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Kansas Plant Disease Survey

Kansas has a long tradition of plant disease surveys dating back to 1912. As participants in the original Plant Disease Survey Program begun in 1917 by the United States Department of Agriculture's Bureau of Plant Industry, Kansas plant pathologists made many contributions to the fledgling *Plant Disease Reporter* (1). Observations made during those surveys were recorded on 3 × 5 in. index cards, which remain on file. The USDA survey was discontinued about 1945, and some attempts were made to continue the use of the index cards in Kansas for several years, but their use was discontinued in the early 1950s. Important Kansas plant disease information was published in the *Transactions of the Kansas Academy of Science* during the 1950s and 1960s (2,3). The Kansas State University (KSU) Plant Disease Diagnostic Laboratory (now located in Throckmorton Hall) was formally established in 1962, and records from 1962 to the present are maintained in a logbook within the Department of Plant Pathology.

A formal plant disease survey was initiated by the Kansas State Board of Agriculture (KSBA) in 1975 as an adjunct to an existing insect survey program that began in 1954. The insect survey received minimal funding from USDA-APHIS-PPQ from 1954 to 1979, at which time the funding was discontinued. The Kansas plant disease survey program has been state-supported since its inception.

Because of the large acreage of crops grown in Kansas (over 20 million acres), the size of the state (82,264 square miles), and resource limitations, cooperative relationships with several institutions and organizations in Kansas were established at the outset of the current program. The closest relationship in the plant disease survey program exists between KSBA and KSU. The decision was made early in the program to house the survey plant pathologist in the KSU Department of Plant Pathology. This has proved beneficial to both institutions.

The current plant disease survey program has two major goals: 1) to facilitate the movement of Kansas commodities in interstate and foreign trade and 2) to monitor development of endemic or established diseases so that Kansas producers can make management decisions to reduce disease losses. Major emphasis is on the state's major crops of wheat, sorghum, corn, alfalfa, and soybeans. Minor crops such as barley, oats, sunflowers, dry beans, red clover, and horticultural crops, including nursery stock, turf, fruits, and vegetables, are surveyed as conditions warrant or as required by statute. Detection surveys for new or exotic diseases are included in all survey activities.

Plant disease survey information is utilized by many clients, including state and federal regulatory agencies, state and federal extension services, agribusiness interests such as private crop consultants, chemical companies, seed companies, local grower cooperatives, and public and private research interests.

Fig. 1. Tom Sim using a portable computer to record field survey data.

Staffing

The Plant Protection Section of the KSBA Plant Health Division employs six area staff members who are responsible for all plant regulatory functions as assigned by statute, including export certification, interstate commodity certification, nursery inspection, and plant disease and insect surveys. A survey plant pathologist, survey entomologist, and state apiarist have statewide responsibility for assigned programs. Two clerical positions and one administrator provide administrative support in Topeka. The survey plant pathologist and survey entomologist have offices in their respective departments at KSU in Manhattan and are afforded adjunct faculty appointments.

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Data Type: Survey    RAM available: 200
County:    . Date:        . Crop:      .
Fld.No:    . G.Stg:       .Loc.:       .
  Pest:    .  A/I:                     .
D/S:       . P.Stages:          .
Comments:                         .
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Fig. 2. Radio Shack Model 100 computer data entry screen.

Fig. 3. Wheat variety demonstration plots planted by extension agents in most Kansas counties are valuable for monitoring disease incidence, severity, epidemic development, resistance, and losses. Here Bill Willis is rating wheat in the Saline County plot for reaction to wheat soilborne mosaic virus.

The Kansas Cooperative Extension Service employs four extension plant pathologists to manage extension functions. These specialists regularly contribute timely survey data. The Plant Disease Diagnostic Laboratory is also an important source of current plant disease information. State and area entomologists, agronomists, and crop protection specialists also contribute survey information. KSU research and teaching faculty likewise contribute survey data and provide such technical support as diagnostic tests.

Some data and information are received from knowledgeable persons in the private sector, including private consultants, chemical company representatives, seed company agronomists, and farmers.

System for Data Coding, Collection, and Summary

An efficient data coding, collection, and summarization system is essential if survey data are to be made available to users on a near real-time basis. The current Kansas system has evolved from note-taking with paper and pencil to the use of portable computers for recording field survey data. A major goal in the development of the computerized system was to keep it as simple as possible for the person in the field while taking advantage of available computer technology. We felt simplicity was absolutely necessary to obtain timely and accurate data from a wide variety of contributors.

The Kansas coding system is quite simple. Codes for plants consist of three obvious letters, e.g., ALF for alfalfa, CRN for corn, MLO for milo (grain sorghum), SOY for soybeans, WHT for wheat, SUN for sunflowers, OAT for oats, APL for apple, ZOY for zoysia grass, and PAN for pansy. Over 375 host plant codes have been assigned (4). Codes for plant diseases consist of two, three, or four letters, again, as obvious as possible. For example, codes for wheat diseases include BYD for barley yellow dwarf, CS for Cephalosporium stripe, LR for leaf rust, LS for loose smut, SLB for speckled leaf blotch, TA for take-all, TS for tan spot, and WSM for wheat streak mosaic. Some disease codes are used for several hosts, e.g., BYD is used for barley yellow dwarf of wheat, barley, and oats.

Data entry software was developed for use on several different types of computers used in the Kansas survey program, including Radio Shack Model 100 portable computers, MSDOS desktop and lap personal computers, and the KSBA Plant Protection Section's Tandy Model 6000, which serves as the central repository for the survey data. Two telephone lines are available on the Tandy 6000 for data transmission. The XMODEM error-checking protocol is available on the Tandy 6000 when transmitting survey data to assure accurate file transfer.

KSBA staff use Radio Shack Model 100 portable computers for recording survey data in the field (Fig. 1). Communication software using the XMODEM error-checking protocol was installed on these machines to allow error-free data transmissions. The Model 100 has a built-in 300-baud modem and connects directly to modular telephone lines. These machines have been extremely reliable in the 2 years they have been in use. No data loss has occurred during that period.

KSU state and area extension specialists use desktop and lap personal computers to format survey data and transmit the data to the KSBA computer in Topeka, using the XMODEM file-transfer protocol.

The computer data entry software is menu-driven and was designed to allow the following types of data to be entered: survey, trap (spore, insect black light, insect pheromone, etc.), export certification, and diagnostic laboratory. The data entry program is simple to use and prompts the user for the data. Data editing is possible both during and after data entry. Data files are saved in ASCII format.

Figure 2 is a diagram of the data entry screen from the Radio Shack Model 100 computer; the end of each data field on the screen is indicated by a period. The screen size is 40 characters wide by eight lines. The top line displays the type of data being entered and the amount of memory available in number of 80-character records. A short explanation of each data field used in the survey data portion of the program follows:

County. A two-letter code for each county has been assigned by the Kansas State Department of Transportation. This code appears on Kansas license plates and is familiar to survey data contributors.

Date. The observation date is recorded. The current date is automatically entered by pressing the ENTER key.

Crop. The length of this data field is five characters, the first three for the plant and the last two for a crop situation code. A crop situation code may modify the crop code or be used alone. For example, if a county wheat variety plot is being surveyed, the crop situation code for variety plot (VP) is entered after the crop code (WHTVP).

Field number (Fld.No). Each contributor is assigned a unique set of three-digit numbers (4). These numbers are used to identify the observer and the field location. Observers maintain a set of county plat maps and mark field locations for future reference.

Growth stage (G.Stg). The growth stage of the crop is recorded using the codes developed for that crop (4).

Location (Loc.). The location of the field is recorded using the legal description (township-range-section), the nearest town, or the general location in the county, e.g., NE = northeast, C = central, etc.

Pest. A disease code is entered.

A/I. This field is used to record plant disease incidence (the percentage of diseased plants in the field) or insect abundance. Specific survey methods have been developed for most major crop diseases (4). Subjective ratings may also be used.

D/S. This field is used to record plant disease severity or insect damage. Some

methods of assessing plant disease severity were developed using percentage of leaf area affected, etc. (4). If no method is available, a subjective rating may be entered.

Pest stages (P.Stages). This field is used to record insect developmental stages and is not used in the plant disease survey.

Comments. This field is used for remarks pertaining to the particular observation.

The bottom two lines of the screen are used to display various menus that allow the user to correct current data entries, change data types, or exit the program.

Contributors transmit data files to the Topeka computer weekly during the growing season. Files may contain plant disease and insect survey, export certification, trap catch, and diagnostic laboratory data. Thursday noon is the deadline for data inclusion in the current week's summary and survey report. Once all the data for the current week are submitted, the individual data files are combined and the data are separated into plant disease, insect, trap catch, or export certification files. The plant disease data are then sorted and summarized. The summary lists the diseases reported for each crop by county and contains all the aforementioned data fields. This summary is available to the Kansas Cooperative Extension Service each Friday morning before 8 a.m. The summary is used to produce extension newsletters and the weekly KSBA plant disease survey report. Similar summaries are produced for insect survey and trap catch data and are made available to extension entomologists. Software to summarize export certification data is being developed.

Survey data are also submitted to the National Agricultural Pest Information System (NAPIS) on a weekly basis as part of the state's participation in the Cooperative National Plant Pest Survey and Detection Program sponsored by USDA-APHIS-PPQ. Conversion software was developed that translates Kansas data into the format required by NAPIS. A total of 3,563 observations on 148 diseases on 53 plant species was submitted to NAPIS in 1987.

Plant disease data are maintained in a database on the Tandy 6000 computer in Topeka. The database can be queried to extract data as needed. Plans are under way to incorporate historical survey data.

Who Uses the Data

Data gathered and information generated by the Kansas plant disease survey program are used primarily by four major groups: regulatory agencies, extension service, agribusiness, and research interests. The material has both immediate and long-range uses by a variety of clients for making pest management decisions.

State and federal regulatory agencies use the data collected to make enlightened regulatory decisions regarding the movement of plants and plant products in foreign and domestic trade. Each state and foreign country has regulations that must be met in order for commodities to be granted entrance into that state or country. The issuance of Kansas and federal phytosanitary certificates depends on accurate and timely survey data.

Detection of new diseases is especially important to regulatory officials in facilitating movement of plants and plant products as well as in protecting Kansas commodities. Control procedures are more easily implemented when pests are detected early.

Disease distribution in Kansas is also maintained to facilitate interstate and foreign shipment of Kansas products. By combining the use of disease distribution information with trade leads provided by marketing agencies, the movement of Kansas products in domestic and foreign markets is enhanced. KSBA is currently developing a computerized plant disease distribution database.

Current disease information is quickly disseminated without fee in newsletters during the growing season. The KSBA "Plant Disease Survey Report" is mailed each Friday to approximately 325 subscribers, including KSU research personnel, state and area extension specialists and county extension agents, crop consultants, agribusinesses, and various state and federal agencies. The KSU "Kansas Plant Disease Alert," written by extension plant pathologists, is mailed Monday or Tuesday to extension agents, specialists, experiment stations, field staff, and approximately 100 others who request it. The Kansas Agricultural Statistics Service (KASS) now includes excerpts from these reports in their weekly crop reports. Commodity traders and market analysts are regular users. These newsletters provide chemical company representatives and seedsmen with current plant disease information. There is considerable commercial advertising and promotion of fungicides for wheat leaf disease control, and growers considering treatment and businesses trying to sell fungicides need to know the current disease situation.

Computer data processing and transmission provide users with accurate near real-time information. A computer-based electronic communication system, "The Sunflower Dispatch," now being implemented by the Kansas Cooperative Extension Service, will soon permit public and private users who have the necessary equipment to access the data immediately after compilation.

Some users do not require near real-time survey data but use the information in making short-term management decisions. Chemical companies need to know the current pest trends when deciding which pesticides to stock and promote. Breeders and seedsmen use plant disease and insect severity information in developing, releasing, and deploying cultivars. Scientists prioritize research and justify grant and funding proposals with survey and yield loss data. Survey personnel often collect samples of diseased plants for research and teaching use. In turn, researchers develop specialized diagnostic techniques. A current example of a mutually beneficial project is collection of wheat streak

Table 1. Reduction in wheat yield due to soilborne mosaic (SBM) at the Sandyland Experiment Field in Kansas, 1986

	Yield in bu/acre (kg/ha)			
	Irrigated, SBM		Dryland, no SBM	
Average of 13 resistant varieties	86.0	(5,780)	54.6	(3,669)
Average of 11 susceptible varieties	59.8	(4,019)	55.2	(3,209)
Bushel loss	26.2	(1,761)		
Percent loss	30.0			

Table 2. Reduction in wheat yield due to stem rust in Kansas, 1986

	Yield in bu/acre (kg/ha)					
	Susceptible variety		Moderately resistant variety		Advantage	
Light stem rust	52.5	(3,528)	57.0	(3,830)	4.5	(302)
Severe stem rust	32.4	(2,177)	49.8	(3,347)	17.4	(1,170)
Statewide estimated stem rust loss					12.9	(868)

mosaic virus isolates by field workers and identification of wheat viruses with ELISA techniques in the research laboratory. Disease incidence and loss information assists extension specialists in developing effective pest management and control programs to meet grower needs.

Estimating Losses in Wheat

Survey information provides the foundation for estimating wheat disease losses. Losses are calculated immediately after harvest and released annually about 1 August. Losses are calculated by combining disease incidence, severity, and distribution information with losses measured in performance tests and in research and demonstration plots (Fig. 3), along with acreage and variety data from KASS.

For example, in 1986, soilborne mosaic (SBM) was moderately severe in the irrigated wheat performance test at the Sandyland Experiment Field in south central Kansas. An identical dryland test in the same field was unaffected by SBM. The replicated tests included 13 resistant and 11 susceptible varieties. We were thus able to compare average yields of resistant and susceptible varieties where SBM affected yield and where it did not (Table 1). Resistant and susceptible varieties yielded essentially the same where there was no SBM. Susceptible varieties yielded 26 bushels (30%) less with SBM, so that was our calculated loss. This value agreed with previous research results. This loss figure was combined with SBM distribution and incidence survey data to estimate statewide losses of 1.4%.

In 1985, leaf rust (LR) losses were estimated by comparing average yields of two varieties in 30 different tests where the disease level was known. In previous years when LR was not severe, the average yield of Arkan (resistant) was 59 bu/acre (3,965 kg/ha) and that of TAM 105 (susceptible) was 60 bu/acre (4,032 kg/ha). In 1985, when LR was moderate to severe over most of the state, the average yield of Arkan in 16 replicated performance tests was 62 bu/acre (4,166 kg/ha) and that of TAM 105 was 56 bu/acre (3,763 kg/ha). In 14 unreplicated county variety demonstration plots, Arkan averaged 51 bu/acre (3,427 kg/ha) and TAM 105 averaged 42 bu/acre (2,822 kg/ha). Severity of LR across the state obtained from survey data was combined with these figures and yield increases in fungicide-treated plots to estimate statewide losses of 5.0%.

In 1986, stem rust (SR) losses were calculated by comparing yields of TAM 105 (susceptible) and TAM 107 (moderately resistant) in replicated performance tests where SR severity was known. Leaf rust effects were not considered in the comparison, since both varieties are equally susceptible. In six tests in western Kansas where SR was light, TAM 107 outyielded TAM 105 by 4.5 bu/acre (302 kg/ha). In five tests in central and eastern Kansas where SR was severe, the yield advantage of TAM 107 was 17.4 bu/acre (1,170 kg/ha). Estimated losses of 12.9 bu/acre (868 kg/ha) were attributed to SR (Table 2). This figure was combined with survey incidence and severity data and percentage of resistant and susceptible varieties planted to calculate losses.

Annual disease loss estimates provide direction for extension, research, teaching, and regulatory emphases. The great variability and general trends of disease severity evident in the 12-year summary (Table 3) are valuable in making management and priority decisions. For example, major wheat disease research efforts are directed toward controlling diseases that consistently cause significant loss, such as soilborne mosaic, wheat streak mosaic, leaf rust, tan spot, and take-all. Diseases that occasionally cause heavy losses, such as barley yellow dwarf, stem rust, and strawbreaker, are given lower priority.

Plant disease survey data are used with weather data in wheat disease forecasting. Wheat disease severity data are entered from daily or weekly survey data files into a wheat disease alert network program, which combines environmental data for Kansas counties with the disease observations. These data are accessible by research, extension, and regulatory personnel in an on-line database. Besides maintaining the disease, temperature, and precipitation observations in an ASCII file, contour and/or density maps of specific diseases (Fig. 4) can be displayed that are useful in estimating epidemic development and potential reductions in wheat yields within the state.

A Cooperative Effort

The current Kansas plant disease survey program is a cooperative effort that combines the talents and resources of several agencies to benefit a wide range of interests and users. The cooperative nature of the program is evident throughout its entire scope, including field data collection, data processing and storage, information distribution, and program planning.

Both near real-time and historical plant disease survey information are necessary for effective decision making and priority setting by regulatory officials, extension advisors, researchers, farmers, agribusiness, and funding

Table 3. Wheat disease loss estimates in Kansas during 1976–1987

Disease	Estimated percent loss[a]												
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	Av.
Soilborne mosaic and spindle streak	5.0*	5.0*	3.5*	1.6	3.0	2.0	1.7	1.2	2.5	2.4	1.4	1.0	2.5
Streak mosaic	0.3	1.0	3.5*	0.5	0.3	7.0*	0.4	1.2	0.1	T	3.0	2.0	1.6
Barley yellow dwarf	4.5	0.5	0.8	T	T	T	T	0.3	T	0	T	3.5	0.8
Leaf rust	1.0	1.0	1.5	1.5	T	1.5	2.8*	2.5	1.5	5.0*	9.0*	4.0*	2.6
Stem rust	0.1	T	T	0	0	0	0	0.1	0.1	0.1	4.6	0.1	0.4
Stripe rust	...[b]	...	...	...	...	...	...	0.1	T	T	...	T	T
Speckled leaf blotch	2.0	0.5	1.0	0.5	1.0	0.5	2.5	5.8*	3.5*	2.8	1.0	1.5	1.9
Tan spot	...	3.0	1.0	1.5	3.5*	0.7	1.3	1.8	2.5	2.5	1.0	3.5	1.9
Powdery mildew	0.4	0.2	0.5	1.0	0.1	1.3	0.6	0.8	0.5	0.2	0.3	0.3	0.5
Bacterial leaf blight	...	...	...	...	...	...	...	0.1	0.3	T	...	T	...
Take-all	3.0	1.0	2.0	0.5	0.6	0.7	0.4	1.1	1.2	2.0	1.0	0.4	1.2
Root and crown rots and winter injury	...	...	1.8	2.0*	...	...	0.5	0.1	1.0	0.2	0.2	0.4	0.5
Strawbreaker	...	...	...	...	...	...	...	...	0.8	1.0	0.1	T	0.2
Bunt loose smut	0.4	0.2	T	T	0.2	T	T	0.1	0.1	T	T	T	0.1
Scab	...	...	T	...	T	...	2.1	0.2	0.2	T	0.2	0.2	0.2
Cephalosporium stripe	3.0	1.0	0.9	1.5	1.3	T	1.5	1.0	0.4	0.4	0.1	T	0.9
Total	19.7	13.4	16.5	10.6	10.0	13.7	13.8	16.4	14.7	16.6	21.9	17.0	15.3

[a] * = Disease causing most loss for that year; T = trace (less than 0.1%).
[b] No estimate made.

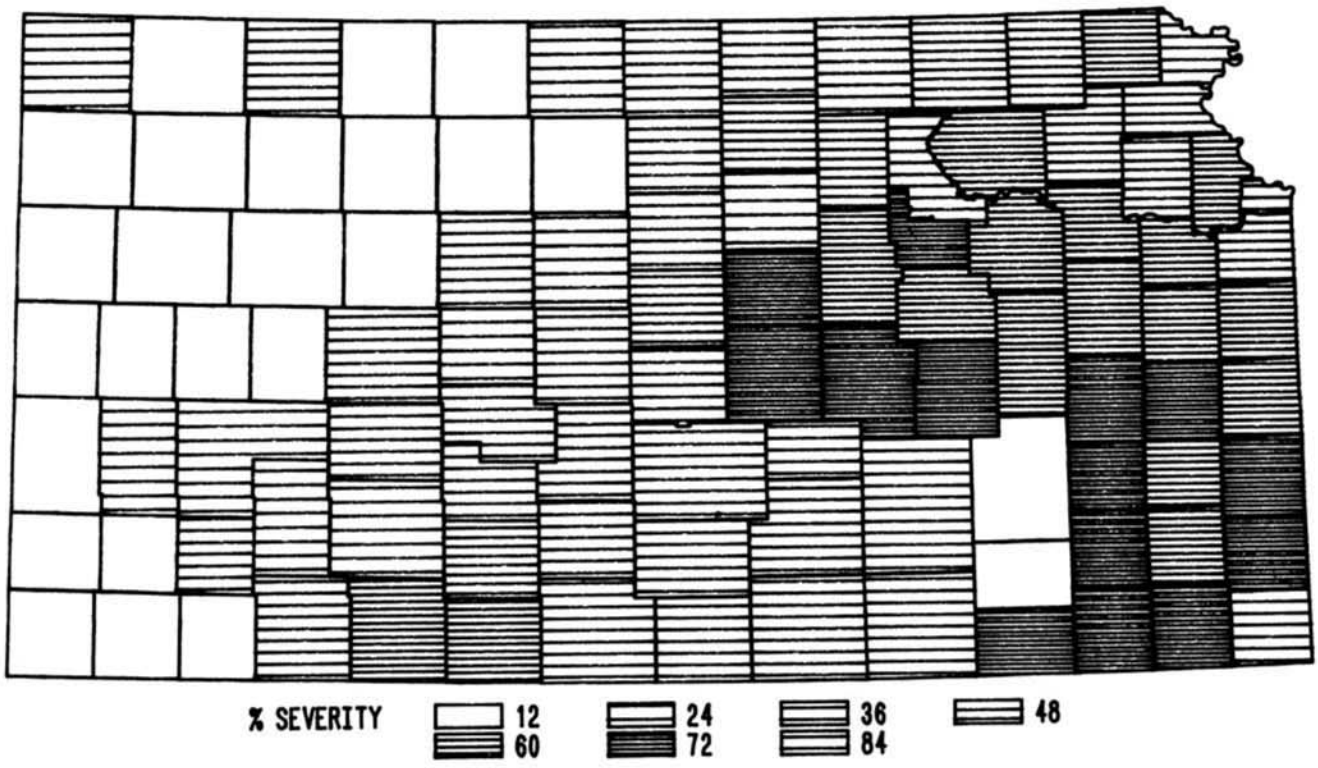

Fig. 4. Density gradient map of Kansas showing the levels of wheat leaf rust observed in each county as of 20 May 1986.

agencies. The annual wheat disease loss estimates provide an example of one specific use made of survey data and their derivative information.

The use of computers and the development of necessary data-processing software have evolved through several years of field testing and refinement. Throughout this development, the needs of contributors and users of plant disease survey information were paramount. The Kansas plant disease survey program will continue to take advantage of computer technology as resources allow. Current projects include development of a Kansas plant disease index and distribution database and graphics software that will produce distribution maps from Kansas survey data files. Data-processing software is upgraded as needed to increase efficiency.

The cooperative nature of this program cannot be overemphasized. Without the contributions and ideas of many people, this program would not have progressed to its current level.

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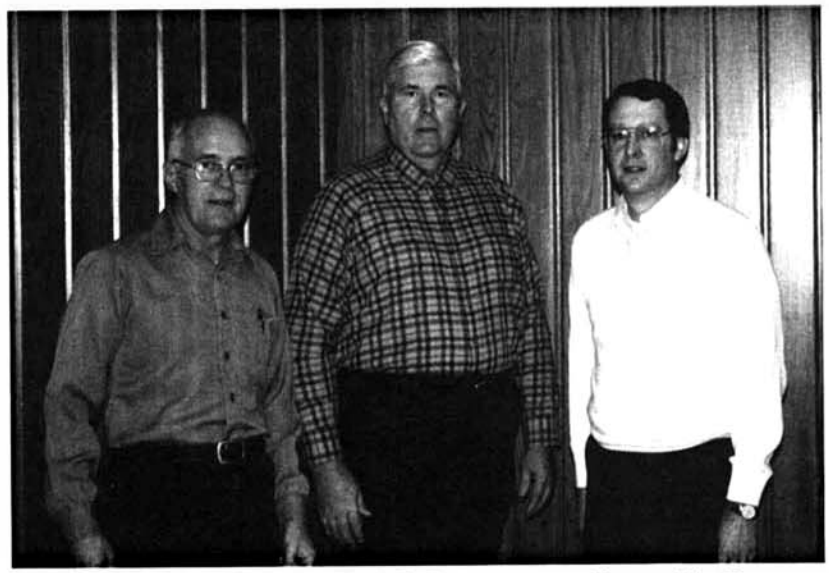

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Dr. Willis is an extension specialist in plant pathology and a professor in the Department of Plant Pathology at Kansas State University, Manhattan. He was awarded his Ph.D. degree at Kansas State University in 1967. Wheat and alfalfa diseases are his major responsibility.

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Mr. Sim is the survey plant pathologist in the Plant Health Division of the Kansas State Board of Agriculture, Topeka, and an adjunct assistant professor in the Department of Plant Pathology, Kansas State University, Manhattan. He received his M.S. degree from Kansas State University in 1975. His major responsibility is coordinating and conducting plant disease surveys in Kansas.