates representing 15 genera were identified. Greater taxonomic diversity was associated with collections from more mature portions of trees and there were qualitative differences between the taxa isolated from the two cultivars. In simple dual culture screenings, approximately 30% of the isolates were inhibitory to growth of the peach pathogen *Cytospora leucostoma*. Substantial variation was observed in the relative inhibition expressed by morphologically similar isolates of several genera, and at least some representatives of most genera were inhibitory. The most prevalent fungi isolated were yeast-like fungi and hyphal/yeast-like types of varying pigmentation. Also prevalent were isolates of *Cladosporium*, *Microsphaeropsis*, *Alternaria* and *Coryneum*.

A448

PHYTOPHTHORA MEGASPERMA VAR. GLYCINEA SUPPRESSIVE SOIL OF SOYBEAN. H. Tachibana, J. D. Hatfield, and P. M. Higley. USDA-ARS and Dept. of Plant Pathology, Seed and Weed Science, Iowa State Univ., Ames, IA 50011

Phytophthora megasperma var. *glycinea* race 1 (Pmg-1) caused severe damage to soybean plants 10-yrs ago in a field at the Iowa State University Curtiss Farm near Ames and then the disease decreased in severity with continuous cropping of soybeans. In 1972, three resistant soybeans averaged 670 kg/h more than their near isogenic susceptible lines which were severely affected with the root rot. In 1980, the soil was re-infested with Pmg-1 and planted with susceptible soybeans, but no significant disease occurred. In 1982, severe *Phytophthora* root rot occurred in many plots and fields in the vicinity but no root rot kill appeared in the field soil suspected of suppressiveness. A greenhouse test was conducted with the soil to test for suppressiveness. Soil from a Pmg-1 problem field in 1982 and the suspect soil were inoculated with Pmg-1 and planted with susceptible 'Pike' cultivar. Statistically significant higher stands were obtained with the suspected soil than the control.

A449

A NEW TECHNIQUE WHICH IMMUNIZES AGAINST BLUE MOLD (*PERONOSPORA HYOSCYAMI* F. SP. *TABACINA*) AND INCREASES GROWTH OF TOBACCO S. Tuzun and J. Kuć, Department of Plant Pathology, University of Kentucky, Lexington, Ky 40546

Conidial suspensions of *Peronospora hyoscyami* f. sp. *tabacina*

or distilled water were injected into the stems of 2-2.5 month-old tobacco plants grown in the greenhouse. Injections were made into the tissue external to the cambium. Plants infected by this technique were protected 95-99% against disease caused by subsequent inoculation with the pathogen. Protection was based on the area of necrosis and amount of sporulation. Immunized unchallenged plants at the start of flowering were approximately 40% taller, had a 30% increase in fresh weight and 5-7 more leaves than control plants. Immunized plants flowered 2-3 weeks before control plants.

A450

BIOTIC AGENTS FOR CONTROL OF APPLE CROWN ROT. R.S. Utkhede, Agriculture Canada, Research Station, Summerland, B.C. VOH 1Z0

Twenty-one isolates of a bacterium, *Bacillus subtilis*, and one of an unidentified bacterium were tested for antagonism to six isolates of *Phytophthora cactorum*, causal agent of apple crown rot, on corn meal agar (CMA). All of the bacterial isolates produced diffusible antibiotics antagonistic to the growth of all *P. cactorum* isolates. The antagonists were further evaluated in a replicated greenhouse trial for their ability to control crown rot infection on McIntosh apple seedlings. Five isolates of *B. subtilis* markedly reduced the number of infections by *P. cactorum*. Protection from infection with *P. cactorum* isolates was better with exotic *B. subtilis* isolates compared to local isolates. Local isolates Ph01 and Ph03 of *P. cactorum* were significantly more virulent compared with Barr 153 and Barr 333 from soils in eastern Canada. No correlation was observed between width of inhibition zone *in vitro* and protection from *P. cactorum* infections. The level of protection provided by some of these *B. subtilis* isolates in pot trial suggest a potential for control of apple crown rot.

A451

PATHOLOGY AND HISTOLOGY OF *ALTERNARIA CASSIAE* IN BIOCONTROL OF SICKLEPOD IN NORTH CAROLINA SOYBEANS. C. G. Van Dyke and B. C. Haning, Dept. Plant Pathology, N. C. State Univ., Raleigh 27650.

As part of a regional field test, seedlings of sicklepod (*Cassia obtusifolia*) in the cotyledon to first leaf stage were sprayed with a formulation of 10^6 conidia of *Alternaria cassiae*/ml plus 0.02% sterox. This was a natural population of sicklepod in soybeans. Within 5 days, 100% of the seedlings were infected, and 96% were rated as killed; surviving plants were severely stunted. When two applications of spores were made, 7 days apart, 99% kill was achieved 14 days after the initial inoculation. Light and scanning E.M. studies revealed that each conidium produced 1-7 germ tubes of variable length. Terminal appressoria formed with equal frequency over stomata or on the cuticle surface. Host mesophyll cells beneath appressoria became necrotic soon after formation of appressoria, but penetrations were observed only occasionally. Necrosis extended to cells adjacent to those beneath appressoria, suggesting the effects of a diffusible toxin.

A452

THE RELATIONSHIP OF TRIFLURALIN TO COLLAR ROT OF TEXAS GOURD CAUSED BY *FUSARIUM SOLANI* F. SP. *CUCURBITAE*. Su-May Yu and G.E. Templeton. Dept. of Plant Pathology, University of Arkansas Fayetteville, AR 72701.

In greenhouse tests, technical grade trifluralin at field rates (0.5 to 1.0 μ g/g) in soil artificially infested with *Fusarium solani* f. sp. *cucurbitae* resulted in earlier and greater incidence of collar rot of Texas gourd. In liquid culture, trifluralin at concentrations of 0.5 to 50 μ g/ml increased mycelial growth of the fungus after 12 days incubation. Carbon dioxide evolution increased in sterilized soil cultures infested with the fungus and amended with trifluralin at 2.5 or 10 μ g/g. Higher levels, 25 to 50 μ g/g retarded CO $_2$ evolution for 12 days, but not thereafter. Carbon dioxide evolution in sterile soils treated with trifluralin paralleled population change of the fungus in unsterile trifluralin-treated soils. Virulence of the fungus was not enhanced by growing inoculum in media containing trifluralin. Incidence of collar rot was not increased by pre-treatment of seedlings with field rates of trifluralin prior to inoculation.

A453

ZEARALENONE IN SORGHUM FRACTIONATED BY DENSITY SEGREGATION. M. Babadoost¹, K. Tyczkowska¹, W.M. Hagler, Jr.¹, D.S. Bowman², and W.E. Huff³. Departments of Poultry Science¹ and Crop Science², N.C. State Univ., Raleigh, NC 27650 and USDA-ARS Poultry

Research Laboratory³, RD 2, Georgetown, DE 19947.

Nine samples of 1982 sorghum (ca 2.8 kg each) from North Carolina were harvested, dried, and segregated into a fraction buoyant in water (7.4% of original samples based on weight), a fraction buoyant in 30% NaCl but not water (2.2% of samples weight), and a fraction nonbuoyant in either liquid (90.4% of samples weight). Fractions were immediately dried, ground, and analyzed for zearalenone. Zearalenone concentrations in fractions buoyant in water ranged from 317-1791 ppb (\bar{X} =672); those of fractions buoyant in brine ranged from 121-1102 ppb (\bar{X} =320) while zearalenone was not detected in nonbuoyant kernels (limit of detection ca 20 ppb). Zearalenone levels calculated for the original samples ranged from 30-123 ppb. Buoyant fractions were clearly enriched in zearalenone; those buoyant in water or in brine and those nonbuoyant in brine contained 87, 13, and 0% of the zearalenone in the samples.

A454

ELISA DETECTION OF TRICHOHECENES IN SPIKED AND *FUSARIUM* INFECTED CORN EXTRACTS. E.H. Gendloff*, J.J. Pestka**, and L.P. Hart*. Departments of *Botany and Plant Pathology and **Food Science, Michigan State University, East Lansing, MI 48824.

Antibodies against a hemi-succinate derivative of T-2 toxin (T-2HS) were used in a competitive ELISA procedure. In a phosphate buffered saline solution containing 10% (v/v) methanol (MPBS), the trichothecenes T-2, T-2HS, HT-2, and deoxynivalenol (DON) were detected at ca. 50, 50 and 100 pg/ml and 50 ng/ml, respectively. Non-infected and *Fusarium*-infected corn were extracted in 60% methanol, diluted to various degrees with MPBS, and tested by the ELISA method. Thin layer chromatography was used with infected samples to determine T-2 and DON concentrations. When spiked into diluted, non-infected extract, T-2 and DON were detected by ELISA at ca. 50 pg/ml and 100 ng/ml, respectively. When *F. tricinctum*-infected corn was extracted, diluted, and assayed by ELISA, T-2 was detected at the same concentration as in spiked extracts. When *F. roseum* infected corn was treated similarly, the DON present was not detected by ELISA.

A455

COLONIZATION OF MAIZE EARS BY *ASPERGILLUS FLAVUS*. S. F. Marsh and G. A. Payne, Dept. of Plant Pathology, N. C. State University, Raleigh, NC 27650.

Field studies were conducted in 1981-82 in NC to determine the rate and nature of colonization of corn ears by *Aspergillus flavus*. Non-inoculated and silk-inoculated ears were sampled throughout the season. Ears were split transversely into tip, middle and base sections and samples of silks, kernels and cob from each third were aseptically plated onto a selective medium. *A. flavus* growth generally proceeded from the tip towards the base, colonizing the silks first, then the glumes and crowns of kernels (by late milk stage), but rarely into the cob pith. Internal infection of kernels did not appear until early dent stage. A more intensive study of silk-inoculated ears involved the systematic plating of all silks and kernels from the ear in order to completely map silk and kernel surface colonization as well as insect damage. Distribution of *A. flavus* was clustered and correlated ($r \geq 0.67$ for six of eight harvest dates) with infection of adjacent silk bundles, but was not correlated with insect damage.

A456

RELATION OF DROUGHT SOIL TEMPERATURES TO INVASION AND AFLATOXIN PRODUCTION IN PREHARVEST PEANUTS BY THE *ASPERGILLUS FLAVUS* GROUP T. H. Sanders¹, R. J. Cole¹, P. D. Blankenship¹, and R. A. Hill²
¹National Peanut Research Laboratory, 600 Forrester Drive, Dawson, GA 31742; ²University of Georgia, Tifton, GA 31793.

Factors related to enhanced *Aspergillus flavus* group invasion and aflatoxin production in preharvest, drought stressed peanuts have been studied for three years. Soil, plant and peanut pod temperatures increased substantially in drought conditions and pod temperatures reached a higher maximum and lower minimum than soil temperature each day. When drought pod temperatures were at or near the optimum for *A. flavus* growth (ca. 35 C), aflatoxin concentrations increased. Aflatoxin concentration in edible grade peanuts was positively correlated to late season, mean geocarposphere temperatures from ca. 26 C (1981) to 32 C (1982), the range in which aflatoxin production occurred. Percentage of edible kernels infected by *A. flavus* increased from 14.3 in the irrigated treatment to 72.7 in the drought treatment in 1981. Infection percentage and aflatoxin concentration were inversely proportional to peanut maturity and seed size, respectively.

A457

PLASMID TRANSFER FROM *RHIZOBIUM JAPONICUM* TO *PSEUDOMONAS SYRINGAE* PV. *SYRINGAE*. Aruna K. Alahari and Anne K. Vidaver, Dept. of Plant Path., Univ. of Nebraska, Lincoln, NE 68583.

Gentamycin and rifampicin resistant markers were introduced into strain 5D4132 of *Pseudomonas syringae* pv. *syringae* by conjugal transfer from an extra slow-growing strain of *Rhizobium japonicum*. The frequency of transfer was approximately 2.1×10^{-8} per recipient cell. Plasmid transfer occurred only in plate matings; neither filter matings nor liquid culture matings were successful. Transconjugants acquired a plasmid of about 57 Mdal; no plasmid was detected in recipients. In addition to acquired antibiotic resistance, transconjugants produced much more diffusible yellow-green pigment on rich medium, with or without antibiotics. Gentamycin resistance was unstable, as assessed by serial transfer under non-selective conditions.

A458

ESTIMATION OF LEVELS OF HETEROZYGOSITY FOR VIRULENCE GENES IN POPULATIONS OF BEAN RUST, *Uromyces phaseoli* VAR. *typica*. Helen Miller Alexander, J.V. Groth, and A.P. Roelfs. Department of Plant Pathology and Cereal Rust Laboratory, University of Minnesota, St. Paul, MN 55108.

Polymorphism for virulence in a pathogen population can be maintained if selection favors individuals that are heterozygous at virulence loci. We have studied progeny obtained by selfing three to five single uredium isolates from each of four midwestern bean rust populations for segregation in their disease response on five bean lines. These hosts differed in their genes for specific resistance. Approximately half of the disease reactions showed segregation. The proportion showing segregation appeared to vary among isolates within populations, as well as among populations, and also depended on the bean line. In the future, we will compare these estimated levels of heterozygosity for virulence loci to heterozygosity of perhaps more selectively neutral allozyme loci.

A459

Tn5 TRANSPOSON MUTAGENESIS OF TWO PHYTOPATHOGENIC *PSEUDOMONAS SYRINGAE* PATHOVARS. Dirk Anderson and Dallice Mills, Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331.

Transposition of Tn5(Km^r) into the genomes of *Pseudomonas syringae* pv. *phaseolicola* strain PP701(Sm^r Rif^r) and *P. syringae* pv. *syringae* strain R32(Sm^r) was achieved using *Escherichia coli* donor strain SM10 containing the suicide plasmid, pSUP1011. Transposition of Km^r occurred at frequencies of from 0.03 to 2.1×10^{-7} per donor cell in matings with strain PP701, and from 0.7 to 3.8×10^{-5} per donor cell with strain R32. Auxotrophic mutants, representing 8 phenotypic requirements, have been identified. The frequency of mutation to auxotrophy per transposition event for PP701 and R32 is 0.3 and 0.7 percent, respectively. Preliminary results of screening over 1000 Km^r colonies of each pathovar on *Phaseolus vulgaris* cultivar Red Mexican, identified one colony of each pathovar which exhibits attenuated virulence. Physical and genetic studies are underway to demonstrate a causal relationship between Tn5 transposition and altered virulence in these strains.

A460

GENOTYPE ASSAY: NUMBER OF EFFECTIVE FACTORS (GENES) CONTROLLING REACTION TO *PSEUDOMONAS SYRINGAE* ON SNAP BEANS. S. H. Antonius and D. J. Hagedorn, Dept. Plant Pathology, University of Wisconsin-Madison, Madison, WI 53706.

Estimates of the number of effective factors (EF) (genes) controlling reaction to bacterial brown spot (*Pseudomonas syringae*) on bean were obtained using the genotype assay technique. For each of three susceptible x resistant crosses, estimates were obtained independently for laboratory inoculated pods and foliage evaluated in the field. An estimate of EF for seedling reaction was also determined for one of the crosses. In all cases, each of approximately 24 F₃ individuals were assayed for heterozygosity by subjecting four of their F₅, grand-progeny families to an analysis of variance for mean disease reaction. EF estimates were generally low (1-5). Estimates for pod reactions were higher than those for foliage. A known single gene seed-color trait was satisfactorily used as a control for this procedure: an EF estimate of one was obtained for this trait.

A461

HETEROTHALLISM IN *SPHAEROTHECA PANNOSA* VAR. *ROSAE*. C. L. Bender and D. L. Coyier, Dept. of Botany and Plant Pathology, Oregon State University, USDA-ARS, Corvallis, OR. 97331

Nine monoconidial isolates of *Sphaerotheca pannosa* var. *rosae* were inoculated to four rose cultivars in 11 combinations and grown in isolation chambers. Combinations of isolate RR1 and either of two other isolates demonstrated heterothallism by forming cleistocarps with eight well-developed ascospores in a single ascus. Two morphologically immature ascospores developed in the ascus of several cleistocarps on one plant inoculated with isolate RR1 alone, but this was not considered evidence for homothallism. In the nine unsuccessful combinations, both coinoculated isolates were reisolated and identified by differential host reactions when the experiment was terminated. Therefore, failure of these to mate could not be explained by host incompatibility. These data indicate the necessity of mutual host and fungus isolate compatibility to complete development of the sexual stage.

A462

RELATIVE HETEROTHALLISM AND PRODUCTION OF HYBRID PERITHECIA BY AUXOTROPHIC MUTANTS OF *GLOMERELLA CINGULATA* FROM APPLE. L. Bernha, USDA ARS MPL, Chicago, IL 60605, and E. D. Garber, Biol. Dept. of Chicago, Chicago, IL 60637.

Glomerella cingulata is a homothallic species but produces a ridge of fertile perithecia at a frontier between certain wild-type strains on agar. To account for the presence or absence of the ridge of perithecia, earlier workers suggested that alleles at A & B loci control the formation of perithecia at mycelial frontiers in "+" and "-" strains. We propose that *G. cingulata* demonstrates "relative heterothallism". Of 7 induced nutritionally deficient mutants (auxotrophs) in 2 wild-type strains from apple, only one methionine (*met-1*) and one arginine (*arg*) mutant in only one of the wild-type strains formed the ridge of perithecia. Neither the *met-1* nor *arg* mutation has been identified as the A or B locus. The perithecia were either homozygous (selfs) for *met-1* or *arg*, or heterozygous (hybrids). Paired *met-1* and *arg* segregants from hybrid perithecia as well as diauxotrophic strains derived from *met-1* or *arg* mutants also gave hybrids or selfs.

A463

THE PROBABLE OCCURRENCE OF TWO *Lr* GENES IN MARIS FUNDIN WHEAT AND THEIR EXPRESSION AT DIFFERENT TEMPERATURE. L. E. Browder and M. G. Eversmeyer, USDA-ARS, Dep. of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

The *Triticum aestivum* cultivars 'Maris Fundin', previously shown to have resistance expressed at 20 C but not at 9 C (Hyde, Plant Pathology 31:25-30), and 'Thatcher' were inoculated as seedlings with 13 cultures of *P. recondita* and placed at 20 C and at 5 C. Most of the cultures produced higher infection types on Maris Fundin at 5 C than at 20 C. These data confirm Hyde's results. Cultures C5 and C22, however, produced a 03C on Maris Fundin at 5 C and a 23X at 20 C. These results indicate that Maris Fundin has two *Lr* genes. One is expressed, along with its corresponding *Lr* gene, at 20 C but not at 5 C and another expressed at 5 C but not at 20 C, or at least differently at 20 C. These results further demonstrate that low IT is the result of parasite:host:environment interaction.

A464

HOMOLOGY DETECTED BETWEEN DNA SEQUENCES IN THE GENOMES OF UNINFECTED NICOTIANA SPP. AND THE Ti PLASMID OF AGROBACTERIUM TUMEFACIENS Ag63. Randall R. Carlson, Wallace G. Buchholz, and Michael F. Thomashow. Dept. of Bacteriology and Public Health, Washington State University, Pullman, WA 99164-4540.

When *Agrobacterium tumefaciens* infects a wide range of dicots a portion of the Ti plasmid (the T-DNA) is transferred to the plant cells and becomes integrated into the nuclear DNA. Subsequent expression of the T-DNA results in plant cells becoming tumorous. A natural question that arises is where did these T-DNA oncogenes originate? An attractive hypothesis is that they are actually homologs of normal plant genes that have critical roles in regulating plant cell proliferation and development. Consistent with this hypothesis is that we have recently detected homology between the DNA isolated from uninfected *Nicotiana* spp. and the Ti plasmid pTiAg63. Initial mapping data indicates that the plant related Ti sequences are located either within or very close to the T-DNA region. Current studies will establish if the plant sequences are related to T-DNA oncogenes.

A465

CHANGES IN ALLELE FREQUENCIES IN *USTILAGO HORDEI* POPULATIONS AFTER SELECTION ON TWO BARLEY CULTIVARS. B. J. Christ and C. O. Person. Department of Botany, University of British Columbia, Vancouver, B. C. V6T 2B1.

Three populations (pop.) of *Ustilago hordei* were created using teliospores of 5 different dikaryons for each pop. Each dikaryon was heterozygous for a known virulence gene governing virulence to the barley cultivar Trebi. The object of this experiment was to monitor allele frequencies in each pop. after each was divided and simultaneously selected on Trebi and Odessa, a resistant and susceptible cultivar, respectively. The pop. started in Hardy-Weinberg equilibrium but after 1 generation of selection on Trebi, the estimates of the virulence allele (V) frequency in pop. I, II and III were .70, .42 and .80, respectively. After 1 generation of selection on Odessa the V frequencies for I, II and III were .85, .76 and .80, respectively. The increase in the V frequency in all pop. with no difference with regard to the host selection regime was not expected.

A466

EFFECT OF *Lp10/Lr10* ON MYCELIAL AND HAUSTORIAL DEVELOPMENT OF *Puccinia recondita* IN WHEAT. D. B. Cooper and L. E. Browder, Dept. of Plant Pathology and USDA-ARS, Kansas State University, Manhattan, KS 66506.

Seedling plants of *Triticum aestivum* LR10(TC) (*Lr10*) and Thatcher (*Hr10*) wheats were inoculated with *P. recondita* cultures C1(*Lp10*) and C2(*Hp10*). These materials constituted a quadratic check for the *Lp10/Lr10* gene pair where only C1/LR10(TC) produced a low infection type. Mycelial and haustorial development were studied in SEM and UV fluorescence preparations of samples taken at daily intervals for 3 to 14 days after infection. Viable mycelium was found in preparations from all samples, although mycelial growth was restricted in C1/LR10(TC) samples. The major effect of *Lp10/Lr10* was observed as capitate 3-5 μ m haustoria while *Lp10/Hr10*, *Hp10/Lr10*, and *Hp10/Hr10* produced elongated 3-5 μ m x 15-30 μ m haustoria.

A467

GENETICS OF TURNIP MOSAIC VIRUS RESISTANCE USING RAPID-CYCLING *BRASSICA CAMPESTRIS*. Robert G. Fjellstrom and Paul H. Williams. Dept. of Plant Pathology, Univ. of Wisconsin, Madison, WI 53706.

The *Brassica campestris* stock, CGS-1, with a generation time of 40 days, was used to facilitate a genetic study of turnip mosaic virus (TuMV) resistance originating in oriental vegetable cultivars, having a generation time over 100 days. Twelve-day-old seedlings were first inoculated with one of four strains of TuMV, inoculated a second time 10 days later, and evaluated for resistance 10 days after the second inoculation. Resistant plants showed no symptoms. CGS-1 plants were uniformly susceptible to all strains of TuMV. Flowering in the resistant cultivars was promoted by cold-vernialization. Cultivar x CGS-1 hybrids flowered without cold-vernialization. Backcrosses of resistant progenies to CGS-1 and selfs provided a genetic analysis of resistance.

A468

PISATIN METABOLISM BY *NECTRIA HAEMATOCOCCA*: GENETICS OF REGULATION AND IMPLICATION FOR VIRULENCE. H. C. Kistler and H. D. VanEtten. Dept. of Plant Pathology, Cornell University, Ithaca, NY 14853.

Isolates of the fungal pea pathogen, *Nectria haematococca*, can demethylate the major pea phytoalexin, pisatin, to a less toxic product. Some isolates can be induced to demethylate pisatin at a high rate by pretreatment with the substrate, while others demethylate at a low rate regardless of pretreatment. These pisatin demethylase phenotypes were subjected to random ascospore and tetrad analysis to determine their genetic basis and to test for their possible involvement in fungal virulence. Our results indicate that at least three non-allelic genes for pisatin demethylase exist in *N. haematococca*. One gene confers the inducible, high-activity pisatin demethylase phenotype. The two other genes confer the low-activity pisatin demethylase. All highly virulent progeny in four generations of backcrosses are of the inducible phenotype. Thus, the ability to express a high, inducible level of pisatin demethylase activity may be required for high virulence to pea.

A469

CHANGES IN PATHOGENICITY OF CUCUMBER MOSAIC VIRUS BY PASSAGE THROUGH A SPECIFIC HOST. D.K. Leishman, F. Cornelius, Plant Pathology, Cornell University, Geneva, NY 14456 and R.W. Fulton, Plant Pathology, U. of Wisconsin, Madison, WI 53706.

Various strains of Cucumber Mosaic Virus (CMV) caused necrotic lesions, 0.1-0.2 cm in diameter, following inoculation of *Vigna unguiculata* ssp. *unguiculata* (Black-eye) and *V. unguiculata* ssp. *cylindrica* (Catjang) primary leaves. In the latter, additional large necrotic lesions, 0.4-0.6 cm in diameter, appeared at a rate of 0.2-5.6% of total lesions. Large lesions rarely appeared on Black-eye. However, subsequent inoculation of large lesion isolates from Catjang also produced large lesions on Black-eye. Large lesion isolates were identical with the parent strains in symptomology on diagnostic hosts, serology, RNA profile and coat protein peptide map. Some large isolates broke down hypersensitive resistance of Black-eye. CMV RNA-2 conditioned for large lesion formation. Expression of large lesion mutants on Catjang at a high frequency provides an example of specific host selection mechanism that might contribute to the high variability of CMV.

A470

THE NATURE OF PATHOGENIC VARIABILITY IN *PYRICULARIA ORYZAE*. Hei Leung, Paul H. Williams, and Deane C. Army. Department of Plant Pathology, 1630 Linden Drive, Madison WI 53706.

To determine whether the anomalous variability in pathogenicity of *Pyricularia oryzae* is related to genetic, chromosomal or extrachromosomal behavior, the interrelationship between the nuclear cytology, enzyme polymorphism and pathogenic variation of the fungus is being studied. A survey of 80 isolates from diverse origins, using 10 enzyme systems separated by starch gel electrophoresis, showed no variation. In contrast *P. grisea* was found to be polymorphic for aconitase, phosphoglucosylase and phosphoglucose isomerase. In a study of living hyphae, both uninucleate (91%) and binucleate cells (8%) were found among isolates from different geographical regions. An electron microscopic study of nuclear division is in progress. Pathogenic variation is being assessed on inoculated excised leaf fragments floated on 50 μ M benzyladenine solution. Results indicated that differential interaction can be obtained within 7 days of inoculation.

A471

COSMID CLONING OF FLUORESCENT SIDEROPHORE GENES FROM *PSEUDOMONAS SYRINGAE*. J. E. Loper, C. S. Orser, N. J. Panopoulos, M. N. Schroth and S. E. Lindow. Department of Plant Pathology, University of California, Berkeley, CA 94720.

Several genes involved in the production of a fluorescent siderophore were successfully cloned from *Pseudomonas syringae* pv. *syringae* strain 31R1. A genomic library of *P. syringae* 31R1 was constructed by *in vitro* packaging of partially digested DNA fragments ligated to the cosmid vector pLAFR1 and transducing *E. coli* HB101. Five separate complementation groups were identified by triparental matings with individual recombinant clones from the genomic library and non-fluorescent *P. syringae* mutants. Each group was comprised of one or more nonfluorescent mutants complemented by a given recombinant plasmid. Nonfluorescent mutants, obtained after EMS mutagenesis, did not grow in an iron-deficient medium. Forty-nine of 151 nonfluorescent mutants were complemented by one of the five structurally distinct recombinant plasmids resulting in fluorescent transconjugants which then grew in an iron-deficient medium. These results indicate that several genes are involved in the production of the fluorescent siderophore of *P. syringae*.

A472

Cryptic plasmids in *Pseudomonas solanacearum*. V.M. Morales and L. Sequeira. Plant Pathology, University of Wisconsin, Madison WI 53706

When 41 strains of *P. solanacearum* were screened for the presence of plasmids 19 of them were shown to harbor one or two replicons ranging from 40 to more than 300 mdaltons. Kado's rapid procedure (Kado, C.I. and S.T. Liu. 1981. J. Bacteriol. 145:1365-1373) for plasmid extraction was suitable to isolate the small and medium-size replicons (40 to 120 mdaltons) but the very large ones could be visualized only by electrophoresis after lysing the cells directly in the wells. Two plasmids with molecular weights of 71 and 120 mdaltons from strains 85 and 10, respectively, were purified by CsCl₂ density gradient centrifugation and compared by restriction enzyme analysis. There are no apparent relationships between the presence of plasmids and pathogenicity or geographical origin of the strains.

A473

CONJUGAL TRANSFER AND INCOMPATIBILITY PROPERTIES OF A PLASMID FROM A PLANT PATHOGENIC PSEUDOMONAD. A. R. Poplawsky and D. Mills. Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331

A 35 kbp plasmid, pEX8080, derived by partial excision of pMC7105 (147 kbp) from the chromosome of *Pseudomonas syringae* pv. *phaseolicola*, is comprised of three Bam HI fragments. They are pMC7105 fragments 9 (7.3 kbp), 10 (4.1 kbp) and a 23.8 kbp fusion fragment between 1 and 4. The individual fragments and pEX8080 have been separately cloned into pBR322 and transformed into *Escherichia coli*. The chimeric plasmid containing pEX8080 was capable of conjugal transfer to other *E. coli* recipients at a frequency of 1.3×10^{-3} , whereas pBR322 alone was not ($<10^{-8}$). Of the four chimeric plasmids only those containing either pEX8080 or the 23.8 kbp Bam HI fragment expressed incompatibility against pRK290. Antibiotic resistance and DNA analyses showed that in more than 90% of the cases pRK290 could not be maintained in the same *E. coli* host with either of these two plasmids on non-selective medium.

A474

GENETICS OF *GIBBERELLA FUJIKUROI* 3. ALLELISM AT THE MATING LOCUS. G.S. Sidhu, Univ. of Nebraska, Dept. of Plant Pathology, Lincoln, NE 68583-0722.

Gibberella fujikuroi (Saw.) Wollenw (conidial state *Fusarium moniliforme* Sheld.) is a heterothallic bipolar fungus. Both the mating types are found in variable proportions in nature. The wild type mating types do not cross with each other either in nature or controlled laboratory conditions. However, they cross readily with the standard mating types under controlled conditions. Interestingly, natural isolates exhibit a variable degrees of compatibility when crossed with standard mating types. The degree of compatibility varied from an average 10% to 90% successful crossing. The genetic studies from crosses made between various natural isolates and the standard mating types indicate multiple allelism at the mating locus. Different alleles confer different degrees of compatibility. The multiple allelism is maintained through some switch mechanism at the mating locus.

A475

GENETICS OF ALFALFA RESISTANCE TO *PERONOSPORA TRIFOLIORUM*. D. Z. Skinner and D. L. Stuteville. Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

Infection-type data, derived from inoculating all possible S₁ and F₁ populations of six diploid *Medicago sativa* plants (P1-P6) with three pathogenically different monoconidial isolates of *Peronospora trifoliorum* (I5, I7 and I8), were interpreted in terms of a gene-for-gene relationship. Four genes individually capable of preventing conidium production were identified in P5, three were identified in P6, and none were found in P1-P4. I8, I5 and I7 possessed two, four and five corresponding low pathogenicity genes, respectively. P1-P4 possessed many genes with additive effects. F₂ data indicated P5 and P6 possessed similar genes. Diallel analysis of infection severity data indicated host and pathogen polygenes operated in a gene-for-gene relationship. Resistance to I5 and I7 appeared to be largely dominant in all plants. Resistance to I8 appeared to be largely recessive in P1-P4 but dominant in P5 and P6. Complementary genes conditioning susceptibility were suggested in I7 and I8 infection severity data.

A476

REPETITIVE SEQUENCES INVOLVED IN GENETIC RECOMBINATION IN *PSEUDOMONAS*. L.J. Szabo & D. Mills, Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331

Genetic instability seen in many phytopathogenic bacteria may result from recombination mediated by insertion sequences (IS) or transposons. These mobile genetic elements have been shown to cause deletions, insertions and inversions in DNA sequences. The phytopathogenic bacterium *Pseudomonas syringae* pv. *phaseolicola* strain LR719, contains a 149kbp plasmid pMC7105, which has integrated into the bacterial chromosome. Excision of this replicon has resulted in the formation of plasmids ranging in size from 33 to 250kbp. Blot analysis of Bam HI restricted plasmid DNA has identified 3 different repetitive sequences on pMC7105. Analysis of the fusion fragments formed by excision within pMC7105 reveals that in each case, recombination occurred between Bam HI fragments containing homologous repetitive sequences. In addition, the plasmid site of integration contains a repetitive sequence which shows homology to 5 Bam HI chromosomal fragments. These 3 repetitive sequences may be analogous to the IS elements found in *E. coli*.

A477

ISOLATION OF Tn5 INSERTION MUTANTS OF *ERWINIA CHRYSANTHEMI* DEFICIENT IN OLIGOGALACTURONATE LYASE (OGL). K. K. Thurn, D. J. Tyrell, and A. K. Chatterjee, Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

To determine the role of OGL in polygalacturonate (PGT) catabolism and the regulation of pectic enzymes, Tn5 (Km^r) insertion mutants were obtained using the "suicide" plasmid, pJB4JI. Ogl⁻ (Km^r) mutants did not cleave diuronides or utilize either PGT or diuronides as a carbon source. In one mutant, studied in detail, pectate lyase (PL) and polygalacturonase (PG) were induced by 3-deoxy-D-glycero-2,5-hexodiuronate but not by PGT or saturated digalacturonate. The absence of a basal level of OGL in the mutant suggested that the Tn5 inactivated the *Ogl* structural gene. Genetic and physical evidence revealed that the phenotypic changes resulted from a single site Tn5 insertion. We conclude that in *E. chrysanthemi* OGL is required in the catabolism of PGT and diuronides and in the induction of PG and PL with these substrates.

A478

GENETIC VARIATION IN *PHYTOPHTHORA INFESTANS* IDENTIFIED THROUGH ISOZYME ANALYSIS. P. W. Tooley and W. E. Fry, Cornell Univ., Ithaca, NY 14853.

Twenty-six isolates of *Phytophthora infestans* from diverse geographic regions were surveyed for isozyme variation using horizontal starch gel electrophoresis. Resolvable banding patterns were obtained for 21 of 48 enzymes. Putative isozyme polymorphism was observed for 8 enzymes (β -glucosidase, glutathione reductase, diaphorase, peptidase with glycyl-leucine, glucosephosphate isomerase, mannosephosphate isomerase, isocitrate dehydrogenase, and glucokinase); 13 additional enzymes were monomorphic. Banding patterns were consistent with a diploid vegetative stage; on this assumption, most isolates were heterozygous at the majority of loci. Rare homozygotes will be used as genetic markers in future studies. A single isolate of A2 mating type originating from Mexico showed banding patterns that were distinctly different from those of 25 isolates from the U.S., Canada, and North Wales.

A479

HYPERINDUCTION BY DIURONIDES OF PECTATE LYASE (PL) AND OLIGOGALACTURONATE LYASE (OGL) IN *ERWINIA CHRYSANTHEMI* STRAINS WITH MUTATIONAL BLOCKS IN THE DEOXYKETOURONATE PATHWAY. D.J. Tyrell, K.K. Thurn, and A.K. Chatterjee, Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

Previous studies suggested that the intermediate(s) of the deoxyketouronate pathway may regulate the production of pectic enzymes. To test this hypothesis, mutants defective in 3-deoxy-D-glycero-2,5-hexodiuronate acid (DGH) dehydrogenase were isolated by ethylmethane sulfonate or Tn5 mutagenesis. Cell-free extracts of such mutants cleaved diuronides and produced 4-deoxy-L-threo-5-hexoseulose uronate and DGH, but failed to produce 2-keto-3-deoxy-D-gluconate from DGH. Compared to the parents, the mutants in the presence of 0.14 mM saturated digalacturonate produced about 4-fold higher PL, 10-fold higher OGL and 2-fold higher polygalacturonase. High levels of PL and OGL were produced in mutants, concomitant with much reduced concentrations of the diuronides. This suggested an accumulation in mutant cells of a catabolic intermediate, possibly DGH, which induced PL and OGL synthesis in a "gratuitous" manner.

A480

GENETIC FINE STRUCTURE OF THE M1-a LOCUS IN BARLEY. R.P. Wise and A.H. Ellingboe. Genetics Program and Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

There are approximately 30 different genes conferring resistance to *Erysiphe graminis* f. sp. *hordei* located in the M1-a region on barley chromosome 5. The M1-a locus is bracketed by the hordein genes which code for storage proteins in the barley endosperm. Crosses were made between near-isogenic lines differing in genes for resistance to *E. graminis*. The F₁ was selfed in the greenhouse and the F₂ was space planted in the field. F₃ families were harvested and screened for susceptibility to culture CR3 of *E. graminis*. Susceptible recombinants were scored for flanking marker exchange by SDS-gel electrophoresis. The tentative order of six genes in this region is HOR 1 (M1-a, M1-a6), M1-a10, M1-a13, HOR 2. The data indicate that the distance in map units from M1-a6 to M1-a13 is .67 and from M1-a to M1-a10 is .013.

A482

EXPLANATORY SIMULATION OF SUGAR BEET YIELD LOSSES FROM POWDERY MILDEW USING COUPLED MODELS OF HOST AND PATHOGEN. S.S. Adams and R.S. Loomis, Department of Agronomy & Range Science, University of California, Davis, CA 95616

Physiologically based models of sugar beet (SUBGRO) and powdery mildew (MILGRO) were coupled to simulate the seasonal dynamics of host-pathogen growth and development with emphasis on carbon economy. Supplied with daily weather, the preliminary combined model (SUBMIL) provides an explanatory hypothesis for the patterns of disease progression and crop loss observed in field experiments at Davis. The major portion of yield reduction may be ascribed to the diminished gross photosynthesis of the host canopy, but carbohydrate uptake by the parasite population can also be significant when moderate values for fungal specific weight (0.01 mg·cm⁻² infected leaf surface for each sporulating colony) and maintenance respiration (0.02 g glucose·g⁻¹ fungal biomass·hr⁻¹) are assumed and when the disease appears within 60 days after crop emergence. Sensitivity analyses show the initial infection date and rate of disease increase to be dependent on the ambient spore concentration and plant density.

A483

CORRELATION OF ETHANOL-SOLUBLE PRODUCTS AND INDUCED RESISTANCE IN ALFALFA IN RESPONSE TO *COLLETOTRICHUM TRIFOLII*. C. Jacyn Baker and Stanley A. Ostazeski. USDA, ARS, Beltsville, MD 20705.

It has been reported that resistance to race 2 of *C. trifolii* can be induced in race 1 resistant 'Arc' alfalfa by a prior spray inoculation with race 1. A similar phenomenon occurs in clones of alfalfa resistant to race 1, but susceptible to race 2, when needle-inoculated with a conidial mixture of both races. The latter method was used to investigate the level of phytoalexin production in susceptible and resistant clones of alfalfa inoculated with race 1, race 2 or a mixture of the two races. Chromatography of ethanol extracts of inoculated stem segments showed that production of medicarpin and two other compounds correlated with the resistant reaction. Susceptible clones did not produce these compounds in the presence of the fungus. However, clones resistant to race 1 but not race 2 produced these compounds only when race 1 was present. Clones resistant to both races produced these compounds after inoculation with either race.

A484

COMPOSITIONAL AND STRUCTURAL ANALYSIS OF O-CHAIN POLYSACCHARIDES OF *PSEUDOMONAS SYRINGAE* pv. *GLYCINEA*. Paula A. Barton-Willis, Noel T. Keen, and M. C. Wang. Department of Plant Pathology, University of California, Riverside, CA 92521.

O-chain polysaccharides from the lipopolysaccharides (LPS) of *Pseudomonas syringae* pv. *glycinea* were isolated and examined for composition and structure. LPS was extracted by the hot water/phenol method followed by treatment with cetylalton, precipitation in ethanol and gel filtration through Bio-Gel A-15m in the presence of triethylamine at pH 7.0. Purified LPS was subjected to mild acid hydrolysis and fractionated on Sephadex G-50 to yield high and low molecular weight, anthrone positive peaks. Rhamnose (ca. 90%) and glucose (ca. 10%) accounted for approximately 70% of the high molecular weight peak by weight. This peak was assumed to contain O-chain polysaccharides. Methylation analysis (Hakomori's method) revealed a highly branched arrangement of rhamnose residues and permitted the assignment of tentative structures.

A485

BLOCKED CHLOROPLAST DIFFERENTIATION IN SUGARCANE LEAF SCALD DISEASE. Robert G. Birch, and Suresh S. Patil. Department of Plant Pathology, University of Hawaii, Honolulu, HI 96822.

Ultrastructural study of chlorotic leaf tissue from sugarcane and sweet corn with systemic leaf scald infection confirmed that the pathogen, *Xanthomonas albilineans*, was confined to the xylem during early disease development. Xylem vessels were sometimes blocked by tightly packed bacteria, but adjacent bundle sheath and mesophyll parenchyma were not invaded. Chloroplasts were absent from cells surrounding invaded vessels in narrow white leaf stripes, and from uninvaded white leaves emerging after invasion of sugarcane stalks by the pathogen. Proplastids, etioplasts, and vesicular forms, but no degenerating chloroplasts, were present in white leaf areas. The evidence suggests that *X. albilineans* in invaded xylem may produce a diffusible phytotoxin, which blocks chloroplast differentiation at proplastid or etioplast-like stages.

A486

ELICITATION OF PHYTOALEXINS BY ARACHIDONIC AND EICOSAPENTAENOIC ACIDS: A HOST SURVEY. C. B. Bloch, and J. Kuć, Department of Plant Pathology, University of Kentucky, Lexington, KY 40546

Accumulation of the sesquiterpenoid phytoalexins rishitin and lubimin in potato tubers is elicited by the polyunsaturated fatty acids all-cis-5,8,11,14-eicosatetraenoic acid (arachidonic) and all-cis-5,8,11,14,17-eicosapentaenoic acid, which are present in the fungus Phytophthora infestans. The ability of these acids to elicit the accumulation of phytoalexins in the Solanaceae (potato, tobacco, pepper, tomato), Umbelliferae (carrot, parsnip), Leguminosae (pea, french bean, soybean, broad bean), and Convolvulaceae (sweet potato) was investigated. The acids elicited accumulation of rishitin and lubimin in potato, as previously reported, and the sesquiterpenoid capsidiol in pepper fruits. The acids did not elicit phytoalexin accumulation in the other hosts.

A487

EFFECTS OF MONOVALENT CATIONS ON INFECTION OF BARLEY EPIDERMIS BY ERYSIPHE GRAMINIS F. SP. HORDEI. W. R. Bushnell and C. Curran. USDA, Cereal Rust Laboratory, Dept. of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Infection of epidermal tissue from coleoptiles of barley (Hordeum vulgare) by Erysiphe graminis f. sp. hordei was inhibited by Na^+ , K^+ , or NH_4^+ if ion solutions were applied directly to the tissue. The fungus failed to produce haustoria on treated tissue. Normal appressoria were produced except with highly inhibitory treatments. Papillae were not associated with failures to form haustoria. Rates of haustoria produced per spore as percentage of rates on tissues not supplied ions were 0, 2, and 19% with NH_4Cl , NaCl , and KCl respectively at 0.01M, and 29, 48 and 52% at 0.001M. NaNO_3 and Na_2SO_4 were as inhibitory as NaCl . $\text{Ca}(\text{NO}_3)_2$ at 0.01M completely reversed the inhibition by 0.01M NaCl and KCl and partly reversed the inhibition by 0.01M NH_4Cl . The results indicate that haustorium formation requires a high ratio of Ca^{2+} to monovalent ion concentrations in host tissue.

A488

LEVELS OF KIEVITONE HYDRATASE, A PHYTOALEXIN-DETOXIFYING ENZYME, IN FUSARIUM-INFECTED BEAN HYPOCOTYLS. T. E. Cleveland, Y. Zhang, and D. A. Smith, Department of Plant Pathology, University of Kentucky, Lexington, Ky, 40546-0091.

Kievitone hydratase (KHase) activity was measured in dialysed (50,000 MW cut-off) buffer extracts of F. solani f. sp. phaseoli-infected bean hypocotyls. Beans were inoculated by placing mycelium composed of 24 hr-germinated spores on the lower hypocotyls, without wounding. Enzyme levels in infected tissues increased for several days, peak activity occurring five days after inoculation. No detectable KHase activity was evident in healthy bean hypocotyls. Other hypocotyls were inoculated with the same fungus by removing the upper portions of bean seedlings and injecting inoculum into the central portions of the lower stems. Again, substantial amounts of KHase activity were recovered from extracts of these infected tissues. The presence of KHase in F. solani f. sp. phaseoli-infected bean tissues soon after inoculation, and for several days thereafter, suggests that the enzyme plays a role in the establishment of this fungus in its host's tissues.

A489

ROLE OF MICROBIAL EXTRACELLULAR ENZYMES IN PLANT DISEASE DEVELOPMENT. Alan Collier. Department of Botany, University of Maryland, College Park, MD 20742

The curiosity of early workers concerning the involvement of polymer-degrading enzymes in penetration, maceration, and plant cell death ultimately led to important advances in the last decade. Researchers in several laboratories substantially elucidated the activities in plants of the cutinase produced by Fusarium solani f. sp. pisi and the pectate lyase produced by soft rot Erwinia spp. Antibodies prepared against purified cutinase were used to demonstrate that the enzyme is necessary for penetration of the cuticle. Studies with purified pectate lyase revealed that the ability of the enzyme to macerate and kill plant tissues results from the structural role of galacturonans in the middle lamella and primary cell wall. Research on both enzymes has turned to the genetic and biochemical factors underlying their synthesis and secretion and to the effects of variations in enzyme production on pathogenesis. These and more recent advances will be discussed.

A490

COMPARISON OF NODULATION AND NITROGEN FIXATION OF TILL AND NO-TILL SOYBEANS INFECTED WITH FUSARIUM OXYSPORUM. J. L. Corriveau and R. B. Carroll, Dept. of Plant Science, Univ. of Delaware, Newark, DE 19711.

Fusarium-infected and healthy soybean plants were collected in 1982 from conventionally tilled and no-till field plots established at Georgetown, DE. These were assayed for nodule number/plant, nodule size, total nitrogen content of above-ground plant parts, leghaemoglobin concentration, and nitrogen fixation. Five physiological growth stages included in the study were; V₃, R₂, R₄, R₅, and R₇. There was a significant difference ($P = 0.01$) in nodule number/plant between treatments. Diseased plants had fewer nodules than healthy plants and plants from tilled plots had fewer nodules than those from no-till. There were no significant differences ($P = 0.05$) for any of the other variables measured.

A491

PURIFICATION OF PHYLLOSTICTA MAYDIS TOXIN. S.J. Danko, Y. Kono, S. Kim, J.M. Daly, and H.W. Knoche. Dept. Agricultural Biochemistry, University of Nebraska, Lincoln, NE 68583-0718.

PM toxin, specific for TMS corn, was obtained from culture filtrates and mycelium of Phyllosticta maydis grown on Fries' medium at 20 C and under light, using methods developed for T toxin (from Helminthosporium maydis, race T). Toxins from both the mycelium and culture filtrates contained the same three major and ten or more minor components, but the culture filtrate was enriched in the minor, more hydrophilic, components. On TLC, the components of PM toxin migrate to positions very close to those of T toxin. Three purified components of PM toxin exhibit toxic activity against TMS corn at 1-10 ng/ml, and no activity against N corn at 10 ug/ml in assays of dark CO₂ fixation. The specific activity and qualitative effects of PM toxin on mitochondrial oxidation are similar to those of T toxin. Infrared and nuclear magnetic resonance data indicate that the PM toxins are structurally related, though not identical, to T toxin.

A492

EFFECTS OF LIGHT ON THE RESPONSES OF CORN TISSUES TO HELMINTHOSPORIUM MAYDIS RACE T TOXIN AND METABOLIC INHIBITORS. S.J. Danko, K.J. Tegtmeier, and J.M. Daly. Dept. Agricultural Biochemistry, University of Nebraska, Lincoln, Nebraska 68583-0718.

Helminthosporium maydis race T toxin (T toxin) inhibits CO₂ fixation, stimulates ion leakage, and inhibits respiration in TMS corn roots, etiolated mesocotyls and epicotyls, and green leaf tissues, but has no effect on N tissues. Green leaf tissue, however, demonstrates different responses to T toxin in the light and dark, while non-green tissues do not. Other metabolic inhibitors were tested for their effects on CO₂ fixation. DCMU inhibited photosynthesis, but not dark fixation unless the tissue was pretreated in the light. Oligomycin inhibited dark, but not photosynthetic, fixation. Cyanide inhibited CO₂ fixation under all light/dark conditions. Antimycin A, like T toxin, inhibited dark fixation, and did not affect photosynthesis unless the tissue was pretreated in the light. These results demonstrate the importance of light in the response of green leaf tissue to T toxin and other compounds, and suggest that chloroplasts may be involved in the response of TMS corn to T toxin.

A493

NONDEGRADATIVE TOLERANCE OF NECTRIA HAEMATOCOCCA MP VI TO THE PHYTOALEXIN PISATIN. T. P. Denny and H. D. VanEtten, Dept. of Plant Pathology, Cornell University, Ithaca, NY 14853.

Many isolates of N. haematococca MP VI, a pea pathogen, can detoxify pisatin, a pea phytoalexin. However, early log phase shake cultures of 10 isolates grew equally well in pisatin-containing medium regardless of whether pisatin was detoxified. Pretreatment with pisatin enhanced tolerance to pisatin, even in isolates that could not detoxify pisatin. The effects of temperature, pisatin concentration and length of induction period on the enhancement of tolerance suggested that this non-degradative tolerance requires an active metabolic response. Inducing tolerance to pisatin simultaneously induced tolerance to amphotericin B, indicating alteration of the cell membrane. Development of tolerance was also associated with decreased retention of pisatin by the mycelium. Cycloheximide, oligomycin or CCCP prevented this decrease in pisatin retention. A

modification of the cell membrane to decrease influx or increase efflux of pisatin could be part of the nondegradative tolerance mechanism in *N. haematococca*.

A494

SOLUBILIZATION OF PISATIN DEMETHYLASE FROM NECTRIA HAEMATOCOCCA. A. E. Desjardins, D. E. Matthews, and H. D. VanEtten, Dept. Plant Pathology, Cornell University, Ithaca, New York 14853.

The fungal pea pathogen *Nectria haematococca* can demethylate pisatin, a phytoalexin from pea (*Pisum sativum*). Pisatin demethylation, which appears to be necessary for tolerance to pisatin and virulence on pea, is catalyzed by a microsomal cytochrome P-450. Pisatin demethylase activity was obtained in the 100,000 g supernatant of detergent treated microsomes, if detergent was removed before assaying. Cholic acids were the most effective of the detergents tested for solubilizing enzyme activity. Loss of enzyme activity during solubilization could not be prevented or reversed by addition of substrate, reducing agents, antioxidants or phospholipid. However, the enzyme was partly stabilized by sucrose and by phenylmethylsulfonyl fluoride, a protease inhibitor. The CO-binding spectrum of the soluble enzyme preparation confirmed the presence of cytochrome P-450.

A495

INHIBITION OF DARK CO₂ FIXATION IN SUGARCANE LEAF SLICES BY HELMINTHOSPORIUM SACCHARI (HS) TOXIN ISOMERS AND RELATED COMPOUNDS. J. Duvick, J.M. Daly, Dept. of Agric. Biochem., Univ. of Nebraska, Lincoln, NE 68583, Z. Kratky, V. Macko, Boyce Thompson Inst., Ithaca, NY 14853, and W. Acklin, D. Arigoni, Dept. Org. Chem., Swiss Fed. Inst. Tech., CH-8092 Zürich.

The toxicity to sugarcane of purified HS toxin isomers (A, B, and C) (Macko et al., *Experientia* 39, in press) and structurally-related, pathogen-produced compounds including mono-, di-, and trigalactofuranosyl and [tetragalactofuranosyl, diglucopyransoyl] homologues (HS₁, HS₂, HS₃, and HS₄) was assayed by measuring their ability to inhibit dark CO₂ fixation in sugarcane leaf slices. Isomer C gave 50% inhibition of dark fixation at $\approx 1 \times 10^{-6}$ M on susceptible clone CP52-68 but no significant inhibition at 10^{-4} M on resistant clone CP761343. B and A were respectively two- and three-fold less active than C, whereas HS₁, HS₂, HS₃, and HS₄ showed very little or no inhibitory activity at 10^{-4} M on susceptible tissue. HS₁, HS₂, and HS₃, but not HS₄, prevented inhibition of dark fixation by active toxin when added in molar excess to incubation mixtures.

A496

EVALUATION OF A ROLE FOR OXALIC ACID IN THE PATHOGENESIS OF ENDOETHIA PARASITICA IN CHESTNUT BLIGHT. J.R. Elkins, D. Weyand, K. Porterfield, and A. Davis, Concord College, Athens, WV 24712

Englander and Corden (1971. *Appl. Microbiol.* 22:1012) observed an isolate of *E. parasitica* (Ep) which was inhibited by the oxalic acid (OxA) it produced. McCarrall and Thor (1976. In: *Proc. Amer. Chestnut Symposium*, WVU Press, Morgantown, p60) showed that OxA could kill chestnut tissue. Several isolates of Ep have been reported (by titration) and observed (by HPLC) to produce OxA on various media at concentrations an order of magnitude below that reported to kill tissue and that observed to inhibit Ep. Though OxA concentrations have been reported to be higher at the canker margin, most of it is probably in the form of calcium oxalate since no free OxA has been observed in healthy or diseased bark; therefore OxA is apparently not the source of the reported increased acidity at the canker margin. This increased acidity appears important to pathogenesis, but gallic acid released during the utilization of tannins by Ep (Elkins, et al., 1981. p2 In: USDA For. Serv. Gen. Tech. Report NE-64) appears to be a more likely source.

A497

COMPARISON OF THE BIOLOGICAL ACTIVITY AND SPECIFICITY OF NATIVE T-TOXIN AND BOROHYDRIDE REDUCED SYNTHETIC ANALOGS. K. A. Frantzen and J. M. Daly, Department of Agricultural Biochemistry, UNL, Lincoln, NE 68583.

To further investigate the mode of action of the toxin produced by *Helminthosporium maydis* race T (T-toxin) synthesis of labeled analogs of the native toxin complex is required. Use of analogs can only be justified if they possess the requisite biological specificity and activity. Synthesis of such analogs has been

accomplished through the complete reduction of the carbonyl groups of native and chemically synthesized toxicants using borohydride salts. Comparisons of biological activity and specificity have been done using mitochondrial respiration and inhibition of dark CO₂ fixation bioassays. The results show that all toxicants possess the same specificity. Native T-toxin shows strong effects between 5-20 ng/ml, while reduced T-toxin shows similar activity between 50-100 ng/ml. A polyhydroxyl - C25 analog of T-toxin is an order of magnitude less active than native T-toxin.

A498

FURTHER CHARACTERIZATION OF RESPONSES IN PEA-FUSARIUM SOLANI INTERACTIONS ASSOCIATED WITH RESISTANCE AND SUSCEPTIBILITY. Lee A. Hadwiger, Wendy Wagoner, David Kendra, and Felix Mauch, Department of Plant Pathology, Washington State University, Pullman, WA 99164-6430.

Cytologically observed, temporary resistance of pea pod endocarp tissue to *Fusarium solani* f. sp. *pisi* is associated with synthesis of ≈ 20 "resistance" proteins up to 24 hours after inoculation. This phase is followed by a susceptibility phase (24-96 h) during which there is a decrease in the mRNAs which code for some of these proteins. Further, other mRNAs accumulate (24-96 h) which code for different proteins of either plant or fungal origin. A published hypothetical scheme (Phytopathology 71:757-762) of the molecular aspects of the *Fusarium* interaction will be re-evaluated on the basis of quantitative increases in pea chitinase and Beta-glucanase. Also, the optimal sizes of hexosamine polymers associated with both inhibition of fungal growth and induction of host responses have been determined and will be described.

A499

ASSOCIATION OF LIGNIFICATION WITH NON-HOST RESISTANCE OF CUCURBITS. R. Hammerschmidt¹, A.M. Bonnen¹ and G.C. Bergstrom². Dept. of Botany and Plant Pathology¹, Michigan State Univ., East Lansing, MI 48824-1312 and Dept. of Plant Pathology², Cornell Univ., Ithaca, NY 14853-0331.

Five species of cucurbits (cucumber, muskmelon, watermelon, squash and pumpkin) were inoculated with fungi which are non-pathogenic on these hosts. *Helminthosporium carbonum* and several species of *Colletotrichum* germinated and formed appressoria on these hosts, but few penetrations were observed. Histochemical staining revealed the deposition of lignin in upper and lateral epidermal cell walls around the appressoria and in papillae under appressoria. Treatment of lignified tissues with 0.5 N NaOH or with hot ethanol did not alter the staining reactions. Hot aminoethanol, however, completely eliminated the staining reaction. The presence of lignin was verified by CuO oxidation and thioglycolic acid derivatization. Little or no lignification occurred in compatible fungus host interactions. These results suggest that lignification may be a general resistance response in the cucurbitaceae.

A500

TOXIC COMPONENTS PRODUCED BY *FUSARIUM OXYSPORUM* F. SP. *MEDICAGINIS* AND THEIR USE IN ALFALFA CELL CULTURE SELECTION TECHNIQUES. C. HARTMAN-MITCHELL, T.R. KNOUS, T.J. MCCOY* DEPT. OF INTEGRATED PEST MGMT. AND *USDA-ARS. UNIVERSITY OF NEVADA, RENO, NV 89557-0004.

Culture filtrate containing toxic components produced *in vitro* by *Fusarium oxysporum* has been used to select resistant cell lines and regenerated plants that appear to be resistant in preliminary testing. A total of nine selected clones have been regenerated from culture of which two have been determined to be hexaploid and seven are octoploid. Three of the resistant regenerated clones have been tested against the pathogen and have given a resistant response. Analysis of the culture filtrate has indicated that the toxic components are heat stable, non-proteinaceous, and soluble only in polar solvents. Thin layer chromatography using ninhydrin as an indicator resolved two major areas of separation. Further analysis of the toxic components will be discussed.

A501

Use of isolated plant cells in a quantitative assay for pachotoxins. Martha C. Hawes, Department of Plant Pathology, U. F., Gainesville, FL 32611

Root cap cells from corn lines with Texas male sterile (Tms) cy-

toplasm are much more sensitive to HMT-toxin than are cells with normal (N) cytoplasm. Isolated root cap cells, which were separated from the root by agitation in water, were used to compare toxin sensitivity of (1) several seed lots of 2 Tms cultivars and (2) 10 Tms cultivars which vary in susceptibility to Helminthosporium maydis, race T. Sensitivity of root cap cells was consistent among seed lots that differed greatly in vigor, and toxin sensitivity of cells of various Tms cultivars was highly correlated with susceptibility to the fungus. The root cap cell assay was previously used to study the mode of action of victorin, the pathotoxin produced by H. victoriae. Use of the same quantitative assay for both victorin and HMT-toxin allows direct comparison of their lethal effects and may provide a rapid, accurate and economical test for other chemicals that influence plant cell viability.

A502

INFLUENCE OF HETERODERA GLYCINES ON GLUTAMINE SYNTHETASE ACTIVITY AND LEGHEMOGLOBINS IN SOYBEAN NODULES. J. S. Huang, and K. R. Barker, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650

Glutamine synthetase (GS) and leghemoglobins (Lb) were isolated from nodules of Heterodera glycines-infected (N-I) and nematode-free (N-F) soybean roots 42-45 days after seeding (35-38 days after nematode inoculation). GS activity was reduced 40% and Lb content was reduced 42% in nematode-infected plants compared to that in the N-F soybeans. Electrophoretic profiles of GS isolated from N-I and N-F soybeans were similar. Lb from N-I and N-F soybeans were separated into four components (Lba, Lbb, Lbc, and Lbd) by DEAE-cellulose column chromatography. The ratio of Lbc/Lba was higher from N-I soybeans than from N-F plants. The significance of this difference in regulation of nitrogen fixation will be discussed.

A503

PURIFICATION OF VICTORIN. N. T. Keen, S. Midland and J. J. Sims. Dept. of Plant Pathology, Univ. of California, Riverside, CA 92521.

The toxin was isolated from culture fluids of Helminthosporium victoriae by adsorption to Amberlite XAD-7, chromatography on a column of Bio-Rad AG4 acidic alumina and silica gel thin-layer chromatography. Three major and several minor peaks were observed when TLC preparations were examined by high performance liquid chromatography (HPLC) on a Radial Pak C18 radial compression column (Waters Associates). The three major peaks all completely inhibited growth of a susceptible oat line (Iowa X-469) at 10-100 $\mu\text{g ml}^{-1}$, but were inactive against a near-isogenic resistant line (Iowa X-424) at 10 $\mu\text{g ml}^{-1}$. Sep-Pak C18 cartridges (Waters) were used to adsorb the toxins from crude culture fluids and, following elution, the same three peaks were observed by HPLC as in the toxin preparations from TLC. The purified toxins were relatively stable when kept acidic, but both toxicity and the HPLC peaks disappeared following incubation with base. Characterization data will be presented relative to the structures of the three toxic molecular species.

A505

BIOLOGICAL ACTIVITIES OF HELMINTHOSPORIUM SACCHARI TOXINS AND RELATED COMPOUNDS. R.S. Livingston and R.P. Scheffer, Dept. of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824.

H. sacchari produces host-selective toxins and similar, lower mol wt compounds (toxoids). Three forms of HS toxin (4 galactose units/mol) were separated by HPLC. The three forms differed in specific activity, as determined by electrolyte leakage assay. Five forms of toxoid III (3 gal units/mol) were detected by HPLC; the five were separated into two groups (A and B). Toxoid IIB (100 $\mu\text{g/ml}$) did not induce losses of electrolytes from any of the sugarcane clones tested. Toxoid IIIA (1 $\mu\text{g/ml}$) induced losses of electrolytes from two clones that were sensitive to HS toxins; at 100 $\mu\text{g/ml}$, it did not induce losses from two other toxin-sensitive clones. Maximum leakage was obtained when leaf disks were cut and held in water for 6 h prior to toxin exposure. The several isomeric forms of HS toxins and toxoids, which differ in toxic and protective effects, may provide powerful tools for studying the kinetics of toxin-induced loss of electrolytes.

A506

EFFECT OF A TOXIN FROM CERCOSPORA RODMANII ON PEANUT. H. A.

Melouk, D. J. Banks, and G. R. Waller. USDA-ARS, and Depts. of Plant Pathology, Agronomy, and Biochemistry, Oklahoma State Univ., Stillwater, OK 74078.

A toxin was extracted from mycelium of Cercospora rodmanii, a non-pathogen of peanut (Plant Dis. Rep. 61:262-266), and fractionated on CaHPO_4 with 1.5% methanol in chloroform (Phytopathology 72:370-374). The red fraction was evaporated under a stream of nitrogen, and residue suspended in 2.5 μl of 20% aqueous dimethylsulfoxide (DMSO). Twenty μl of this suspension was spread on the adaxial surface of leaflets of Arachis hypogaea cv. Pronto. Brown lesions surrounded by yellow halos were observed in 4-6 days. The lesions were similar to those produced by the leaf spot pathogen C. arachidicola. No lesions were observed on leaflets on which 20% aq. DMSO alone was applied. Three peanut genotypes resistant to C. arachidicola were affected by the toxin to a much lesser extent than susceptible ones. Structure of the toxin is being investigated by mass spectroscopy and nuclear magnetic resonance.

A507

EFFECT OF CRICONEMELLA XENOPLAX ON NINHYDRIN POSITIVE COMPOUNDS IN 'LOVELL' AND 'NEMAGUARD' PEACH ROOTSTOCKS. W. R. Okie and C. C. Reilly, USDA, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA 31008.

The short-term effects of ring nematode, C. xenoplax, on peach rootstocks grown in the greenhouse was studied. Seedlings and rooted cuttings of 'Lovell' and 'Nemaguard' peaches were maintained for 1 year in 3 l plastic pots containing pasteurized soil. Approximately 2,310 C. xenoplax/pot were initially added to half the pots. The final nematode populations for inoculated pots for 'Lovell' and 'Nemaguard' were 29,560 and 45,300/pot, respectively. Nematodes reduced dry root weight, and ninhydrin positive compounds on a dry weight basis for both shoots and roots of 'Lovell' and 'Nemaguard'. Nematode counts were highly correlated with the reduction of ninhydrin positive compound in shoots ($r=0.61$) and roots ($r=0.50$), based on inoculated pots only.

A508

REGENERATION OF SORGHUM PLANTS FROM NODAL PLATE DERIVED CALLUS. J.E. Partridge, C.A. Wozniak and Sally Schroeter, Univ. of Nebr., Dept. of Plant Pathology, Lincoln, NE 68583-0722.

Callus was derived from nodal plate section of Sorghum bicolor Moench. (c.v. NB9040) seedlings by culturing on Murashige-Skoog (MS) medium containing various growth regulators. 3-Indoleacetic acid (IAA), α -naphthaleneacetic acid (NAA), 5-butylpicolinic acid (FA), 2,4-dichlorophenoxyacetic acid (2,4-D) and 4-amino-3,5,6-trichloropicolinic acid (Picloram) were evaluated for their effects on induction, maintenance, and differentiation of callus tissue. Optimal conditions for explantation and establishment of callus was found to be 5-day-old etiolated seedlings on MS with 17 mM 2,4-D or 20-40 mM Picloram. Transfer to MS containing 3-6 mM IAA initiated organogenesis which subsequently led to whole plant regeneration.

A509

PHENYLALANINE AMMONIA-LYASE ACTIVITY IN MAIZE MESOCOTYLS AFTER WOUNDING OR INOCULATION WITH HELMINTHOSPORIUM MAYDIS AND H. CARBONUM. Sergio F. Pascholati, R.L. Nicholson, and L.G. Butler. Dept. of Botany and Plant Pathology, and Dept. of Biochemistry, Purdue University, West Lafayette, IN 47907.

PAL was determined in wounded maize mesocotyls maintained in a photoperiod or in the dark. An increase in extractable PAL occurred in response to wounding in the photoperiod but not in the dark. No significant differences in PAL levels were observed for mesocotyls inoculated with either H. maydis (susceptible interaction) or H. carbonum (resistant interaction) and maintained in a photoperiod. Mesocotyls maintained in the dark and inoculated with H. maydis exhibited a gradual increase in PAL activity expressed on a fresh weight basis but the specific activity did not change. PAL from mesocotyls inoculated with H. carbonum were indistinguishable from controls. PAL specific activity increased only slightly in the dark. The data suggest that PAL activity following infection is different from that induced by wounding.

A510

ENZYMED MEDIATED OXALIC ACID DEGRADATION BY CARROT CELLS. R. C. Peet, J. G. Hancock, and Z. R. Sung, Department of

Oxalic acid is implicated as a toxin in several serious diseases caused by fungi (e.g., *Sclerotinia* spp. and *Sclerotium rolfsii*). Because of its ease of manipulation and regeneration in tissue culture and demonstrated value in somatic cell genetic research, carrot (*Daucus carota*) was chosen as a model host to study the biochemistry of oxalic acid catabolism. Degradation of ^{14}C oxalic acid occurs in intact diploid carrot cells, cell homogenates and a fraction precipitated with ammonium sulfate (85% of saturation) as evidenced by the release of $^{14}\text{CO}_2$. Degradation in cell homogenates was found to be inactivated after heating at 90 C for 2 min, to have a pH optimum of approximately 4, to be inhibited under anaerobic conditions, to be competitively inhibited by glyoxylate and glycolate and was not inhibited by the addition of catalase to the reaction mixture. The reaction obeys Michaelis-Menten saturation kinetics. The evidence is consistent with enzyme mediated oxalic acid degradation.

A511

REGULATION OF THE SESQUITERPENOID-ELICITING ACTIVITY OF C-20 FATTY ACIDS IN POTATO BY CARBOHYDRATE ISOLATED FROM *PHYTO-PHTHORA INFESTANS*. C. Preisig and J. Kuć, Department of Plant Pathology, University of Kentucky, Lexington, Ky 40546

The polyunsaturated fatty acids 20:4 (5,8,11,14) and 20:5 (5, 8,11,14,17) were active elicitors of rishitin and lubimin accumulation in potato slices, whereas 20:3 (8,11,14) was weakly active and 20:1 (11), 20:2 (11,14) and 20:3 (11,14,17) were inactive. However, 20:1 (11), 20:2 (11,14), and 20:3 (11,14, 17) elicited the accumulation of high levels of rishitin and lubimin in the presence of a carbohydrate preparation from *Phytophthora infestans*. This promoter markedly enhanced elicitation by the other polyunsaturated C-20 fatty acids. In the presence of 100 μg of promoter, as little as 0.01 μg of 20:4 (5,8,11,14) acid per slice elicited significant accumulation of rishitin and lubimin. The promoter did not elicit sesquiterpene accumulation. The acids 14:0, 16:0, 18:0, 20:0, 22:0, 16:1 (9), 18:1 (9), 18:2 (9,12), and 18:3 (9,12,15) were inactive in the presence or absence of the promoter.

A512

THE EFFECT OF RING NEMATODE, *CRICONEMELLA XENOPLAX*, ON AMYGDALIN LEVELS IN 'LOVELL' AND 'NEMAGUARD' PEACH ROOTSTOCKS. C. C. Reilly and W. R. Okie. USDA-ARS, Southeastern Fruit and Tree Nut Research Laboratory, P. O. Box 87, Byron, GA 31008.

The cyanogenic glucoside, amygdalin, was extracted from young and old, fibrous roots of 'Lovell' and 'Nemaguard' rootstocks grown in the greenhouse for 1 yr. The amygdalin fraction (R.T. 7:30 min) was separated from the crude extract by HPLC using μ Bondapak C₁₈ with 25% methanol mobile phase. The fraction was then reacted with β -glucosidase and the reaction product, mandelonitrile (R.T. 18:30 min) separated by HPLC using the same chromatography conditions, then used to quantitate amygdalin concentration of the root extracts. Ring nematode had no effect on amygdalin content in young roots of either rootstock. Amygdalin content in old 'Lovell' roots without nematodes was 0.94 mg/g dry weight, whereas with nematodes it was 1.79 mg/g dry weight, a 1.9 x increase. Old 'Nemaguard' roots without nematodes contained 0.58 mg/g dry weight and with nematodes 1.98 mg/g dry weight, a 3.4 x increase.

A513

cDNA CLONING OF mRNA TRANSCRIPTS INDUCED BY THE HOST-PARASITE INTERACTION. R. Riggleman*, B. Fristensky*, T. Okita**, and L. Hadwiger*. *Department of Plant Pathology, **Institute of Biological Chemistry, Wash. St. Univ., Pullman, WA 99164.

We have constructed a pea cDNA library representing mRNAs induced by the infection process. High MW RNA was extracted from pea endocarp tissue inoculated with the incompatible pathogen *Fusarium solani*, f. sp. *phaseoli*. The poly A+ mRNA was purified with oligo-dT cellulose, annealed to 3'-dT-tailed pUC9 and copied with AMV reverse transcriptase to form cDNA covalently attached to the vector. The cDNA was then 3'-tailed with dG and fractionated on a denaturing sucrose gradient. Selected fractions were hybridized with 3'-dC-tailed pUC9, repaired with Klenow fragment of RNA polymerase I and transformed into *E. coli* 78-18. Recombinant clones were selected on X-gal/ampicillin medium and screened for inducible clones by differential hybridization with induced and non-induced ^{32}P -cDNA. These clones will be used to study the mechanisms of host-parasite interaction at the molecular level.

A514

EFFECT OF PLANT AGE ON THE DEVELOPMENT OF *VERTICILLIUM DAHLIAE* ISOLATES IN ROOTS OF GUAYULE. J. C. Stutz, Division of Agriculture, Arizona State University, Tempe, AZ 85287.

Guayule (*Parthenium argentatum*), at 2 ages, 1-week-old and 10-week-old, were inoculated at the root tip with six isolates of *Verticillium dahliae* which differed in virulence. The rate of penetration of the root epidermis and colonization of the cortex by these isolates was compared. Seedling roots were more rapidly penetrated and colonized by all isolates than roots of 10-week-old plants. In 10-week-old plants, highly virulent isolates penetrated epidermal cells and colonized the root cortex more rapidly than isolates of medium and low virulence. In contrast, there was little difference between the rate of extravascular development of these isolates in roots of 1-week-old plants. For all isolates, papillae were frequently found at points of fungal penetration in the roots of 10-week-old plants.

A515

CELLULAR ALTERATIONS IN THE BLACKSPOT OF RAPESEED CAUSED BY *ALTERNARIA BRASSICAE*. J. P. Tewari, Dept. of Plant Science, University of Alberta, Edmonton, Alta., Canada T6G 2P5

The lesions caused by *Alternaria brassicae* on the leaves of rapeseed (cultivars Candle and Altex) have been studied by transmission electron microscopy. The fungus heavily colonizes the necrotic centre and is not present in the chlorotic area indicating that a diffusible metabolite may be directly or indirectly responsible for leaf chlorosis. Examination of the diseased material in various stages of pathogenesis indicates that the plasma membrane is the first target of the diffusible metabolite. Subsequently, the chloroplasts are either directly or indirectly affected leading to leaf chlorosis. Relative to chloroplasts, the effect on mitochondria is seen at a much later stage. The cells in the necrotic area are almost completely devoid of cellular organelles and reveal electron dense lamellar deposits. The progression of cellular alterations in Altex is slower than those in Candle. This may explain lesser susceptibility of Altex to *A. brassicae*.

A516

IN VITRO ETHYLENE PRODUCTION BY *VERTICILLIUM DAHLIAE* IN LIQUID CULTURE IN RELATION TO *VERTICILLIUM WILT* DEVELOPMENT IN COTTON. D. D. Tzeng and J. E. DeVay, Department of Plant Pathology, University of California, Davis, CA 95616.

Ethylene was produced in liquid cultures of *V. dahliae* in Czapek's medium; its production appeared to be light dependent and was not related to shaking or growth rate of cultures. L-, D-, and DL-methionine, L-ethionine and α -keto- γ -methylthiobutyrate (KMBA) served as good substrates for ethylene production. KMBA was a possible intermediate. Pathotype SS4 of *V. dahliae* in the presence of 1 mM L-methionine produced up to 74 nl/hr of ethylene. Ethylene production was inhibited 10 fold by Na-azide while it was stimulated 15 fold by the addition of riboflavin. SS4 (non-defoliating pathotype) produced significantly more ethylene than T9 (defoliating pathotype) with all substrates tested. This is in contrast to the *in vivo* production of stress ethylene by T9- and SS4-inoculated cotton plants. The data suggest that *in vitro* ethylene production is not a primary indicator of virulence. The possible involvement of ethylene production in pathogenesis will be discussed.

A517

METABOLIC DETOXIFICATION OF THE PHYTOALEXIN, PHASEOLLINISOFLAVAN, BY *FUSARIUM*. E. A. Wietor, D. A. Smith, P. A. Orlandi, and R. A. Laine, Departments of Plant Pathology and Biochemistry, University of Kentucky, Lexington KY, 40506.

Phaseollinisoflavan (PIF), an isoflavanoid phytoalexin produced by *Phaseolus vulgaris*, was metabolized by *Fusarium solani* f. sp. *phaseoli*. A major product of this reaction, designated metabolite-1 (M-1), was isolated from fungal shake cultures and *Fusarium*-infected bean tissues. M-1 was purified by TLC, gel-filtration, GLC, and HPLC, and was partially characterized. The ultraviolet absorption maxima of M-1 occur at ca. 260 and 228 nm as previously reported (Physiol. Pl. Pathol. 5:225-237). The MW of M-1 is 342, 18 mass units greater than that of PIF, and suggests the possibility of the addition of the elements of H₂O. Bioassays indicated that M-1 was less fungitoxic than PIF. Structural characterization of M-1 continues.

A518

A NEW METHOD FOR RENIFORM NEMATODE CONTROL ON SWEET POTATOES. W. Birchfield, USDA, ARS, Dept. Plant Path. & Crop Physiol., La. Agric. Expt. Sta., La. State Univ. Agric. Ctr., Baton Rouge, LA 70803.

The reniform nematode, *Rotylenchulus reniformis*, causes a disease of sweet potatoes resulting in yield losses and grades. Field trials with nematicides applied in transplant water to cuttings gave effective reniform nematode control, improved sweet potato yields and grades. The emulsifiable nematicides were applied in transplant water (80 ml per plant). Among 7 different nematicides tried for 2 seasons Vydate (Oxyamyl) gave the lowest nematode counts. Vydate at 1.0 lb active per acre, increased the average total yields 35 bu per acre. Standak (Aldoxycarb) and Mocap (Ethoprop) significantly increased total marketable sweet potato yields 197, and 108 bu/acre, respectively in 1982. This new and different method of nematode control on sweet potatoes is easier and more cost effective.

A519

POPULATION DYNAMICS AND RELATIONSHIPS TO TREE VIGOR OF PRATYLENCHUS PENETRANS AND XIPHINEMA SPP. ON APPLE.

A. S. Carpenter, R. W. Miller, Plant Pathology & Physiology Dept., Clemson Univ.; N. G. Conrad, Agricultural Services Lab, Clemson Univ., Clemson, SC 29631; R. H. Baum, Biology Dept., Florida Southern College, Lakeland, FL 33802; M. M. Zugzda, Plant Pathology Dept., North Carolina State Univ., Raleigh, NC 27650.

Densities of *Pratylenchus penetrans* and a mixed population of *Xiphinema americanum* and *X. rivesi* were monitored quarterly from July 1980 to May 1981 and monthly from May 1981 to September 1982 in two South Carolina apple orchards. Tree vigor was rated monthly as healthy, declining or weak. Rainfall and temperature were recorded. *P. penetrans* densities were highest from late summer to mid-fall 1981, and trends were similar in 1982 for both sites in soil and root tissue. *Xiphinema* spp. densities fluctuated between 20 and 100/100 cm³ soil and were highest during mid-late fall 1981 for both sites. Correlations between nematode densities and tree vigor for all sampling dates were absent or slightly positive for both sites.

A522

DISTRIBUTION OF THE CITRUS NEMATODE IN A TEXAS GRAPEFRUIT ORCHARD. R. M. Davis, Texas A&I University Citrus Center, Weslaco, Texas 78596.

Characteristics of populations of the citrus nematode (*Tylenchulus semipenetrans* Cobb) were studied for 18 months in a 7-year-old red grapefruit orchard on sour orange rootstock. The soil was relatively uniform across the five acre orchard which was under chemical weed control with no tillage and was flood irrigated. Highest populations were found 15 cm deep and 75 cm away from the trunks of trees at about the drip line. Populations reached a peak in March and April and declined to a low ebb in July and August. Populations and soil temperature at 15 cm deep were positively correlated below 29 C but were negatively correlated at higher temperatures. The relationship between nematode populations and soil moisture was inconsistent. A square root transformation of the sample counts was used to normalize the frequency distribution for most analyses. In this orchard 11 samples of 4 cores each would provide an estimate within 15% of the true population mean with 95% confidence.

A523

EFFECTS OF NEMATICIDES AND APPLICATION METHODS ON THE SOYBEAN CYST NEMATODE AND ON SOYBEAN YIELD. A. P. Elliott, D. E. Babineau and P. M. Phipps, Dept. of Plant Path. & Physiol., VPI & SU, Blacksburg, VA 24061.

A field experiment was conducted on a sandy loam soil in Virginia to study the effects of nematicide treatments of Counter 15G, Nemacur 15G, Temik 15G and Soilbrom 90EC applied in 7" bands at planting and at cultivation on population densities of *Heterodera glycines*. On September 15, the lowest density of cysts was associated with the Counter treatment of 13.33 lb/A at planting + 13.33 lb/A at cultivation. At midseason, the lowest numbers of cysts, eggs and second stage larvae were detected in plots with the Nemacur treatment of 15.0 lb/A at planting + 15.0 lb/A at cultivation. Yields were increased in all nematicide-treated plots. Final densities of second stage larvae were higher in all nematicide-treated plots, and this could be related to the increased root systems obtained from initial control of *H. glycines* with nematicide treatments.

A524

ECOLOGICAL RELATIONSHIPS AMONG CONCOMITANT POPULATIONS OF PLANT PARASITIC NEMATODES ASSOCIATED WITH SOYBEAN CULTIVARS. A. P. Elliott, D. E. Babineau, P. M. Phipps, S. A. Meredith and C. Harris, Dept. of Plant Path. & Physiol., VPI & SU, Blacksburg, VA 24061.

A field experiment was conducted in a sandy loam soil in Virginia to study the ecological relationships and effects of plant parasitic nematodes associated with four soybean cultivars. Dynamics of population densities of all nematodes varied depending on the cultivar. Among the concomitant population of *Meloidogyne* sp., *Belonolaimus* sp., *Hoplolaimus galeatus*, *Trichodorus christiei*, and *Helicotylenchus* sp. detected at midseason, the highest relative densities of 71, 47, 42, and 41% were associated with *Meloidogyne* sp. in plots planted with the Essex, Forrest, Lee 74 and Bedford, respectively. The highest and lowest relative densities of *Belonolaimus* sp. (24.7 and 11.2%) were associated with Lee 74 and Essex, respectively. Yield from the Essex cultivar (9.4 bu/A) was significantly (P=0.05) lower than yields from the other cultivars.

A525

PLANT PARASITIC NEMATODES ASSOCIATED WITH STRAWBERRY CULTIVARS UNDER DIFFERENT MANAGEMENT PRACTICES. S. Garber, A. P. Elliott, S. A. Tolin, N. K. Rogers and C. R. Drake, Dept. of Plant Path. & Physiol., VPI & SU, Blacksburg, VA 24061.

The effects of a nematicide Temik 15G® (15.0 lb/A) and herbicide Dacthal® 75W (12.0 lb/A), applied singly and in combination, on nematode populations on two cultivars of strawberry (Guardian and Surecrop) were studied in a clay loam soil in Blacksburg during the growing season, April-November, 1982. In soil samples taken at ten 3-wk intervals, *Pratylenchus* spp., *Xiphinema* spp., *Tylenchus* spp., *Helicotylenchus* spp., *Tylenchorhynchus* spp., *Paratylenchus* spp., *Hoplolaimus* spp., *Meloidogyne* spp., and *Macroposthonia* spp. were present in the entire planting at the relative frequencies 46.6, 21.2, 11.0, 9.4, 5.7, 3.1, 1.3, 0.8, and 0.4%, respectively. Nematode populations varied with the cultivar and treatment.

A527

NEMATODE STRUCTURE AND THE MAMMALIAN BRAINSTEM. J. P. Hollis, Jr., Dept. Plant Path. & Crop Physiol., La. Agric. Expt. Sta., La. State Univ. Agric. Center, Baton Rouge, LA 70803.

In terms of interdisciplinary neurophysiology there is excellent agreement between nematode structure and that of the mammalian brainstem; the latter consists of a nonspecific Reticular Activating System (RAS) surrounded by pathways of the specific sensory system (SSS). Analogically and homologically, nematodes consist of nonspecific nerve ring (RAS complement) surrounded by hypodermis and cuticle containing specific peripheral and internal nerves, and receptors (SSS complement). Up to this point in time nematode studies have been concentrated on the peripheral sensory system with respect to behavior. Since it is well established that RAS is fundamentally responsible for arousal and attention in vertebrates, studies now should be directed toward structural/functional aspects of the nerve ring in nematodes.

A528

NEMATODE NERVE RING AND MAMMALIAN RETICULAR ACTIVATING SYSTEMS. J. P. Hollis, Jr., Dept. Plant Path. & Crop Physiol., La. Agric. Expt. Sta., La. State Univ. Agric. Center., Baton Rouge, LA 70803.

The hypothesis that the nematode nerve ring (NR) is structurally/functionally equivalent to the mammalian reticular activating system (RAS) is supported by elementary knowledge of nematode behavior. For example, plant parasites in vitro (1) become motionless in absence of stimuli, (2) cannot be aroused to motion by mechanical stimulation of the afferent peripheral sensory system, but can be aroused by (3) application of pressure in vicinity of NR. This sequence is in conformity with the arousal function of RAS in vertebrates, suggesting that the NR is performing a similar function in nematodes (invertebrate animals). Likeness of NR to RAS opens an experimental approach to the function of the nervous system in nematodes.

A529

PINEWOOD NEMATODE SAMPLING METHODS USED AT THE MORTON ARBORETUM.

Sabine M. Huhndorf and Thomas L. Green, The Morton Arboretum, Lisle, Illinois 60532

The Morton Arboretum has stands of Scots pine (*Pinus sylvestris*) over 50 years old, many of which have died of pine wilt disease. Our 1981 sampling technique, with an increment borer and pole pruner, showed the pinewood nematode (PWN), *Bursaphelenchus xylophilus*, in 38 of 119 dead trees sampled (32%). The altered procedure for 1982 revealed PWN in 18 of 20 dead trees sampled (90%). In 1982, slices (1-2 cm) were cut from felled trees at 7 locations in each tree: basal, lower, middle, and upper trunk and 10-15 cm, 5-10 cm, and <5 cm branches. Samples were placed in water in petri dishes. Emerged nematode populations (comprised of various species) were rated from 0-4 (0=none, 4=abundant). Samples rated 3 or 4 always contained PWN. Recently killed trees had large nematode populations in middle and upper trunk and in large and small branches. Trees dead for longer periods had more nematodes in lower portions and large branches. We believe that the combination of the 7 samples provides a thorough method for the detection of the PWN.

A531

FIELD INTERACTIONS BETWEEN *HETERODERA GLYCINES* AND *PRATYLENCHUS SCRIBNERI* ON SOYBEAN. D. A. Lawn and G. R. Noel, Dept. of Plant Pathology and USDA ARS, Univ. Illinois, Urbana, 61801.

Interactions of the soybean cyst nematode (SCN), *Heterodera glycines*, and the lesion nematode, *Pratylenchus scribneri*, were studied in the field. Plots were nontreated or treated with aldicarb banded at 144 g/100 m of row, establishing four treatments: Williams 79 (SCN sus.) with (W⁺) and without (W⁻) and Fayette (SCN res.) with (F⁺) and without (F⁻) aldicarb. Gravid cysts averaged 35/250 cm³ of soil at planting and increased more on W⁻ than W⁺ and declined more on F⁺ than F⁻. White females peaked 6 wk after planting (149/250 cm³ on W⁻ and 10/250 cm³ for W⁺, F⁺, and F⁻) and declined until harvest. *P. scribneri* population climax also occurred at 6 wk in W⁻ and F⁻. Populations increased from 113/250 cm³ to 597/g dry root and from 84/250 cm³ to 1160/g dry root for W⁻ and F⁻, respectively. In W⁺ and F⁺ numbers remained near the initial populations of 131 and 61/250 cm³, respectively. Yield differences were significant between cultivars but not between nontreated and aldicarb-treated soybean, indicating that *P. scribneri* did not reduce yields.

A533

MORPHOLOGICAL VARIATION AMONG SUBPOPULATIONS OF *HETERODERA GLYCINES* (RACE 3). J.E. O'Laughlin and D.H. MacDonald, Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Freshly hatched second-stage larvae of 34, randomly selected, single cyst-derived subpopulations of the soybean cyst nematode, *Heterodera glycines* (race 3, Hayward, MN) were compared for differences in morphological variability. The measurements made at X200 were body length and width at stylet and anus. Stylet length, distance from anterior end to excretory pore and overlap, distance from base of stylet to dorsal gland orifice, tail length and tail terminus length were measured at X1000. There were significant differences among the populations for all nine measurements. Larval length (range 372.5-535.4 μ , mean 450.7 μ), tail length (range 29.9-58.6 μ , mean 47.8 μ), and tail terminus length (range 7.2-34.7 μ , mean 24.4 μ) were the characteristics that allowed for the greatest separation of the subpopulation. These measurements of morphological characteristics provide an estimate of genetic variability in the Hayward race 3 population.

A534

EFFECTS OF *VERTICILLIUM ALBO-ATRUM*, ORGANIC MATTER AND MOISTURE REGIMES ON RELATIONSHIP OF *MELOIDOGYNE HAPLA* AND *V. ALBO-ATRUM* IN WILT OF POTATO. J.A. Thies and D.H. MacDonald, Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Solanum tuberosum 'Norland' plants were grown in pasteurized silt loam soil in a glasshouse at 21-28 C for 65 days. At planting, soil in each of 3 sets of pots was treated as follows: (1) 1 g *V. albo-atrum* colonized straw (2) sterile straw (3) uninoculated. One week after planting 5,000 *M. hapla* eggs were added to 1/2 the pots. Four weeks later 10⁸ conidia were added to (2) and (3). Controls included: uninoculated, sterile straw and nematodes. There were 2 moisture regimes and 16 replicates. Tuber weights, plant weights and plant heights were significantly less ($P < .005$, $P < .005$ and $.05 < P < .1$, respectively) in the presence than in the absence of the fungus. There was no interaction of fungus, nematode or moisture regime in relation

to *Verticillium* infection or symptom development. Plants were significantly taller ($.01 < P < .025$) when both organisms were present in combination than when only the fungus was present.

A535

MODE OF PARASITISM BY *GNOMONIA PLATANI* ON *PLATANUS OCCIDENTALIS*. Vernon D. Ammon and Dallas L. Seifers, Department of Plant Pathology and Weed Science, Mississippi State, Mississippi 39762 and Kansas Agricultural Experiment Station, Fort Hays Branch, Fort Hays, Kansas 67601

Mode of parasitism of *Gnomonia platani* and associated ultra-structural alterations in American sycamore were observed in tissues from inoculated seedlings using transmission electron microscopy. Two modes of direct penetration were detected. Infection hyphae penetrated between cells or the fungus grew radially beneath the cuticle before penetrating the underlying epidermal cell wall. Alteration of cell wall structural components was minor. Within four days, intracellular colonization was well established. Colonization was accompanied by extensive accumulation of electron-dense host reaction products around the periphery of hyphal strands and by complete loss of normal cytoplasmic configuration. Structural integrity of cell walls surrounding colonized cells was not altered significantly. These observations tend to explain reduced symptom expression commonly observed under natural conditions.

A536

GALLERIES OF *Saperda inornata* AS INFECTION COURTS OF *Hypoxyylon mammatum* ON TREMBLING ASPEN. N.A. Anderson and M.E. Ostry, Department of Plant Pathology and U.S. Forest Service, University of Minnesota, St. Paul, MN 55108.

A total of 1207 cankers caused by *H. mammatum* were noted over a period of six years in a plantation of *Populus tremuloides* at Rosemount, MN. Of this total, 95% originated in galleries made by *S. inornata*, 3% in mechanical wounds and 1% at the bases of small branches. The downy woodpecker, *Dendrocopos pupescens*, increases the chances of infection by making a wound 2-10 mm in diam. into the gall while extracting *S. inornata* larvae. During the past three years, 80% of the infected galls had woodpecker injury. During 1978-1980, 2738 oviposition wounds were tagged. Cankers were noted on 1% of these galls. During the same time period, 548 galleries were inoculated, each with 20 *H. mammatum* ascospores in 0.1 ml sterile water and 240 galleries with sterile water. As of November 1982, cankers were noted in 7% of the ascospore- and 3% of the water inoculated galleries. Average time from inoculation to symptom expression was 22 months (range 10-39).

A537

THE OCCURRENCE OF OAK WILT IN TEXAS. D.N. Appel, T. Fox, and C. Frost Drees, Department of Plant Sciences, Texas A&M University, College Station, Texas 77843.

Oak wilt, caused by *Ceratocystis fagacearum*, has been found in 23 counties, most of which lie within the Edwards Plateau and the Cross Timbers and Prairies of central Texas. The disease causes significant loss of oaks in forest, range and urban areas. Species most commonly affected include *Quercus fusiformis* (West Texas live oak), *Q. virginiana* (southern live oak), and *Q. texana* (Spanish oak). Infection of *Q. stellata* (post oak) is occasionally observed. Centers of infection range in size from a single tree up to 200 acres. Fungal mats have been observed on Spanish oak but not on live oak, and both mating types of the pathogen have been isolated from diseased trees. Extensive survey and control efforts are in progress to precisely define the extent and severity of oak wilt in Texas and to attempt to limit disease losses.

A538

LATENCY OF *HYPOXYLON ATROPUNCTATUM* IN OAKS AND CANKER INCIDENCE ON BLACK AND WHITE OAKS. E.N. Bassett and P. Penn, Dept. of Plant Pathology, University of Arkansas, Fayetteville, AR 72701

H. atropunctatum canker increased dramatically after a severe drought in 1980, with ca. twice the incidence on black than on white oaks. To clarify possible causes of this increase, living phloem and sapwood samples from 300 healthy-appearing oaks (162 black and 138 white) were plated to isolate *H. atropunctatum*. The fungus was isolated with greater frequency from branch (57%) than from trunk samples (11%). Isolation frequencies between the species were not significantly different. In a second test, 196 non-inoculated healthy-appearing oaks (108 black and 88 white)

were girdled in May 1982. Cankers developed on 76% of the black and on 71% of the white oaks by Oct. 1982. Latency of this fungus in healthy trees helps to explain the rapid increase in disease incidence following drought. Similar frequencies of isolation from healthy trees and of canker development on girdled trees suggest that the greater natural incidence on black than on white oaks might relate to host differences in drought tolerance

A539

NECTRIA CINNABARINA CANKERS OF HONEY LOCUST: FACTORS INFLUENCING DEVELOPMENT AND CONTROL. P.J. Bedker and R.A. Blanchette. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Nectria cinnabarina is a serious canker-causing pathogen of newly transplanted honey locusts in Minnesota. Of eight honey locusts inoculated with N. cinnabarina, four were root-pruned to simulate transplanting stress. Cankers caused by N. cinnabarina were larger on trees that were root-pruned than on those not root-pruned. Noninoculated wounds had less wound closure on root-pruned trees than on nonroot-pruned trees. Four commonly planted varieties of honey locust (Skyline, Sunburst, Imperial, and common Thornless) were inoculated to determine their susceptibility to N. cinnabarina. Sunburst, Skyline, and Imperial were approximately equal in their susceptibility to cankers when inoculated in the spring; the common Thornless variety was least susceptible. Wounds inoculated in the fall, on all four varieties were not significantly longer ($P>0.05$) than noninoculated wounds.

A540

THE SHIGOMETER: HOW IT DETECTS GROWTH RATE IN BALSAM FIR. Robert O. Blanchard, Botany & Plant Pathology, University of New Hampshire, Durham, New Hampshire 03824.

Experiments were designed to determine the most likely mechanism for explaining the commonly observed relationships between cambial electrical resistance (CER), width of cambial zone, and radial growth rates in balsam fir. The protoplasm of the vascular cambial zone (VCZ) contained high concentrations of potassium which were released into the apoplastic solution when membranes were ruptured by inserting electrodes of a Shigometer through the bark and into wood. Potassium concentrations were not significantly different between the VCZ of fast and slow growing trees. However, the thicker VCZ of fast growing trees released more potassium into the solution contacting electrodes than the thinner VCZ of slow growing trees. Thus, the most probable mechanism relating CER and growth rate in balsam fir was variation in thickness of the VCZ and its correlation with potassium content.

A541

VARIATION IN DELIGNIFICATION CAPACITY BY Ischnoderma resinotum AND Ganoderma applanatum. Robert A. Blanchette and Lewis Otjen. Department of Plant Pathology, 304 Stakman Hall, University of Minnesota, St. Paul, Minnesota 55108.

Acer spp., Betula spp., and Populus spp. wood decayed by Ischnoderma resinotum (Fr.) Kar. and Ganoderma applanatum (Pers.:Wall.) Pat. under field conditions had two distinct types of degradation; selective delignification and a simultaneous rot or white rot. Micromorphological aspects of delignified wood indicate a loss of middle lamellae causing a defibration of cells. Chemical analyses of selectively delignified wood showed a substantial loss of lignin and hemicelluloses but not cellulose. White-rotted wood had a progressive thinning of the cell walls leaving a shot hole appearance and lignin and carbohydrates were removed in approximately a 1:1 ratio. Environmental and substrate differences appear to be responsible for inducing selective delignification. Selectively delignified wood was rapidly differentiated from white-rotted wood by scanning electron microscopy.

A542

EFFECTS OF THIABENDAZOLE ON PITCH CANKER OF LOBLOLLY PINE. Robert I. Bruck, Dept. of Plant Pathology, North Carolina State University, Raleigh, NC 27650.

Pitch canker (Fusarium moniliforme var. subglutinans (FMS)) is becoming a significant pathogen of loblolly, slash and Virginia pine nurseries, seed orchards and plantations throughout the

South. Experiments were initiated to investigate the efficacy of thiabendazole (Mertect^R-340F and Arbotect^R-20-S) on preventing and ameliorating infections by FMS in 20-wk old loblolly pine seedlings. Five-hundred seedlings each of 5 half-sib loblolly pine families were treated with one of the two thiabendazole compounds (0,1,10,50,100,500,1000, ug(a.i.)/ml, spray till runoff) either 3 days before, the day after or 7 days following wound inoculation with 5,000 FMS macroconidia (eastern N.C. isolate). Controls (no spray) began to exhibit typical apical die-back symptoms 16 days following inoculations. All doses of both compounds at or exceeding 100 ug(a.i.)/ml controlled the disease before and after inoculation; the fungus could not be recovered from wound sites. No significant differences were observed between families ($P=0.05$). Field trials will begin Spring of 1983.

A543

THE PINE WOOD NEMATODE IN DWARF MISTLETOE INFESTED JACK PINE IN MANITOBA. T.A. Burnes, M.J. Wingfield, F.A. Baker, and D.W. French. Department of Plant Pathology, University of Minnesota; and K. Knowles and E. Beaubien, Department of Natural Resources, Winnipeg, Manitoba, Canada.

The pine wood nematode, Bursaphelenchus xylophilus (Steiner and Buhner) Nickle was found in declining jack pine (Pinus banksiana Lamb.) infested with dwarf mistletoe (Arceuthobium americanum Nutt. ex Engelm.) All trees or tree parts containing B. xylophilus were also infested with cerambycid beetles (Coleoptera:Cerambycidae) and bark beetles (Coleoptera:Scolytidae). The nematode was not found in vigorous trees without mistletoe, or trees with living witches' brooms. Dwarf mistletoe appeared to be the primary cause of tree death, whereas bark beetles, cerambycid beetles and B. xylophilus were secondary colonists of the declining trees. Bursaphelenchus xylophilus has not previously been reported in Canada.

A544

IMPACT AND DISTRIBUTION OF DWARF MISTLETOES IN MONTANA. Oscar J. Dooling, USDA Forest Service, P.O. Box 7669, Missoula, MT 59807

Dwarf mistletoes (Arceuthobium spp.) (DM) reduce tree height and diameter growth, and thereby reduce volume production. Recent surveys have measured this reduction and delineated distribution of the parasites on 3 hosts in Montana. A. douglasii causes an estimated annual reduction of 9 million cubic feet (MM ft³), or about 12 percent of the total volume growth of Douglas-fir. A. americanum causes an annual reduction of 17 MM ft³, or about 14 percent of the total lodgepole pine volume growth. A. laricis causes an annual reduction of 7 MM ft³, or about 29 percent of the total western larch volume growth. Collectively, DM's cause an annual reduction of 33 MM ft³, or about 15 percent of the total volume growth of the 3 host species. If this volume could be recovered, it could build more than 31,000 3-bedroom single family houses each year. The survey was a combination road-plot system described by Drummond (Drummond, D.B. 1978. USDA Forest Serv. Rpt. PSW-31, pp 55-61).

A545

Pine wilt of Virginia pine in southern seed orchards. L. D. Dwinell and Jane Barrows-Broadus. USDA For. Ser., For. Sci. Lab., Carlton St., Athens, Ga. 30602

Pine wilt, caused by the pinewood nematode Bursaphelenchus xylophilus, is emerging as a major problem of Virginia pine (Pinus virginiana) in seed orchards in Alabama, Georgia, and South Carolina. In two orchards in Alabama and South Carolina, tree mortality to date is 30% and 28% (80% in one block), respectively. The pinewood nematode has been extracted from branches and bole sections, but not from deteriorating root systems. Evaluation of boles of trees in a Georgia seed orchard revealed as many as 852 nematodes/g sapwood fresh wt ($X = 352$). Branch samples averaged 4.5 nematodes/g of tissue. Stress factors thought to contribute to susceptibility of pines to the pinewood nematode include drought, subsoiling, over-fertilization and high incidence of pitch canker, caused by Fusarium moniliforme var. subglutinans. This is the first report of the pinewood nematode in Georgia.

A546

Infection of fusiform rust galls on slash pine by the pitch canker fungus hastens seedling mortality. L. D. Dwinell and

Jane Barrows-Broadbent. USDA For. Serv., For. Sci. Lab., Carlton St., Athens, Ga. 30602

In the past, the pitch canker fungus *Fusarium moniliforme* var. *subglutinans* (FMS) has been isolated from rust galls, caused by *Cronartium quercuum* f. sp. *fusiforme* (CQF) on slash, loblolly and longleaf pines. To determine if FMS contributes to the mortality of rust-infected pines, 900 one-year-old galled and healthy seedlings of two open-pollinated families of slash pine were inoculated with FMS. Seedlings were inoculated by puncturing the bark in the gall area with a needle and then inserting FMS hyphae in the wound. Control seedlings were wounded with a sterile needle. FMS rapidly colonized the rust-infected tissue and 62.4% of the galled seedlings were dead after 4 months. Mortality due to FMS and CQF alone was 13.2% and 13.6%, respectively. There were no familial differences.

A547

THE SPREAD OF *ENDOTHIA PARASITICA* IN AN AMERICAN CHESTNUT GROVE AND THE CHARACTERIZATION OF dsRNA IN MICHIGAN HYPOVIRULENT ISOLATES. S.W. Garrod, C.P. Paul and D.W. Fulbright, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Pentachloronitrobenzene resistant (PCNBR) virulent and hypovirulent strains and wild type strains were introduced into a blighted chestnut grove to study spread of the strains. *E. parasitica* was isolated from the trees 2, 4, and 6 months later. No PCNBR isolates were found on trees with introduced wild type isolates, however, PCNBR isolates were recovered on trees with introduced PCNBR strains. dsRNA was found in isolates from trees with introduced PCNBR hypovirulent strains. Hypovirulent isolates of *E. parasitica* were collected from cankers on American chestnut trees in Michigan. The dsRNA banding patterns observed on 5% polyacrylamide gels were found to vary between groves and within groves. The number of distinct bands within an isolate varied from 2 to 5, and the molecular weight of the bands ranged from approximately $0.4-6.0 \times 10^6$.

A548

ECONOMIC IMPACT OF DECAY ON BLACK WALNUT. J.H. Hart and R. Baughan, Departments of Forestry and Botany & Plant Pathology, Michigan State University, East Lansing, MI 48824 and N.E. Jennings, Davey Environmental Services, Lincoln, NB 68502.

Total volume, volume lost to decay, total value, and value lost to decay were determined for 930 black walnut trees during harvest in NB, IA, KN, MN and WI. Sale units (total 37) ranged from 3 to 198 trees. Total volume was 133,000 B.F. (Doyle); total merchantable volume lost due to decay was 7450 B.F. or 6%. 184 trees contained enough decay to lower their value. Value of trees if they had had no decay totaled \$87,600; value lost to decay was \$11,235 or 13%. Less than 15% value loss was recorded for 28 units; over 40% for 5 units. High levels of decay in a unit were often associated with previous livestock grazing, particularly swine. Other factors important in predisposing trees to decay were flooding, lightning and mechanical injury of an undetermined nature.

A549

CELLULOSE DEGRADATION BY WHITE-ROT WOOD DECAY FUNGI: ELECTRON MICROSCOPY STUDY. T. L. Highley, L. Murmanis and J. G. Palmer, Forest Products Laboratory, P.O. Box 5130, Madison, WI 53705

The ultrastructural changes in cellulose and diffusibility characteristics of the cellulolytic system during white-rot attack of cellulose was studied by scanning and transmission electron microscopy. Five white-rot fungi were grown on cellulose fibers: *Coriolus versicolor*, *Pycnoporus sanguineus*, *Phellinus pini*, *Phanerochaete chrysosporium*, and *Xylobolus frustulatus*. All the white-rot fungi produced hyphal sheaths in contact with cellulose fibers. Intracellular products from autolyzed hyphae seldom diffused into sheaths and fibers. Hence, the sheath may not be involved in the degradation of cellulose, but may function for attachment, nutrition and protection. The fungi disrupted fiber surfaces but did not thin fibers. Degradation was not localized around hyphae but occurred at a distance from hyphae. Thus, the white-rot fungi must produce a diffusible cellulose-degrading system.

A550

RESISTANT REACTIONS OF TWO ASIAN PINES TO WESTERN GALL RUST,

Endocronartium harknessii. Y. Hiratsuka and P.J. Maruyama, Northern Forest Research Centre, Canadian Forestry Service, 5320 - 122 St., Edmonton, Alberta, Canada, T6H 3S5. Two hard pine species, *Pinus thunbergiana* (Japanese black pine) and *P. densiflora* (Japanese red pine), exhibited resistant reaction to western gall rust (*Endocronartium harknessii*). In both species dark purple-brown streaks appeared but no hypertrophy of stem occurred. Histological examinations revealed that the fungus invaded the stem and produced haustoria, but the mycelia were confined to the cortex and were eventually isolated by abnormal development of wound periderm beneath the infection. These reactions are similar to those found in pines resistant to white pine blister rust (*Cronartium ribicola*).

A551

RELATIONSHIP OF STROMATAL DEVELOPMENT OF *HYPOXYLON ATROPUNCTATUM* TO SAPWOOD DECAY IN OAKS. R. Holland and P. Fenn, Dept. of Plant Pathology, University of Arkansas, Fayetteville, AR 72701

Chemical and physical methods were used to determine the sapwood components depleted during stromatal development and to determine the fuel value of sapwood from cankered black and white oaks. Specific gravities of sapwood interior to conidial stromata were reduced 20% for black and 15% for white oaks compared to sound wood, while interior to perithecial stromata sp. gr. were reduced 30-33% in both species. Extractives were decreased 50-70% in both species, and both lignin and cellulosic fractions were depleted. In black oaks a constant ratio of H_2SO_4 -insoluble lignin to reducing sugars in acid hydrolysates was characteristic of a white-rot decay, however, progressively increasing ratios associated with sp. gr. losses in white oaks indicated a brown-rot decay. Calorimetry showed that heat values of sapwood from both species (ca. 4700 cal/g dry wt.) did not change during decay associated with stromatal development. Thus, weight losses as reflected in sp. gr. losses are an accurate index of the reduced fuel value of cankered sapwood.

A552

VERTICILLADIELLA PROCERA IN PINE SEED ORCHARDS IN THE SOUTH. W. E. Horner and S. A. Alexander, Dept. of Plant Path. & Physiol., VPI & SU, Blacksburg, VA 24061.

Fourteen southern forest tree seed orchards were evaluated for root disease incidence. These *Pinus taeda*, *P. elliotii*, *P. echinata*, *P. virginiana* and *P. strobus* seed orchards were located in North Carolina, South Carolina, Florida, Alabama and Tennessee. Roots wounded in the course of cultural activities were excavated and isolations for pathogenic fungi made. The cultural activities which caused the majority of wounds were root pruning and roto-tilling. The number of trees infected by *Verticilladiella procera* averaged 11.7% with a range of 0-36%. *Heterobasidium annosum* was found in 16% of *P. strobus*. Only wounded roots yielded pathogenic fungi. *V. procera* was found on all species and was the most prevalent pathogen. Cultural activities which wound roots should be recognized as increasing the risk of root disease development.

A553

SIMILARITY OF ANNUAL ANTHRACNOSE EPIDEMICS IN YOUNG JUGLANS NIGRA PLANTATIONS DURING 1978-1982. K. J. Kessler, Jr., North Central Forest Experiment Station, Forestry Sciences Laboratory, Carbondale, IL 62901.

During 5 years of observations (1978-1982) of walnut anthracnose development in young black walnut plantations, first lesions arising from ascospore infections always appeared during May. Lesion numbers increased through early summer as a result of secondary leaf infection by conidia. Disease development peaked in late July and early August when most previously infected leaflets fell. Leaf-wetness periods of at least 12 hours, long enough for leaf infection, occurred often enough each summer to perpetuate each yearly anthracnose epidemic.

A554

RELATIONSHIP OF AECIOSPORE INOCULUM DENSITY TO UREDIAL AND TELIAL PRODUCTION OF *CRONARTIUM QUERCUM* F. SP. *FUSIFORME* ON WATER OAK. M. C. Klapproth and R. A. Schmidt, School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611.

Leaves of water oak (*Quercus nigra*) seedlings at near-optimal conditions for infection (six-day-old leaves, 20°C) were inoculated with five densities of aeciospores of *Cronartium*

quercuum f. sp. fusiforme. Inoculum densities of ca. 47, 90, 159, 283, and 620 aeciospores/cm² (A) resulted in a maximum of 0.6, 1.2, 1.2, 3.4, and 8.7 uredia/cm² (U) [U = -0.429 + 0.014 A, r² = 0.98] and 4.6, 11.1, 9.4, 22.5, and 53.1 telia/cm² (T) [T = 0.034 + 0.084 A, r² = 0.98]. The number of telia/uredium ranged from 0-31 (mean = 8.7 telia/uredium). The latent period for uredia was 6-7 days. At least 75% of urediospore production occurred within 23 days of inoculation (minimum infectious period = 16 days); maximum daily urediospore production (ca. 2200-3000 urediospores/uredium/day) occurred 11-12 days after inoculation.

A555

RECOVERY PROTOCOL FOR PSEUDOMONAS SYRINGAE PV. SYRINGAE FROM INOCULATED AMERICAN ELMS. S. J. Kostka and T. A. Tattar, Dept. of Plant Path., Shade Tree Labs, Univ. of Mass., Amherst, 01003.

To limit extensive cultivation of contaminant or indigenous bacteria from *P. syringae* pv. *syringae* (Pss) inoculated American elms an aseptic sampling and isolation protocol was developed. Pss-inoculated, water-inoculated and uninoculated trees (>25 cm dbh) were felled and sequentially sampled from root flare to canopy. Sample sites and tools were disinfested with 70% ethanol. Excised twig samples and wood/bark wedges were placed in sterile polyethylene bags and immediately frozen on dry ice. For isolation, thawed tissue samples were immersed in ethanol (10 sec.) and flamed. Bark and exposed xylem were removed to expose non-sterilized xylem. Wood chips excised from the outermost xylem were incubated at 25 C in a BCBRYB Sands broth. Seven oxidase negative, dihydrolase negative fluorescent pseudomonads were recovered from Pss-inoculated trees, while none were isolated from controls. Of 270 isolation attempts, 19 cultures yielded non-Pss group bacteria demonstrating low numbers of indigenous or contaminant bacteria in American elm xylem.

A556

Pachnocybe ferruginea in Douglas-fir utility poles. B.R. Kropp, C.M. Sexton, and M.E. Corden. Botany & Plant Pathology Dept., Oregon State University, Corvallis, Oregon 97331.

Wood cores from 13,799 Douglas-fir utility poles in western Oregon were sampled over a 6 year period. They yielded a relatively high incidence of *Pachnocybe ferruginea* (Sow.ex Fr.) Berk. (21.8% of the poles) and a lower incidence of basidiomycetes associated with internal decay (4.6% of the poles). *P. ferruginea*, though originally described as a synnematosus hyphomycete from wood, has recently been reclassified as a bisidiomycete by Oberwinkler and Bandoni (Can.J.Bot.60: 1726-1750). A conidial phase was commonly found in isolations of *P. ferruginea*. Single spore cultures indicate that *P. ferruginea* is a primary homothallic species and that the conidial phase is its anamorph. *P. ferruginea* produces a polyphenol oxidase and rapidly colonizes Douglas-fir heartwood, influencing its structural properties.

A557

COMPARING TECHNIQUES FOR HYPOVIRULENCE CONVERSION WITH CONIDIAL OR MYCELIAL SUSPENSIONS. E. G. Kuhlman, USDA For. Serv., Southeast. For. Exp. Stn., Research Triangle Park, NC 27709.

Conversion of virulent (V) isolates of *Cryphonectria parasitica* [= *Endothia parasitica*] to the hypovirulent (H) condition is dependent on vegetative compatibility of the H and V isolates. To enhance conversion, conidia or mycelia of 14-27 H isolates suspended in 0.75% water agar were added to 3-day-old cultures of 100 V isolates. Suspensions were: (1) placed in four 5-mm diameter wells at the colony margin, (2) streaked on the colony surface along perpendicular lines from the colony center either to within 5 mm of the colony margin, or (3) streaked beyond the colony margin. Mycelial and conidial suspensions converted 64 and 44% of V isolates when streaked to within 5 mm of the colony margin. Conidial suspensions placed in wells at the colony margin converted more V isolates (92%) than did conidial suspensions streaked to within 5 mm of the colony margin (49%). However, conversion occurred with equal frequency (90%) if conidial suspensions were placed in wells or streaked beyond the colony margin.

A558

COMPARISON OF HYPOXYLON MAMMATUM NATURAL INFECTION, ARTIFICIAL INOCULATION, AND CULTURE FILTRATE TOXIN BIOASSAY OF NINE CLONES OF *POPULUS TREMULOIDES*. P. D. Manion, D. H. Griffin, and L. Gustavson. SUNY College of Environmental Science and Forestry, Syracuse, NY 13210.

Hypoxylon canker percent infection was determined in nine naturally occurring wild clones of *P. tremuloides*. The clones were vegetatively propagated and planted in a replicated randomized block design garden plot. Ten years later, five single ascospore isolates of *H. mammatum* were used to inoculate nine trees of each clone in the garden. Canker length, callus formation and branch death were recorded at 4, 12, and 15 months. Natural infection in the garden plot was also recorded. These same isolates and clones were tested using a culture filtrate toxin leaf bioassay test. Although all of the various measurement criteria showed considerable variation among the clones, the most significant correlation with natural infection in the wild was the toxin leaf bioassay.

A559

A CENTURY OF FOREST PATHOLOGY INSTRUCTION AT IOWA STATE UNIVERSITY. Harold S. McNabb, Jr. and Elwood R. Hart, College of Agriculture, Iowa State University, Ames, Iowa 50011.

In June 1883, Charles E. Bessey initiated at Iowa State University what is believed to be the first Forest Pathology course in North America. This course, covering topics in wood deterioration, had an enrollment of three engineering students. In 1904 a Forestry Curriculum was established and the course was broadened to cover nondecay diseases of living trees. This instruction was continued either by a pathologist or the mycologist until 1955-56 when McNabb became the first forest pathologist to take responsibility for the course. His immediate predecessor, mycologist J. C. Gilman, had developed a comprehensive tree disease course in place of the typical "conk identification" of that time. Hart, a forest entomologist, joined with McNabb in 1976-77 to develop an Integrated Forest Pest Management sequence. This cooperative effort has enabled students to develop a systems understanding of forest resource protection.

A560

MORPHOLOGY AND ULTRASTRUCTURE OF A SAGEBRUSH (*ARTEMISIA TRIDENTATA*) SNOWMOLD FUNGUS. D. L. Nelson*, W. M. Hess**, and D. L. Sturges*. *USDA Forest Service, Intermtn. For. and Range Expt. Sta., Provo, UT 84601 and Rocky Mtn. For. and Range Expt. Sta., Laramie WY 82070; **Dept. Botany and Range Science, Brigham Young University, Provo, UT 84602.

A snowmold fungus, for which no fruiting state is known, induces an important disease of mountain big sagebrush in the western United States. During the winter, the fungus is active on the shoots of plants when they are covered with snow. It oversummers, in part, as mycelial mats on dead shoots and resumes growth when snow-cover returns. Numerous knob-like projections from the outer layer of hyphal cell walls form a sheath that may protect hyphae from desiccation and mechanical injury. We found possibly unique cellular inclusions that appear to be specialized microfibrils permeating the cytoplasm. Among other functions, these inclusions may provide structural support.

A561

ANIMAL VECTORS OF LODGEPOLE PINE DWARF MISTLETOE. Thomas H. Nicholls and Frank G. Hawksworth, North Cent. For. Exp. Stn., 1992 Folwell Ave., St. Paul, MN 55108, and Rocky Mt. For. and Range Exp. Stn., 240 W. Prospect, Ft. Collins, CO 80526.

Arceuthobium americanum is an important pathogen of lodgepole pine (*Pinus contorta*). It reduces growth and seed production and kills many trees. Establishment of mistletoe infections beyond the normal range of seed expelled from explosive fruits indicates involvement of vectors. A study on the Fraser Experimental Forest in Colorado identified 8 bird and 3 mammal species as potential vectors. All told, 320 birds (including retraps = IRT) of 29 species, and 375 mammals (IRT) of 4 species were trapped and examined. Seven percent of the birds and 14% of the mammals carried seed. During a 16-day peak seed-dispersal period at one site, 32% of the birds (N = 25 IRT) and 23% of the mammals (N = 99 IRT) carried seeds. Important vectors appear to be the least chipmunk (*Eutamias minimus*), gray jay (*Perisoreus canadensis*), Steller's Jay (*Cyanocitta stelleri*), and Audubon's warbler (*Dendroica auduboni*).

A562

STREPTOMYCES spp. AS BIOLOGICAL CONTROL AGENTS OF DUTCH ELM DISEASE. J.G. O'Brien and R.A. Blanchette, Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108; and J.B.

Sutherland, Assistant Professor, Biological Sciences, Texas Tech. University, Lubbock, TX 79409.

Streptomyces griseus and *S. albobinaceus*, recovered from the xylem of American elm (*Ulmus americana*) were both antagonistic to *C. ulmi* in vitro. In the greenhouse, three-year-old American elm saplings inoculated with either *S. griseus* or *S. albobinaceus* and 2 weeks later, with *C. ulmi*, subsequently developed symptoms of Dutch elm disease. *Ceratocystis ulmi* was recovered after 6 weeks from 100% of the saplings inoculated with the fungus. *Streptomyces griseus* was recovered from 58%, and *S. albobinaceus* from 30% of the inoculated saplings 8 weeks after inoculation. Isolations from saplings that were not inoculated with either *Streptomyces* isolate did not yield actinomycete colonies. Although *Streptomyces* spp. could be successfully inoculated into American elm and recovered after 8 weeks, no inhibitory effects on the development of Dutch elm disease symptoms were observed.

A563

CONTROL OF SEPTORIA CANKER IN HYBRID POPULUS NURSERIES, M. E. Ostry, P. E. Gerstenberger and H. S. McNabb, Jr. North Central For. Exp. Stn., 1992 Folwell Ave., St. Paul, MN 55108 and Iowa State University, Ames, Iowa 50011.

Cankers caused by *Septoria musiva* are a serious threat to hybrid poplars in nurseries and plantations. Clones we tested with *P. trichocarpa*, *P. laurifolia*, or *P. maximowiczii*, as a parent are highly susceptible. Multiple cankers on a tree reduce fiber quality and ultimately kill the tree. Canker incidence can be high on densely spaced, multiple stems in nursery cutting beds. The fungus can spread to areas with healthy trees on infected hardwood planting stock. Benomyl applied at 1 lb. AI per 100 gal. of water once in spring or bimonthly throughout the growing season eliminated cankering of susceptible clones. Spring cultivation to bury infected leaf debris did not reduce disease on adjacent unsprayed susceptible trees. Spores from infected leaf debris in uncultivated plots infected nearby trees. Planting resistant clones is the best long-term control.

A564

DECAY OF *Quercus* spp. BY *Xylobolus frustulatus*: PROGRESSIVE STAGES OF WHITE POCKET FORMATION. Lewis O'Leary and Robert A. Blanchette. Department of Plant Pathology, 304 Stakman Hall, University of Minnesota, St. Paul, MN 55108.

The progressive stages of white-pocket rot caused by *Xylobolus frustulatus* (Pers.:Fr.) Boid. in *Quercus* spp. were elucidated using scanning electron microscopy. During initial stages of decay, wood was selectively delignified, leaving only the white cellulose microfibrils of the cell walls intact. Middle lamellae were completely removed. Chemical analyses showed that delignified tissues contained 2% lignin and 87% total sugars; whereas sound, decorticated oak had 24% lignin and 65% total sugars. Medullary ray parenchyma bordered the pockets and appeared as barriers to decay. During the decay process, pigmented substances accumulated in wood surrounding the delignified areas. Since *X. frustulatus* caused a white-pocket rot in dead trees, host response did not restrict decay. Instead, substances in cells surrounding pockets appeared to be formed by polymerization products of the fungus during selective delignification.

A565

MICROCOMPUTER-CONTROLLED ENVIRONMENTAL CHAMBER FOR STUDIES OF FOLIAR DISEASE DEVELOPMENT IN CEREALS. V. D. Pederson, Department of Plant Pathology, North Dakota State Univ., Fargo, ND 58105

An environmental chamber using a microcomputer as a programmable controller was built to precisely control light, dew, temperature and relative humidity for studies of foliar disease development in barley. Temperature controlled, humidified air is circulated through a duct system of 4 clear plastic rectangular tubes each 60 X 8 X 8 cm through which intact leaves are mounted. Light is provided by a bank of 48 inch VHO cool white fluorescent tubes. Dew is provided by nebulizers. Humidification is provided by a fine mist of water introduced into the circulating air supply under wet thermistor control. Air temperatures are regulated ± 1 C by a dry thermistor. Any variation or combination of dew period, light period, dry or wet bulb temperatures can be programmed to sequence up to 153 cycles to study the effects of environmental parameters on disease development.

A566

INSECTS AS CARRIERS OF VIRULENT AND HYPOVIRULENT ISOLATES OF

ENDOTHIA PARASITICA. John S. Russin and Louis Shain, Dept. of Plant Pathology, Univ. of Kentucky, Lexington, 40546. Insects were collected from an area containing stems of *Castanea dentata* with cankers incited by virulent (V) and hypovirulent (H) isolates of *Endothia parasitica*. Sections of fiberglass screening sprayed with Tree Tanglefoot[®] aerosol served as insect traps. These traps were affixed to both infected and non-infected chestnut, as well as a variety of other hardwood species. Captured insects were screened for propagules of *E. parasitica* by placement on a semi-selective medium composed of 2% malt extract, 0.5% tannic acid and 2% agar. Cultures of *E. parasitica* were obtained from 75 insect species, with 55 of these species belonging to Coleoptera. Several isolates obtained from insects exhibited abnormal morphology. Some of these abnormal isolates were shown to contain double-stranded RNA. Insects carrying propagules of V and H isolates were captured at distances as great as 12 m and 32 m, respectively, from the nearest sources of inoculum. This indicates that insects are capable of carrying propagules of H as well as V isolates under natural conditions.

A567

Geotrichum PINK STAIN OF PENTACHLOROPHENATE-TREATED RED OAK. E.L. Schmidt, M.G. Dietz, and F.E. Hartmann. 208 Kaufert Lab, University of Minnesota, St. Paul, MN 55108 and Buckman Laboratories, Inc., Memphis, TN 38108.

Sodium pentachlorophenate-dipped red oak lumber (*Quercus rubra* L.) held for 11 mo under a plastic tarp as part of a fungicide efficacy trial developed a jasper-pink (Ridgeway) stain in 15 of 16 boards. This soluble-type stain was limited to the heartwood and penetrated to a depth of 6 mm. Cream-colored hyphal tufts typical of *Geotrichum* were observed on the lumber surfaces. Most isolation attempts provided cultures of *G. microsporum* (sensu Smith). Single spore isolates used to inoculate sapwood and heartwood red oak blocks produced the pink stain within 4 wk in vitro. Oak blocks dipped for 3 min in a 1.2% solution of sodium pentachlorophenate and subsequently inoculated also developed stain after 6 wk. Though a few reports of *Geotrichum* sp. associated with minor pink stain in oak and pine are known, this is the first report of *G. microsporum* developing stain on oak wood treated with a fungicide known to be effective against stain organisms other than *Ascocybe* (*Cephalosporium*) sp.

A568

INDEXING FIR AND SPRUCE TREES FOR DECAY SUSCEPTIBILITY. K.T. SMITH, Dept. of Botany and Plant Pathology, University of New Hampshire, Durham, New Hampshire 03824.

A method for indexing fir/spruce sites for periodic growth rate using cambial electrical resistance, has been developed to determine vulnerability of the standing crop to stress caused by spruce budworm defoliation. A method for indexing decay susceptibility is needed to supplement the index of vulnerability. Standardized measurements of electrical resistance (ER) were correlated with visible, electrical, and chemical properties of wood associated with progressive stages of decay. The results of standardized measurements indicated that spruce and fir trees with ER > 250 k Ω contained mostly wood free from decay, but trees with ER < 100 k Ω contained mostly wood in progressive stages of decay.

A569

LEAF RUST ON HYBRID POPLARS IN THE NORTH CENTRAL REGION. R. W. Stack and M. Ostry, Dept. of Plant Pathology, N. D. State Univ., Fargo, ND, and U.S. Forest Service, St. Paul, MN.

Poplars (*Populus* spp) used in maximum fiber production plantations, are usually fast-growing interspecific hybrids. If high yields are to be achieved, these trees must resist serious pests. At present, hybrid poplars are tested for resistance to *Melampsora medusae*, the principal rust pathogen in the central U.S.A. Various authorities report several other *Melampsora* species on North American *Populus* but little is known about their occurrence on hybrid poplars in the central U.S. In 1980-81 we collected rusted poplar leaves in Wisconsin, Minnesota, Iowa, North Dakota, and Montana. *Melampsora* species are distinguished in the uredial stage by host species and size and echination of the uredospores. We examined uredospores from these collections by a combination of light and scanning electron microscopy. Of 75 collections, 67 fit the description for *M. medusae*. The remaining eight fit other *Melampsora* species or intermediate types.

A570

EFFECT OF CLIMATE ON GROWTH, DECLINE, AND DEATH OF RED OAKS IN WESTERN NORTH CAROLINA. F. H. Tainter and J. D. Benson, Department of Forestry, Clemson University, Clemson, SC 29631.

During 1979 an unusually high incidence of red oak decline and death occurred in the Nantahala National Forest, North Carolina. Since diseases and insects were likely not involved, climatic conditions were suspected of initiating the decline. Stepwise multiple regression and ridge regression identified climatic independent variables which were biologically sound and had significant relationships with growth. A four variable model was found to give a best fit on earlywood growth ($R^2=.464$). Average temperature for December of the year prior to growth and for current February and April had positive effects, whereas current May precipitation had an inverse relationship. For latewood growth, average temperature and total precipitation for July of the year prior to growth had positive effects, whereas average current August temperature had an inverse effect. Average current temperature for May and total July precipitation had positive effects ($R^2=.609$). Decline was probably due to a series of drier than normal years from 1975-78.

A571

SEM OF *CERATOCYSTIS FAGACEARUM* GROWN AT HIGH TEMPERATURE. F. H. Tainter and L. P. Copeland. Department of Forestry, Clemson University, Clemson, SC 29631.

The oak wilt fungus, *Ceratocystis fagacearum*, causes a lethal vascular disorder of oak trees in northeastern United States. In the Southeast, the fungus does not survive well in trees, because it is believed to be sensitive to the high summer temperatures. This research describes changes in *in vitro* cultures exposed to higher than normal temperatures. A South Carolina isolate of *C. fagacearum* was grown on PDA at 24°C for 7 days and then transferred to 24, 28, and 32°C incubators, respectively, for an additional 3 days. Compared to normal growth at 24°C, growth at 28°C was slower, sparser, and with fewer aerial hyphae. Examination with SEM showed there was decreased mucilage production and fewer conidia at 28°C than at 24°C. At 32°C there was no mucilage production and no conidia.

A572

SEVERITY OF *ENDOCRONARTIUM HARKNESSII* ON *PINUS PONDEROSA*. C.S. Thomas, and J.H. Hart, Departments of Botany and Plant Pathology and Forestry, and C.E. Cress, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Transplants (2-1 stock) representing 73 seed sources of *Pinus ponderosa* were planted at two sites (74 km apart) in 1968 in southwestern Michigan. Transplants were planted in 6-tree plots in 5 randomized complete blocks at each site. One stand is situated on rolling glacial moraine; the other on flat terrain. Prior to planting in MI, 0.5% or less of the stock became infected with *E. harknessii* at a Nebraska nursery. In 1982, disease severity (number of galls per tree) was recorded for each tree and mapped. Disease severity was not closely associated with microclimate, but may have been dependent on a tree's proximity to initially infected trees. *P. ponderosa* var. *scopulorum* was more severely diseased than *P. ponderosa* var. *ponderosa*, $P=.05$. Within *P. ponderosa* var. *scopulorum*, 2 southern ecotypes, Colorado Plains and Southern Rockies, were more severely diseased than others, $P=.001$ (R.A. Read, 1980. For. Sci. Monograph 23). Highly resistant and highly susceptible seed sources occurred within the same ecotype of both varieties.

A573

ROT FUNGI ON GREEN ASH IN NORTH DAKOTA WINDBREAKS RESURVEYED. J. A. Walla, North Dakota State Univ., Fargo, ND 58105

Sporocarps of rot fungi on live green ash were more common in 1982 than in 1978 in 30 Prairie States Forestry Project windbreaks (planted 1935-1942) in five North Dakota counties. In 1978, *Fomes fraxinophilus* and *Phellinus punctatus* sporocarps were found in 47% and 43% of the windbreaks and on 0.3% and 0.1%, respectively, of 25,558 live green ash examined. In 1982, *F. fraxinophilus*, *P. punctatus*, *F. conchatus*, and other sporocarps were found in 79%, 100%, 45% and 38% of the windbreaks and on 1.0%, 3.7%, 0.3%, and 0.1%, respectively, of 24,730 live green ash. One of the 30 windbreaks had been removed since 1978. A total of 5.1% of the live green ash examined had sporocarps of rot fungi in 1982 as compared to 0.4% in 1978. Although this increase may not proportionately represent an increase in trees with rot, it is a large increase in trees with sporocarps of rot fungi in only four years. The 1982 survey found that stem decay of live green ash in windbreaks is a significant problem.

A574

THE INTERACTION OF *ARMILLARIA MELLEAE* WITH PHENOLIC COMPOUNDS IN THE BARK OF ROOTS OF BLACK OAK.

Philip M. Wargo, NEFES, 51 Mill Pond Road, Hamden, CT 06514
Colonization of the root bark of black oak, *Quercus velutina*, by *A. mellea* effected decreases in total phenols, hydrolyzable tannin, and condensed tannin and an increase in "browned" compounds (absorbance at 450 nm). Decrease in the phenols (oxidation) began in a light brown zone immediately in advance of mycelial growth. Phenols did not increase in bark in advance of the brown zone. Metabolism of phenols by *A. mellea* in extracts from root bark of black oak depended on supplemental nitrogen and glucose but subsequent mycelial growth was 5 times greater than growth in the supplements alone. Growth was proportional to the decrease in total phenols. *In vitro* tests with commercial sources of phenols found in black oak showed that most phenols stimulated the fungus. The ability of *A. mellea* to oxidize and then metabolize phenols affords the fungus an advantage in colonizing stress-weakened tissues. Its inability to oxidize phenols without supplemental nitrogen and carbon sources may restrict the fungus to colonizing only weakened tissues that provide these supplements.

A575

A MODIFIED COHORT LIFE TABLE FOR *CRONARTIUM QUERCUM* F.SP. *FUSIFORME* SPORULATION ON *QUERCUS RUBRA*.

P. G. Webb. Fruit Crops Department, University of Florida, Gainesville, FL 32611.

Five-day-old leaves of red oak (*Quercus rubra*) were inoculated with either aeciospores or urediospores (1000 spores/cm²) of *Cronartium quercuum* f. sp. *fusiforme* and were incubated at 21 and 18°C, respectively. The leaf discs were examined microscopically for aeciospore or urediospore germination, appressoria formation, uredial pustule incidence, and the occurrence of telia. An average of 3000 stomata/cm² were counted on sample leaf discs and the occurrence of fungal infection units were adjusted on the basis of numbers of aeciospores or urediospores per 1000 stomata. A modified cohort life table was calculated for aeciospores or urediospores which described the proportion of fungal infection units developing into the respective subsequent infection stages. Survivorship curves for aeciospore or urediospore development through telial formation were also calculated.

A576

A COHORT LIFE TABLE ANALYSIS FOR FUSIFORM RUST DEVELOPMENT AMONG YOUNG SLASH PINE PLANTATIONS IN NORTH WEST FLORIDA. R.S. Webb, School of Forest Resources and Conservation, University of Florida, Gainesville 32611.

Paired 0.1-ha plots were established in separate but nearby slash pine (*Pinus elliotii* var. *elliotii*) plantations 1-7 and 10 years old in a high-hazard fusiform rust area of Taylor Co., FL. Extensive and intensive measurements of sample tree health, location within the plot, and distribution of fusiform rust symptoms were collected. The areas had been planted by Buckeye Cellulose Corp. at similar spacings and on similar flatwoods soils. One-year-old trees exhibited an average 3% stem colonization incidence with no observable mortality due to fusiform rust. By age 5, 42% of the seedlings were colonized and by age 10, 46% of the seedlings were colonized and an additional 25% were dead due to the disease. Predictive regression equations were developed to describe the cohort life table dynamics due to fusiform rust in young slash pine plantations.

A577

PATHOGENICITY OF *Verticicladiella procera* AND *Leptographium terrebrantis* IN GREENHOUSE AND FIELD INOCULATIONS. M.J. Wingfield. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Pathogenicity tests with *Verticicladiella procera* Kendrick and *Leptographium terrebrantis* Barras and Perry were conducted under greenhouse and field conditions. Twenty, two-year-old Eastern white pine (*Pinus strobus*) seedlings were inoculated in the greenhouse with isolates of *V. procera* from the United States, Yugoslavia and New Zealand and an isolate of *L. terrebrantis* to compare the pathogenicity of *V. procera* isolates and reconfirm the pathogenicity of *L. terrebrantis*. *V. procera* did not kill seedlings and caused only localized lesions around inoculation points after five months. Eighteen seedlings died after inoculation with *L. terrebrantis* which appeared to girdle stems

and colonize bark before xylary tissues. Root collars of 15-year-old *P. strobus* were also inoculated with isolates of the two fungi. After 12 months, *V. procera* had caused only local lesions. *L. terrebrantis*, however, developed extensively in inoculated trees, producing lesions up to 1.5 m long.

A578

TRANSMISSION OF THE PINE WOOD NEMATODE, *Bursaphelenchus xylophilus* DURING OVIPOSITION OF *Monochamus carolinensis*, *M. scutellatus* and *M. mutator*. M.J. Wingfield and R.A. Blanchette. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Pairs of *Monochamus carolinensis*, *M. scutellatus* and *M. mutator* in cages were allowed to oviposit on pine bolts for 4 to 8 weeks. Bolts were replaced weekly and nematodes extracted from oviposition niches. Nematodes were transmitted during oviposition by all three beetle species. Of 322 oviposition niches made by three pairs of *M. carolinensis*, 29 contained *B. xylophilus*. Four pairs of *M. scutellatus* made 286 oviposition niches of which seven contained nematodes while five pairs of *M. mutator* made 227 oviposition niches of which four contained *B. xylophilus*. The average number of *B. xylophilus* transmitted per pair of *M. carolinensis*, *M. scutellatus* and *M. mutator* examined was 96, 12, and 69, respectively. Transmission of *B. xylophilus* during vector oviposition explains the presence of the nematode in dying trees and cut timber in the United States.

A579

CHARACTERISTICS OF RHIZOCTONIA ISOLATES CAUSING COOL SEASON DISEASE ON *POA PRATENSIS*. T. Abernethy and P. O. Larsen, Dept. of Plant Pathology, The Ohio State University, Columbus, OH 43210 and Ohio Agr. Res. and Dev. Cntr., Wooster, OH 44691.

Rhizoctonia isolates associated with damage observed on Kentucky bluegrass in Michigan in the spring and fall were obtained from diseased plants and thatch. When isolates were inoculated onto 'Fylking' Kentucky bluegrass to determine pathogenicity, more damage occurred at 20 C and 15 C than at 25 C. These isolates were binucleate and exhibited right angle branching. On potato dextrose agar the mycelia were tan in color and grew closely appressed to the agar surface. Pathogenicity and fungal characterization evidence from this study indicates that the cool season damage on Kentucky bluegrass was caused by *Rhizoctonia cerealis*, the causal agent of Yellow Patch. Studies on host range and fungicidal control of Yellow Patch on Kentucky bluegrass are in progress.

A580

EFFECT OF SYSTEMIC ACTIVITY OF PROPAMOCARB ON THE CONTROL OF PYTHIUM BLIGHT ON *FESTUCA RUBRA*. F. M. Ashbaugh and P. O. Larsen, Dept. of Plant Pathology, The Ohio State University, Columbus, OH 43210 and Ohio Agr. Res. and Dev. Cntr., Wooster, OH 44691.

The fungicide, propamocarb, prevented infection of *Pythium aphanidermatum* on 4-6 week old red fescue (*Festuca rubra* L. "Pennlawn") when injected into the root zone. Plants were grown in styrofoam cups (8 cm X 11 cm) in 1:1:1 soil:peat:vermiculite and treated at rates of .011, .022, .045, .09, .18 and .36 g active ingredient per cup. Plants were inoculated with *Pythium* infested millet seed 72 hrs. after fungicide treatment, then incubated in plastic bags at 30 C for 5 days. Lower rates of fungicide were not effective in reducing disease, but at rates higher than .09 g a.i. per cup, disease control increased with fungicide concentration. Propamocarb at a concentration of 7.2 g a.i./l applied as a dip to the tips of leaves did not control disease on the untreated portion of the leaf. Root injection data indicate that propamocarb is translocated acropetally whereas leaf dip data indicate it is not translocated basipetally.

A581

THE OCCURRENCE OF YELLOW PATCH ON TURF IN MICHIGAN. C.L. Brown, J.M. Vargas, D.L. Roberts. Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824

A new disease was identified on Kentucky bluegrass (*Poa pratensis* L.) in Michigan in 1981 and 1982. Symptoms developed during the spring and fall and included a foliar blight, a frog-eye pattern and/or straw-like patches 6-12" in diameter. A binucleate

Rhizoctonia-like fungus was consistently isolated from diseased tissue, and Koch's postulates were completed in greenhouse and field experiments. Hyphal morphology, nuclear state and anastomosis with known isolates suggested that this organism was *R. cerealis*, recently reported to cause yellow patch of turf-grasses in other midwestern states. In vitro bioassays and inoculation of fungicide treated plants in greenhouse studies indicate that chlorothalonil, iprodione, triadimefon and experimental CGA-64250 (propiconazole) should be field tested for chemical control.

A582

IDENTIFICATION AND PATHOGENICITY OF *RHIZOCTONIA SOLANI* ASSOCIATED WITH BROWN PATCH OF WARM-SEASON TURFGRASSES. M. P. Grisham, Department of Plant Sciences, Texas A & M University, College Station, Texas 77843

Rhizoctonia solani anastomosis group 2 type 2 (AG2-2) was isolated from four warm-season turfgrasses (St. Augustinegrass, bermudagrass, zoysiagrass, and centipedegrass) displaying brown patch symptoms. Isolates from each of the turfgrass species anastomosed with each other as well as with the AG2-2 tester from carrot. An earlier report identified *R. solani* AG2 as the causal agent of brown patch of St. Augustinegrass. In other previous work, *R. solani* AG1 and AG4 have been reported as causal agents of brown patch of turfgrasses. St. Augustinegrass was inoculated with two isolates from each turfgrass species. All caused typical brown patch symptoms on St. Augustinegrass, although isolates from bermudagrass were less aggressive than those from the other turfgrass species.

A583

TRANSMISSION OF SPRING DEAD SPOT DISEASE OF BERMUDAGRASS BY TURF/SOIL CORES. John C. Pair, Professor of Horticulture; Frederick J. Crowe, Assistant Professor of Plant Pathology; and William G. Willis, Professor of Plant Pathology; Kansas State University, Manhattan, Kansas 66506.

Transmission of spring dead spot (SDS) disease of bermudagrass (*Cynodon dactylon* L. Pers.) was accomplished with turf/soil cores taken in 1973 from edges of dead turf patches in a bermudagrass lawn and transplanted into 24 established bermudagrass clones located in an area in which SDS had never been observed. Two to four years were required for symptom expression. The percentage of all inoculation sites at which SDS symptoms appeared was 19.9, 36.0, 35.6, and 25.5% for 1976, 1977, 1978 and 1982, respectively. No disease occurred either at sites into which symptomless cores were transplanted nor at otherwise random locations in or near the test plots. In addition to demonstrating SDS transmissibility, this technique appears promising in screening for SDS resistance among bermudagrass clones.

A584

SURVEY OF "NECROTIC RING SPOT" DISEASE IN WISCONSIN LAWNS. Gayle L. Worf, Kristen J. Brown, and Roseann V. Kachadoorian, Dept. of Plant Pathology, University of Wisconsin-Madison, Madison, WI. 53706

Thirty-four lawns in Madison, WI were examined in 1980 and 20 diseased lawns were revisited in 1982 to record the incidence and severity of "necrotic ring spot" disease. Cultural factors were examined that might influence disease development. Lawns established prior to 1974 did not exhibit symptoms (0/16 lawns) while 12/18 lawns established later were diseased in 1980. Disease was not related to broad leaf or crabgrass weed control treatments or thatch levels. Soil profile effects were uncertain. By 1982, 10/20 lawns had improved dramatically, and five were somewhat improved. Two lawns remained unchanged, while three were more severely diseased. These data support the general observation that NRS is especially important in younger turf, and the disease declines after several years. Symptoms were present in some lawns throughout the season, but were most obvious in July and August.

A585

INCREASE OF ALTERNARIA BLIGHT IN TWO ORNAMENTAL FOLIAGE PLANT SPECIES TREATED WITH BENOMYL. R. A. Atilano, University of Florida Agricultural Research and Education Center, 3205 S.W. College Ave., Fort Lauderdale, 33314.

Benomyl (0.6 g/liter) applied as a soil drench (5.2 liters/m²) and again one wk later as a foliar spray significantly increased the number of leaf spots in *Brassica actinophylla* following inoculation with *Alternaria panax*. Two foliar sprays one wk apart and a benomyl drench alone resulted in similar responses in both *B. actinophylla* and *Schefflera arboricola*. No increase of blight occurred in plants sprayed with benomyl plus mancozeb (1.4 g/liter).

A586

ASSOCIATION OF A MYCOPLASMA-LIKE ORGANISM WITH A DISEASE OF ANNUAL STATICE IN MICHIGAN. K.K. Baker^{1,2,3}, S.K. Perry¹ and J.M. Mowry². ¹Department of Botany and Plant Pathology, ²Department of Entomology, ³Center for Electron Optics and the Pesticide Research Center, Michigan State University, East Lansing, MI 48824.

Mycoplasma-like organisms (MLO's) were found in ultrathin sections of phloem cells of stems, leaves and pedicels of annual statice (*Limonium sinuatum*) exhibiting the following symptoms: yellowing and malformation of young leaves, leaf reddening in older rosettes, bunching of flower stalks, phyllody, reduced flower size and abnormal flower color. MLO's were not found in phloem cells of symptomless plants. The MLO's were transmitted to healthy statice, celery and aster by the leafhopper, *Macrosteles fascifrons*. Symptoms in statice resembled those observed in the field. Symptoms in celery and aster resembled those associated with the aster yellows MLO. This is the first report of an MLO associated with a disease of annual statice in Michigan.

A587

TEMPERATURE EFFECTS ON MELAMPSORIDIUM BETULINUM UREDOSPORE GERMINATION AND DISEASE DEVELOPMENT. H. L. Doolley, USDA-ARS, Horticultural Crops Research Laboratory, Corvallis, Oregon 97330.

Spore germination and pustule development studies in *Melampsorium betulinum* showed that uredospores germinate in vitro at temperatures of 1 to 20 C with a 10 C optimum. Uredospores incubated for 6 and 24 hr at 30 C, followed by 24 hr incubation at the optimum, did not germinate, suggesting that the spores were killed. Uredospores incubated at 25 C for 24 hr or 3 hr at 30 C did not germinate, but did if then incubated 24 hr at 10 C. Uredospores germinated within 3 hr under optimum conditions. Rust inoculated birch trees develop pustules in 13 days under a constant 10 C. Detached inoculated European birch leaf discs developed pustules in 14 to 22 days at 10 to 20 C and 100% relative humidity. Stem infections by *M. betulinum* were observed but believed to be rare in nature.

A588

SOME ETIOLOGICAL AND SYMPTOMOLOGICAL ASPECTS OF ROSE ROSETTE. R.L. Doudrick and D.F. Millikan. Dept. of Plant Pathology, University of Missouri-Columbia 65211.

The rose rosette disease occurs extensively in naturalized multiflora rose and appears to be spreading in the garden types. Infected plants are recognized by the characteristic reddening of leaves and shoots and witches'-broom. Shoots from infected garden roses may be very thorny and the flowers sterile, deformed, or aborted. The infectious agent can be transmitted from rose to rose by grafting but efforts to transmit the causal entity by sap or through dodder have failed. An incubation period of at least three weeks is necessary before the appearance of symptoms after grafting. Other than man, no above-ground vector has been identified. The nature of the infectious agent is under current investigation.

A589

SPRAY PROGRAM FOR LEAF SPOT CONTROL ON PHOTINIA FRASERI. Austin Hagan, C. H. Gilliam, J. M. Mullen and R. L. Shumack. Auburn University, AL 36849.

Tests were conducted to develop a fungicide spray program for the control of leaf spot on photinia caused by *Entomosporium maculatum*. Plants, 2-3 years old, were arranged in a randomized complete block of 4 replications. Fungicides were applied at label rates to run-off with a CO₂-powered sprayer. Diseased photinias were placed in each block of treatments to maintain disease pressure. Daconil 2787 4.17F and 75W consistently provided effective leaf spot control. Manzate 200 and Bordeaux mixture tank mixed with a surfactant also significantly reduced

leaf spot incidence and severity. Benlate, Zyban, Bayleton, and Chipco 26019 did not provide adequate disease control under heavy inoculum pressure. To provide effective leaf spot control, fungicides must be applied at or shortly after bud break. Delaying the first application until spring growth began to mature resulted in poor leaf spot control. A 2 wk interval between applications was needed to insure coverage of expanding foliage and maintain effective disease control.

A590

A BACTERIAL CROWN ROT OF STATICE. J. B. Jones and A. W. Engelhard. Assistant Plant Pathologist and Plant Pathologist, respectively. Univ. of Fla., IFAS, Agricultural Research & Education Center, Bradenton, FL 33508.

A crown rot was observed on statice plants in the fall of 1982 in Manatee county, Florida. A bacterium was isolated from the crowns of two plants which exhibited internal black discoloration. The bacteria induced a hypersensitive reaction when injected into pepper and tobacco leaves. The bacterium, a Gram negative rod with 1 or more polar flagella, was initially yellow on nutrient yeast dextrose agar and eventually turned brown. It was non-fluorescent on KMB, strictly aerobic, able to accumulate poly-β-hydroxybutyrate and utilize betaine and arginine. The bacterium was oxidase positive, arginine dihydrolase negative and caused a rot on onion but not on potato slice. Inoculation of crowns of healthy statice plants with the bacterium resulted in partial or complete deterioration of the crown and eventual death of the plant. Based on biochemical and physiological tests we are tentatively classifying the bacterium as *Pseudomonas cepacia*.

A591

THE EFFECTS OF TEMPERATURE AND HIGH HUMIDITY ON DEVELOPMENT OF BACTERIAL SPOT OF GERANIUM AND CHRYSANTHEMUM. J. B. Jones†, B. C. Raju** and A. W. Engelhard*. *Univ. of Fla, IFAS, AREC-Bradenton, FL 33508 and **Yoder Brothers, Ft. Myers, FL 33902.

'Sprinter Scarlet' geranium leaves and 'Florida Marble' and 'Polaris' chrysanthemum leaves and stems were inoculated with a suspension of *Pseudomonas cichorii* by the pinprick method. For temperature tests inoculated plants were placed in incubators at 16, 20, 24, 28, 32 and 36C. Lesion diameter and the number of lesions that developed into typical bacterial spot lesions were greatest at 28C. In leaf moisture studies, inoculated chrysanthemum plants were placed in polyethylene bags for various periods of time to maintain high relative humidity. No lesions developed on plants that were unbagged throughout the experiment. Once the plants were removed from high relative humidity, lesion development ceased.

A592

SYMPTOMATOLOGY AND SUSPECTED CAUSE OF THE ANTHURIUM BLEACHING PROBLEM. W.T. Nishijima, R.Y. Iwata, D.K. Fujiyama, and D.M. Sato, Univ. of Hawaii, Coop. Ext. Serv., Hilo, HI 96720.

The anthurium industry in Hawaii experienced a devastating problem starting September 1980. An estimated 30% of the anthuriums grown under saran shadecloth were affected and caused 20 to 60% reduction in marketable flower production for a minimum of 3 to 6 months. The first obvious, acute symptoms were purple spots ca. 1-5 mm diam. on the spathe with tiny necrotic centers, petiole lesions, and scattered leafspots to necrosis of the entire young leaf. Chronic symptoms included lack of color development of the spathe and spadix, spathe deformation, severe chlorosis and stunting of new leaves, root necrosis, and discolored stele. The cause of the bleaching problem is proving to be extremely complex that is thought to involve nutritional imbalances brought about by environmental and cultural factors such as drought with associated high temperatures and certain fertilizer practices in relation to the inert media used.

A593

NITROGEN-15 UPTAKE AND TRANSPORT BY HYPHAE OF A VESICULAR-ARBUSCULAR MYCORRHIZAL FUNGUS. R.N. Ames, C.P.P. Reid, L.K. Porter*, and C. Cambardella. Natural Resource Ecology Lab, Colorado State University, and (*) ARS/USDA, Fort Collins, Colorado 80526 (*80521).

Glomus mosseae inoculated, mycorrhizal (M) celery plants

derived significantly ($p=0.01$) more nitrogen (N) than non-mycorrhizal (NM) plants from a small soil volume, separated from the roots by a fine mesh, which was treated with either $(^{15}\text{NH}_4)_2\text{SO}_4$ (AS) or ^{15}N -enriched ground sorghum leaf tissue (ST). Shoot N in M plants was significantly ($p=0.01$) lower than NM plants in the AS but not ST treatment. No differences in shoot P were found. Shoot ^{15}N in M plants in the AS treatment was significantly ($p=0.001$) correlated with number of hyphae crossing the mesh ($R^2=0.63$) and with total hyphal length in the ^{15}N placement area ($R^2=0.66$). Shoot ^{15}N and % VAM were poorly correlated ($R^2=0.34$). No correlations existed with shoot ^{15}N and any parameter in the ST treatment. M hyphal N flux was $7.42 \times 10^{-8} \text{ mol N cm}^{-2} \text{ s}^{-1}$ for the 30-day AS treatment and $1.74 \times 10^{-8} \text{ mol N cm}^{-2} \text{ s}^{-1}$ for the 88-day ST treatment.

A594

THE ISOLATION AND IDENTIFICATION OF TRICHOHECENE MYCOTOXINS FROM A PATHOGENIC STRAIN OF MYROTHECIUM RORIDUM. G. A. BEAN, G. Pavanadasivan, B. Jarvis and T. Fernando, Department of Botany and Department of Chemistry, University of Maryland, College Park, Maryland 20742

Myrothecium roridum, isolated from severely diseased, immature muskmelon fruit, *Cucumis melo*, produced at least 4 trichothecenes in *in vitro* culture. The fungus was grown for 3 days on a corn steep medium and then transferred to a medium consisting of inorganic salts, sucrose (40g/L) and glycerol (10g/L). Mycelium and filtrate were extracted separately by solvents and the combined extracts were subjected to analyses by HPLC and NMR. Structures of these trichothecenes will be presented. Muskmelon seedlings placed in an aqueous solution of macrocyclic trichothecene roridan A, absorbed, translocated and metabolized roridan within 24 hours. These results cause concern in that plants may be able to absorb mycotoxins under field conditions.

A595

T.E.M. OF ENGLISH OAK ECTOMYCORRHIZAE. Edwards, H. H. & R. V. Gessner, Department of Biological Sciences, Western Illinois University, Macomb, Illinois 61455

The incorporation of caffeine in standard T.E.M. fixation procedures has allowed good preservation and embedment of ectomycorrhizal short roots of English oak (*Quercus robur* L.). In the mantle the most conspicuous structures are cystidia which radiate outwards from the surface. These conically-shaped cells have knobs at their tips and thickened cell walls. The cystidia and other outer mantle cells contain many cytoplasmic constituents; whereas the inner mantle cells are nearly devoid of cytoplasm. The mantle cells are held together by an intercellular slime network. The Hartig net cells are filled with cytoplasm and contain numerous lipid bodies. Typical dolipore septa separate the cells, however these cells have irregularly branched shapes. The host root tissue appears little altered by the presence of the fungal symbiont. However the root cap consists of only a few cell layers and the epidermis is absent. The apical meristem is functional as evidenced by the presence of newly divided cells and microtubules lining enlarging cells.

A596

ENDOMYCORRHIZAL FUNGUS ACTIVITY IN RELATION TO TIME SINCE RECLAMATION OF ABANDONED STRIPMINE LAND. Ann B. Gould, and James W. Hendrix, Department of Plant Pathology, University of Kentucky, Lexington, 40546.

Three adjacent sites in western Kentucky, stripmined and abandoned at least 25 yr ago, then leveled and reclaimed, were assessed for the activity of mycorrhizal fungi. Randomly collected soil was bulked from each of 4-5 subsites, and the number of propagules/g soil (ppg) and percent root colonization were estimated using the Most Probable Number and grid-line intersect methods, respectively. Soil was diluted serially in 2-fold dilutions with steamed sand. Sorghum-sudangrass was seeded into 200 g of diluted soil and the roots were assessed after 30 days. Sites reclaimed for ca. 8 yr, 4 yr and 4 mo had an estimated 3.41, 1.44 and 0.02 ppg (significantly different at $p < 0.003$), respectively, and root colonization levels in undiluted soil were 39, 31 and 13% (significantly different at $p < 0.0001$), respectively. Therefore, the newly reclaimed site was nearly devoid of mycorrhizal fungi, but with time mycorrhizal fungus populations apparently increase.

A597

DISTRIBUTION OF VAM INFECTION IN ALLIUM PORRUM S.H. Jabaji-Hare, Dept. of Biology, University of

Waterloo, Waterloo, Ontario, Canada N2L 3G1

Leek seedlings were inoculated with *Glomus* sp. at 22 da, each plant receiving 0.5 g finely chopped infected root inoculum evenly distributed throughout the soil. Entire root systems were examined 40 and 60 da later. Roots were cut into 1-cm segments, cleared, stained and mounted in their natural sequence. Each segment was scored for number of vesicles, and presence/absence of arbuscules and external hyphae. Root system lengths were 171 cm at 40 da, 488 cm at 60 da. Number of segments infected was 91 at 40 da and 191 at 60 da (53% and 39% respectively). Extent of individual infections ranged from 1-11 cm. Number of vesicles per cm ranged from 1-220. Localized infections were very common. Root segments near the base of the bulb and the root tip had infective hyphae, but no arbuscules and vesicles. Distribution of infection is clearly non-uniform.

A598

FALLOW TILLAGE, WINTER WHEAT, AND VESICULAR-ARBUSCULAR MYCORRHIZAE IN WESTERN NEBRASKA. H. J. Larsen, J. R. Ellis, M. G. Boosalis, and C. R. Fenster. USDA-ARS, Dept. of Plant Path., and Dept. of Agron., Univ. of Nebraska, Lincoln, NE 68583-0722

Plow (P), subill (S), chemical (C), and plow + chemical (PC) fallow plots established in crested wheat sod at two W. Nebraska locations in early 1981 were cropped to winter wheat in 1982. Tillage treatment affected soil moisture (P, PC > S, C) and grain yield (P, PC > C) but not vesicular-arbuscular mycorrhizae (VAM) spore counts, rates of field root infections, or root infection potentials except on a temporary basis. Location effects were observed: southern location soil profile moisture, spore counts, and grain yield were greater than at the northern location, but the northern location had higher rates of field root infections (35-54% vs. 19-26%). Spore counts at both locations peaked at harvest (North 128.9 vs. South 201.8 spores/cc dry soil). The most common VAM species were *Glomus microcarpum* (33-57% of totals) and *G. fasciculatum* (28-40% of totals). *Glomus macrocarpum* and *G. mosseae* each represented < 2% of the total spore counts.

A599

GERMINATION OF GLOMUS EPIGAEUM SPORES IN MIXED AND AXENIC CULTURE. K. Mayo, and R. E. Davis, Department of Botany, University of Maryland, College Park, MD 20742, and Plant Virology Laboratory, PPI, ARS, USDA, Beltsville, MD 20705

Spores of *Glomus epigaeum* were separated from sporocarps in a blender and partially purified by sucrose density gradient centrifugation. Subsequent germination of the spores was influenced by surface disinfection regime, medium on which germination was tested, and presence of non-mycorrhizal microflora. Germination of surface sterilized spores was stimulated in mixed culture with specific bacteria. The findings suggest that manipulation of selected factors can markedly affect the early development of the mycorrhizal fungus.

A600

MYCORRHIZAL ASSOCIATIONS WITH *POPULUS GRANDIDENTATA* AT FOUR COAL SPOILS IN WEST VIRGINIA. J. B. Morton and A. Rizzo, Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506.

Bigtooth aspen growing on abandoned coal spoils at four locations were examined for mycorrhizal associations. Trees at all locations were ectomycorrhizal. Vesicles and intramatrical hyphae were present in stained aspen roots at two locations. *Glomus pallidum* and *Glomus fasciculatum* predominated at one location (41 and 28 spores/gm dry wt. soil, respectively), whereas *Glomus constrictum* and an undescribed yellow *Glomus* spore type occurred most frequently at the other (9 and 112 spores/gm dry wt. soil). At both of these locations, other plant species were presented which contained similar rhizosphere spore populations. At the other two locations, where aspen grew without associated vegetation, no vesicular-arbuscular mycorrhizae were observed. Hence, dual mycorrhizal associations were not essential for aspen survival, but may have important implications where plant mixtures are contemplated for re-juvenating disturbed strip mine sites.

A601

THE EFFECTS OF DROUGHT STRESS, MYCORRHIZAL INOCULATION, AND SOIL

NUTRITION ON WHEAT YIELD. C.E. Nelsen and T.C. Maiti, I.P.R.I., 853 Industrial Road, San Carlos, CA 94070.

Single spring wheat plants (*Triticum aestivum* L. cv. Anza) were grown in the greenhouse in large PVC tubes (1.5m tall, 0,15m dia.) containing 35 kg dry soil. Three replicates of each of 36 treatment combinations were arranged in a factorial design of 2 water levels, 2 levels of mycorrhizae (*Glomus etunicatum*), 3 levels of nitrogen, and 3 levels of phosphorus. Plants were grown to maturity and the experiment performed twice. Analysis of variance on yield, head number, grain number, and average grain weight showed that fertilizer had little effect on yield and that water level was the major factor in determining yield ($x=12.63$ g per plant at 40 cm available water and $x=2.12$ g per plant at 10 cm available water). Increased water level increased head number/plant and grain number/head. In experiment I, but not experiment II, there was a small but significant decrease in yield due to the presence of mycorrhizae and there was a significant interaction between mycorrhizae and water level. Mycorrhizae decreased yield 6% and 3% at 40 and 10 cm water.

A602

EFFECT OF STORAGE TEMPERATURE AND MOISTURE ON TWO SPECIES OF *GLOMUS* AND THEIR SUBSEQUENT INFECTION IN *CITRUS* SEEDLINGS. S. Nemeec, USDA, ARS, Orlando, FL 32803

Pot culture inoculum of *Glomus etunicatum* (G.e.) and *G. mosseae* (G.m.) containing 25, 50, 98 or 192 spores in sand of about 1% moisture and stored at 1.1, 4.4, 10, 16 and 21 C for 6 mo. resulted in no subsequent infection of G.m. in citrus seedlings in any treatments and infection by G.e. on citrus seedlings in all treatment combinations. Best infection of citrus roots by G.e. occurred at 1.1 and 4.4 C with all spore concs and from 10 to 21 C with 50 to 192 spore concs. In a similar test with G.e. stored for a yr, viability was reduced in only the 25 and 50 spore conc of the 4.4 and 21 C treatments. G.e. inoculum of 2368 spores in sand stored at 1.1 C from 0 to 25% soil moisture levels survived all treatments after 197 days, but G.m. inoculum of 523 spores did not survive these treatments. G.m. inoculum of 523 spores stored in the same way for 56 days survived all treatments. G.e. inoculum heat treated in sand from 43-77 C survived 49 C for 1 hr but did not survive 60 C. G.m. inoculum survived 43 C but not 49 C.

A603

PHLYCTOCHYTRIUM SP. - A PATHOGEN OR SAPROPHYTE OF MYCORRHIZAL SPORES? T. C. Paulitz and J. A. Menge. Department of Plant Pathology, University of California, Riverside, CA 92521.

An unidentified species of *Phlyctochytrium* (*Phly.*) is reported to be a mycoparasite on spores of VAM fungi. Studies were undertaken to determine whether *Phly.* attacks viable or non-viable *Gigaspora margarita* spores. The VAM spores were incubated in sterile sand on nylon mesh and inoculated with zoospores of *Phly.* *Phly.* almost exclusively attacked non-germinated but not germinated spores. *Phly.* did not reduce incidence of spore germination. Pre-killing of spores with propylene oxide (P.O.) or heat greatly increased infection by *Phly.* Water soluble exudates from P.O.-killed spores chemotactically attracted more *Phly.* zoospores than healthy spores. High populations of *Phly.* did not reduce infection or growth response of cotton by *G. margarita*. Similarly, infection and growth response of citrus by *Glomus deserticola* was not reduced. This evidence suggests that *Phly.* is primarily a saprophyte which attacks non-viable spores of *G. margarita*.

A604

HEALTHY AND DECLINING ENGLISH OAK ECTOMYCORRHIZAL AND ROOT DISTRIBUTION. H. Zare-maivan and R. V. Gessner, Department of Biological Sciences, Western Illinois University, Macomb, IL 61455

Two healthy and two declining *Quercus robur* L. growing in a meadow at the Morton Arboretum were studied. Cylindrical soil cores were taken and root volume, mycorrhizal volume, and percent mycorrhizal infection (PMI) were determined. Healthy trees, in general, had more mycorrhizal volume than declining trees but there was no clear difference in the PMI. Healthy trees also had a higher root volume, mycorrhizal volume, and PMI in samples taken at 1m intervals from the trunk to the edge of the canopy. The healthy tree, in general, had a greater PMI, total root dry wt., and total fine root dry wt. than the declining tree and more significant differences were found at half-canopy than at the edge of the canopy. When healthy and declining trees were compared by sector (NE, SE, SW, NW) significant differences were found in PMI and fine root dry wt. Differences were not significant when N and S sectors were compared.

A605

A METHOD TO QUANTITATIVELY ASSESS WHEAT SEEDLING CROWN AND ROOT INFECTION BY *FUSARIUM ACUMINATUM*. Charla Rae Armitage and J.P. Hill, Dept. Botany & Plant Path., Colorado State University, Fort Collins, Colorado 80523.

Wheat seeds were surface sterilized for 30 seconds in 95% ethanol and 5.25% NaOCl (1:1 v/v), washed in sterile distilled water, and placed between two strips of white cotton fabric (30 by 90 cm). The cloth was rolled up around the short axis, fastened with a single rubber band, and stood in a 1 liter glass beaker containing sterile distilled water. One to 2 days later, the cloth was unrolled and water agar disks (5 mm diam) containing 25 *Fusarium acuminatum* macroconidia were placed on the newly germinated wheat crowns and roots. Six days after inoculation, the crowns and upper root regions were excised, surface sterilized for 15 seconds in the ethanol/NaOCl mixture and placed on petri dishes containing acidified potato-dextrose agar. The isolation percentage of *Fusarium acuminatum* was used because visually symptomless crowns were often found to contain the fungus. Preliminary tests indicate significant percentage infection differences between cultivars.

A606

SYNERGISM BETWEEN *COLLETOTRICHUM GRAMINICOLA* AND EUROPEAN CORN BORER IN STALK ROT OF CORN IN NEW YORK. G. C. Bergstrom, B. S. Croskey, and R. I. Carruthers, Departments of Plant Pathology and Entomology, Cornell University, Ithaca, NY 14853.

Anthraxose stalk rot (ASR) of corn in New York State has been most severe in areas impacted by high populations of European corn borer (ECB). The ASR-ECB interaction was studied in overhead irrigated plots at Freeville, NY in 1982. In populations of dent corn infested with ECB egg masses at the 8 leaf, silking, or dough stages, few plants developed significant levels of ASR by the end of the season. Plants inoculated behind leaf sheaths with *C. graminicola* developed leaf blight and some superficial stalk lesions but few developed internal ASR. In populations infested with both pests, ASR developed mainly in stalks tunnelled by ECB and the severity of ASR increased proportionately with an increase in the amount of insect damage. While *C. graminicola* can invade unwounded corn stalks, stalk infection in the field may occur more commonly in conjunction with insect injury.

A607

PRODUCTION OF FLOATING INOCULA OF *RHIZOCTONIA SOLANI* AND *R. ORYZAE*. C. D. Boyette, H. L. Walker, and G. L. Sciumbato, Delta State University, Cleveland, MS 38773, USDA-ARS, So. Weed Sci. Lab., Stoneville, MS 38776, and Miss. Ag. and For. Exp. Stn., Stoneville, MS 38776, respectively.

Floating inocula of rice sheath blight (incited by *R. solani*) and brown bordered leaf and sheath blight (incited by *R. oryzae*) were produced using a modification of the procedures developed by H. L. Walker and W. J. Connick, Jr. (Weed Science 1983 In Press). The fungi were grown for 4 days in liquid culture, harvested, diluted 1:1 with distilled water, blended with 1% (w/w) sodium alginate, 10% (v/v) mineral oil, paraffin oil, or various vegetable oils, streptomycin sulfate (125 mg/L) and chloramphenicol (75 mg/L). The mixtures were dripped into a .25 M solution of CaCl₂ where they gelled into 3-4 mm granules. The granules were collected with sieves, rinsed, air dried, and stored at 4C. The granules floated on water surfaces and were infective on rice (cv. 'Labelle'). Practical application for disease and/or fungicide screening is envisioned.

A608

EFFECTS OF HERBICIDES ON GROWTH AND CARPOGENIC GERMINATION OF *SCLEROTINIA SCLEROTIIFORMIS*. *R.F. Cerkaskas, P.R. Verma, and D.L. McKenzie. Agriculture Canada, *Vineland Res.Stn., Vineland Stn., Ontario, LOR 2E0, and Res.Stn. Saskatoon, Saskatchewan, S7N 0X2.

Nineteen pre- and post-emergent herbicides used in Saskatchewan were tested for effects on linear growth of mycelia and sclerotial production of *Sclerotinia sclerotiorum* which affects canola (rapeseed) in western Canada. PDA was amended with herbicides at concentrations of 1-1,000 ug a.i./ml and tests were run at 21°C. None of the herbicides stimulated mycelial growth but most of them significantly inhibited growth. Glyphosate and metribuzin at 1-50 ug/ml and TGA at 1-25 ug/ml had no effect on mycelial growth. Herbicide concentrations of 50-1,000 ug/ml did not stimulate mean sclerotial weight. Barban at 1-5 ug/ml, nitrofen at 2.5 ug/ml and 2,4-DB at 25 ug/ml significantly increased mean weight of individual sclerotia. Dalapon and nitrofen did not affect numbers of

sclerotia. Effects of trifluralin, triallate, and EPTC at 0.1, 5, 10, 20 ug a.i./gm of Sutherland clay loam soil on carpogenic germination of sclerotia and upon subsequent colonization of sclerotia by soil fungi were discussed.

A609

FIELD INTERACTION BETWEEN RHIZOCTONIA SOLANI AND FUSARIUM OXYSPORUM ON SOYBEANS. L. E. Datnoff and J. B. Sinclair, Dept. of Plant Path., Univ. of Illinois, 1102 S. Goodwin Ave., Urbana, IL 61801.

Six-day-old Wells II soybean seedlings were planted in 7.5-cm peat pots containing soil infested with either 0.04 g/g of *R. solani* (RS) or 2.4×10^6 spores/g of *F. oxysporum* (FO), alone or in combination and transplanted to the field on 6 June 1982. Data were taken at 2-week intervals. Topweights and plant heights were significantly ($P=0.01$) lower in RS and RS + FO plots than the controls, but not from each other. Topweights, but not heights were significantly reduced by FO. Severity ratings of RS and RS + FO generally did not differ from one another, but were significantly different from the controls. Root piece infection did not differ among fungal treatments. No apparent interaction exists between RS and FO.

A610

INFLUENCE OF PHOTOSYNTHATE SINK SIZE ON SUNFLOWER RESPONSE TO SCLEROTINIA STALK ROT. I. J. Gulya. U. S. Dept. of Agriculture, Agricultural Research, and Dept. of Plant Pathology, North Dakota State University, Fargo 58105.

Modifying the photosynthate sink size did not significantly alter the response of sunflower inbreds to stalk rot incited by *Sclerotinia sclerotiorum*. Plots of normal and deheaded plants of six sunflower inbreds were established in naturally infested field plots to compare the effect of different sink size on disease incidence and rate of disease progression. Stalk rot was assessed at five weekly intervals commencing one week prior to bloom. No significant differences in stalk rot incidence or rate of progression due to deheading were noted at any date within an inbred. The inbreds, however, differed in response among themselves at every date. Genotypes with high yield capabilities thus may not inherently be more susceptible to *Sclerotinia* stalk rot than low yielding genotypes.

A611

EFFECT OF TILLAGE SYSTEMS ON CORN STALK ROT. G. L. Hartman, R. P. McClary, J. B. Sinclair, Dept. Plant Path., and J. W. Hummel, Dept. Agr. Engr., Univ. Illinois, Urbana, IL 61801.

Five tillage practices: conventional (C), ridge-subsoil (RS), sweep plow (SP), disk (D) and no-till (N) and two crop sequences: continuous corn (B73xPa91) and corn following soybeans were studied. In rotation plots for 1981, RS had significantly higher percentage of plants with stalk rot than all others; in 1982 RS, C, and SP were sig. higher. N had the lowest stalk rot in both years. In plots with continuous corn in 1981, C and RS had sig. higher stalk rot and N was sig. lower. Paired comparisons of ears from healthy plants and adjacent plants with stalk rot were evaluated for no. of kernel rows (NOR), kernel number (KN), and 1000-seed weight (TSW). For rotation plots in 1981 and 1982, KN and TSW was higher with healthy plants. NOR was sig. less with healthy plants in 1981.

A612

CULTIVAR REACTION TO INFECTION OF WHEAT SEEDLING LEAF WOUNDS BY FUSARIUM ACUMINATUM. J.P. Hill, Dept. of Botany & Plant Path., Colorado State University, Fort Collins, CO 80523.

Wheat seedlings were grown in 11 by 15 cm plastic pots containing 508.3 gms of Fort Collins clay loam maintained at a matric potential of -5 or -10 bars. The seedlings were grown in a growth chamber at 21 ± 1 C and thinned to 4 per pot. Four wks after planting 2 leaves per seedling were pierced with a sterile dissecting needle. The plants were inoculated by fastening 5mm agar discs containing approx. 25 macroconidia of *Fusarium acuminatum* over the wounds with cellophane tape. The pots, containing the inoculated plants, were covered with clear plastic to maintain high relative humidity and facilitate infection. Lesion size was measured 1 wk after inoculation. No significant lesion size differences were found

between the same cultivars grown under different matric potentials. A series of cultivars were concurrently compared in sets of two. Significant lesion size differences occurred between certain cultivar pairs.

A613

PREDISPOSITION OF WINTER RYE (SECALE CEREALE L.) TO ERGOT (CLAVICEPS PURPUREA (FR.) TUL.) BY BARLEY YELLOW DWARF VIRUS INFECTION. H. Jedlinski, USDA, ARS, Dept. of Plant Pathology, University of Illinois at Urbana-Champaign, Urbana, IL 61801

Barley yellow dwarf virus (BYDV) infection increased susceptibility of winter rye to natural infection by ergot in 1980. Fall infected plants had 14 % sclerotia by kernel wt and 33 % by kernel count, while the spring infected and BYDV-free plants had 0.9 and 1 %, and 0.3 and 0.4 %, respectively. Heading was delayed by 4 and 2 days due to fall and spring BYDV infections, respectively. Sterility was increased to 68 % and 34 % for the BYDV fall and spring infected plants, respectively, as compared with that of 27 % for the virus-free plants. Similar results were obtained in 1981 and 1982 but without a consistent increase in sterility.

A614

PATHOGENICITY AND GEL ELECTROPHORETIC PROTEIN PATTERN COMPARISONS AMONG STRAWBERRY ANTHRACNOSE FUNGI. J. L. Maas, USDA, Beltsville, MD 20705

Several species and forms of *Colletotrichum* and *Gloeosporium* have been reported to cause anthracnose diseases. Apart from *C. fragariae*, little is known concerning the etiology of anthracnose fungi from other plants to strawberry, or the genetic relationships among these fungi. Pathogenicity studies were done using isolates of *C. gloeosporioides*, *C. fragariae*, *C. coccodes*, *C. trifolii*, *C. dematium*, *Glomerella cingulata* and *Gloeosporium* spp. Pathogenicity varied with isolate and tissue inoculated. Slab gel electrophoretic protein analyses were made with representative isolates to determine coefficients of similarity. In general, the results of the protein analysis confirmed the pathogenicity tests. Surprisingly, *C. fragariae* showed the highest similarity coefficient with *C. coccodes* and somewhat less so with *C. gloeosporioides*.

A615

SOYBEAN RUST IN NEPAL. J. B. Manandhar and S. Joshi, Div. Plant Path., Dept. Agr., Khumaltar, Lalitpur.

Soybean rust, caused by *Phakopsora pachyrhizi*, was first observed in mid-August, 1981 on several cultivars of soybeans in Khumaltar. The disease appeared in 1982 during the first week of September following 3 to 4 days of continuous rain. Soybean rust disease surveys in 1981 and 1982 showed that the disease is endemic in Nepal. Severity of the disease was high in the late-maturing cultivars Bragg, Cobb, Hardee, P-28 and P-32. Most of the early-maturing cultivars, including all indigenous ones, are susceptible when planting is delayed. Tainung 3, Tainung 4 and PI 200492 were resistant; and yam bean (*Pachyrhizus* sp.) and cowpea (*Vigna unguiculata*) are susceptible. However, several cultivars of pigeon pea (*Cajanus cajan*) and other cultivated summer legumes are not affected. The telial stage of the fungus was not observed.

A616

ANTHRACNOSE OF WILD RICE CAUSED BY A *Colletotrichum* sp. J.A. Percich, R.L. Bowden, M.K. Kardin, and E.S. Hotchkiss. Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

In 1979 a disease of wild rice (*Zizania aquatica* L.) was first found in 2 natural stands and 4 commercial fields in Minnesota. Subsequent disease surveys in 1981 and 1982 revealed the presence of anthracnose in all of 6 natural stands and 15 of 22 commercial fields, respectively. The symptoms of the disease were characterized by the presence of elliptical to fusiform leaf lesions (0.1-1.5 x 0.1-0.6 cm) with light tan centers and dark brown margins. Lesions contained numerous black, setose, vein-limited acervuli (0.05-2.0 x 0.05-0.2 mm) covered with orange-pink masses of conidia. The lesions were observed on the leaves of aerial plants as well as on the floating leaves of young plants. Incidence and severity of disease generally was low. The pathogen was determined to be a *Colletotrichum* sp. similar to *C. graminicola*.

A618

EFFECT OF SEEDING DATE OF WINTER WHEAT ON INCIDENCE, SEVERITY, AND YIELD LOSS DUE TO CEPHALOSPORIUM STRIPE. P. J. Raymond and W. W. Bockus. Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506.

Cephalosporium stripe (CS) is a severe disease of winter wheat in Kansas caused by *Cephalosporium gramineum*. Root infection occurs when roots are frozen and/or wounded during winter soil heaving. Reduced fall root growth (infection sites) with delayed planting has been reported to decrease CS incidence. A 2-yr. field trial was established to study the effect of delayed planting of winter wheat on disease incidence, severity, and yield loss due to CS. Although the reduction was not significant in one of the years, a trend toward reduced CS with delayed planting was evident. However, disease severity and percentage yield loss due to CS were not significantly affected and there was a 14% yield reduction for non-inoculated plots with each week delay beyond the optimum planting date. Thus, under Kansas conditions, reduction in CS incidence can be expected with delayed seeding, but this benefit is negated by the loss in crop yield potential associated with this practice.

A619

COMPENSATORY YIELD RESPONSE IN SOYBEAN: A SUBTLE BUT IMPORTANT EXPRESSION OF DISEASE RESISTANCE. J. P. Ross. USDA, Department of Plant Pathology, North Carolina State University, P. O. Box 5397, Raleigh 27650.

Closely related soybean mosaic virus (SMV)-resistant (DMR) and susceptible (DMS) soybean lines, which in prior field tests yielded equally when exposed to SMV (Crop Sci. 17:869-872), were planted in pure stands and in blends of DMS (80%) and 20% DMR plants. DMS plots and those with DMR and DMS were inoculated with SMV twice in June, and DMR plants in mixed stands were labeled. At maturity each plant was cut out and threshed separately. DMR and DMS plants in pure stands yielded 34.2 and 25.5 g/plant, respectively. In plots with DMR plants adjacent to DMS plants, yields per plant were 45.1 and 22.3, respectively. The 32% increase in yield per DMR plant grown in mixed stands over that where DMR was grown in pure stands demonstrates the important role that compensatory yield responses can have in mitigating disease loss.

A620

PLANT DIAGNOSTIC CLINICS. Gail E. Ruhl, Dept. of Botany and Plant Pathology, Purdue Univ., W. Lafayette, IN, 47907.

In the past 20 years plant diagnostic clinics have become integral parts of many state cooperative extension services, state departments of agriculture, industry regulatory agencies and private consulting firms. At the present time there are at least 83 plant diagnostic clinics in the United States. These clinics provide prompt, accurate and complete diagnosis of plant problems with appropriate control recommendation. In addition to the diagnostic services, many clinics serve other functions including a) training and instruction of students and the public b) recording disease occurrences c) aiding in detection of new plant problems d) a resource for information pertaining to plant health and e) a public relations contact not otherwise reached by the agency involved. Clinic diagnosticians evolved in an effort to improve the delivery of plant health information to the public. Extensive training plus several years of experience help provide the background for the diagnostic specialist. Increasing emphasis is placed on more advanced techniques, such as immunofluorescence, ELISA, electron microscopy, etc., in the diagnostic procedures.

A621

CORN HEAD SMUT CONTROL BY HYBRID SELECTION AND CHEMICAL SEED TREATMENT. W.C. Stienstra, T. Kommedahl, C.A. Matyac, C.E. Windels, and J.L. Geadelmann. University of Minnesota, St. Paul, MN 55108.

Head smut caused by *Sphacelotheca reiliana* occurred only in four counties of Minnesota from 1980 to 1982. Restriction in spread of this corn disease may be attributed to (1) rotation with other crops, (2) growing smut-resistant hybrids, and (3) cleaning of machinery moving from farm to farm. Also, warm, moist soil in the early spring, which is required for head smut infection, occurs in relatively few areas of the state. During 1981-82, 63% of 171 commercial hybrids, 88% of 19 public lines, and 49% of 53 F₁ hybrids among 10 public lines had head smut incidence of 10% or less. About 20% of the 53 F₁ hybrids had some degree of resistance. Baytan^R as a seed treatment gave 97% control during a 2 year period, while Vitavax^R was not effective; several experimental formulations had some promise. Thus, control of head smut is possible by choice of resistant hybrid^R or by seed treatment of a susceptible hybrid with Baytan^R.

A622

ASSOCIATION OF PHYTOPHTHORA ROOT ROT OF SOYBEAN WITH CONSERVATION TILLAGE. H. Tachibana, USDA-ARS and Iowa State Univ., Ames, IA 50011 and A. Van Diest, Webster City, IA 50595

A severe Phytophthora root rot of soybean was observed associated with chisel and ridge-till-plant soil conservation tillage treatments. Plants of the same cultivar 'AH 325' grown under traditional moldboard plow treatment were not killed nor stunted. Yields ranged from 1747 to 2896 kg/h with and w/o disease, respectively. In 76 cm wide rows with disease, yields were 1747 kg/h for chisel and 2298 kg/h in ridge-till-plant treatments. In 36 cm rows, chisel plowed and diseased, yield was 2419 kg/h. Moldboard plow without disease had the highest yield of 2896 kg/h. Although lower yields and disease were encountered with the chisel plow treatment for both narrow and wide rows, the yield was 672 kg/h greater in narrow than in wide rows and significantly greater than normally expected with narrower rows. It is hypothesized from these observations that conservation tillage may increase the disease but higher populations of narrow rows will reduce effect upon yields in soybeans.

A623

RADIOMETRIC CLASSIFICATION OF CEREAL DISEASE SEVERITY
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Assessment of the severity of plant disease infestations is essential for successful, timely and cost-effective control. Conventional methods are labor-intensive and results may vary among individuals. Remote sensing offers the possibility of efficient, rapid and accurate quantification of infestation levels. Field plots of wheat and barley cultivars in Bozeman, Montana were inoculated with *Puccinia* spp., *Septoria* spp., *Xanthomonas*, and *Pyrenophora graminea* pathogens. In situ spectral measurements were taken through the 1982 growing season with an Exotech Model 100 hand-held radiometer and correlated with agronomic and meteorological data. Experimental results indicate that spectral data are highly correlated to several agronomic variables including pathogen infestation levels.

A624

BIOASSAYS TO EVALUATE WHEAT LINES FOR RESISTANCE TO CEPHALOSPORIUM LEAF STRIPE. S.L. Van Wert and D.W. Fulbright, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312.

Winter wheat lines with and without field tolerance to *C. gramineum* were screened in seedling and leaf-sheath bioassays. Seedlings were assayed by dipping cut roots of 10-day-old wheat plants in spore suspensions of *C. gramineum*. After 14 days, the plants were rated for severity of chlorosis, leaf striping and death. Leaves with intact sheaths were assayed by cutting 16-day-old plants at the soil line and placing the shoots in graminin A, a toxic metabolite of *C. gramineum* implicated in disease development. After 3 days, the leaves were rated for severity of chlorosis and wilting. Most wheat with high levels of field tolerance gave limited chlorosis in seedling and leaf-sheath assays. *C. gramineum* mutants with increased and decreased virulence were selected and are being assayed for production of graminin A in culture. The purpose is to evaluate the role of graminin A in disease development.

A625

BRACT NECROSIS, A NON-PARASITIC DISEASE OF SUNFLOWER. S. M. Yang, USDA-ARS, P.O. Drawer 10, Bushland, TX 79012, and R. W. Berry, Texas Agric. Ext. Serv., Lubbock, TX 79401.

Sunflower on the Texas High Plains may develop necrosis of the involucral bracts during hot summer weather. Necrosis symptoms are typically brown discoloration of disk flowers and bracts. The brown discoloration becomes black after rain. When bract necrosis occurs during the bud stage, buds may remain unopened. Some injured buds may open but produce few disk flowers and little pollen, and others produce neither ray flowers nor disk flowers. *Alternaria alternata* (Fries) Keissler, *Curvularia lunata* (Wakker) Boedign, and *Fusarium solani* (Martius) Saccardo and *Rhizopus arrhizus* Fischer were isolated from the necrotic bracts, but none of the four fungi caused bract necrosis after they were atomized on to sunflower heads. Detached sunflower heads, with peduncles emersed in tap water in a flask, manifested brown discoloration of bracts when they were kept in a growth chamber at or above 40°C. These results indicate that a high temperature can cause bract necrosis of sunflower.