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SEED PRODUCTION RESEARCH
AT OREGON STATE UNIVERSITY
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Edited by William C. Young III

Page

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FOLIAR DISEASES OF ORCHARDGRASS GROWN FOR SEED AND THEIR CONTROL

R.E. Welty

Weather conditions that are cooler and wetter than normal favor infection and development of three important leaf and stem diseases in orchardgrass: eyespot (*Mastigosporium rubricosum*), scald (*Rhyncosporium orthosporum*), and leaf streak (*Cercosporidium graminis*).

In five years of field testing, data show fungicides control these three leaf diseases and increase seed yield in years when rainfall is more-than-normal (1984, 1986, and 1988). In these years, fungicides (especially chlorothalonil) applied at boot or boot + heading increased seed yields above nontreated controls. In 1985 and 1987 when rainfall was less-than-normal, these leaf diseases were not severe and fungicide applications did not result in higher seed yields. (See earlier reports in the publication series for specific data).

Results obtained in these studies indicate April and May are critical months for fungicide applications to control these diseases. In most years, flag leaves are emerging and seed heads are developing in late April and in May. In a year when these diseases were severe (1984), one application of chlorothalonil (Bravo) at either boot or heading increased seed yield 27% and 30%, respectively; two applications of chlorothalonil (boot + heading) increased seed yields 55%. In all five years of the study, chlorothalonil applied at flowering provided no increase in seed yield. Disease scores in fungicide treated plots were inversely related to yields (i.e. when disease scores were high, seed yields were low).

It is important to remember chlorothalonil applied to foliage protects only the part of the plant covered by the fungicide. This protection is for infection by the fungus only and does not stop or cure a disease after it has started. Also, chlorothalonil is not absorbed, but has an ability to redistribute on the leaf surface. It does not move to different parts of the plant, for example new growth. Therefore, it is absolutely critical to apply chlorothalonil before scald, eyespot, or leaf streak diseases are observed on the plant.

To do this effectively, weather conditions and weather trends should be carefully observed during April and May so timely applications of chlorothalonil can be made before fungus infection occurs. Quite often, when spring rains begin, they often persist for 5 to 10 days. This can prevent entry to the fields to apply protectant fungicides. As always, follow labelled instructions for fungicide application rates and safety precautions.

In 1988, disease pressure was high (i.e. weather conditions were favorable) and scald developed in a field study containing 10 cultivars of orchardgrass and provided an opportunity to evaluate scald resistance. Early maturing cultivars (Juno, Potomac, Sterling, and Hallmark) were the most susceptible which indicates these cultivars would benefit the most from fungicide applications to control scald.

In the fall of 1989 and 1990 at Hyslop Field Laboratory, natural infections of stripe rust (*Puccinia striiformis* var. *dactylis*) in 10 cultivars of orchardgrass allowed an evaluation of disease resistance. In both years, stripe rust severity (percent of leaf area rusted) differed significantly ($P = 0.01$) among cultivars. Disease damage ranged from 15 to 83% in 1989 and 2 to 50% in 1990. Results from the two field tests were consistent ($r = 0.87$, 8 df, $P = 0.01$). The two-year average rust severity (ranked least to most) were Cambria 9%, Potomac 14%, Hallmark 22%, Pennlate 24%, Able 31%, Aonami 32%, Juno 38%, Sterling 40%, Frontier 43%, and Latar 67%.

Applications of fungicides in the fall to control stripe rust is not considered economical. However, fall surveys indicate if a cultivar is highly susceptible to stripe rust. Highly susceptible cultivars should be examined carefully in May. In wet years, fungicides, such as propiconazole (Tilt) or triadimefon (Bayleton) will provide stripe rust control and will prevent stripe rust development. Follow labeled directions for fungicide application rates and safety precautions.

CONTROL OF STEM RUST IN PERENNIAL RYEGRASS GROWN FOR SEED

R.E. Welty

At Hyslop Field Laboratory, propiconazole (4 fl. oz/A Tilt) was applied one, two, or three times to 'Delray' and 'Linn' perennial ryegrass to control stem rust (*Puccinia graminis* spp. *graminicola*). Dates of fungicide applications were 26 April, 9 May, or 29 May when plant growth stages (50% of the plants in the plots were at that stage of growth) were at boot (flag leaf just emerging), ¼th heads emerged, or all heads emerged (no flowering). The experiments contained 6 fungicide application treatments and a nontreated control: a single application made at each stage of plant growth; a double application made at boot and ¼th heading or at ¼th heading and 100% heading; and an application at each of the three stages of plant growth. Each experiment contained six replications; data were statistically analyzed and means were compared using a protected LSD 0.05.

Stem rust was scored (percent of seed head rusted) in both cultivars (Delray and Linn) on 13 June, 27 June, and 5 July. Delray was harvested on 28 June; Linn was harvested on 3 July. Seeds were harvested with a small plot harvester, dried, threshed, cleaned, and weighted. Seed yields are given as grams of seed per plot.

Table 1. Stem rust development and seed yield in 'Delray' perennial ryegrass treated with 1-3 applications of Tilt (4 oz./A). Hyslop Field Lab., Corvallis, OR. 1990.

TILT (4 oz/A) APPLIED DATES	Growth Stage	STEM RUST SCORES Dates 6/13	6/27	7/5	SEED YIELD Harvest 6/28
CHECK	-	0	29	88	499
4/26	Boot	0	12	83	509
5/9	25% Head	0	2	64	544
5/29	100% Head	0	1	31	552
4/26+5/9	Boot+25%	0	3	49	544
5/9+5/29	25%+100%	0	1	13	582
4/26+5/9+5/29	B+25+100	0	0	0	599
LSD 0.05		-	6.8	13.8	54.9

Results

On 13 June, no stem rust was observed in plants, including the nontreated checks, in any plots of either Delray (Table 1) or Linn (Table 2). In check plots, stem rust had increased by 27 June to 29% in Delray and 38% in Linn, and increased by 3 July to 88% in Delray and 85% in Linn. By 27 June, rust that had developed in fungicide treated plots of both cultivars was significantly less (P = 0.05) than nontreated controls. By 5 July, stem rust was still controlled by single and multiple applications of propiconizole applied on 9 May and/or on 29 May. The most effective fungicide treatments were those applied on 9 May and 29 May.

Table 2. Stem rust development and seed yield in 'Linn' perennial ryegrass treated with 1-3 applications of Tilt (4 oz./A). Hyslop Field Lab., Corvallis, OR. 1990.

TILT (4 oz/A) APPLIED DATES	Growth Stage	STEM RUST SCORES Dates 6/13	6/27	7/5	SEED YIELD Harvest 7/3
CHECK	-	0	38	85	458
4/26	Boot	0	16	64	422
5/9	25% Head	0	6	44	516
5/29	100% Head	0	1	5	504
4/26+5/9	Boot+25%	0	7	55	414
5/9+5/29	25%+100%	0	0	3	420
4/26+5/9+5/29	B+25+100	0	0	2	462
LSD 0.05			11.1	21	NS

Seeds were harvested when field moisture contents (wet-weight basis) reached 40-45%, which occurred in Delray on 28 June and Linn 3 July. Fungicide applications to Delray resulted in significantly (P = 0.05) higher seed yield compared to the nontreated control (a 17-20% increase). Seed yields of Linn among the experimental treatments were not statistically different (P = 0.05) from the nontreated control. Apparently Linn has characteristics that maintain seed yields under severe pressure from stem rust. These results are similar to observations in Linn in other years - rust was controlled by fungicides but seed yields are not statistically different from nontreated controls. (See earlier annual reports in this publication series.)

The final rust score (5 July) was made after plots were harvested. This was possible because harvests were made as a 1 meter cut (39 inches) through the middle of a 2.4 meter (8 foot) plot. The rapid increase and appearance of stem rust in nontreated controls of Delray between 27 May and 5 July indicates how rapidly stem rust can increase when temperatures are higher late in the season. The 5 July rust score supports also the importance of having fungicide protection on plants before severe rust develops.

Discussion

During the past 2-3 years, growers have reported systemic fungicides are not providing adequate control of stem rust, even after 3 or 4 applications at the highest labeled rates. Most often, applications are made after stem rust is observed in the field. Although some systemic fungicides are reported to have fungus-eradicative properties (sometimes called "kick-back"), the best utilization of fungicides is to provide protection to plants before fungus infection occurs. this is true for fungicides described as either "contact" or "systemic."

In this study, the lowest labeled rate of Tilt (4 fl. oz/A) provided protection from stem rust in both cultivars when it was applied before stem rust was observed in the plants. Fungicides applied in May controlled stem rust development through most of June and protected plants from severe rust increase even 2 to 7 days after harvest.

Linn and Delray are different in seed yield responses in the presence of severe stem rust development. Other cultivars may share a characteristic of maintaining seed yield or suffering seed yield losses in the presence of stem rust, however, the number of cultivars is too many to test in replicated field tests. Therefore, growers are encouraged to evaluate seed yield in cultivars they grow under their production practices. If this is done, it is critical to apply fungicides before stem rust is observed and to leave untreated strips in the field or untreated areas in the corners of a field. Seed yields from both areas should be harvested and measured separately.

No evidence was obtained to support the existence of fungicide-resistant races of stem rust.

Results are, however, based on one year of data. The study will be repeated in 1991 and the results will be reported next year.

STEM RUST AND ENDOPHYTE INTERACTION IN TALL FESCUE GROWN FOR SEED

R.E. Welty

Stem rust disease reaction (i.e. pustule infection type) in endophyte-infected (EI) and endophyte-free (EF) seedlings of tall fescue (*Festuca arundinacea*) was evaluated in two experiments in the greenhouse. In the first experiments, seedlings (11-wk-old) of EI and EF cv. Kentucky 31 (Ky 31) were inoculated with urediniospores (isolate Bonanza) and rated (0 to 4) for infection type two wk after inoculation (two replications). Seedlings rated 0 or 1 were rated resistant; seedlings rated 2, 3, or 4 were rated susceptible. For EI Ky 31, 27% of the seedlings had infection types 0 or 1; for EF Ky 31, 19% of the seedlings had infection types 0 or 1.

In the second experiment, 14 seedlings (10-wk-old) of each of 20 cvs (12 with and eight without endophyte-infection) were inoculated with the stem rust fungus and rated as before (five replications). For 12 cvs EI, 7% of seedlings were rated infection type 0, 2% were rated 1, 7% were rated 2, 21% were rated 3, and 63% were rated 4. For 8 cvs EF, 7% were rated 0, 1% were rated 1, 4% were rated 2, 17% were rated 3, and 71% were rated 4. Based on observations in both studies, endophyte infection in seedlings of tall fescue grown in the greenhouse had no apparent effect on infection type of *P. graminis* ssp. *graminicola*.

In a third study, investigating stem rust development, differences were found in the latent period (time between inoculation and urediniospore production) for stem rust development in tall fescue incubated at 50 F (10 C), 65 F (18 C), 77 F (25 C), and 81 F (27 C). No differences were found for latent period among the five cultivars tested at these temperatures. Urediniospore blisters developed six days after inoculation on the bottom surface of the leaves at 77 F and 81 F, and after eight days at 65 F and 13 days at 50 F. Maximum number of sporulating pustules occurred 18, 12, 9, and 8 days after inoculation at 50 F, 65 F, 77 F, and 81 F, respectively. Similar responses occurred in each of five runs. Urediniospore development was uniform and severe, and was not dependent upon leaf position on a tiller.

ASSESSMENT OF ERGOT AND BLIND SEED IN THE WILLAMETTE VALLEY

S.C. Alderman

The levels of ergot and blind seed among samples submitted to the Oregon State University Seed Lab between 1986 and 1989 were assessed. Significantly (P=0.05) more ergot infested samples were observed in 1988 than in 1989 but differences were not significant among any of the other years. Significant differences in blind seed incidence among years was not detected. Levels of ergot and blind seed were similar to those observed in field samples collected during disease surveys conducted in 1988 and 1989.

This work indicates that ergot and blind seed incidence in the Willamette Valley can be monitored through the examination of randomly selected Seed Lab samples. Because less time and resources are needed to assess the diseases using Seed Lab samples, a larger number of samples, representing a broader range of grasses, can be examined. Yearly assessments of ergot and blind seed in the Willamette Valley are planned.

Analysis of the spatial pattern of blind seed in tall fescue and perennial ryegrass in the Willamette Valley revealed that diseased fields occurred at random within each of three areas of intensive production. Blind seed incidence among fields increased from the northern to the southern end of the valley. Ergot was distributed at random throughout the Willamette Valley.

During the fall of 1988 and 1989, growers of fields sampled in the field survey were queried for management information. Growers were asked if the selected fields were open burned, propane burned, not burned, or newly planted. Information was obtained for 179 and 218 fields in 1988 and 1989, respectively.

In 1988 blind seed was detected in 38% of the fields open burned and 0% of the fields not burned (Table 1). In 1989, 6% of the fields were open burned and 4% of the fields not burned contained blind seed. The percentages of ergot in burned and non-burned fields was similar in 1988 and 1989 and the incidence ranged from 4-11%. It is not clear why a high incidence of blind seed was associated with burned fields in 1988. However, only trace levels of blind seed were detected in the fields. It is possible that trace levels of disease may have been introduced from inoculum source outside the field, i.e. from infected weed grasses.

Table 1. Percentage of fields with ergot or blind seed under various management treatments in 1988 and 1989.

Management Treatment	1988 Total number of fields	1988 % fields with ergot	1988 % fields with blind seed	1989 Total number of fields	1989 % fields with ergot	1989 % fields with blind seed
Open Burned	93	11	38	115	4	6
Propane Burned	31	0	6	31	0	3
Not Burned	29	7	0	52	4	4
Newly planted	26	4	4	20	0	5

SILVERTOP IN ANNUAL RYEGRASS PRODUCED BY A LEPIDOPTERA STEM BORER (*OCHSENHEIMERIIDAE, TINEOIDEA*)

J.A. Kamm and G.C. Fisher

In June 1990, an estimated 10-15 percent of the heads of annual ryegrass had silvertop symptoms in several hundred acres near Harrisburg, Oregon. Unlike the white heads or silvertop produced by plant bugs (characterized by shriveled stems just above the upper most node), these culms were packed with frass (feeding excrement) from an extremely long slender larvae of what are commonly referred to as larvae of stem moths. Stem boring larvae in the flies (relatives of the Hessian fly) are common in the Northwest and are best described as short and thick when compared with long slender larvae of stem moths.

All of the larvae in the taxon Ochsenheimeriidae are stem borers in the grass-like monocots Cyperaceae and Juncaceae, and in the grasses. Bromegrass, wheat, and rye are the only known host plants reported in the literature. However, host plants are known for only half the species in this taxon. Stem borers in this group are serious pests of winter wheat and rye in Russia. Members of this group were restricted to the Palearctic region until 1964 when *Ochsenheimeria vacculella* F.R. was found in Ohio and subsequently spread into New York and Pennsylvania.

The biology of the species that infested the annual ryegrass near Harrisburg is unknown, but the biology of known species in this group is very similar. Typically, eggs are laid on grass foliage, piles of straw, or other organic matter in late summer. Eggs or first instar larvae overwinter. Larvae become active in the spring, usually mining the leaves of their host. Within a week, they become stem borers capable of passing from one stem to another. In other words, expect to find culms with silvertop symptoms but with no larvae inside because it left and infested another stem. The infested annual ryegrass near Harrisburg had numerous culms with exit holes and no larvae inside. Larvae pupate in early summer, and adults emerge in late summer. The abundance of straw now available in the Willamette Valley during the egg-laying season of adults could provide the necessary environment for this insect to become a recurrent pest of ryegrasses.

If the stem borer that produced silvertop in the Harrisburg area was recently introduced into the Willamette Valley, it may spread and become a pest. At this point, fields with silvertop symptoms should be checked for the presence of long slender larvae (10 times longer than they are thick) in culms showing silvertop symptoms.

EFFECTS OF POST-HARVEST RESIDUE MANAGEMENT ON KENTUCKY BLUEGRASS SEED YIELD AND SEED QUALITY IN CENTRAL OREGON

D.D. Coats, W.C. Young III and F.J. Crowe

Kentucky bluegrass has been grown in central Oregon since 1954. Open-field burning has evolved as the standard post-harvest management practice in this area. Over the years, growers and seedsmen have observed that annual field burning improves seed yield and quality of Kentucky bluegrass in central Oregon. Increased concern for air quality, however, has created pressure for grass seed growers to find alternatives to open field burning.

Commercial grass seed fields in central Oregon will normally have a large portion of the crop residue removed as baled straw followed by open-burning of stubble and/or supplemental propane burning. Thus, the primary focus of this research was to compare this "field treatment" with several alternative stubble management systems. The specific objectives at these sites were to: 1) demonstrate different residue management practices; 2) observe crop growth and development; and 3) evaluate seed yield. These sites were designed to allow for a multi-year study of the various management practices being evaluated.

Plots were established following harvest of the 1989 seed crop in ten fields, representing several varieties of varying stand age, which had been established by local growers. Treatments included: 1) Field treatment (normal grower management) 2) Bale-only (no subsequent stubble management) 3) Close clipped (mechanical removal of stubble after baling) 4) Close clipped and propane.

Three stand ages and three variety types were evaluated. Fertile tiller number and seed yield estimates were determined for all treatments at each location. More detailed sampling of fall and spring tiller development was restricted to three sites. In addition, at four of ten sites sheep were fenced into one half of each of the treatments above, which allowed for assessments on residue removal by grazing.

Seed yield of alternative treatments to the grower field treatment (open field burn) were dependant on the type of cultivar and the age of the stand. Over all testing sites, seed yield of the field treatment was 1145 lb/a, followed by 1029 lb/a for close clip with propane and 916 lb/a for close clipping, and 808 lb/a for the bale-only treatment.

Age of Stand: Seed yield decreased with increasing stand age. Seed yield of second-year stands showed smaller difference in the close clipped, close clipped with propane, and field treatments, which ranged from 1471 - 1520 lb/a. Bale-only treatments applied to second year stands yielded only 932 lb/a, a reduction of 539-588 lb/a when compared with other treatments. For third-year stands, the close clipped with propane and bale-only treatments differed little in seed yield (1011 lb/a and 1024 lb/a, respectively), and were between the close clipped (731 lb/a) and field treatments (1346 lb/a). Fourth-year stands showed less treatment variation due to overall lower seed yield potential. Bale-only treatment (on the lower end) yielded 467 lb/a, while field treatment (on the upper end) yielded 618 lb/a.

Variety Type: The semi-dwarf varieties out-yielded the tall and dwarf type cultivars. Across treatments, the dwarf plant types showed fewer differences. In the tall and semi-dwarf varieties, close clipped and bale-only treatments had lower seed yields than close clipped with propane and field treatments.

Grazed Treatments: Overall, the ungrazed areas out yielded the grazed areas. This follows the observations of many growers for this year. However, in most years these same growers report the opposite effect. Across the treatments an upward trend in both grazed and ungrazed areas was comparable to the overall summary: field treatment yielded the highest, both close clipped treatments yielding slightly less and the bale-only treatment yielding the poorest.

Tiller Development: The fertile tiller development was reduced in the bale-only treatment. Close clipped and close clipped with propane treatments were intermediate, with the close clipped with propane treatment having the larger number of fertile tillers than the two close clipped treatments. Field treatment resulted in the greatest number.

It should be kept in mind that these preliminary results represent only one production season. As observed in our survey, decreased yield production with stand age, and difference in yield by variety type are well-known aspects of Kentucky bluegrass seed production. The overall yields for second-year stands were comparable to typical yields in the region. Yields for the fourth-year stands were substantially lower than typical yields, although we are uncertain why this occurred.

Certain trends about the treatments seems to support general grower experiences with respect to open-field burning versus bale only. Field burning encouraged higher fertile tiller numbers and seed yield. This was true for the older stands but was even more so on younger stands. Results of close clipping were intermediate with respect to fertile tiller number and seed yield, to the open-field burning and the bale-only treatment.

The trend in seed yield for other residue management approaches was similar for the areas grazed and ungrazed. When yields of residue management treatments were averaged together, the ungrazed areas out yielded the grazed areas by an average of 157 lb/a. We have no immediate explanation why the ungrazed area was superior in 1990, however, growers reported the same effect in their production fields.

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EFFECT OF HERBICIDE TREATMENT AND CROP RESIDUE REMOVAL METHOD ON VOLUNTEER WEED CONTROL AND YIELD IN TALL FESCUE AND PERENNIAL RYEGRASS

G.W. Mueller-Warrant, M.E. Mellbye, and W.C. Young III

Traditional weed control practices in established stands of perennial grasses have centered around open field burning after harvest and subsequent application of atrazine or other herbicides in the fall after rains have dispersed the soot left from the field burn. A major concern of grass seed growers attempting to produce crops without field burning is whether they can control volunteer seedlings well enough to meet seed certification standards. Volunteer seedlings of the currently growing crop are restricted by standards for production of certified seed in order to reduce genetic drift. Because the potential density of volunteer seedlings from shattered crop seed and combine losses far exceeds certification allowances, volunteer crop seedlings are the most common weeds in grass seed production.

A two year study was initiated in 1989 to evaluate the effect of selected herbicides and post-harvest residue management on volunteer control and seed yield in PR and TF. Volunteer crop seedlings are a convenient weed for evaluating herbicide effectiveness, since they are so reliably present. However, the potential for other weed species to differ in their susceptibility to herbicides must be kept in mind.

Fourteen herbicide treatment sequences plus an untreated check, in combination with 5 post-harvest residue removal methods, were applied to established stands of perennial ryegrass and tall fescue. Experiments were conducted at two sites per crop with four replications per site. Herbicide treatments were applied as subplots within residue removal mainplots. Crop residue removal methods for all plots started with double raking the straw, and baling. The BALE-ONLY plots received no further treatment. The PROPANE flame plots were burned once at 3 mph, similar to common grower practice. The FLAIL CHOP plots were cut at a 2.5 to 3 inch stubble height with a flail chopper. The CREW-CUT plots were cut at a 1 to 1.5 inch stubble height with a flail head, material was collected in a stackwagon and removed. For the simulated FIELD BURN treatment at perennial ryegrass site #2, 2 tons per acre of straw was then returned the plots, spread out, and ignited with a propane flamer. At the other sites, field burning was simulated by making two separate passes with the propane flamer. It should be emphasized that none of the non-burn treatments involved leaving the full straw load on the field, as that is already known to reduce seed yield.

Herbicide treatments included Goal, Dual, Prowl, Balan, and Treflan applied preemergence (late October) followed by either Diuron, Diuron + Goal, Kerb + Goal, Sinbar + Goal, or metribuzin (Sencor, Lexone) + Goal applied postemergence (early December). The late October treatments were truly preemergence to fall-germinating seedlings at all sites, except at ryegrass site #1. These early germinating seedlings emerged primarily from cracks in the soil.

Data presented in this report are a partial summary of the most important factors. Not all treatment interaction detail is included, but the factors discussed in this report are those of greatest significance. All herbicide rates are given in lb per acre of active ingredient.

Weed Control

When totalled over all of the sites, treatments controlled volunteer seedlings well enough to pass seed certification in 58 percent of the cases, or 656 times out of 1120 ratings (14 herbicides X 5 residue systems X 4 sites X 4 reps). Control was also close to adequate in a number of other cases, and probably would have escaped helicopter search for combine trails.

At Pugh's perennial ryegrass, propane burn and crew cut were the most effective programs and the field burn was the poorest (Table 1). The field burn treatment there left a large amount of soot on the soil surface, which tied up the preemergence herbicides and greatly reduced their effectiveness. However, the field burn also failed to destroy much of the volunteer seed, and those two factors together resulted in poor control.

In general, treatments were less effective at Glaser's perennial ryegrass than at Pugh's. Propane and field burning were the two most effective programs at Glaser's. The major problem at this site was seedlings that had germinated early, before herbicides were applied. Most of the early germinating ryegrass came from within large cracks in the soil, and many of these seedlings survived the October timing ('preemergence') herbicides.

Excellent results were obtained at Pugh's tall fescue with most treatments. Crew-cut was the most effective program and flail chop the least effective (Table 1). Even for the flail chop treatment, however, most of the herbicides controlled volunteer tall fescue well enough to pass seed certification (Tables 2 and 3). Herbicides were clearly less effective at Coon's tall fescue than at Pugh's. The propane and field burn were superior to the other residue removal programs at Coon's. The major problem at this site was the large number of one year-old volunteer plants present between the rows. These older plants acted as sites for chaff collection, and residue removal was less uniform and complete than at Pugh's tall fescue.

Table 1. Effect of crop residue removal method on volunteer tall fescue and perennial ryegrass ground cover in 1990. Ground cover values are averaged over 14 herbicide treatments and 4 replications.

Crop and test site	Bale-Only	Flail Chop	Crew-Cut	Propane	Field Burn
	Crop residue removal method				
	-------(% ground cover[1])-----------				
Tall fescue					
#1 (Coon's)	16.1	5.2	5.9	2.7	2.8
#2 (Pugh's)	2.2	3.2	1.0	1.5	1.6
Average T.F.	9.2	4.2	3.4	2.1	2.2
Perennial ryegrass					
#1 (Glaser's)	12.6	12.4	10.3	5.9	6.3
#2 (Pugh's)	4.9	2.3	1.5	1.2	6.4
Average P.R.	8.8	7.4	5.9	3.6	6.4
Average both crops	9.0	5.8	4.6	2.8	4.3

[1]Seed certification limits for seedling volunteer crop correspond to ground cover of 2.6 percent in this system.

Performance of specific herbicides varied between sites and residue removal treatments, but some general conclusions can be drawn. Preemergence herbicides applied in October were extremely helpful in reducing the number of seedlings to manageable levels (Table 2). The value of doing this was especially obvious in perennial ryegrass. Prowl and Dual were effective preemergence herbicides at both perennial ryegrass sites, and Goal and Balan only at Pugh's (Table 2). Goal and Treflan did not work well enough at Glaser's, and as a result, the Diuron and Diuron + Goal postemergence treatments could not finish off the seedlings. Tank mixes of low postemergence rates of Kerb + Goal controlled seedlings well, but caused unacceptable crop injury. The Sencor + Goal tank mix looked very promising, especially following a good preemergence treatment. On perennial ryegrass, the effects of Diuron at 1.6 lbs were nearly identical to those of a tank mix of Diuron at 1.2 lb plus Goal.

On tall fescue, postemergence Diuron was applied at 2.4 lb alone or 1.6 lb tank mixed with Goal following preemergence herbicides. The lower rate mixed with Goal was more effective than the higher rate alone (Table 3). This differed from the results in perennial ryegrass, and was mainly due to greater Diuron tolerance in tall fescue, but may also indicate a slightly greater susceptibility to Goal. One of the best treatments in terms of weed control at both tall fescue sites was the registered program of preemergence Goal at 0.25 lb per acre followed by postemergence tank mix of Diuron at 1.6 lbs plus Goal at 0.125 lb. (Section 18 emergency registration).

Table 2. Effect of preemergence herbicides on volunteer tall fescue and perennial ryegrass ground cover in 1990. Ground cover values are averaged over 5 crop residue removal methods, 2 postemergence herbicides (Diuron and Diuron+Goal), and 4 replications.

Crop and test site	Goal 0.25	Dual 1.5	Prowl 2.0	Balan 3.0	Treflan 1.7	No Pre-E, no Post-E check
	Preemergence herbicide and rate (lb a.i./a)					
	-------------(% ground cover)------------					
Tall fescue						
#1 (Coon's)	6.4	8.2	5.6	---	10.1	39.0
#2 (Pugh's)	2.4	1.5	2.0	2.2	---	32.5
Average T.F.	4.4	4.8	3.8	---	---	35.8
Perennial ryegrass						
#1 (Glaser's)	14.3	5.8	7.9	---	18.5	52.3
#2 (Pugh's)	4.0	2.6	3.1	3.4	---	50.4
Average P.R.	9.2	4.2	5.5	---	---	51.4
Average both crops	6.8	4.5	4.6	---	---	43.6

An interesting interaction between residue removal methods and herbicide treatment occurred at Glaser's perennial ryegrass site #1. At this site, several herbicides worked better in flail chop or bale-only management than with crew-cutting. While crew-cutting did reduce the overall numbers of volunteer ryegrass seedlings in the untreated checks, it mainly controlled those that would have germinated on the soil surface. It appeared that crew-cutting slightly increased the problem of seedlings germinating early from within cracks in the soil. The cohort of early germinating seedlings has been the hardest to control, and the possibility that crew-cutting might favor this group may be a cause for concern in soils that crack badly during the summer.

Crop Tolerance and Seed Yield

Residue removal methods had only minor impact on grass seed yield. When averaged over all sites and crops, the highest yielding treatment was flail chop and lowest yielding was propane burn, but they differed by only 64 lb of seed per acre (Table 4). Bale-only management of perennial ryegrass resulted in an average yield loss compared to field burning of less than 4%.

Table 3. Effect of postemergence herbicides on volunteer tall fescue and perennial ryegrass ground cover in 1990. Ground cover values are averaged over 5 crop residue removal methods and 4 replications.

Crop and test site	Postemergence herbicide and rate[1] (lb a.i./a): Diuron alone	Diuron + Goal 0.125	Sencor + Goal 0.125	Goal 0.125 alone	No Post-E check	No Pre-E, no Post-E check
	(% ground cover)					
Tall fescue						
#1 (Coon's)	9.8	5.4	4.3	7.9	6.2	39.0
#2 (Pugh's)	3.1	1.0	0.8	3.2	5.0	32.5
Average T.F.	6.4	3.2	2.6	5.6	5.6	35.8
Perennial ryegrass						
#1 (Glaser's)	10.9	12.4	4.6	8.7	11.1	52.3
#2 (Pugh's)	3.2	3.3	1.4	4.4	6.9	50.4
Average P.R.	7.0	7.8	3.0	6.6	9.0	51.4
Average both crops	6.7	5.5	2.8	6.1	7.3	43.6

[1]Diuron alone and Diuron + Goal treatments are averaged over all 4 preemergence herbicides applied at any site; Sencor + Goal, Goal alone, and the no-postemergence check followed only Prowl. Higher rates of Diuron and Sencor were applied to tall fescue than to perennial ryegrass; rates in lb a.i./acre applied to the two crops were 2.4 and 1.6 for Diuron alone, 1.6 and 1.2 for Diuron + Goal, and 0.75 and 0.5 for Sencor (metribuzin, Lexone).

Most herbicide effects on yield were reasonably consistent across residue management practices. On the average, Prowl was slightly safer than Dual or Goal as a preemergence herbicide. In tall fescue, preemergence Goal reduced yield slightly relative to the other herbicides, averaging 81 lb of seed per acre less (Table 5). There did not appear to be any meaningful differences in seed yield among Dual, Prowl, Balan, and Treflan treatments. Tall fescue seed yield was reduced slightly more by Goal followed by Goal plus Diuron than by Goal followed by Diuron alone.

In perennial ryegrass, Dual reduced yield by 160 lb of seed per acre compared to Goal and Prowl at Glaser's site #1, but had no effect at Pugh's site #2. There was essentially no difference between Goal and Prowl in perennial ryegrass yield. It should be emphasized that differences in seed yield among the preemergence herbicide treatments were relatively small.

Table 4. Effect of crop residue removal method on tall fescue and perennial ryegrass seed yield in 1990. Yields are averaged over 15 herbicide treatments and 4 replications.

Crop and test site	Crop residue removal method: Bale-Only	Flail Chop	Crew-Cut	Propane	Field Burn
	(lb/a)				
Tall fescue					
#1 (Coon's)	1573	1601	1540	1581	1637
#2 (Pugh's)	1289	1269	1234	1169	1185
Average T.F.	1431	1435	1387	1375	1411
Perennial ryegrass					
#1 (Glaser's)	1395	1462	1404	1379	1428
#2 (Pugh's)	1387	1491	1454	1441	1456
Average P.R.	1391	1476	1429	1410	1442
Average both crops	1411	1456	1408	1392	1426

Table 5. Effect of preemergence herbicides on tall fescue and perennial ryegrass seed yield in 1990. Yields are averaged over 5 crop residue removal methods, 2 postemergence herbicides (Diuron and Diuron+Goal), and 4 replications.

Crop and test site	Preemergence herbicide and rate (lb a.i./a): Goal 0.25	Dual 1.5	Prowl 2.0	Balan 3.0	Treflan 1.7
	(lb/a)				
Tall fescue					
#1 (Coon's)	1542	1631	1561	----	1580
#2 (Pugh's)	1134	1216	1278	1227	----
Average T.F.	1338	1434	1420	----	----
Perennial ryegrass					
#1 (Glaser's)	1470	1310	1469	----	1382
#2 (Pugh's)	1521	1487	1449	1414	----
Average P.R.	1496	1398	1459	----	----
Average both crops	1417	1416	1440	----	----

The only postemergence treatment with dramatic effects on yield was 0.2 lb per acre Kerb plus Goal. This treatment killed over half the perennial ryegrass plants at Pugh's site #2, and reduced yield 20%. In both tall fescue and perennial ryegrass, postemergence herbicides reduced yield slightly compared to preemergence Prowl alone (the no POST-E check in Table 6).

Table 6. Effect of postemergence herbicides on tall fescue and perennial ryegrass seed yield in 1990. Yields are averaged over 5 crop residue removal methods and 4 replications.

Crop and test site	Diuron alone	Diuron + Goal 0.125	Sencor + Goal 0.125	Goal 0.125 alone	No Post-E check
	Postemergence herbicide and rate (lb a.i./a)				
	------------------(lb/a)------------------				
Tall fescue					
#1 (Coon's)	1569	1588	1595	1547	1626
#2 (Pugh's)	1221	1206	1212	1251	1261
Average T.F.	1395	1397	1404	1399	1444
Perennial ryegrass					
#1 (Glaser's)	1404	1411	1354	1452	1490
#2 (Pugh's)	1459	1478	1429	1490	1501
Average P.R.	1432	1444	1392	1471	1496
Average both crops	1414	1420	1398	1435	1470

In perennial ryegrass, postemergence application of 0.125 lb per acre Goal reduced seed yield by 25 lb per acre relative to the Prowl-only check. Postemergence Diuron-alone and reduced-rate Diuron plus Goal both reduced yield somewhat more than the Goal-alone treatment, more noticeably at Glaser's site #1 than at Pugh's site #2 (Table 6). The Sencor (metribuzin) plus Goal treatment had the greatest impact on seed yield, dropping it by an average of 104 lb per acre. The effect was more pronounced at Glaser's than at Pugh's. These effects on yield relative to the Prowl-only check must be viewed considering the fact that the volunteer seedling ryegrass control in the Prowl-only check was not quite good enough to pass seed certification.

In tall fescue, application of postemergence herbicides caused an average yield loss of 40 to 50 lb of seed per acre relative to the preemergence-Prowl-only check. There were no other yield differences among the various postemergence herbicides in tall fescue (Table 6).

In conclusion, seedling volunteer crop must be controlled for purposes of meeting seed certification standards and also for maintenance of yield in non-burned grass stands. Seedling volunteer crop can be controlled by many different herbicide treatments. Seedling germination timing patterns caused wide variation in treatment effectiveness between sites. Specific herbicide treatments that were effective even under adverse conditions of large seedling size (i.e., early germination) when applied were also most likely to reduce crop yield. Detrimental effects of herbicides on crop yield were generally minor in 1990; such may not always be the case, especially in years with harsher winters.

ANNUAL BLUEGRASS AND RATTAIL FESCUE CONTROL UNDER NON-BURNING SYSTEMS OF RESIDUE MANAGEMENT

M.E. Mellbye, W.C. Young III, T.B. Silberstein, and G.W. Mueller-Warrant

Annual bluegrass (AB) and rattail fescue (RT) are two of the more common contaminants reported by the OSU Seed Laboratory in cleaned lots of Willamette valley grass seed. AB is especially undesirable in turf seed, and may reduce marketability of a seed lot even though the lot has passed minimum certification standards for purity. This field trial was initiated to evaluate the effect of stubble management and herbicide treatments on AB and RT contamination in harvested seed from a field of established Derby perennial ryegrass.

The field selected for this study was known to contain AB and RT. Three post-harvest residue management treatments were applied in early September, 1989, following seed harvest and removal of straw by baling. Residue management systems were: (1) Propane, (2) Crew-cut, (3) Re-clip stubble and rake to distribute residue. Each residue management plot was 30 x 112 ft, and was replicated 3 times as main plots in a split-plot design with herbicide treatments as sub-plots.

Five herbicide treatments (listed below) were applied across each residue management block in 7 x 30 ft plots. Preemergence treatments (PRE) were applied October 7 to dry, warm soil (70F); early postemergence treatments (EPOST) were applied November 11; and postemergence treatments (POST) were applied December 10, 1989. In addition, an unsprayed check plot was maintained in each main plot.

1. Goal 1.5EC at 1pt/ac - PRE
   Goal at 1pt/a + Karmex 80W at 2lb/a - EPOST
2. Goal at 1pt/ac - PRE
   Karmex at 1lb/a + metribuzin 75DF (Sencor, Lexone) at 0.75lb/a - EPOST
3. Dual 8EC at 1.5pt/ac - PRE
   Goal 1pt + Karmex at 1.5lb/ac - POST
4. Dual at 1.5pt/ac + Goal at 1pt/ac - PRE
   Dual at 1.5pt/ac - POST
5. Kerb 50W at 0.4lb/a + Goal at 1pt/ac - PRE
   Karmex at 1.5lb/a - POST

Visual ratings of seedling grass control (0-100%) were made February 23, 1990. Plots were harvested for seed yield on July 9, 1990. Samples from the threshed seed (field run samples) were taken prior to cleaning for a purity analysis, which was performed by the OSU Seed Laboratory.

Post-harvest residue management had no significant effect on seed yield, and only minor effects on AB and RT levels in the field run samples; herbicide treatment effects were clearly significant (Table 1). Mill check samples from the re-clip and rake system had over two times the AB and over 4 times the RT found in samples from the other residue management treatments. The re-clip and rake system was the least expensive residue management option in this study, but it also left the greatest amount of residue on the surface of the soil and around the plant crowns. Herbicide treatments generally were less effective on the re-clip and rake system (average control 88%), compared to the more thorough stubble pruning and residue removal accomplished with crew-cutting or propane flaming (average control 94%).

Herbicide treatments did vary somewhat in their effectiveness across the different residue management practices. Herbicide treatments that included Dual or Kerb as a preemergence application performed the most consistently, while applications that included Goal alone as the preemergence treatment provided less control on the re-clip and rake system.

Herbicide treatments significantly increased seed yield and quality over the unsprayed check (Table 1). The threshed seed from the check plot contained an average of 11% rattail fescue and 14% annual bluegrass. All herbicide applications significantly reduced these contamination levels; however, treatments varied in effectiveness and crop safety.

Goal or Dual followed by Goal + Karmex ranked as the best herbicide treatments in this trial. Both had comparable reductions in the AB and RT impurity levels, and seed yields exceeded that of most other herbicide treatments. Visual observations in February indicated that the treatment using Dual as a preemergence application provided better AB control than the Goal/Goal + Karmex treatment. These differences were not apparent in the field run samples. Perhaps spring germinating AB or variations in seed shatter masked these earlier differences.

Crop safety was a concern with the treatment that included Kerb, and the Dual application that was followed by a second application of Dual. Both treatments reduced seed yield relative to the best treatments, although they still increased yield over the untreated check.

Least effective in reducing impurity levels was the Goal/Karmex + metribuzin treatment, although this application did provide good volunteer control with good crop safety at this location. Preliminary results from treatments made in the fall and early winter of 1990 indicate that a Goal plus metribuzin tank mix applied early postemergence is more effective on AB and RT than a tank mix of Karmex plus metribuzin, at rates tolerated by perennial ryegrass.

The soil type at this location was a silty clay loam, pH 4.9, and organic matter content of 5.4%. Due to the high clay and organic matter content, full label rates of Karmex and metribuzin were used and appeared to be tolerated by the crop. Crop safety would be less on coarser soils with less organic matter.

Table 1. Effect of residue management and herbicides on seed yield and purity of Derby perennial ryegrass, 1990.

Treatment[1]	Seed Yield	Seedling Grass Control	Mill Check: Annual Bluegrass	Mill Check: Rattail Fescue
	(lb/a)	(%)	--- (%)	-------
Unsprayed Check Plot	664	0	14	11
Residue Management				
Propane	965	94	0.85	0.08
Crewcut	1020	94	0.96	0.07
Reclip & Rake	980	88	2.00	0.40
LSD 0.05	NS	NS	NS	NS
Herbicide				
Goal/Goal + Karmex	1091	91	0.61	0.04
Goal/Karmex + Sencor	1044	79	3.60	0.61
Dual/Goal + Karmex	1054	96	0.72	0.10
Dual + Goal/Dual	850	97	0.94	0.07
Kerb + Goal/Karmex	906	97	0.41	0.10
LSD 0.05	148	4	2.50	NS

[1]Residue management averaged over herbicide treatments; unsprayed check plot and herbicide treatments averaged over residue management main plots.

POST-HARVEST RESIDUE MANAGEMENT EFFECTS ON SEED YIELD IN FINE FESCUE SEED PRODUCTION

T.B. Silberstein, W.C. Young III, and G.A. Gingrich

New tiller development in fine fescue during the fall following harvest is essential for the subsequent seed crop. In addition, the position of fall-formed tillers relative to the crown is important to their development and maturation. Tillers starting higher in the canopy, due to the presence of crop residue and vegetative tillers from the previous year will not develop as well as tillers formed out of the crown of the plant. By effectively removing the old crop residue and exposing the crown to light, more basal tillers are formed and floral induction of mature tillers is facilitated.

Open burning is the most effective method currently used to remove crop residue and expose the crown area for new tiller development. However, alternative methods of residue management are needed to minimize the impact on air quality while maintaining optimum economic productivity of the crop. Therefore, research was initiated during the fall of 1989 to examine the impact of several non-thermal residue management systems as alternatives to open-field burning in field conditions with fine fescues. Earlier research on fine-leaf fescue had shown good results in maintaining seed production using close clipping and removal of straw over several years (W.C. Young, et al., Ext/CrS 50). Using results from those experiments and applying some new adaptations to the equipment, a three-year study was started in the fall of 1989. The field selected was a first-year crop of creeping-type fine fescue (cv Cindy) with plans to follow it for three years. In 1990, a second field planted to chewings-type fine fescue (cv Center) was includes in our study and will be evaluated with similar treatments.

Post-harvest residue treatments in 1989 followed harvest of the first seed crop of Cindy creeping fescue. Five treatments were arranged in a randomized complete block with four replicates. Each plot was 23 feet by 150 feet to allow for swathing and combining at least a full swather width. Treatments established and dates of application are listed in Table 1.

Table 1. Post-harvest residue treatment application dates, 1989.

Treatment	Date of treatment
1) Early open burn	August 14
2) Late open burn	September 12
3) Propane burn	August 17
4) Crew-cut	August 17
5) Flail chop	August 14

Prior to residue treatments, straw on all plots was baled off. Straw load was estimated and re-spread by hand on the two open burn treatments, then ignited and allowed to burn freely, simulating an open field burn. The propane burn plot was first flail chopped to a height of 5 inches, then passed over at 3 - 5 mph with a standard Rear's field flamer pulled behind a tractor. The crew-cut treatment was applied using a Rear's chopper that removes all chopped material into an attached container. Cutting height of the crew-cutter was set to leave 2 - 3 inches of stubble while removing remaining crop residue. The flail chop treatment was performed using a Brady chopper set at 5 inches to chop the stubble and return all chopped material to the plots. All other cultural practices were handled by the cooperating farmer.

Table 2. Effect of residue management on seed yield, clean-out, seed size, fertile tiller number.

Residue treatment	Seed yield	Clean-out	1000 seed weight	Fertile tillers
	(lb/a)	(%)	(lb/a)	(#/sq yd)
Early Open Burn	888	8.7	1.14	2327
Late open Burn	949	7.4	1.15	2508
Propane Burn	905	10.3	1.13	2105
Crew-cut	767	13.1	1.15	1904
Flail Chop	703	12.6	1.11	1442
LSD 0.05	67	2.0	0.02[1]	657

[1] P value=0.07; LSD reported at 0.10

Plots were swathed and harvested by the farmer. A full swath width was taken down the middle of each plot. Combine output for each plot was emptied into 30-gal garbage cans and weighed. Sub-samples of approximately 300 grams were taken from each plot to assess clean-out and thousand seed weight. Percent clean-out of the sub-samples was used to convert the actual combine yield to an equivalent clean seed yield. All plots were swathed on July 9 and combined on July 16.

Seed yield was significantly reduced in the non-burned treatments (Table 2). Other factors that were affected by treatments are also shown. The flail chop treatment had the greatest effect on all factors listed. Flail chopping the plots left the greatest level of crop residue and effectively covered the crown area with straw, forcing any new tillers to elongate much further than other treatments before reaching light. In addition, a higher clean-out, the result of lighter seed and more chaff, and reduced 1000 seed weight affected seed yield. The crew cut treatment also decreased seed yield. Crew-cutting stubble to a height of 2 - 3 inches was not sufficiently low enough to effectively remove old plant material and expose the crown to light. Fertile tiller number, the factor with the greatest influence on seed yield, decreased as the amount of the previous crop residue left on the field increased. Although thermal sanitation resulted in the highest number of fertile tillers, crew-cutting was seen to be intermediate in this effect when compared with the flail chop treatment.

In this first year of study the cumulative detrimental effect of three factors: clean-out, thousand seed weight, and fertile tiller number reduced seed yield in relation to the amount of crop residue left on the field. With the addition of residue trials in a chewings-type fine fescue, results next year will be able to compare the effects of post-harvest management between creeping-type and chewings-type fine fescues.

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NITROGEN FERTILIZER REQUIREMENTS FOR GRASS SEED PRODUCTION IN NON-BURN POST-HARVEST RESIDUE MANAGEMENT SYSTEMS

W.C. Young III, T.B. Silberstein, and J.M. Hart

This study, initiated in 1988, continued during the 1989-90 crop year to examine the interaction between post-harvest residue management and nitrogen (N) fertilization on perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*). As growers shift from a burn to non-burn management of grass seed fields the ability to predict nutrient response over time for different species over several post-harvest residue management systems is desired. In addition, perennial crops may be influenced by the duration of treatments; thus, older stands may respond differently to the same treatment when measured over time. Data presented in this report are from the second of a three-year investigation.

Two locations for both perennial ryegrass and tall fescue were selected for study in fields established by Willamette Valley seed growers in the 1987. Initial post-harvest residue management treatments were made following harvest of the first seed crop in 1988. Identical residue management treatments were positioned in the same locations following seed harvest in 1989.

At each site, straw residue was baled following harvest and straw weight estimates (ton/acre) were recorded. Straw was then returned in an equal weight to main plots receiving an open burn treatment. In addition to the open burn treatment, four other stubble management treatments were established. Each of these five treatments is 20 x 100 ft, and is replicated four times as main plots in a split-block (N treatments) experimental design. Main plot post-harvest management treatments are listed below:

(1) Open burn with full straw load
(2) Flail chop stubble (straw residue baled)
(3) Propane burn stubble (straw residue baled)
(4) Flail chop stubble + Enquik
(5) Propane burn stubble + Enquik

All residue management treatments were completed during the last week of August and the first week of September. Enquik was applied on November 2 or 3 at all locations at the recommended rate of 15 gallons per acre, with an equal volume of water, plus 0.25% non-ionic surfactant. In addition to the contact herbicide/desiccant activity, Enquik contains 1.9 pounds of ammonic nitrogen and 2.0 pounds of sulfate sulfur in each gallon. Thus, those plots not treated with Enquik, were fertilized with 145 pounds per acre ammonium sulfate $[(NH_4)_2SO_4]$ to maintain equal N and S nutrition across all plots. Standard soil-active herbicides were applied to all plots in mid-November.

Single spring N applications were applied in late March as subplot treatments. Urea fertilizer (46-0-0) was used at all sites to achieve spring-nitrogen treatment rates of 60, 100, 140 lbs N/a. Total N applied (fall + spring) in these treatments was 90, 130, 170 lbs N/a.

Visual observations of the main plots in late-November provided evidence as to the effectiveness of open-field burning on volunteer seedling control. Only shattered seed protected by cracks in the soil and unburned residue germinated in the open-field burn treatments. Propane burning was intermediate in the reduction of seedlings, while flail chopping had no effect on seedling control. Problems with seedling control was particularly apparent in the combine "chaff trails" at all sites.

Enquik was applied to both propane burned and flail chopped plots, and initially resulted in visibly better seedling control in tall fescue only. The effect on perennial ryegrass seedings was short lived, as many seedlings recovered after initially being burned back. Seedling control was influenced by residue management more than the use of Enquik. Where residue was minimized, fewer seedling were present and fewer were able to establish. By late-winter and early-spring the visual differences in seedling control between the Enquik and non-Enquik plots was even less apparent. In addition, tall fescue appears to require a longer period of time for recovery following an application of Enquik. In early-spring, the canopy height of Enquik treated plots in Rebel II tall fescue appeared noticeably shorter than the non-Enquik treated plots.

Post-harvest residue management had no significant effect on seed yield of Regal perennial ryegrass (Table 1). At the Pleasure perennial ryegrass site, however, the open burn plot yielded significantly higher than the other post-harvest treatments. In addition, seed yield of both propane burn and flail chop treatments was slightly reduced when followed by an application of Enquik.

Seed yield of Rebel II tall fescue was favored by thermal sanitation (open burn or propane burn). Both propane burn and flail chop treatments were slightly reduced when followed by an application of Enquik. The flail chop treatment was intermediate in relation to the above plots.

In both perennial ryegrass varieties, spring N rates greater than 60 lb N/a resulted in a significant seed yield increases. No advantages were seen for spring applications greater than 100 lb N/a [total N (fall + spring) 130 lb/a].

Seed yield of Rebel II tall fescue was not affected by spring N application rate, suggesting that the maximum yield potential of this variety was attained with 90 lb N/a (total N).

Table 1. Effect of residue management and spring nitrogen rate on seed yield of two perennial ryegrass and two tall fescue varieties, 1990.

Treatment: Residue x Nitrogen	Perennial ryegrass Regal	Perennial ryegrass Pleasure	Tall fescue Martin	Tall fescue Rebel II
	(lb/a)			
Residue Management				
Open burn	1391	1608	1207	1977
Propane burn	1394	1478	1185	1906
Flail chop	1299	1412	1230	1769
Propane burn + Enquik	1298	1352	1121	1635
Flail chop + Enquik	1361	1283	1213	1688
LSD 0.05	NS	172	*[1]	NS[2]
Spring N Rate (lb/a)				
60	1171	1359	1173	1781
100	1404	1431	1217	1784
140	1470	1489	1183	1820
LSD 0.05	199	66	*[1]	NS

[1]Significant Residue x N management interaction
[2]P-value: 0.09

Data from the Martin tall fescue site is presented in Table 2. At this location the residue management x spring N interaction was significant. Seed yield was not significantly affected by spring N application rate on propane burn, propane burn + Enquik, or flail chop + Enquik treatments. For plots open burned, however, spring N rates greater than 60 lb N/a resulted in a significant seed yield increase. In the flail chop plots the highest rate of spring N significantly reduced seed yield.

Table 2. Interaction of residue management and spring N rate on seed yield of Martin tall fescue, 1990.

Spring N rate	Residue Management: Open burn	Propane burn	Flail chop	Propane burn + Enquik	Flail chop + Enquik
	(lb/a)				
60	1099	1146	1208	1163	1250
100	1270	1221	1300	1119	1172
140	1252	1186	1181	1080	1216
LSD .05	111	111	111	111	111

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POTASSIUM FOR GRASS SEED PRODUCTION

J.M. Hart, D.A. Horneck, W.C. Young III and T.B. Silberstein

Political pressures and lack of adequate burn days are causing western Oregon grass seed growers to modify straw disposal and field sanitation techniques. Annual open field burning is displaced by straw removal through a combination of baling and chopping. Physical straw removal takes nutrients from the field that would have been recycled by an open field burn. Potassium is one element removed with the straw in sufficient quantities to decrease soil test levels and seed yield.

Growers and fertilizer dealers realize physical removal of straw presents the need for substantially different management than open field burning. The first question raised is the straw removal impact on seed yield. Other questions follow, including changes in fertilization that may be necessary to produce satisfactory seed yields without burning fields. To answer these questions a field experiment was initiated. Sites planted to perennial ryegrass and tall fescue with high and low soil test K were treated with, burn and bale straw management, and with and without potassium fertilization. In 1990, low soil test sites had 61 and 67 and high soil test sites 185 and 279 ppm ammonium acetate extractable K in the upper six inches of soil for perennial ryegrass and tall fescue sites respectively.

K in Straw

The interaction between site soil test level and straw management was significant (P = .05) for straw K concentration when data from all four locations were analyzed together, Table 1.

Table 1. Straw K concentration for straw management and site soil test K, 1989.

Straw Management	Site Soil Test K Low	High
	---------------(%)---------------	
Bale	.81 a	1.73 d
Burn	1.10 b	1.61 c

These data illustrates the response of grass straw K to available soil K. The high K soil test sites produced straw with a higher K concentration than the low soil test K sites. Low soil test K site plots, where straw was burned, produced straw with higher K concentrations than when straw was baled. The opposite was true for the high K soil test sites. At the low soil test K site, K return through burning has a greater effect on straw K concentration than at the high K soil test site. When K is removed with straw, the K soil test level and K concentration of subsequent crops is reduced. Grass straw accumulates K depending on the soil K availability. This difference in straw K concentration was produced in one year of treatment.

The interaction of grass species and site soil test K level on straw K concentration is given in Table 2. The increase in tall fescue straw K concentration from the low to high soil test K site (1.14%) was three times the increase for perennial ryegrass (.32%). The average tall fescue straw K concentration was higher than straw K concentration for perennial ryegrass (1.47% vs 1.15%). The K concentration differences are probably a combination of site and grass species differences.

Table 2. Straw K concentration for grass species and site soil test K, 1989.

Grass Species	Site Soil Test K Low	High
	---------------(%)---------------	
Perennial Ryegrass	.98 b	1.30 c
Tall Fescue	.90 a	2.04 d

Straw Production

In 1990 tall fescue produced significantly more straw (9097 lb/a vs 6244 lb/a) than perennial ryegrass. A combination of higher K concentration and straw yield in tall fescue fields resulted in substantially more K removal than perennial ryegrass fields where straw was baled rather than burned (133 lb/a vs 72 lb/a). Conversely, burning straw recycles this amount of K. Removal of 6 - 7 lb K/a by seed is not considered in the above discussion. Seed K concentration remained constant across all treatments and sites.

Straw removal depletes available soil K. The average K soil test in the 0-1 inch layer at the tall fescue high soil test site in 1990 was 468 ppm in burned plots, and 248 ppm in baled plots. The 220 ppm difference represents 60 to 70 lb K/a. A similar reduction in soil test K was measured in the 0-6 inch layer (246 ppm baled vs 311 ppm burned). This reduction in K soil test represents 130 lb K/a, which approximates the amount removed in tall fescue straw.

Seed Yield

Reduction in soil test K or low soil test K at a site did not necessarily translate into a yield reduction. Seed yield increased with K fertilization only at the low soil test perennial ryegrass site. Here, K fertilized plots produced 1649 lb seed/a and plots receiving no K, 1529 lb seed/a. A similar yield difference existed between burned and baled plots at this site , but was not significantly different (1647 lb seed/a burned vs 1531 lb seed/a baled).

Summary

Residue management influenced straw K concentration at the low soil test sites. Burning straw increased straw K concentration. Tall fescue produced more straw with a higher K concentration than ryegrass. Baling and subsequent straw removal results in a greater removal of K for tall fescue than for perennial ryegrass due to a combination of high straw concentration and high straw production. The removal of K is reflected in decreased soil test K in the 0-1 and 0-6 inch soil layers. Decreased or low soil test K values do not necessarily mean a yield response to K fertilization. Only the low soil test K (61 ppm) perennial ryegrass site produced an increased yield when fertilized with K.

Growers should monitor soil test K. Applications of K fertilizer when soil test K is above 100 ppm have not, to date, produced a seed yield response. The uptake of K beyond crop needs is commonly called luxury consumption. Luxury consumption occurs in these grasses when K soil test levels are above 100 ppm. Straw K concentration increases when K fertilizer is applied beyond the need of the grass. Subsequent removal of the fertilizer K occurs with straw removal.

RESPONSE OF TALL FESCUE AND PERENNIAL RYEGRASS TO LIME AND PHOSPHOROUS

D.A. Horneck and J.M. Hart

Results from a 1987 Department of Environmental Quality funded survey of Willamette Valley grass seed fields found that management of seed production in perennial grass species produces stratification of nutrients and differential soil pH within the surface 6 inches of soil. Soil test data from the field survey also showed all but a few of the 77 fields sampled had low pH values (less than 5.2) and high P levels (greater than 50). These survey results generated questions regarding the timing and placement of liming materials and P fertilizer. In addition, current trends toward baling as a method for grass seed residue disposal have raised questions about fertilizer and lime placement.

Lower soil pH is a result of perennial surface applications of the preferred, less expensive ammoniacal N fertilizers. Ammoniacal N applied to soils will be transformed to the nitrate (NO_3) by nitrifying microorganisms. This process acidifies the soil by releasing H from the ammoniacal N into the soil system. As the soil pH decreases, P availability decreases. The acidified surface inch of soil resulting from N transformations and leaching is also the recipient of repeated P fertilizer applications. Low pH has been cited by growers and dealers as a reason for continued P application even though soil P levels substantially exceed OSU critical levels.

Acidic soils are amended by the incorporation of lime. Many Willamette Valley crops respond to liming with additional growth, yield and/or quality. Incorporation of lime is not practical in established perennial grass seed fields. Topdressing lime is the only feasible alternative. Gardner and Kauffman topdressed lime on grass seed fields with inconclusive results (Personal Communication). Little data is available evaluating surface acidity, P application methods, and P rates for grass for seed production even though lime and P fertilization are recommended in OSU Fertilizer Guides (Doerge et al.).

New fertility strategies must be developed as growers shift from burning to nonburning management of residue in grass seed production. Phosphorus is a key nutrient due to its immobility and sensitivity to acidic soil. Thus, research is needed to determine optimum P application rate, timing and method of application in relation to liming practices. In addition, considerable interest exists in nutrient management for grass seed production among growers and agricultural advisors as evidenced by numerous inquiries and requests for data presentation.

The objectives for this project were to: 1) Assess the effect of soil pH, especially surface soil pH, on seed yield for turf type perennial ryegrass and tall fescue; 2) evaluate the effect of P rate and application method with varying soil pH on seed yield and P uptake in grass seed production; and 3) compare the agronomic and economic benefits of incorporation of lime at seeding and surface lime application for grass seed production.

Methods and Materials

Two experimental sites with low soil pH were established with perennial turf type grasses for seed production. One site was planted with perennial ryegrass (Lolium perenne cv SR 4000) in Bashaw clay (typic pelloxerert) at G & R Farms, Shedd, Oregon (Saddle Butte Site). The Bray-P1 extractable P was 12 ppm and the 2:1 soil pH 5.2. The second site was planted with tall fescue (Festuca arundinacea cv Falcon) at the Oregon State University Hyslop Crop and Soil Science Farm near Corvallis, Oregon. The soil type at this location is Woodburn silt loam (aquultic Argixeroll) with a Bray-P1 of 108 ppm and a 2:1 soil pH of 5.2. A split-plot design was used with three and four replications in a factorial arrangement for Saddle Butte and Hyslop respectively. The main plots were lime with 0 and 4 t/a. Subplots were P rates of 0, 30, 60 and 90 lb/a applied band and broadcast on the surface after planting. Lime was incorporated prior to planting. Grass was seeded in 30 cm rows. Carbon was surface banded at planting and the field was treated with 2.5 lb ai/a diuron. Soil samples from 0-1, and 0-6 inch depths were analyzed for P and pH annually. Tissue samples were harvested in March, May and August and subsequentially analyzed for total P. Analysis of variance (ANOVA) for seed yield and plant tissue data was performed.

Results and Discussion

No significant interaction existed among lime application, P application rate or method of application for seed yield, therefore the lime and P main effects will be viewed independently. Phosphorus rate and method of application produced no significant differences in seed yield at either site (Tables 1 & 2). No seed yield differences for method of application was expected since the rate of application produced no seed yield increase.

Table 1. Grass seed yield at two locations for P rates, 1990.

P rates	Hyslop	Saddle Butte
(lb/a)	--------------- (lb/a) ---------------	
0	858	1435
30	809	1391
60	760	1433
90	819	1409
LSD .05	NS	NS

Table 2. Grass seed yield at two locations for P application methods, 1990.

Application Method	Hyslop	Saddle Butte
	---------- (lb/a) --------	
Broadcast	842	1407
Band, Fall	766	1443
Band, Spring	827	1402
LSD .05	NS	NS

No yield response from P was expected at the Hyslop site where the Bray P1 was 108 ppm. However, a seed yield increase from P application was expected at the Saddle Butte site where the Bray P1 was 12 ppm. Phosphorus fertilization is recommended for established stands when the Bray P1 soil test is below 25 ppm and for new stands when the P soil test is below 30 ppm. Lack of seed yield response to P may be at least partially due to the low P uptake as measured in the straw (7.9 lb/a at the Hyslop site vs. 6.2 lb/a at the Saddle Butte site).

Two factors contribute to low P uptake of perennial ryegrass. First, turf-type perennial ryegrass does not produce a large dry matter yield, (average 4858 lb/a). Secondly, the P concentration of the mature grass is low. Low P concentration in headed ryegrass is reported by Kelling and Matocha. The low P demand of perennial ryegrass was supplied by the soil even though soil test P indicated a response to P fertilization should be obtained. Tissue P was sufficient since neither P rate nor method of application influenced tissue P concentrations (data not shown). The low P demand is not indicative of low seed yield. The average industry seed yield for this cultivar in 1990 was equivalent to the Saddle Butte average (Seed Research Inc., Personal Communication).

Lime applications increased seed yield at the Hyslop site when compared to the unlimed check. The only significant difference in seed yield at the Saddle Butte site was between the two unlimed plots (Table 3). Therefore, at Saddle Butte a trend existed showing an increase in seed yield due to lime only when the limed treatment is compared to the treatment topdressed with lime after the 1990 harvest, Table 3. The same trend existed for the 1989 harvest. No explanation can be provided for the difference in yields provided from the two unlimed treatments. Lime clearly increased seed yield at the Hyslop site, even with the low seed yields produced from the first harvest.

Table 3. Grass seed yield for Lime treatments, 1990.

Lime	Hyslop	Saddle Butte
(T/a)	---------- (lb/a) --------	
0	740	1464
0[1]	818	1337
4	877	1451
LSD .05	115	118

[1]This plot received no lime initially but was topdressed with 2 T/after the 1990 seed harvest.

Definite conclusions should not be made at this juncture. Seed yields have been obtained for 2 years from the Saddle Butte site and only one year from the Hyslop site. A minimum of three years data collection from each site is planned. Indications to date are that lime increases seed yield for both grasses when the soil pH is 5.2. OSU Fertilizer Guides recommend lime be applied when the soil pH is below 5.5 which based on this research, to date, is confirmed.

Seed yield increases of 137 and 114 lb/a respectively were produced by tall fescue and ryegrass from the application of 4 T lime/a. Lime costs approximately $45/t. Current prices for tall fescue and perennial ryegrass are $49.90 and $47.70 /cwt respectively. Therefore, at these sites, lime application costs would be recovered in the third year of production for tall fescue and in the fourth year for perennial ryegrass.

The soil pH after liming at the Saddle Butte site was 6.7 and at the Hyslop site, 6.0. These soil pH's indicate that the soil at both sites probably will not need lime for several years. The high pH at the Saddle Butte site indicates a lime application that was higher than necessary. These data suggest that liming grass grown for seed production produces a return over a several year period.

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RESPONSE OF PERENNIAL AND ANNUAL RYEGRASS TO NITROGEN MANAGEMENT IN COMBINATION WITH CERONE PLANT GROWTH RETARDANT

T.B. Silberstein and W.C. Young III

Cerone is a foliar applied, slow ethylene-releasing plant growth retardant that is used to reduce lodging in barley and wheat. Its primary effect is through inhibition of stem elongation and an increased radial expansion of stems. The benefit of these effects is reduced plant height and increased straw strength, which usually results in greater resistance to lodging. Timing of application in cereal grains is between flag leaf emergence and boot stage, but before spike emergence growth stage.

Premature lodging causes less than ideal conditions for pollination, seed fill, and disease control. With the ability to control or delay lodging enhanced seed production may result from increased N rates. Test plot evaluations on tall fescue were conducted in 1988 and 1989 with limited results as to the effectiveness in lodging control and subsequent effect on seed yield. Continuing interest by Rhone-Poulenc Ag Company in other grass seed crops encouraged us to establish research plots at Hyslop research farm with perennial and annual ryegrass.

In order to test both the effect of Cerone and spring N management on seed yield and lodging, a factorial arrangement of CERONE and RATE OF NITROGEN was used. The two factors were replicated four times in a randomized complete block design.

Evaluations prior to maturity included: an assessment of lodging, whole plant culm and internodal length measurements, and potential seed number per spike. Spike samples were used to compare potential crop yield with the actual seed harvest.

Perennial Ryegrass

Perennial ryegrass (cv Caravelle) was carbon-band planted during the fall of 1989. Prior to planting, 185 lb/a 16-20-0 fertilizer was incorporated into the seedbed. Irrigation was employed to ensure a well established stand. Standard weed control practices were used.

Cerone was applied in several combinations of time and rate to evaluate chemical control at differing stages of development and growth. Nine regimens of timing and rate were used along with an untreated check. Two spring N rates (100 and 140 lb/a) were applied in combination with all Cerone treatments making a total of 20 treatments (10 Cerone x 2 N). Spring N was applied April 2 as a single application of urea (46-0-0). Cerone applications were made May 5, 21, and 26 at the sequential stages of growth as listed in Table 1. Cerone was applied using compressed air on a bicycle sprayer with an 8 foot side mounted boom. Tilt fungicide was applied June 7 and 29 for rust control. Plots were harvested July 13 using a small plot harvester equipped with a sickle bar cutter and draper to allow bagging of the plot into large burlap sacks. The bagged material was air dried and threshed to remove the seed for cleaning and weighing.

Table 1. Treatment schedule for perennial ryegrass showing time and rate of Cerone application.

Time of application			Total
1st & 2nd nodes visible	Flag leaf emerged	Approx. 30 % heads emerging	Cerone Rate Applied
-------------------(lb ai/a)-------------------			Total
0.75	0.75	0.75	2.25
1.00		1.00	2.00
1.00	1.00		2.00
1.00	1.00	1.00	3.00
0.75	1.50		2.25
1.50			1.50
1.50	1.50		3.00
1.50	1.50	1.50	4.50
1.50		1.50	3.00
----	---	---	check

Cerone treatments had no significant effect on seed yield. There was a measurable reduction (P value = 0.06) in the length of the internode directly below the spike due to first and second Cerone treatment times. This internode length reduction did not influence the severity of lodging measured, nor significantly reduce the total culm length. No other factors measuring plant growth or yield components were significantly affected by the application of Cerone.

Table 2. Effect of N levels on straw weight, seed yield, and severity of lodging, 1990.

Spring N rate	Total straw load	Seed yield	Lodging severity
(lb/a)	(ton/a)	(lb/a)	(1-5)[1]
100	3.6	1065	3.8
140	3.9	1109	4.2
LSD 0.05	0.2	NS	0.3

[1] Scale: Range is from 1 (vertical) to 5 (flat on ground)

The high rate of nitrogen resulted in a significant increase in total dry matter produced, but not in seed yield. The increase in total dry weight was the result of increased straw production (Table 2). In addition, the higher spring N rate significantly increased lodging severity.

Annual Ryegrass

Annual ryegrass (common) was planted in the same manner as the perennial ryegrass during the same week. The Cerone treatment regimen for annual ryegrass included only two growth stages (flag leaf emerged and early heading) combined with three rates at each stage (0.50, 0.75, and 1.00 lb ai/a) for a total of 7 treatments (including the check). Two spring N rates were used (100 and 140 lb/a) in combination with the Cerone for a total of 14 treatments (7 Cerone X 2 N). Applications were made in the same manner as the perennial ryegrass.

No significant response to seed yield was observed from Cerone or N management in annual ryegrass (overall average yield: 1610 lb/a). Early applications of Cerone reduced spike length over a later application. Neither total dry matter or straw load were affected by Cerone or N.

Application of Cerone in annual ryegrass may need to go on earlier in order to reduce the rapid growth this crop is quite capable of. By reducing growth early enough there may be benefits in reduced lodging and harvest efficiency.

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EFFECTS OF CERONE AND FUNGICIDE APPLICATION ON REBEL II TALL FESCUE SEED PRODUCTION

M.E. Mellbye and W.C. Young III

Cerone is a foliar applied slow ethylene - releasing plant growth retardant used to reduce lodging in cereal and grass seed crops. Use of Cerone on winter wheat has increased foliar disease symptoms on varieties susceptible to septoria, unless a suitable fungicide is also applied. In tall fescue, there is a complex of organisms causing leaf spot disease symptoms during spring growth, and after head emergence stem rust can become a severe problem under warm moist conditions. It is not known if Cerone has an impact on the development of these diseases in tall fescue.

Previous trials have not shown a consistent benefit from the use of Cerone on tall fescue. The objective of this trial was to evaluate the effects of Cerone and fungicide treatments on seed yield and disease severity on Rebel II tall fescue.

Cerone and fungicide were applied alone or in combination to an established stand of Rebel II tall fescue in Linn County on April 20, 1990, at the boot stage of growth. Cerone 4L was applied at 3 pt/a (0.75 lb ai/a). Fungicide treatments included Bravo 720 6EC at 2 pts/a, Tilt 3.8EC at 4oz/a, and Bravo (2pts/a) plus Tilt (4oz/a). Treatments were replicated five times in a randomized complete block. Tilt at 6oz/a was aerially applied May 21 to prevent an outbreak of stem rust in the field.

Leafspot disease severity was evaluated May 28, 1990, by estimating the leaf area damaged by disease (0-100%). Eight tillers were scored per plot. The incidence of stem rust and degree of crop lodging were also evaluated at this time. Plots were harvested for seed yield on July 4, 1990.

Table 1. Seed yield, lodging score, and disease severity on Rebel II tall fescue treated with Cerone and fungicide combinations, 1990.

Treatment[1]	Seed Yield	Lodging Score	Area Diseased Flag Leaf	Area Diseased Second Leaf
	(lb/a)	(1-5)[2]	-- (%) ----	
Check	1556	1.5	8	29
Cerone	1590	1.8	6	10
Bravo	1636	1.5	6	6
Bravo & Cerone	1412	1.4	4	7
Tilt	1438	1.4	6	9
Tilt & Cerone	1601	1.2	5	6
Bravo & Tilt	1729	2.1	7	14
Bravo & Tilt & Cerone	1678	1.4	6	14
	NS	NS	NS	NS

[1]Rates: Cerone 4L=1.5 pt/a, Bravo 720=2 pt/a, Tilt 3.8 EC=4 oz/a.

[2]Lodging Score: 1=none, 2=slight, 3=moderate, 4=severe, 5=complete.

Lodging, leafspot diseases, and stem rust were not a problem at this location in 1990. Under these conditions, seed yield, disease severity, and lodging score were not significantly affected by Cerone or fungicide treatments (Table 1). The diseased leaf area from plants in the Cerone treated plots was slightly less than from plants in the plots that did not receive Cerone (P=.12 for flag leaves). Although this trend was not significant statistically, it is opposite to the effect of Cerone on Septoria leaf disease in wheat. Further study is necessary to determine if Cerone has an influence on disease development or crop response to fungicides in grass seed crops.

Acknowledgements: Help in disease evaluation was provided by R.E. Welty, research plant pathologist USDA-ARS, and Paul Koepsell, Extension Specialist, OSU.

BREEDING ORCHARDGRASS FOR IMPROVED FORAGE CHARACTERISTICS IN IOWA COMBINED WITH SATISFACTORY SEED YIELD IN OREGON

I.T. Carlson and W.C. Young III

Orchardgrass is a valuable forage crop in Iowa and other midwestern states. It is usually grown in mixture with legumes such as alfalfa, red clover and birdsfoot trefoil for pasture, hay, or silage; however, it can be grown alone or in mixture with other grasses such as smooth bromegrass. Lack of sufficient winterhardiness and leaf disease resistance is frequently a deficiency of available varieties in Iowa.

The Iowa Agricultural Experiment Station has conducted breeding research on orchardgrass continuously since the early 1940's. Improvement in winterhardiness, disease resistance, forage yield, dry-matter digestibility, and legume compatibility has been sought. In 1980, cooperative research was initiated with Oregon State University on breeding for seed production. Clones, polycross progenies, synthetics, and populations selected in Iowa for winterhardiness, disease resistance, and drought tolerance were evaluated in replicated seed yield tests near Corvallis, Oregon and Ames, Iowa. On the basis of that research, three narrow-based synthetics (five parents each) were formed as follows:

- OG-1 - parent clones selected on the basis of progeny testing for high Oregon seed yield combined with high Iowa forage yield, *in vitro* dry-matter digestibility (IVDMD), and rust resistance;
- OG-2 - parent clones selected for high Oregon progeny seed yield;
- OG-3 - parent clones selected for high predicted Oregon seed yield based on Iowa clonal data (combination of early maturity, high seed yield per panicle, high seed set as determined by fertility index, and high 100-seed weight).

Subsequently, five broad-based synthetics (36 to 59 parents each) were developed to investigate the effectiveness of individual plant selection for seed production traits in Iowa with regard to improving seed yield in Oregon. Selection criteria for each synthetic were as follows:

- OG-I - resistance to rust and other diseases, acceptable vigor, high fertility index, and high 100-seed weight;
- OG-II - rust resistance, high seed yield/panicle, high fertility index, high 100-seed weight (more intensive selection for the latter two traits than OG-I);
- OG-III - high 100-seed weight;
- OG-IV - high fertility index;
- C1-IA - rust resistance, superior winter survival, and high seed yield/panicle.

Six additional broad-based synthetics were developed by bidirectional selection for birdsfoot trefoil-compatibility traits. Six groups of 50 parent plants each were selected respectively for early (ME) and late (ML) maturity, tall (HT) and short (HS) spring canopy height, high (CH) and low (CL) compatibility index values that incorporated spring vigor, spring canopy height, growth habit, and tiller number. No attention was given to seed traits. The ML, HS, and CL synthetics permitted significantly more birdsfoot trefoil production than the ME, HT, and CH synthetics when grown in mixtures.

These 14 synthetics were all derived from Iowa 79-OGP-DT, a population that ranks relatively high in winterhardiness, forage yield, rust resistance, and IVDMD in Iowa, but it was mediocre in seed yield in Oregon in 1981 and 1982. The 14 experimental synthetics, Iowa 79-OGP-DT, and three commercial cultivars are being evaluated in forage yield tests in Iowa and a seed yield test in Oregon.

Forage yield test plots consist of 5 rows 6 inches apart and 12 feet long. Yield of dry matter was determined in late May or early June, mid-July, and mid-September by harvesting entire plots. Samples were saved from two reps at each harvest for determination of IVDMD. Nitrogen fertilizer was applied in early spring and after the first and second harvests to promote growth.

The seed yield trial was established at Hyslop Crop Science Field Laboratory, Corvallis, in June 1988 and followed commercial field practices of Willamette Valley seed growers. Seeding rates were adjusted for germination percentage and 1000 seed weight to plant an equal number of pure live seed per length of row. Each entry was seeded in a 2-row plot (18 inches apart) 16 feet long and replicated four times. A blank row was used to separate entries within blocks. Seed production data were collected for two (1989 and 1990) crop years. All plots were checked weekly each spring to determine heading date (approximately 50% of the stand had headed); harvest maturity was determined by seed moisture content. When mature, the entire plot was harvested with a small plot harvester and bagged for subsequent threshing and cleaning, and determination seed yield.

Table 1. Performance of 14 Iowa experimental orchardgrass strains compared with the base population and three check varieties in two Iowa forage yield tests near Ames and one Oregon seed yield test.

	Iowa Forage Yield Tests					Oregon Seed Yield Test (1989-90 average)				
			1989-90					Seed weight		
	Spring recovery rating	Heading date (1990)	Leaf disease rating	Average forage yield	Average % IVDMD	Heading Date	Panicle number	Per panicle	1000 seeds	Seed yield
	(1-5)[1]		(1-5)[2]	(tons/a)			(m of row)	g	g	(lb/a)
Narrow-based synthetics selected to some degree for seed traits										
Iowa OG-1	1.0	May 25	1.9	5.92	57.0	May 7	223	0.33	1.00	1410
Iowa OG-2	1.3	May 25	2.2	5.44	56.8	May 5	205	0.34	0.90	1314
Iowa OG-3	1.0	May 22	1.7	5.45	56.7	May 4	237	0.31	1.06	1375
Broad-based synthetics selected to some degree for seed traits										
Iowa OG-I	1.2	May 25	1.3	5.48	57.2	May 6	237	0.32	1.02	1423
Iowa OG-II	1.0	May 23	1.9	5.53	56.8	May 5	236	0.34	1.05	1529
Iowa OG-III	1.0	May 24	1.6	5.81	56.8	May 8	232	0.33	1.04	1468
Iowa OG-IV	1.0	May 24	1.7	5.51	56.8	May 5	251	0.34	1.00	1617
Iowa C1-IA	1.0	May 25	1.5	5.37	57.2	May 10	230	0.31	0.93	1390
Broad-based synthetics selected divergently for birdsfoot trefoil compatibility traits										
Iowa CH	1.0	May 24	1.5	5.54	57.6	May 7	218	0.31	0.88	1286
Iowa CL	1.0	May 28	1.7	5.24	58.3	May 12	206	0.20	0.95	768
Iowa HT	1.0	May 22	1.8	5.71	57.5	May 8	211	0.30	0.90	1209
Iowa HS	1.3	May 27	1.5	5.10	57.7	May 11	209	0.29	0.90	1161
Iowa ME	1.0	May 22	1.9	5.55	57.0	May 5	212	0.30	0.99	1207
Iowa ML	1.8	May 29	1.4	4.97	57.5	May 14	220	0.17	0.92	736
Base population from which parents of Iowa synthetics were selected										
Iowa 79-OGP-DT	1.0	May 22	1.9	5.82	57.4	May 7	221	0.33	0.98	1406
Check variety										
Potomac	1.5	May 19	3.1	5.24	56.0	May 1	234	0.39	1.05	1747
Hallmark	1.6	May 21	3.3	5.32	55.8	May 1	248	0.38	1.04	1816
Rancho	1.5	May 26	2.5	5.42	57.7	May 8	206	0.25	0.99	1007

[1] Rated on 4-24-90 from 1=vigorous regrowth and no signs of winter injury to 5= weak regrowth and most winter injury.
[2] Rated from 1=least to 5=most disease (mostly rust) in September.

Results from two Iowa forage yield tests near Ames and the Oregon seed yield test are presented in Table 1 (Page 20). Five experimental synthetics (OG-1, I, II, III, and IV) were similar to the base population (Iowa 79-OGP-DT), Hallmark, and Potomac in 1989 Oregon seed yield; however, in 1990, Hallmark and Potomac yielded significantly more seed than any other entry. Over years, Iowa OG II and IV yielded respectively 86 and 91% of the average of Hallmark and Potomac. The six synthetics selected divergently for birdsfoot trefoil compatibility traits were inferior in seed yield to Iowa 79-OGP-DT and all synthetics selected to some degree for seed traits indicating the importance of selection for seed traits. Those synthetics most compatible with birdsfoot trefoil (ML, HS, and CL) were especially low in seed yield. Eleven of 14 Iowa synthetics were superior to Potomac and Hallmark in winterhardiness, leaf disease resistance (mainly rust), forage yield, and IVDMD in Iowa. The forage yield tests will be continued in 1991.

ITALIAN RYEGRASS SPECIFIC SEED ESTERASE PROTEIN MARKER

S.M. Griffith

In 1979, Dr. S. Nakmura (Japan) was able to distinguish between the seed of annual ryegrass (*Lolium multiflorum*) and perennial ryegrass (*Lolium perenne*) by using a test that detected the presence of a unique annual ryegrass protein. This was later confirmed by work of Payne et al. 1980. Until now, this information has not been directed toward practical application.

I have begun to investigate the possibility of using this knowledge to develop a reliable, fast, and inexpensive method for detecting Italian ryegrass seed contamination in perennial ryegrass seed lots. This could be accomplished by directly screening for the presence of a novel annual ryegrass seed esterase protein, Est-1. If developed, this procedure could be easily performed in a few days by a trained seed technician as compared to the currently used fluorescence test which requires at least 21 days. A reliable test is critical for the purpose of monitoring genetic purity of perennial ryegrass. I hope to accomplish this through the following steps: 1) screen available varieties of *L. perenne, L. multiflorum,* and other *Lolium spp.* to determine if Est-1 is unique to annual ryegrass; 2) purify Est-1 protein to homogeneity; 3) produce monospecific antibodies to purified Est-1 protein; 4) develop an enzyme-linked immunosorbent assay (ELISA) using immunesera raised against the Est-1 protein; and 5) design and develop an apparatus in which this assay can be performed on a routine basis by a seed testing specialist.

A recent survey of 241 seed lots of perennial ryegrass comprising 74 varieties, 38 seed lots of Italian ryegrass comprising 18 varieties, and seed from 6 other annual *Lolium spp.* was conducted to determine the presence of Est-1 isozyme activity. Crude water soluble seed protein, extracted from 10 seeds per seed lot, were electrophoresed using native-PAGE and stained for esterase activity. The presence or absence of bands of Est-1 were recorded.

Results of this survey confirmed previously published findings showing Est-1's uniqueness to Italian ryegrass seed. Eleven out of the 241 seed lots of perennial ryegrass show slight Est-1 activity but when new single and pooled seed extracts were repeated no Est-1 banding appeared. All Italian ryegrass seed contained Est-1 activity. In addition, *L. canariense, L. persicum, L. remotum, L. temulentum* seed contained Est-1 activity; whereas, *L. rigidum* and *L. subulatum* did not. We conclude, based on evidence to date, that Est-1 activity is not present or is at undetectable levels in perennial ryegrass seed.

EFFECTS OF ENHANCED AMMONIA NUTRITION ON TILLER DEVELOPMENT IN ITALIAN RYEGRASS

S.M. Griffith

It is well documented that higher growth rates and grain yields in several crops can be obtained with a combination of nitrate and ammonia nitrogen fertilizer source than with either alone. Interest in ammonia nutrition in herbage grasses grown for seed arises from the following premises: 1) enhanced ammonia supply in cereals has been shown to increase tiller number and grain yield; 2) ammonia is often the nitrogen form most important in acidic soils; and 3) ammonia is not leached from soils as readily as nitrate, thus potentially increasing available nitrogen use efficiency and lessening nitrate ground water contamination. Possibly, through more efficient utilization of soil nitrogen and the maintenance of the most appropriate soil nitrate/ammonia ratio, herbage grass growth and development could be modified to favor seed production over vegetative growth.

Recent experiments were conducted using a greenhouse pH controlled hydroponic system to investigate the effects of enhanced ammonia supply on Italian ryegrass (*Lolium multiflorum*) tiller growth and development. Five solutions, with total nitrogen concentration not exceeding 10mM, contained a balanced mixture of macro- and micro-nutrients plus five nitrate/ammonia ratios (100/0, 75/25, 50/50, 25/75, and 0/100). Plants were sampled weekly until anthesis, 68 days after planting (DAP), at which time the experiment was terminated. Plant tissue was examined for changes in dry weight, total nitrogen, and total water soluble carbohydrates.

The most pronounced effect of mixed nitrogen-source nutrition was on total tiller initiation and development into reproductive spikes. From 34 to 54 DAP, total tiller number was highest among plants receiving nitrate/ammonia ratios of ≤1. By the last harvest date, 68 DAP, no difference in total tiller number was measured, but the reproductive/vegetative tiller ratio was highest among plants receiving enhanced ammonia supply (Figure 1). This indicates that more dry matter and water soluble carbohydrate (WSC) was partitioned away from vegetative apices in support of reproductive growth. Total plant dry weight was not affected by nitrogen-source, but the partitioning of dry weight, WSC, and reduced nitrogen among vegetative and reproductive organs were different. By 68 DAP, plants which received nitrate alone partitioned more dry matter to leaves and roots, while plants receiving enhanced ammonia supply partitioned more dry matter to stems and spikelets. The WSC and reduced nitrogen concentration in shoot and root tissue were inversely related; WSC were highest in root and shoot tissue of plants receiving enhanced ammonia supply.

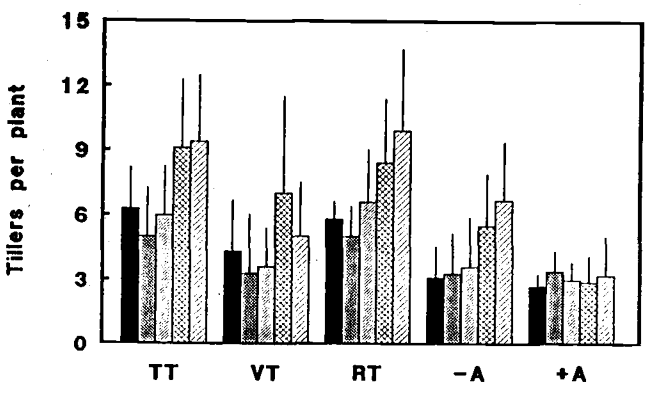

Figure 1 The effect of five nitrate/ammonia (100/0, 75/25, 50/50, 25/75, and 0/100) ratios on total tiller (TT), vegetative tiller (VT), and reproductive (floral) tiller number. reproductive tillers were further subdivided into those not at anthesis (-A) and at anthesis (+A). Plants were grown hydroponically in a greenhouse. Means were calculated from 6 to 14 plants. Vertical lines represent 1 SE.

It appears that the greatest and most significant response of enhanced ammonia supply in Italian ryegrass, in terms of increasing grass seed yield, results from the stimulation of reproductive over vegetative tillering. Further, this response may result from direct changes in carbohydrate and nitrogen utilization and partitioning. This investigation confirms related research in cereal crops. Observed yield increases in cereals has not been from increased grain number per spike or greater grain weight but from an increased number of ear bearing tillers. Herbage grasses respond favorably to high nitrogen fertilization by producing an abundance of vegetative matter to the determent of seed production.

It is hoped that continued research in enhanced ammonia supply will result in better nitrogen/fertilization management through strategies best-suited to support floral over vegetative development in herbage grasses. Further research is underway examining the effects of enhanced ammonia supply in Italian ryegrass and bluegrass (*Poa partensis*) grown under field conditions.

CHANGES IN POST-ANTHESIS CARBOHYDRATES IN STEM AND SPIKELETS OF ITALIAN RYEGRASS

S.M. Griffith

In ryegrass grown for seed, stem carbohydrate reserves may play a vital role in maintaining seed growth, especially under conditions of limited photosynthesis (e.g. lodging). Little is known concerning the processes controlling stem carbohydrate utilization and partitioning in ryegrass with respect to seed growth. Previous studies have examined patterns of ^{14}C-partitioning in reproductive ryegrass stem and spike components, but did not report which ^{14}C-assimilate pools were labeled and did not quantify and identify actual carbohydrate levels. The objective of this investigation was to determine post-anthesis changes in the lower, middle, and upper stem and spikelet carbohydrate as affected by artificial manipulation of source (ability to provide assimilates) and sink (ability to attract assimilates) strength. Source-sink relations were changed by imposing detillering or detillering-defoliation treatments at anthesis.

Plants of Italian ryegrass were grown in the greenhouse. Detillering induced the formation of new tiller sinks, thus increasing sink strength and reversing the water soluble carbohydrate (WSC) gradient from seed sinks to new tiller sinks. Defoliation, combined with detillering, decreased source strength and reduced stem total WSC levels. In control plants, carbohydrate levels appeared adequate to support maximum seed set, while both detillering and detillering plus defoliation lowered seed set and final seed weight. The patterns of carbohydrate distribution of the ryegrass stem were different, both among positions within the stem and with continued seed growth. The sugars and fructan accumulated in ryegrass stems during early stages of seed growth and then declined as seeds matured. Reducing sugars, such as glucose and fructose, only comprised a small fraction the stem's total WSC. The greatest concentration of reserve carbohydrate was located in the lower two-thirds of the stem.

Results suggest, that under conditions of limited source strength (e.g. lower photosynthetic capacity), the stem plays a major role in partitioning assimilates to satisfy sink demand. Factors which might affect pre- and post-anthesis storage of stem carbohydrate reserves may lessen the plant's ability to buffer against photoassimilate limitation during seed fill and fall tiller regrowth. New tiller growth, if stimulated during seed development, may out compete seeds for available carbohydrates and thus reduce seed yields. Reduced seed set of lodged ryegrass plants may, in part, be attributed to a decline in source strength (assimilate limitation).

ATYPICAL SPIKE BRANCHING IN RYEGRASS

S.M. Griffith and J. Burr

Italian (*Lolium multiflorum*) and perennial (*L. perenne*) ryegrass normally forms a single unbranched spike but atypical branching may occur. This occurrence, especially when observed at high frequency, can be quite alarming to seed producers striving to meet seed certification standards. It is not known what causes atypical branching in ryegrass. Some possible factors are: cross pollination with tall fescue, herbicide induction, environmental stress, recessive gene expression, or a combination of one or more of these or other factors. Since information on ryegrass spike branching is scant, we have initiated several studies to gain knowledge about this phenomena. One study is described below.

Atypical spike branching was observed at high frequency in 1990 in 'Caravelle' perennial ryegrass at Central Point and Woodburn, Oregon and in 'Calypso' at Central Point. All fields, at both locations, were planted with the same stockseed lot. Due to the high branching frequency, seed certification of these fields was called into question but with continual roguing passed certification.

To determine if the branched spike condition offered a yield advantage, 50 seed heads of branched and unbranched spikes of each variety were collected at the Central Point site. Seeds were separated, counted, and weighed. Both 'Calypso' and 'Caravelle' had more seeds produced on branched spikes than unbranched, but branched spike single-seed final weight was less; 10% and 33% for 'Calypso' and 'Caravelle', respectively (Table 1). These data suggest that assimilate supply may have limited seeds from achieving their potential final weight. When calculating the total seed yield per spike, only branched 'Calypso' spikes showed a seed yield advantage, by increase due to a 15% in total seed yield per spike. Seeds collected from branched and unbranched spikes are currently being grown out to determine if branching is an inherited trait. No herbicides are being used in this grow out study so possible exogenous growth regulator effects can be ruled out. Recent results of a similar grow out experiment in Italian ryegrass showed the branching trait was inherited, but present at a low frequency.

We are currently conducting genetic analysis of seeds collected from branched spikes to ascertain whether major genetic composition is changed which would suggest foreign pollen cross pollination. Preliminary evidence indicates that seeds of branched and unbranched spikes are genetically similar, based on similar protein profiles. In another study, we are examining the possible induction of atypical spike branching by various phenoxy herbicides. Phenoxy herbicides were applied to the branched-spike fields. These compounds are well known to cause atypical growth in plants.

Table 1. Seed yield components of unbranched and branched spikes of perennial ryegrass (*Lolium perenne* L.) varieties 'Calypso' and 'Caravelle'. Data were collected from 50 each of unbranched and branched spikes.

Variety	Spike Type	Seed Number	Seed Weight	Total Seed Yield
		(seeds/spike)	(mg/seed)	(mg/spike)
Calypso	Single	74	2.0	148
	Branched	94 *	1.8*	169*
Caravelle	Single	67	2.2	145
	Branched	102 *	1.5*	145

* = significance at the $\alpha = 0.05$ level

Acknowledgement: The authors wish to thank Ron Van der Hellen for collecting the spikes used in this investigation.

RED AND WHITE CLOVER SEED PRODUCTION CROP-WATER RELATIONS

R.N. Oliva, J.J. Steiner, and W.C. Young III

Western Oregon receives relatively large amounts of precipitation compared to other western seed production regions, but the amount of soil-water available to the crop during the summer reproductive period of development becomes limited and varies between years. This may contribute greatly to the inconsistencies in seed yields observed in the state. The purpose of this research is to determine the effects of crop soil-water status and supplemental irrigation on red and white clover seed production.

This two-year experiment was begun in 1990 and is being conducted at Hyslop Farm using 'Kenland' red clover and 'Oceola' white clover. Following haying in spring, both crops are subjected to five supplemental water application treatments based on the amount of water in the soil measured by neutron attenuation, and the amount of water used by the crop as estimated by evapotranspiration measured from evaporative pan data. In addition, a non-irrigated control plot is maintained for both crops.

Table 1. Effect of water application timing and amount based on evapotranspiration data and soil-water depletion on seed yield, lodging, and stem length of 'Kenland' red clover grown at Hyslop Farm in 1990.

Irrigation treatment	Seed yield	Stem length	Lodging
	(lb/a)	(inches)	
1. Non-stressed, crop irrigated twice weekly to 100% of field capacity from clipback to three weeks before harvest	938a[1]	39a	+[2]
2. Two irrigations: 100% of field capacity applied after clipback and at peak flowering	788b	35b	+
3. One irrigation: 100% of field capacity applied after clipback	913a	35b	+
4. One irrigation: 100% of field capacity applied at peak flowering	875a	32c	-
5. One irrigation: 50% of field capacity applied at peak flowering	757b	30d	-
6. Non-irrigated control	545c	30d	-

[1]Values within a column followed by the same letter are not significantly different at the 0.05 level of probability.
[2]Lodging notation: + = lodged and - = no lodging at harvest.

For red clover, seed yield from all supplemental irrigation treatments exceeded the non-irrigated control (Table 1). Filling the soil profile (one meter) once to 100% of field capacity, regardless of time of application, exceeded treatment 2 which refilled the soil profile twice (following clipback and at peak flowering) and treatment 5 which refilled the soil profile at peak flowering to 50% of field capacity. There was no advantage to keeping the crop free from water stress by filling the profile twice a week (treatment 1). Delaying water application until peak flowering caused less stem elongation and avoided lodging.

Table 2. Effect of timing of water application based on evapotranspiration data and soil-water depletion on the seed yield and flowering of 'Oceola' white clover grown at Hyslop Farm in 1990.

Irrigation treatment	Seed yield	Flower initiation
	(lb/a)	
1. Non-stressed, crop irrigated twice weekly to 100% of field capacity from clipback to three weeks before harvest	492a	continuous
2. One irrigation: 100% of field capacity applied after clipback	370c	steady then decline
3. One irrigation: 100% of field capacity applied when 20.7% of total available soil moisture was depleted	403b	steady then decline
4. One irrigation: 100% of field capacity applied when 27.5% of total available soil moisture was depleted	485a	continuous
5. One irrigation: 100% of field capacity applied when 31.9% of total available soil moisture was depleted	294d	split pattern, first peak similar to control
6. Non-irrigated control	284d	steady then rapid decline

For white clover, due to a more restricted rooting zone than red clover, seed yields were substantially increased by delaying application of water until 27.5% of total available soil water was depleted (Table 2). Delayed application maintained higher soil-water contents during the reproductive period which allowed a longer flowering period compared with both earlier and later water applications. The number of newly developing flower buds and flowers in bloom declines as soil-water content decreases. Delaying application until 27.5% of total available water has been depleted had the advantage of controlling excessive vegetative growth that can interfere with drying of earlier-maturing racemes and later with harvest by not allowing rapid windrow drying.

Understanding factors that limit seed production, such as crop soil-water availability will help develop management schemes for legume seed crops which are specific to local environments and years of production. While supplemental irrigation is not available to all seed growers and can be a costly operation, knowledge of how red and white clover seed crops respond to soil-water stress levels will help to optimize other management practice decisions such as spring haying time.

ESTABLISHMENT OF KURA CLOVER FOR SEED PRODUCTION

J.P. Snelling and J.J. Steiner

Kura clover (*Trifolium ambiguum* M. Bieb.) is a rhyzomatous perennial legume with potential uses in pastures and soil conservation. There is very little information available concerning kura clover crop management for seed production. In order to evaluate and utilize kura clover for commercial production, adequate seed supplies of improved cultivars must be available. The purpose of this research was to determine optimum biologic and economic strategies for seed crop establishment.

A mid-western pasture agronomist once described kura clover as a crop which "sleeps" in the first year of establishment, "creeps" during the second season, and "leaps" in the third. Because of kura's slow-to-establish nature, any future commercial seed production systems will need to take into account the time during establishment which does not have income from seed. Alternative production systems which use intercropped cereals as a source of income during kura establishment may contribute to a viable future seed industry.

To determine whether land use efficiency can be improved during establishment of kura clover seed fields, treatment combinations of spring- and fall-planted kura clover alone were compared with plantings of wheat either companion-planted at the same time as the clover or as relay-planted the following season using a no-till drill. Both companion- and relay-planted wheat were examined at standard and wide row spacings. The experiment, conducted at the Schmidt Research Farm, used sprinkler irrigation to avoid soil-water limitations. The study was begun in Spring 1989 with kura clover plantings also in Fall 1989 and Spring 1990.

Planted alone, spring-planted kura clover becomes established faster than fall plantings. When planted alone and then followed with relay-planted wheat the following season, the kura becomes established faster than kura companion-planted with wheat the same season. The best planting combination was spring-planted kura with fall-planted wheat which performed as well as spring-planted kura monoculture after 18 months from planting. Wheat yields were not decreased by the presence of kura. Kura clover generally was not affected by wheat row spacing, but wheat yields were decreased in the wide row width.

When cucumber beetles were present with spring-planted kura clover, they preferentially attacked companion-cropped kura clover. This was probably due to increased cover for the pest by the cereal in the clover-wheat treatments. Because of slow kura clover seedling growth, herbivorous pests should be closely monitored and controlled to maintain initial seedling densities.

Preliminary results for spring-planted, monocultured kura clover showed that 78 lb/a of seed was produced in the first year of seed production the summer following establishment. Such low first-season seed yields indicate that alternative production systems are needed to realize economic return while the kura crop is being established. When relay-cropped with fall-planted wheat, there was no clover seed yield the next spring, but this lack of production was off-set by a 5568 lb/a wheat yield. The effect of companion- and relay-cropped wheat on clover seed yields is being determined for two seasons following the establishment year.

PLANTING QUALITY OF PRE-HARVEST SPROUTED WHEAT SEED

T.G. Chastain, B.L. Klepper, and D.E. Wilkins

The negative effects of pre-harvest sprout damage on wheat grain quality have been widely publicized. Soft white wheat, the predominant market class grown in the Pacific Northwest, has the least resistance to pre-harvest sprouting among market classes. The germination process which is initiated during sprouting results in the production of carbohydrate-degrading enzymes that are responsible for reduced milling and baking quality. Growers and seed companies would like to know whether sprouted seed can be used as planting stock. Unfortunately, only limited information has been available regarding the field performance of sprout-damaged seed. The objectives of this research were to (i) determine the effect of sprout damage on wheat emergence, growth, development, and yield; and to (ii) develop visual criteria for determining whether a sprouted seed lot should be planted.

Field trials were planted at the Columbia Basin Agricultural Research Center near Pendleton on October 6, 1989. Certified Stephens wheat seed that was naturally sprouted by rain was used in an experiment to examine the effects of planting depth and fungicide seed treatment (Vitavax-200) on emergence, growth, development, and yield. Treated Stephens seed that was not sprouted was used as the control in this trial. In another trial, the emergence of nine cultivars of soft white common and club, and hard red winter wheat was measured. Each cultivar was adjusted from the naturally occurring level of sprouting so that 50% of the seeds planted were visibly sprouted. This adjustment eliminated inherent genetic differences among cultivars with regard to sprout damage level thereby allowing field performance comparisons. Also planted in this trial was a sprouted Stephens seed lot that was divided into four categories by visual severity of sprout damage to the seed. The four categories developed to quantify sprout damage of seed were based on the following visual criteria:

Category	Visual Sprout Criteria
A	No visual evidence of sprouting, no exposure of the embryo
B	Seed coat over embryo is broken or ruptured resulting in partial embryo exposure
C	Major break in seed coat fully exposing embryo
D	Physically damaged embryo

Four fundamental emergence patterns were observed (Figure 1). The A seed, with or without fungicide seed treatment, demonstrated the best emergence performance (pattern 1). The emergence of A seed was not statistically different from normal seed (not plotted here). This means that emergence was not affected by sprouting when no visible evidence of sprout damage was present, as was the case for A seed. The second pattern (2) exhibited reduced emergence compared to the first (1) pattern and was indicative of B and C seed that was not treated. The third (3) pattern showed poorer emergence than the second (2) pattern and was representative of B and C seed that was treated.

Seedling emergence was markedly reduced when sprouted seed had ruptured seed coats and was further reduced when sprouted seed was treated with a fungicide. Direct exposure of the embryo to the seed treatment contributed to poor emergence of treated sprouted seed. The final pattern (4) was indicative of D seed, both treated and not treated. Sprouted seed exhibiting physical damage to the embryo should not be planted.

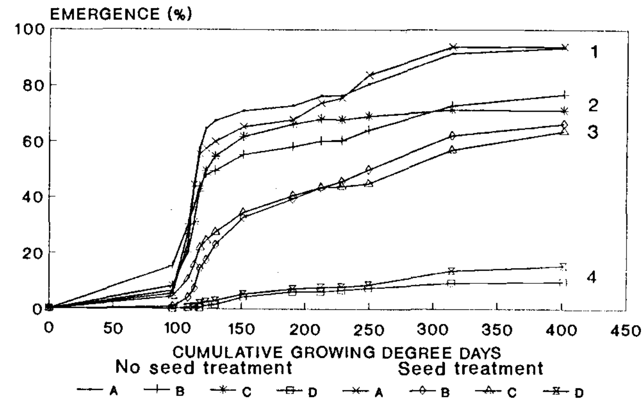

Figure 1. Emergence response of four visually-identified categories of pre-harvest sprouted wheat seed.

Wheat growth at the 3-leaf stage of development was retarded by 36% when plants were grown from untreated, sprouted seed, and was reduced by 45% when grown from treated, sprouted seed. Similar responses were also observed at the 5-leaf stage of development (Table 1). Only Vitavax-200 seed treatment (standard seed treatment for the region) was evaluated, however, it is expected that other treatments would cause similar or perhaps greater reductions in emergence and plant growth. Plants produced from sprouted seed had fewer T_1 tillers per plant but had more T_3 tillers per plant. Surprisingly, grain yield was only 4 bushels per acre less when Stephens wheat was produced from treated, sprouted seed than from normal, treated seed (Table 1). It was apparent that plants produced from sprouted seed compensate for poorer stands by producing more T_3 tillers per plant, and this contributed greatly to the yield values observed for the plants produced from sprouted seed. Test weight of grain from normal plants was slightly greater than from plants produced from sprouted seed.

Shallow seedings (1.4 inches) of sprouted wheat seed produced better stands and yield than deep seedings (3.2 inches) (Table 2). Deep seedings produced fewer T_0 (coleoptile) tillers than shallow seedings. This is also the usual response of wheat seedlings produced from normal seed to deep seedings.

Table 1. Effect of pre-harvest sprouted seed on wheat growth, development, and yield.

Characteristic	Sprouted No Vitavax	Sprouted Vitavax	Normal Vitavax	LSD 0.05
At 5-leaf stage				
Plants/meter crop row	35	27	50	7
Tillers-T_0 (%)	29	42	39	NS
Tillers-T_1 (%)	71	83	90	4
Tillers-T_2 (%)	93	91	92	NS
Tillers-T_3 (%)	62	68	54	10
At harvest				
Heads/meter crop row	117	107	134	11
1000-Seed weight (g)	49.3	49.9	49.7	NS
Test weight (lbs/bu)	61.6	61.5	62.0	0.3
Yield (bu/acre)	92	90	94	NS

Table 2. Effect of planting depth on growth, development, and yield of pre-harvest sprouted wheat.

Characteristic	Depth 1.4 in.	Depth 3.2 in.	LSD 0.05
At 5-leaf stage			
Plants/meter crop row	42	32	8
Tillers-T_0 (%)	58	16	16
Tillers-T_1 (%)	88	80	NS
Tillers-T_2 (%)	88	96	7
Tillers-T_3 (%)	56	67	NS
At harvest			
Heads/meter crop row	133	105	25
1000-Seed weight (g)	49.5	49.8	NS
Test weight (lbs/bu)	61.7	61.7	NS
Yield (bu/acre)	95	90	3

Although club and hard red cultivars showed lower natural levels of visible sprout damage than common white cultivars (54 and 16% vs. 79%), it was evident that all cultivars emerged similarly (Figure 2) if they had the same amount of visible sprout damage (50%). Given that seed from all cultivars performed in a similar manner once sprouted, an emergence index is being developed to predict the emergence potential of sprouted seed lots. Preliminary field testing shows good agreement between index values and actual emergence of the sprouted wheat. The formula uses the relative amounts of the four visible sprout categories present in the seed lot and the emergence of Stephens wheat having similar visible sprout composition. The emergence index for sprouted seed could be used to determine whether a sprouted seed lot should be planted. It could also be used to adjust the seeding rate of a desirable seed lot or to blend in the correct amount of normal seed to improve the crop stand. Field trials are continuing with commercial lots of sprouted wheat seed.

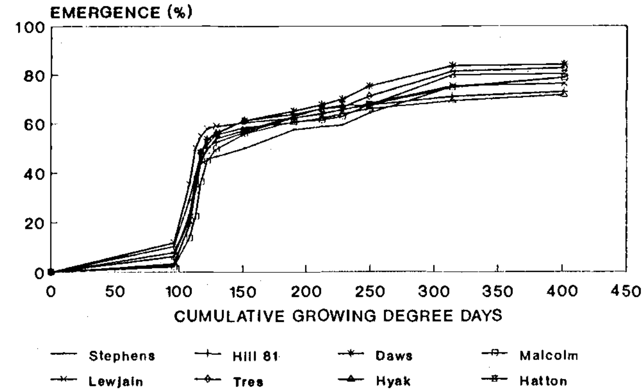

Figure 2. Emergence response of pre-harvest sprouted seed of selected soft white common and club, and hard red winter wheat cultivars.

RESPONSE OF MEADOWFOAM TO NITROGEN FERTILITY AND SEEDING RATE

D.T. Ehrensing, F.E. Bolton, D.F. Grabe, J.M. Crane, and C. Garbacik

The meadowfoam agronomy research project initiated in Fall 1988 was continued during the 1989-90 growing season. Field trials begun on the Hyslop Farm Field Laboratory were repeated and enhanced, and additional experiments were conducted on the farms of several Willamette Valley growers to obtain data under a variety of soil types and environmental conditions.

In general, meadowfoam yields were much lower than normal in 1990 regardless of location or germplasm. This was due to very cool, wet weather during pollination which restricted bee activity while meadowfoam flowers and pollen were receptive. The line 83-545, which usually produces moderate yields, began flowering during good weather, four days earlier than Mermaid or 86-765, and had the highest yields this season.

Off-station trials were established in the southern and central Willamette Valley on the Don Bowers and Gylen Mulkey farms, respectively, and in the Silverton Hills on Ioka Farms. These locations provided a range of soil types and drainage typical of meadowfoam production. Each location consisted of approximately two acres of plots for fertility and harvest methods trials. Due to a severe infestation of annual fescue, much of the data from the Bowers location was not useable.

Seeding Rate and Row Spacing Studies

Two experiments were planted to determine the effect of seeding rate and row spacing on meadowfoam yield. A constant seeding rate per foot of row trial was planted at 20 seeds per foot using 3, 6, and 9 inch row spacings. A constant seed density per unit area trial was planted on 3, 6, and 9 inch row spacing resulting in approximately 1.7 million seeds per acre. Both experiments included the variety Mermaid and the lines 85-765 and 83-545.

In the constant seeding rate trial no significant difference in seed yield was observed due to row spacing even with high plant populations at the narrow row spacings. The only yield differences noted were between genetic lines with 85-765 producing the highest yield and Mermaid the lowest. With constant seed density, 3 inch rows produced significantly less seed than either 6 or 9 inch rows in all meadowfoam lines. Mermaid had significantly lower yields than the other two lines.

Nitrogen Fertility Trials

Experiments to determine the effect of spring nitrogen application on meadowfoam yield were continued during the 1989-90 season. On Hyslop Farm the fertility trial included the lines Mermaid, 83-545, and 85-765 treated with four levels (0, 40, 80, 120 lbs N/A) of spring-applied nitrogen in a factorial design. In addition, trials were expanded this year to include experiments in all three grower locations. Identical fertility trials on grower fields were established with the line 85-765 planted on 6-inch rows at three seeding rates (10, 20, and 30 seeds/ft of row). These were treated with four levels (0, 40, 80, and 120 lbs N/A) of spring-applied nitrogen in a factorial design.

The highest seed and oil yields on Hyslop Farm resulted from 40 lb/A of spring applied nitrogen regardless of the line used. Thousand seed weight was increased with spring N application, but for each line no differences were observed among levels of applied N. No difference in seed oil content was shown between 0 and 40 lb/A N, however, oil content declined with higher N rates. Lodging is often a problem with meadowfoam in poor weather or under high N fertility which can lead to disease and harvest difficulties. The severity of lodging for all three lines increased rapidly with greater spring nitrogen application.

No differences in seed yield, oil content, or oil yield were observed due to seeding rate in trials conducted in grower fields despite decreased thousand seed weight at the 20 and 30 seeds/ft seeding rate. On Ioka Farm the 40 lb N/A rate gave the highest seed and oil yield, and both thousand seed weight and oil content were reduced with higher spring N application. Similar results were obtained at the Mulkey farm, however, no seed yield or thousand seed weight difference were detected between the 40 an 80 lb N/A fertilizer rates.

Insect damage to meadowfoam stems and flower buds was first reported in 1988. Adult fruit flies in the family *Drosophilidae* emerge in early spring and lay eggs in developing meadowfoam stem and flower buds. The resulting larvae consume individual flowers or stem growing points, depending on where the eggs were laid. In 1990 damage was noted in all growers fields as well as on Hyslop Farm.

Since observations in 1989 indicated that damage was more severe in plots with higher nitrogen fertility treatments, damage counts were made in all fertility trials in 1990. This involved collecting 20 stems at random from each plot and counting all damaged and undamaged buds. Such counts do not take into account stems lost by destruction of stem growing points, but these losses may be offset by increased number of flowers per stem.

The graphical summary in Figure 1 shows a definite increase in bud damage with increased nitrogen fertilizer application at all locations. Presumably, adult flies are more attracted to plant tissues under high nitrogen fertility and lay a greater number of eggs on those plants. The effect is particularly evident on Hyslop Farm where meadowfoam has been grown for many years. This phenomena may also provide some explanation for the lack of response to nitrogen fertility previously observed in meadowfoam.

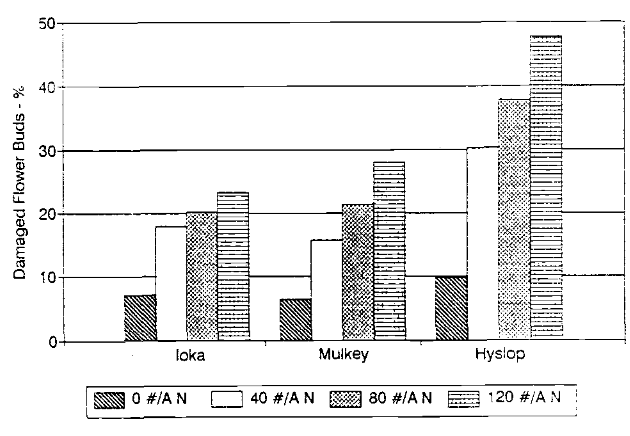

Figure 1. Insect damage to meadowfoam under several rates of spring-applied nitrogen at three locations.

HARVEST METHODS STUDY IN MEADOWFOAM

D.T. Ehrensing, F.E. Bolton, D.F. Grabe, J.M. Crane, and C. Garbacik

Conventional meadowfoam harvest involves windrow drying followed by combining with a pickup attachment. Research scale harvesting has generally been accomplished with the use of a Carter forage harvester that essentially flail chops the entire plant into a burlap bag with very little seed loss. This method requires field or oven drying followed by stationary threshing and so is not commercially practical. Direct combine harvest has also been used commercially but can be limited by severe weed infestations that are still green at harvest. Chemical desiccation of the crop and weeds prior to direct combine harvest is a possible method to overcome this problem. Experiments including the variety Mermaid and the lines 83-545 and 85-765 were planted at several locations to compare windrow/pickup harvest, direct combining with and without desiccation, and the Carter harvester method.

Yield results for all lines grown on Hyslop Farm are summarized in Table 1 (page 30). As in the 1988-89 trial, direct combining produced significantly higher seed yield than the swathing and pickup-combine method. Oil yield from direct combining tended to be higher than from swathed plots, but was not always significantly greater. As expected, use of the Carter harvester generally resulted in the highest seed yields recorded.

Seed losses due to cutting and pickup processes were determined by vacuuming the soil surface after each operation and separating seed from the soil and trash. Combine losses were determined by catching, hand threshing, and cleaning all material coming over the combine shaker screens and sieves. The amount and source of harvest seed losses are shown for each line in Table 2 (page 30). Total yield shown is the sum of harvest yield and all seed losses from each harvest operation. For example, in the swathing and pickup-combine method, seeds on the ground after swathing are called "cutting loss". Additional seeds dropped by the pickup attachment are termed "pickup loss," and seeds that passed over the combine screens and sieves are "combine loss". Direct combining results in both cutting losses at the sickle and combine losses in the threshing operation.

The majority of combine losses appear to be from virtually intact flowers that pass through the combine cleaning system onto the ground. A majority of this loss is attributed to the lack of a return system that would recirculate this material through the cylinder as is common on commercial combines. A return mechanism has been designed for the small-plot combine and will be installed and tested in 1991.

Harvest method trials were successfully completed at Mulkey Farms in the central Willamette Valley and at Ioka Farms in the Silverton Hills. Cool, wet weather during pollination resulted in low yields at both locations. This was followed by a period of hot dry conditions during seed filling. The resulting moisture stress particularly affected the fields on Ioka Farm where soils have light texture and retain less moisture than at the other trial locations. Despite these problems, direct combining produced significantly higher yield than the windrow/pickup method on Mulkey Farms. On Ioka Farms severe moisture stress increased yield variation to the point that no differences were observed between the combine methods.

Chemical desiccation is sometimes detrimental to seed viability. To investigate this possibility, a germination test was conducted on seed from the Hyslop Farm harvest methods trial. Seeds from each of the three windrow and desiccation dates were compared using all three varieties and all replications. Germination conditions were optimum for meadowfoam, 10^{o} C and dark. No significant difference in seed germination was observed due to harvest treatment, and desiccation did not appear to harm seed viability regardless of treatment timing.

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CUPHEA SEED DORMANCY RESEARCH

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Seeds of *Cuphea* species contain medium-chain triglycerides which may be useful in the manufacture of soaps, detergents, pharmaceuticals and food products. The plants, however, are in the very early stages of domestication, and have many characteristics which prevent them from being suitable for agronomic production. One of these characteristics is seed dormancy which ranges from mild to severe, depending on the species.

Prior dormancy work has been done with seedlots of several *Cuphea* species of varying ages grown and harvested under different conditions. Consequently, no conclusive comparisons could be drawn between studies. This year's research involved seedlots of *C. lutea*, *C. viscosissima*, and two lines of *C. lanceolata* grown and harvested under the same conditions two consecutive years. Therefore, direct comparisons could be made. Seed was hand harvested in 1989 and 1990 and trials were conducted during the fall of 1990. Most *Cuphea*

Table 1. Meadowfoam Harvest Methods Study -- Hyslop Farm -- 1989-90

Method	Mermaid Harvest Yield	Mermaid 1000 Sd Wt	Mermaid Oil	Mermaid Oil Yield	83-545 Harvest Yield	83-545 1000 Sd Wt	83-545 Oil	83-545 Oil Yield	85-765 Harvest Yield	85-765 1000 Sd Wt	85-765 Oil	85-765 Oil Yield
	Kg/ha	g	%	Kg/ha	Kg/ha	g	%	Kg/ha	Kg/ha	g	%	Kg/ha
Swathed - early (6/19)	483	8.35	23.2	112	660	7.55	29.3	193	709	8.25	27.5	19
Swathed - mid (6/20)	521	8.65	24.6	128	610	7.74	29.3	178	724	8.09	27.5	19
Swathed - late (6/22)	495	8.22	24.5	122	600	7.43	28.0	168	664	7.87	27.5	18
Desiccated - early (6/19)	621	8.15	24.0	149	763	7.63	29.3	224	821	8.21	27.9	22
Desiccated - mid (6/20)	646	7.91	25.1	162	883	7.63	30.4	269	841	7.99	28.0	23
Desiccated - late (6/22)	639	8.44	24.8	159	784	7.28	28.4	225	841	8.07	27.6	23
Combined - early (7/9)	618	7.90	24.3	151	748	7.44	28.3	212	799	7.94	28.2	22
Combined - mid (7/13)	651	8.45	24.3	159	794	7.61	27.4	218	873	8.01	27.6	24
Combined - late (7/18)	631	8.66	23.9	151	855	7.61	28.3	244	850	7.97	28.9	24
Carter - early (6/21)	705	8.18	21.5	151	1068	8.38	26.0	279	985	8.19	24.8	24
Carter - mid (6/28)	771	8.33	22.5	173	1141	8.26	25.7	294	1090	7.88	25.2	27
Carter - late (7/5)	733	8.49	23.2	170	1026	8.58	24.3	250	1103	7.75	26.6	29
LSD .05	70	N.S.	1.0	18	136	0.53	1.7	50	100	N.S.	2.0	4

Table 2. Meadowfoam Harvest Methods Study -- Seed Loss -- 1989-90

Method	Mermaid Seed moist	Mermaid Cutting loss	Mermaid Pick-up loss	Mermaid Combine loss	83-545 Seed moist	83-545 Cutting loss	83-545 Pick-up loss	83-545 Combine loss	85-765 Seed moist	85-765 Cutting loss	85-765 Pick-up loss	85-765 Combine loss
	....(%)....											
Swathed - early (6/20)	52.7	5.0	0.9	24.9	44.2	6.2	3.9	19.8	52.7	5.5	3.8	19.4
Swathed - mid (6/22)	39.0	5.0	3.0	21.3	42.0	5.8	4.7	23.0	39.0	6.7	5.0	19.0
Swathed - late (6/25)	27.1	4.1	1.6	24.5	26.0	8.8	3.0	18.3	25.0	5.7	6.6	17.2
Desiccated - early (6/20)	52.7	2.5		17.3	44.2	3.1		16.1	52.7	1.4		17.4
Desiccated - mid (6/22)	39.0	1.9		16.9	42.0	2.7		16.3	39.0	1.6		17.3
Desiccated - late (6/25)	27.1	2.2		16.5	26.0	3.1		16.2	25.0	1.9		16.8
Combined - early (7/9)	11.4	3.4		12.3	9.1	5.8		14.3	9.5	3.4		15.5
Combined - mid (7/13)	10.0	1.0		20.7	11.9	2.0		20.1	9.0	1.2		18.9
Combined - late (7/18)	8.3	0.7		22.2	7.6	2.3		22.6	9.9	1.1		22.6
Carter - early (6/21)	45.0	0.9			34.0	0.7			47.0	1.0		
Carter - mid (6/28)	19.5	1.1			15.2	0.8			19.7	0.4		
Carter - late (7/5)	12.0	1.1			11.2	1.0			11.7	0.6		

species will break dormancy within a year when stored under room conditions. Having two year's harvest provided a dormant and a non-dormant seedlot of each species, with one exception. *C. viscosissima* is extremely dormant, and this dormancy is usually not broken within one year.

Tetrazolium tests indicated that all seedlots had a very high viability, usually 100%. Therefore, any lack of germination could be attributed to seed dormancy.

A light duration study showed that exposure to longer periods of light increased germination whenever dormancy was present. As dormancy was broken, the amount of light per day became less of a factor. Very dormant seedlots, however, did not germinate under any light regime. Previous studies have indicated that alternating temperatures were effective at breaking seed dormancy in *Cuphea*. This year's data confirms our results as seeds in 15-25°C alternating temperatures consistently germinated better than those in 25°C constant temperature.

Seeds can often be primed by submitting them to an osmotic potential which allows water absorption but prevents germination. Usually this process is used to promote faster, more uniform germination under adverse conditions. Prior studies have shown that priming may have a dormancy breaking effect on *Cuphea*. Seeds of the four species of *Cuphea* were primed for seven days using a solution of polyethylene glycol 8000 at -10 bars water potential. Seeds primed under light conditions germinated significantly better than the control. Those primed in the dark, however, showed no improvement.

Seed coats were removed from 150 seeds of each seedlot in order to determine the cause of dormancy. Some species appear to have a dormancy totally imposed by the seedcoat, while others seem to have a combined seedcoat and embryo dormancy.

After-ripening experiments conducted by placing seeds of two of the more dormant species under conditions of varying temperatures and humidities also did not show any promise in acceleration of dormancy breakdown.

In general, the classical techniques used to overcome seed dormancy do not appear to be consistently effective on *Cuphea*. Species differences compound the problem. At this time, the only reliable means of breaking dormancy appears to be after-ripening the seeds in storage. The time required for this natural breakdown of dormancy may range from a few weeks in one line of *C. lanceolata* to two years or more in *C. viscosissima*.

ELECTROSTATIC SEPARATION TO IMPROVE GERMINATION OF CARROT AND CELERY SEED

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Electrostatic seed separation exploits the electrical properties of seeds known to result from differences in shape, surface texture, bulk density and moisture content. Electrical properties of seeds differ from more conventional properties on which separations are based because they cannot be directly sensed by human eye or with usual measurement equipment.

One of the more difficult seed separations is removal of nongerminable crop seeds from germinable crop seeds to increase seed lot germination to legal or contractual standards. In celery and carrot seed lots, low germination values are common, but the problem may occur in many types of seed. Often a slight improvement in the germination value of these seed lots makes the seed marketable. The possible causes of low germination are numerous. They may include factors such as weather and seed variety or may be the result of low soil fertility, water stress, insect, chemical, or harvest damage. No single physical factor consistently differentiates nongerminable seed from normal seed and more often these seeds appear identical to normally germinating crop seed in every visible way.

Clean seed lots of carrot and celery were obtained from different commercial sources. Three size fractions of a single carrot seed variety and two varieties of unsized celery seed, were each divided into twenty-four 30-g sublots using a Boerner divider. These were then spread in open containers prior to preconditioning and separation on the electrostatic separator. Three 30-g control sublots were included in the germination tests for each size and variety.

Preconditioning consisted of exposing the sublots to air for varying periods of time. All preconditioning and electrostatic separations were conducted in a controlled environment room set at 10°C and 15% relative humidity. Based on preliminary measurements of weight loss of both species at these conditions, time durations of 0, 6, 24 and 48 hours were selected for preconditioning.

A grounded belt-type electrostatic separator with a 17kV positive charged wire electrode, was used to separate each of the 24 preconditioned sublots into two fractions. This device, with adjustable divider, separates the seed into a pinned fraction (held or attracted to the belt) and a nonpinned fraction (lifted or not attracted to the belt). A total of 240 fractions from the electrostatic separator and 15 control fractions were weighed, packaged, and labeled for later germination tests. Three replications of each test were conducted using two different electrode positions. These positions were: 1) holding, where the wire was between the tube and the belt, and 2) lifting, where the tube was between the wire and the belt. Both electrode positions caused some of the seeds to be pinned and others to be nonpinned creating two fractions.

Electrostatic separations for both carrot and celery seeds resulted in similar trends. Nonpinned fractions from both had significantly higher germination levels than the pinned fractions. Weights of fractions were similar with the nonpinned being the smaller fraction. This trade-off of germination improvement with loss of germinable crop seed is an important consideration for the commercial seed conditioner. It is possible that with experimentation and blending, an acceptable germination improvement and degree of shrinkage can be attained to make the process economically feasible.

Electrostatic separation appears to be a reasonable method for upgrading the germination level of carrot and celery seed lots when conventional methods have failed. Results of this research suggest that germination level improvements of more than 5% are possible. For seed that is only slightly below legal or contractual standards, electrostatic separation provides an alternative to discarding or selling the lot at discount.

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