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Role of Fire for Disease Control in Grass Seed Production

Much of the seed of northern temperate-zone grasses is produced in the western United States because the yields and quality are higher than in other areas. Lower summer rainfall and humidity during maturation and curing result in harvesting and marketing of bright, nearly moldfree seed. Yields were relatively high when production was started in the Pacific Northwest but gradually declined. Yields of some grasses were restored by planting in rows but eventually declined in older plantings. The straw and stubble left in fields formed a blanket that excluded light and smothered the plants, resulting in weak regrowth and low seed yields.

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This paper reports the results of research only, and mention of a pesticide does not constitute a recommendation by the USDA or imply registration under FIFRA.

Unique Problems of Grasses and a Common Denominator

Disease control is difficult because of unique problems in the culture of grasses. Grass seed production is inherently trashy farming that unavoidably creates conditions favorable for maximum development of diseases. Pathogens inevitably build up when inoculum is allowed to accumulate in straw and stubble during several years of continuous grass culture.

These unavoidable difficulties are compounded by the impracticality of major methods used to control diseases of other plants. For instance, resistance to diseases peculiar to seed production or to those occurring only in the West usually is not sought in breeding programs. Genetic change is not encouraged and may not be permitted in grass varieties that are developed in consuming areas and submitted for seed production. Crop rotation is not practiced in the culture of long-term perennial grasses. Seed treatments have only limited value. Except for rusts, chemical control of grass diseases generally has not been feasible. All these problems are aggravated in many grass seed crops by low per-acre returns that dictate inexpensive control methods. Maximum sanitation is imperative, and simple removal of straw and stubble generally is inadequate. Burning fulfills the low cost requirement and, by generating sterilizing heat, furnishes the necessary field hygiene (4).

During 1944–1947, the need to restore yields and improve control of weeds and insects in Oregon grass seed fields coincided with the critical need to control blind seed disease (*Gloeotinia temulenta* [Prill. & Delacr.] Wilson et al) and ergot (*Claviceps purpurea* [Fr.] Tul.). The recommendation to burn all perennial English ryegrass (*Lolium perenne* L.)

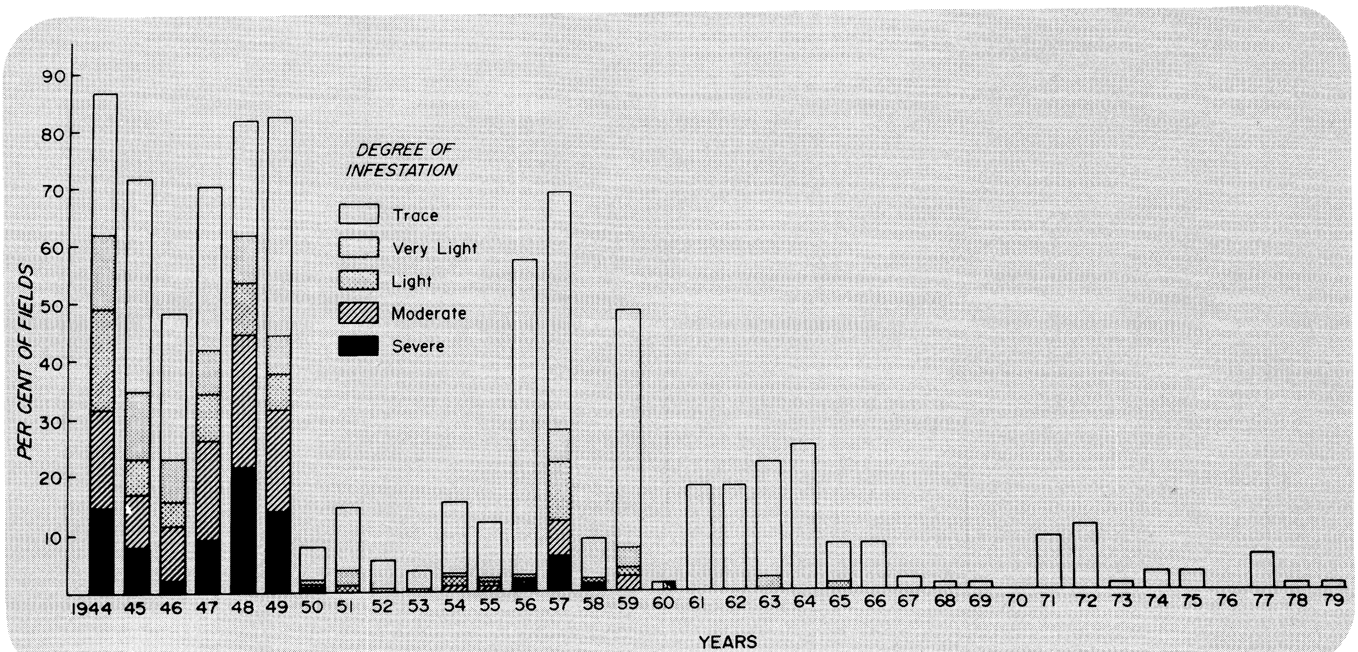


Fig. 1. Incidence of blind seed disease in Oregon perennial ryegrass fields.

fields for disease control after the 1948 harvest served as the impetus to establish use of thermal sanitation, a method I felt was desperately needed. Burning was the one common denominator applicable to most grasses that would restore yields and furnish the basis for disease and pest control programs.

Some Effects and Complications

Thirty years have passed since field burning was universally adopted in Oregon grass seed fields, and some of the effects and complications of this practice are interesting to examine.

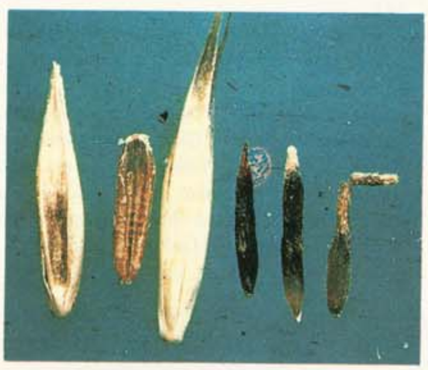
Burning immediately controlled several diseases (Table 1) and some weeds and insects. During 1949–1950, field burning tripled yields in perennial ryegrass. In later years, burning increased seed yields from twofold to tenfold in tall fescue (*Festuca arundinacea* Schreb.), red fescue (*F. rubra* L.), Chewings fescue (*F. rubra* var. *commutata* Gaud.), sheep fescue (*F. ovina* L.), colonial bentgrass (*Agrostis tenuis* Sibth.), Kentucky bluegrass (*Poa pratensis* L.), orchardgrass (*Dactylis glomerata* L.), annual Italian ryegrass (*L. multiflorum* Lam.), and several wheatgrasses (*Agropyron* spp.). The Oregon burning practice was adopted in the 1950s in Washington and Idaho and has been highly beneficial,

Apothecia of *Gloeotinia temulenta* (blind seed disease) from infected seed of *Lolium perenne* (perennial ryegrass).

Table 1. Significant diseases controlled by field burning of major perennial seed crops in Oregon

Crop	Burning started	Diseases: Good control	Diseases: Partial control
Perennial ryegrass	1948–1949	Blind seed disease* Ergot* Silver top	Helminthosporium leaf blotch Stem rust Other leaf diseases
Tall fescue	1949–1950	Blind seed disease* Ergot* Silver top	Cercospora leaf spot Other leaf diseases
Bluegrasses	1950s	Ergot* Silver top*	Stripe smut Flag smut Rusts Powdery mildew Other leaf diseases
Chewings and red fescue	1950s	Silver top* Seed nematode* Ergot*	Red thread Septoria blotch Powdery mildew Leaf rust Other leaf diseases
Colonial bentgrass	1954	Ergot* Silver top*	Seed nematode* Rhizoctonia brown patch Leaf diseases
Orchardgrass	1958	Ergot* Multiple leaf diseases* Silver top*	Stripe smut

*Original reasons for field burning.



(Left) Two healthy Chewings fescue caryopses; (right) four caryopses parasitized by seed nematode (*Anguina agrostis*).

Mass of larvae of seed nematode (*Anguina agrostis*) from softened seed gall in *Agrostis tenuis* (colonial bentgrass).

Kentucky bluegrass (*Poa pratensis*) affected with silver top (short culms).

Ergot (*Claviceps purpurea*) in *Elymus cinereus* (giant wild rye).

particularly to Kentucky bluegrass seed production; yields from burned fields greatly exceed those from unburned and untreated fields. Similar results were obtained more recently in Minnesota, especially when a desiccant was applied 48 hours before burning (L. J. Elling, *personal communication*).

Seed Diseases

Blind seed disease. Widespread postharvest burning was recommended after the 1948 harvest to control blind seed disease and save the perennial ryegrass seed industry in Oregon. About half the perennial ryegrass acreage was burned that year, with immediate excellent control, and nearly all fields have been burned since 1949. Except for a brief recurrence during 1956–1959, when the fuel (straw) was poorly distributed, the disease has been well controlled through 1979 (Fig. 1). Burning tall fescue fields started after the 1949 harvest and virtually eliminated blind seed disease in this grass.

No effective chemical is commercially available, and field burning remains the only practical method of controlling blind seed disease. Breeding for resistance in perennial ryegrass has met with only limited success. *G. temulenta* infection of grass flowers can be prevented by root uptake of certain benzimidazoles applied to the soil, but excessive dosages are necessary. Several chemicals inhibit apothecia in pot tests, but only sodium azide has given satisfactory control in field plots.

Ergot. A major disease of most cultivated grasses in northern temperate-zone countries, ergot was controlled adequately in grass seed fields in western Oregon when straw and stubble in fields were burned after harvest, starting in 1948. Subsequently, burning fields of tall fescue, Kentucky bluegrass, Chewings and red fescue, colonial bentgrass, orchardgrass, and annual ryegrass also controlled ergot (5). Burning dormant dallisgrass (*Paspalum dilatatum* Poir.) controlled ergot (*C. paspali* Stev. & Hall) in Georgia (13).

Field fires destroy most of the sclerotia in crop residues and at the soil surface. Prevention of fall heading of perennial ryegrass plants is a special need because autumn inflorescences form abundantly and are usually heavily infected with ergot. Burning eliminates fall heading and prevents the secondary increase of sclerotia important to the total inoculum.

Field burning is still the only feasible control of ergot in perennial grasses. Because resistance to ergot is unknown in virtually all grasses, breeding for resistance is precluded. Infection of grass flowers can be prevented by root uptake of benomyl and some other benzimidazoles, but, as with blind seed disease, effective dosages are prohibitive. Few chemicals suppress perithecial ascocarps, and only sodium azide satisfactorily checks ascocarps in field plots. Again, no effective chemical is commercially available.

Seed nematode. Grass seed nematode (*Anguina agrostis* [Steinbuch] Filipjev) once caused severe losses in Chewings fescue seed crops in western Oregon, but the incidence dropped sharply after adoption of annual field burning in 1955. In recent years, nematode galls needed

Fig. 2. An effective field fire elevates the smoke column to an altitude sufficient for good dispersal by lateral air currents, thereby reducing the effect at ground level. (Courtesy Air Resources Center, Oregon State University)

Fig. 3. Rapid perimeter ignition of an Oregon grass field provides a strong upward-feeding draft that organizes the energy and pollutants into a convective column. (Courtesy Air Resources Center, Oregon State University)

for experimental work could not be found in Oregon samples of Chewings fescue seed crops. About 1971 in Clackamas County, Oregon, the seed crop in one Chewings fescue field was severely damaged by seed nematode after field burning had been discontinued. A huge increase in seed nematode (*A. funesta* Price, Fisher, and Kerr) (10) occurred in Wimmera ryegrass (*Lolium rigidum* Gaud.), a volunteer annual grass weed, after burning of wheat fields was discontinued in Australia (E. D. Higgs, *personal communication*).

Resistance to seed nematode apparently has not been detected in creeping bentgrass (*A. palustris* Huds.), colonial bentgrass, or Chewings fescue, so breeding for resistance is not yet possible. No chemicals are known to be effective in infested fields. Once again, field burning provides the only control.

Silver top. During 1954 and 1955 in western Oregon, silver top caused complete crop losses in Chewings fescue and Highland colonial bentgrass but has since been virtually eliminated by field burning. Silver top had been controlled earlier in Pennsylvania by burning when the disorder was thought to be caused by *Fusarium tricinctum* (Cda.) Sacc. emend. Snyd. & Hans. f. *poae* (Pk.) Snyd. & Hans. and the mite *Siteroptes cerealium* (Kirchner [*S. graminum* Reuter]). However, later work revealed that the fungus and mite were late-arriving saprophytes and suggested insects as causal agents. Recognized causal insects, such as *Leptopterna* (Mirus) *dolabrata* (L.) (5) and *Capsus simulans* (Stol) (9), deposit eggs in the lower part of grass culms. Field burning destroys the eggs and thus provides excellent control of silver top. Postharvest burning also controls silver top in red fescue, perennial ryegrass, tall fescue, sheep fescue, Kentucky bluegrass, orchardgrass, annual ryegrass, and several wheatgrasses. Control of silver top by burning became particularly significant when persistent insecticides were banned around 1971.

Leaf and Stem Diseases

Field burning has partially controlled a number of leaf and stem diseases in several grasses. In the southeastern United States, burning Bermuda grass (*Cynodon dactylon* [L.] Pers.) removes thatch, increases forage yield, and provides a measure of control of leaf spot and stem blight caused by *Helminthosporium spiciferum* (Bain.) Nicot. and *H. rostratum* Drechs. and should be helpful in seed production (R. T. Gudauskas and R. B. Carver, *personal communication*). In Saskatchewan, fall burning of smooth brome (*Bromus inermis* Leyss) reduced the incidence of leaf spot (*Selenophoma bromigena* [Sacc.] Sprague & A. G. Johnson) and increased the seed yield, and flaming or burning of crop residues significantly reduced the incidence of leaf spot (*Pyrenophora bromi* [Died.] Drechs.) (11). In Oregon, field burning has reduced the incidence of leaf blotch (*H. siccans* Drechs.) on perennial ryegrass, several leaf and stem diseases in orchardgrass and tall fescue, and probably blister smut (*Entyloma dactylidis* [Pass.] Cif.) in Kentucky bluegrass. In Canada, red fescue stem eyespot (*Phleospora idahoensis* Sprague) is controlled by burning (12). Phleospora eyespot apparently has been controlled in Oregon, since it is absent in red fescue seed fields after successive years of burning; however, the disease occurs on wild fescues surrounding the seed-growing areas of the Willamette Valley and eastern Oregon (12).

Burning may reduce the incidence of Septoria leaf blotch (*Septoria macropoda* var. *septulata* [Gonz. Frag.] Sprague). Despite annual burning of bluegrass sod in Oregon, however, incidences of leaf blotch have been high.

During 1976 in Spokane County, Washington, postharvest burning of Kentucky bluegrass seed fields controlled Helminthosporium leaf spot better than chemical treatment did. A striking gradient of diminishing leaf spot incidence was observed from diseased areas in adjacent untreated plots through about 7 m into the burned field, where essentially no disease was evident (G. W. Bruehl, *unpublished*).

In northern Idaho, leaf infection by *Drechslera poae* (Baudys) Shoemaker was reduced by burning susceptible varieties of Kentucky bluegrass (3).

Field burning greatly reduced pink patch (*Corticium fuciforme* [Berk.] Wakef.) in Chewings fescue fields in Oregon, apparently by 1) reducing inoculum by killing sclerotia, 2) removing senescent leaves, which are most subject to infection, and 3) improving nitrogen utilization, which helps plants resist infection. *C. fuciforme* does not damage forage-type perennial ryegrass in fields thoroughly burned with the considerable fuel of a full-season's crop of straw and stubble. Conversely, *C. fuciforme* is a problem in turf-type perennial ryegrass varieties that are weakly burned when the straw is first removed and the stubble is inadequate to fuel an effective fire. Control of pink patch by fire is difficult because of apparently increased susceptibility of turf-type perennial ryegrasses combined with decreased tolerance of some varieties to field burning, dictating fuel reduction.

Other Thermal Treatments

Substitutes for open field burning have long been sought. Mobile field burners were thoroughly studied in Oregon in a well-financed effort, but major defects prevented commercial use and the idea has been abandoned. Flaming devices are useful in special situations but expend fossil fuel extravagantly, and treatments are expensive.

Politics, Legislation, and Regulated Burning

On 12 August 1969, the Oregon Department of Environmental Quality (DEQ), which had the authority but little experience in managing field burning, forecast a good burning day and encouraged field burning for the entire Willamette Valley in western Oregon. The winds changed and moved the smoke into Eugene, resulting in an episode called "Black Tuesday" by the press and likened to the last days of Pompeii. This situation, in part, led to legislation in 1971 prohibiting field burning after 1 January 1975 (1). That ban was replaced in 1975 with a phase-down schedule that would reduce the hectares burned to 20,250 in 1978. This legislation was changed to permit burning of 72,900 ha in 1978 and 1979 and 101,250 ha in 1980 and subsequent years unless effective and economically feasible alternatives are discovered. These and similar severe societal constraints on disease management have been eloquently reviewed by Horsfall and Cowling in their inimical style (6).

Field burning in Oregon has been managed by the DEQ during the past few years, and a cautious approach to daily allocation of burning hectarage has resulted in significant delays. Many fields cannot be burned until late autumn, when abundant green leaves from regrowth and increasingly moist conditions reduce the method's effectiveness.

Alleviation of Air Pollution

The smoke from burning a large field with rapid combustion of as much as 2,700–5,400 t of plant material in a single fast fire invites interest, especially when the convection column is topped with a big mushroom cloud at 1,500–3,000 m on a clear day (Fig. 2). Air pollution has been greatly alleviated in Oregon for several years by a smoke management program that allows fields to be burned when atmospheric conditions are conducive to good smoke transport away from smoke-sensitive areas (1). Technique of burning also aids smoke dispersal. Rapid ignition of residue on the entire field perimeter creates a fast fire with an upward draft that strongly organizes the energy and pollutants into a convective column; this effectively elevates the emissions and reduces their effect at ground level (2) (Figs. 2 and 3).

Other Benefits and Spinoffs

Field burning can help avoid contamination of the crop seed with spores from weed plants infected with smuts and other diseases that have been mistaken for seedborne diseases of the crop. Burning also helps eliminate early maturing weed grasses that otherwise would be sources for buildup of ergot and inoculum transfer to the later maturing main crop.

Field burning allows reduction in the use of pesticides, herbicides, and insecticides. Annual application of 1.121 kg/ha of DDT had been the standard recommendation, but control of silver top by burning 60,750 ha of perennial grass seed fields avoided the application of more than 1,362,000 kg of DDT in the Willamette Valley of Oregon during 1950–1971.

In the mid-1950s, carbon ash (charcoal) from field burning was criticized because it interfered with activity of two herbicides (propham and chlorpropham) applied on the soil surface in the fall for control of winter annual grass weeds. This minor drawback was turned into a major technological breakthrough; activated charcoal is now applied routinely in a band over the seed row, and diuron is broadcast-sprayed over the soil surface. The charcoal band protects the crop seedlings in the row, and diuron eliminates weed seedlings between the rows (7).

The recent fatal poisoning of thousands of cattle and sheep in Australia from ingestion of *Lolium rigidum* infested with seed nematode (*A. funesta*) (10) is disconcerting to livestock producers because of the lack of control for this pest (8). *Lolium* ryegrass growers around the world can take at least some comfort that the Lolium seed nematode can be controlled by field burning.

Field burning conserves energy while sanitizing fields. Plant material, a renewable fuel, is used instead of fossil fuels. The practice also permits long-term culture of perennials and reseeding of annuals without frequent plowing and other energy-intensive tillage operations.

Areas for Further Study

Survival of the pathogens causing ergot, blind seed disease, and grass seed nematode depends on propagules above ground that are vulnerable to heat from field fires, and dramatic control is obtained by burning straw and stubble in grass fields. Although less striking, control of some foliar diseases by fire is sufficiently promising to justify further study.

The effect of burning on various leaf and stem diseases needs study not only to evaluate control but also to aid in determining the relative importance of inoculum above and below ground. If survival of some seasonally important foliar pathogens depends strongly on infected leaves and stems for both newly formed propagules and the nutrient supply from host tissue, destruction of straw, stubble, and regrowth by fire may provide an effective control method. Even if a disease is not controlled completely, field burning may furnish a basis for chemical control by reducing sources of inoculum, making possible a higher degree of control than obtainable with either method alone.

No Substitute Available

Although initiated for disease control, burning grass fields would be necessary to stimulate economic seed yields and aid weed control even if alternate methods of disease control were available. Field burning kills 95–99% of the weed seed at the soil surface and provides a clean soil surface allowing action of fall-applied, soil-active herbicides that perform poorly in unburned fields even with mechanical residue removal.

No substitute for the inexpensive, ancient, and time-honored practice of field burning is either available or apparent. Numerous studies by engineers, biologists, growers, agronomists, and economists have shown that of the methods capable of supplying the thermal sanitation needed for efficient grass seed production, field burning is the cheapest, most effective, and least damaging to the environment (1).

The multiple benefits of fire have been well publicized and are reasonably understood, so further evangelism of the merits of field burning is unnecessary. What is needed is exploitation of this natural force by refinement of the burning technique and fine tuning of the opportunities created by thermal sanitation of fields to the ultimate benefit of the consumer as high-quality seed. Improved techniques and better public understanding should alleviate the air pollution aspect so that the practice may be continued. Disease control and seed quality will be constantly improved by combining fire sanitation of fields with new, more effective fungicides.

For 30 years the consumer has been assured adequate supplies of high-quality seed at a reasonable cost, and the grass seed industry has prospered by introduction and perfection of field burning. If research efforts are continued, the next 30 years should bring even greater technological advances in seed production efficiency.

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