1989
SEED PRODUCTION RESEARCH
AT OREGON STATE UNIVERSITY
USDA-ARS COOPERATING

Edited by William C. Young, III

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The report has been published with a grant from the Oregon Seed Council

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WEED CONTROL WITH OXYFLUORFEN IN ESTABLISHED PERENNIAL GRASSES

G.W. Mueller-Warrant

The herbicide GOAL 1.6E (oxyfluorfen) was granted a Section 18 Emergency Exemption for use on grasses grown for seed in Oregon between Sept. 1, 1989, and Jan. 15, 1990. This herbicide was registered to improve control of volunteer crop seedlings in unburned stands and improve control of diuron-tolerant weeds in all situations. Herbicide residue testing necessary to obtain a full Federal label is being conducted by Rohm and Haas Company in cooperation with the IR-4 program, but will probably not be completed until 1991. Until a full Federal label is obtained following completion of the residue testing, animal grazing will continue to be prohibited. However, there are no restrictions on the use of straw or seed screenings from grass seed fields treated with Goal under the Section 18 registration.

Goal belongs to the diphenyl ether herbicide class, and is quite different from the traditional herbicides used in grass seed production, atrazine, simazine, and diuron (Karmex). Grasses can be killed by Goal only as small seedlings, but substantial injury may occur even to large, well-established grass plants under certain situations. Field testing of Goal alone and in combination with several other herbicides over the past three years has identified several critical factors affecting herbicide weed control performance and crop tolerance.

The extremely low water solubility of oxyfluorfen, the active ingredient in Goal, affects its performance as a herbicide in several ways. First, this means that Goal remains directly at the soil surface, and probably does not penetrate further than 1/8 to 1/4 inch into the soil. Second, the low water solubility means that Goal is highly soluble in lipids such as those forming the surface of leaves, and it rapidly enters treated plants. Third, high levels of soil moisture are necessary if Goal is to kill seedling grasses as they emerge. This is mainly because dry soil conditions limit the amount of soil-applied Goal that reaches seedling grasses.

The behavior of Goal within a plant (and its effectiveness as a herbicide) is strongly influenced by interactions between its mode of action and the external environment, particularly the amount of sunlight. Goal is classified as a contact herbicide that does not translocate appreciably. However, it is quite soluble in lipids and easily reaches the chloroplasts. Once present there, it blocks chlorophyll synthesis, leading to the buildup of a photochemically reactive precursor of chlorophyll. This compound captures the energy of sunlight, and ultimately generates free radicals that destroy plant membranes. The process is quite rapid in full sunlight, and plant tissue treated with Goal will discolor and die within one to two days. When Goal is applied under sunny conditions, damage is generally limited to areas actually in contact with spray droplets, and tissue between the droplets may be uninjured.

In contrast, when Goal is applied under cloudy, foggy conditions in which the intensity of sunlight is low, damage may not show up for a week or more. During this period between application and appearance of symptoms, several things are happening. First, Goal itself migrates further in the plant through the process of diffusion in the lipid phase. Second, larger quantities of the chlorophyll precursor may be accumulating within the plant. These may ultimately become so abundant that even under dark, cloudy conditions enough free radicals will form to destroy membranes. More commonly, a change in the weather will increase the amount of sunlight to a level at which free radical production becomes lethal to the cell. Damage to large, well-estabished plants can be quite severe under these conditions, and recovery does not begin until the treated leaves have died and the surviving growing points have become isolated from the dead leaves.

The most effective time to apply Goal to seedling grasses is between germination and the 2-leaf growth stage. Most grasses in the 3-leaf growth stage or larger will survive treatment with Goal, despite severe initial injury. Perennial ryegrass is particularly tolerant, and many plants in the 2-leaf growth stage will survive. Optimum performance of Goal has been seen when it is applied to moist soil between rains near the end of the first week of prolonged rainy weather in the fall. Under these conditions, seedlings will have germinated and are just emerging through the soil when the herbicide is applied. This timing has been somewhat more effective than application a week to ten days earlier when the soil is still dry and the rains are about to begin. It has also been much more effective than application after grasses reach the 3-leaf stage (2-leaf stage for perennial ryegrass).

Seedlings germinating from deep in cracks in the soil are poorly controlled by Goal. Several factors make these seedlings more likely to survive Goal treatment. First, they often germinate earlier in the fall than those seeds laying directly on the soil surface, and are therefore older and larger in size than the main flush of seedlings. Second, they germinate under much drier soil conditions, particularly at the soil surface. Third, their growing points are relatively well protected by the chaff that surrounds them and by their position below the soil surface. Fourth, sunnier conditions while they are growing early in the fall tend to result in a rapid contact burn from Goal instead of the slower, more systemic effects seen in cloudy weather later in the fall. Addition of a surfactant/wetting agent to Goal will improve distribution on leaf surfaces and performance under sunny and/or dry conditions, but probably not during cloudy, rainy weather.

In the 1987-88 growing season, Goal by itself was tested on established perennial ryegrass, Kentucky bluegrass, and fine fescue at rates from 0.05 to 0.4 lb/a. Only in fine fescue was seed yield reduced by Goal, and even with that species only for rates between 0.2 and 0.4 lb/a. Several groups of tests using Goal by itself and in combination with other herbicides were conducted on a variety of grasses during the 1988-89 growing season. Goal by itself at rates up to 0.5 lb/a did not reduce seed yield in perennial ryegrass, Kentucky bluegrass, tall fescue, orchardgrass, and bentgrass compared to untreated or diuron treated checks (Table 1). Fine fescue yield was reduced at 0.5 lb/a relative to a low rate of Goal or to simazine, but not to an untreated check. Goal at 1.0 lb/a reduced bentgrass yield compared to treatment with 0.25 lb/a, but not compared to an untreated check. Dramatic visual injury occurred in all of the grasses, but with these very few exceptions, did not hurt seed yield.

However, Goal by itself has provided complete weed control only in a few cases, and it will generally need to be tank-mixed or applied in sequence with other herbicides to adequately control weeds and volunteer crops. Results from tests in perennial ryegrass, tall fescue, and orchardgrass in which Goal was applied sequentially or in tank-mixes with other herbicides indicate improved weed control may sometimes occur at the expense of reduced crop yield. Cases in which yield has been reduced seem to be those in which one fairly damaging treatment in October was followed by another in December. Use of soil residual herbicides alone in October increased tall fescue seed yield by only 20 lb/a over the untreated check, mainly because of the very low density of weeds (Table 2). Tall fescue seed yield was reduced an average of 110 lb/a when soil residual herbicides applied in mid-October were followed by Goal at 0.125 lb/a in early December, compared to use of the residual herbicides by themselves (Table 2). Most of the yield loss occurred in the Sinbar/Goal and Surflan/Goal sequences, which averaged 231 lb/a less than Sinbar or Surflan alone (Table 3). With the four other residual herbicides, the average yield loss from December application of Goal in sequence was only 50 lb/a, not statistically significant. A similar, but slightly less severe pattern was seen for Enquik applied in sequence following the soil residual herbicides. While the average yield loss from Enquik was less than that with Goal, only 89 lb/a, the bulk of that yield loss similarly occurred in only two out of the six soil residual herbicide sequences. The Karmex/Enquik and Surflan/Enquik sequences averaged 196 lb/a less seed than Karmex or Surflan alone, while the loss due to Enquik in sequence with the four other soil residual herbicides was only 35 lb/a, not statistically significant.

Goal has the potential to become a widely used component of weed control programs in grasses grown for seed. Its ability to kill seedling grasses within two weeks after application under the dark, cloudy conditions common during late fall in the Willamette Valley is a marked improvement over the behavior of atrazine, simazine, and diuron under the same conditions. Equally important is the obviousness of failure in those cases where Goal has not controlled weeds; the appearance of a single healthy, new, green leaf in the center of a seedling grass is a sure sign that the individual seedling has survived Goal treatment and that additional herbicides will be needed. The limits to Goal's ability to control seedling grasses strongly imply that its final place in programs to control weeds without field burning will be that of valuable component of a variety of tank-mixes. Development and registration of optimal herbicide tank-mix and sequential treatment programs both with and without Goal will require a great deal of further research effort. It will also require cooperation between seed growers, chemical companies, the extension service, and various research organizations.

Table 1. Clean seed yield of perennial ryegrass, tall fescue, Kentucky bluegrass, orchardgrass, fine fescue, and bentgrass treated with Goal in November 1988.

Oxyfluorfen (Goal) rate	Perennial ryegrass		Tall fescue		Kentucky bluegrass		Orchard-grass		Fine fescue		Bent-grass	
(lb ai/a)	(lb/a)											
0	1998	a	455	a	1044	ab	977	a	728	abc	954	ab
0.063	1919	a	435	a	1093	a	1066	a	831	ab	974	ab
0.125	1923	a	364	a	870	b	1006	a	784	abc	867	b
0.25	1997	a	409	a	1017	ab	1100	a	772	abc	1059	a
0.375	1913	a	416	a	995	ab	999	a	721	bc	---	
0.5	1848	a	357	a	873	b	1038	a	663	c	966	ab
1.0	---		---		---		---		---		839	b
0.125+Karmex 1.6	1960	a	389	a	946	ab	1093	a	---		879	ab
Karmex 1.6 alone	1844	a	465	a	975	ab	1118	a	---		994	ab
0.125+Simazine 1.6	---		---		---		---		754	abc	---	
Simazine 1.6 alone	---		---		---		---		863	a	---	
LSD(.05)	160		113		196		147		138		168	

Table 2. Main effects of residual herbicides and timing sequence on Fawn tall fescue in the 1988-89 growing season at the OSU Crop Science Field Laboratory Schmidt Research Farm.

Treatment factor average effects	Seedling tall fescue control		Tall fescue seed yield		Yield loss or gain versus check
Soil residual herbicide[1] (lb ai/a applied)	(%)		(lb/a)		(lb/a)
Cinch (cinmethylin 0.88, 1.5)	98	a	1263	ab	-58
Karmex (diuron 1.76, 3.0)	92	b	1199	b	-122
Sinbar (terbacil 0.44, 0.75)	71	d	1298	ab	-23
Surflan (oryzalin 0.88, 1.5)	100	a	1307	ab	-14
Prowl (pendimethalin 1.76, 3.0)	99	a	1330	a	+9
Sencor (metribuzin 0.44, 0.75)	79	c	1254	ab	-67
LSD(.05)	6		119		--
Timing sequence[2]					
Oct. 18 Residual only	80	b	1341	a	+20
Oct. 18 Residual / Dec. 8 Goal 0.125	99	a	1231	b	-90
Oct. 18 Residual / Dec. 8 Enquik 16 Gal.	81	b	1252	ab	-69
Dec. 8 Tank Mix of Residual + Goal 0.125	99	a	1277	ab	-44
LSD(.05)	5		97		--
Untreated check[3]	0		1321		0

[1]Means for these six soil residual herbicides are averaged over two application rates, four timing sequences, and three replications.
[2]Means for these four timing sequences are averaged over six soil residual herbicides, two application rates of those residual herbicides, and three replications.
[3]Untreated check is the average of six replications.

Table 3. Interactions of residual herbicides and timing sequence on Fawn tall fescue seed yield.

Residual Herbicide	Oct. 18 residual only, no sequential	Oct 18 residual followed by Dec. 8 Sequential: Goal	Oct 18 residual followed by Dec. 8 Sequential: Enquik	Dec. 8 tank mix of residual plus Goal
	----------	----------	(lb/a) ----------	----------
Cinch	1194	1182	1266	1411
Karmex	1295	1214	1086	1201
Sinbar	1392	1129	1320	1350
Surflan	1447	1248	1263	1272
Prowl	1410	1314	1324	1274
Sencor	1307	1299	1255	1153
Untreated	1321	1052	1262	1052

FUNGICIDE STUDIES ON PERENNIAL RYEGRASS AND TALL FESCUE

Ronald E. Welty

Bayleton, Bravo, and Tilt are fungicides registered for use in controlling diseases of grasses grown for seed. Earlier studies in years when April and May are cooler and wetter than the 30-year average, Bravo applied to orchardgrass at flag leaf emergence and/or full head emergence effectively controls fungi that cause leaf and stem diseases (eyespot, scald, and streak) and significantly increases seed yields compared with nontreated controls.

Tilt and Bayleton effectively control stripe rust in Kentucky bluegrass and stem rust in perennial ryegrass. Bravo provides limited protection for controlling rusts. In practice, growers make one to three applications of these fungicides alone or in combination as a tank mix. Except for orchardgrass, limited data are published that evaluate the effect of multiple applications of these fungicides alone or in combination in a single season for controlling fungus diseases in perennial ryegrass and tall fescue.

The objective of this study was to evaluate seed production and disease control in perennial ryegrass and tall fescue following two, three, or five applications of Bravo or Folicur alone and two, three, or five applications of Bravo, Benlate, or Folicur mixed with Tilt or Bayleton. The results were compared with a nontreated control. Folicur and Benlate are not presently registered for use on grasses grown for seed, but were included to evaluate their efficacy for disease control.

MATERIALS AND METHODS

Perennial ryegrass. Fungicides (see Table 1 for rates) were applied alone or in combination as 15 different treatments to 'Delray' perennial ryegrass on two to five dates: April 21, May 1, May 21, June 3, or June 16, 1989. Stages of plant growth on these dates were flag leaf beginning to emerge, head beginning to emerge, head emerged and flowering beginning, flowering complete, or seeds mealy ripe, respectively. For convenience, treatments were designated "E" for "early" applications, "L" for "late" applications, or "C" for "complete" applications. For example, "2E" indicates applications were made on the first two dates; "3L" indicates applications were made on the last three dates; "5C" indicates applications were made on all five dates.

Stem rust severity on seed heads was scored (0-100%) on June 21. Ten handfuls of stems (25-35 stems per handful) were taken from various locations within a plot and given an average score. These 10 scores were averaged for each plot, and means were used for a statistical analysis of variation. The study was arranged in a randomized complete block with four replications.

Seed was harvested June 25 using a small plot harvester. Seed heads and stems were cut, bagged, and air dried in the field to about 15% moisture content. The bags containing the seeds and heads were put into a forced air dryer, and seeds were redried to 11-12% moisture. Seed was threshed and cleaned before weighing.

Tall fescue. 'Bonanza' tall fescue was treated with fungicides according to the same schedule prepared for 'Delray' perennial ryegrass. (Treatment assignments were rerandomized.) The plots were scored for stem rust on June 22 and harvested June 23.

"Large" plot study. In 1989, another field study was done at Hyslop Field Laboratory using "larger-than-normal" plots and two cultivars of perennial ryegrass, 'Linn' and 'Delray'. Each cultivar was treated five times (see Table 2 for application dates) with a tank mix of Bravo 720 (1 pt/A) and Tilt (4 oz/A) applied in strips 10 feet wide. The plots were 220 feet and 120 feet long for 'Linn' and 'Delray', respectively. The study included an equal number of nonsprayed plots as controls. The study was replicated six times for each cultivar. The experiment followed the usual production practices. At harvest (see Table 2 for dates), plant material from each treatment per replication was bulked and seed was threshed, cleaned, and weighed. Seed weights were statistically analyzed by a standard analysis of variance. Seed yields for 'Delray' were determined for plots 10' x 120', but weights were arithmetically converted to yields for 10' x 220' plots so direct comparisons of seed yield can be made. A tank mixture of fungicides was used in the study to provide control of leafspots and rust - Bravo for leafspots and Tilt for rusts.

RESULTS

Perennial ryegrass. Seed yields (g/plot) were significantly (P=0.05) larger (marked with asterisk in Table 1) in 10 of 15 plots treated with fungicides (alone or in combination) when compared with nontreated controls. Stem rust was most severe (62% of heads rusted) in nontreated controls and was significantly (P=0.01) less severe in all 15 fungicide treatments when compared with the nontreated control. Some stem rust developed (9-20% average rust severity of heads) in plots treated with two or three applications of Bravo or Folicur. A trace (up to 1% of the head) of stem rust developed in 5 other fungicide treated plots; no stem rust was found in heads of plants receiving seven other fungicide treatments.

The most effective fungicide treatments for increasing seed yield were those that included Tilt, Folicur, or Bayleton as mixtures. Least effective treatments for significantly increasing seed yields were applications of Bravo or Folicur alone (5 NS treatments), although there were three treatments of Bravo or Folicur alone that resulted in significant increases in yield over the nontreated control.

Tall fescue. Several fungicide treatments resulted in seed yields larger than the nonsprayed controls, but the analysis of variance for the complete study revealed none of the seed yield differences were statistically significant (P=0.10). However, test plots with the highest seed yields were Benlate + Tilt 5C, Benlate 2E + Tilt 3L, and Bravo + Tilt 5C. Although these tank mixes resulted in higher seed yields, five applications are not economical.

Table 1. Seed yield and stem rust severity in 'Delray' perennial ryegrass and 'Bonanza' tall fescue treated with fungicides, Hyslop Field Laboratory, Corvallis, Oregon, 1989

Fungicide[1]	Rate per acre	'Delray' PRG Seed yield[2]	'Delray' PRG Stem rust[3]	'Bonanza' TF Seed yield	'Bonanza' TF Stem rust
		(g/ plot)	(% head)	(g/ plot)	(% head)
Control	--	463	62	700	Trace
Bravo 2E	1 pt	536	Trace	759	0
Bravo 3E	1 pt	552*	12	772	0
Bravo 3L	1 pt	517	20	792	Trace
Bravo 5C	1 pt	556*	Trace	693	0
Folicur 2E	12 oz	480	9	799	Trace
Folicur 3E	12 oz	543	Trace	709	0
Folicur 3L	12 oz	585*	0	741	0
Folicur 5C	12 oz	520	0	712	0
Bravo + Tilt 3E	1 pt, 4 oz	611*	0	756	0
Bravo + Tilt 3L	1 pt, 4 oz	591*	0	676	0
Bravo + Tilt 5C	1 pt, 4 oz	591*	0	804	0
Bravo 2E + Bayleton 3L	1 pt, 4 oz	567*	1	735	0
Folicur 2E + Bayleton 3L	12 oz, 4 oz	570*	Trace	737	0
Benlate 2E + Tilt 3L	4 oz, 4 oz	596*	0	809	0
Benlate + Tilt 5C	4 oz, 4 oz	598*	0	851	0
LSD 0.05		86.1	11.7	NS	NS
LSD 0.01		NS	15.6		

1 Fungicides applied: 2E = April 21, May 1; 3E = April 21, May 1, May 21; 3L = May 21, June 3, June 16; 5C = April 21, May 1, May 21, June 3, June 16.
2 Seeds harvested: June 25 (Delray), June 23 (Bonanza).
3 Stem rust severity: Modified Cobb Scale, 0-100%, June 21 (Delray), June 22 (Bonanza).
* = significantly higher than control.

Only trace amounts (>1%) of stem rust were observed on seed heads in these test plots. A survey of stem rust incidence and severity was made in the borders surrounding the plots. Ten handfuls of stems were examined and rated for stem rust. No stem rust was found on the south and east borders, one of 10 handfuls had 5% stem rust on the seed heads in the west border; stem rust was found in three handfuls (100%, 65%, and 65%) on the north border. The low incidence of stem rust is attributed to early maturity of the crop. It is speculated the crop avoided the last exposure to stem rust inoculum which in other years allows a late increase of disease. In 1989, 'Bonanza' tall fescue was harvested about two weeks earlier than 1988 (July 7, 1988). Stem rust in tall fescue was more severe in 1988 than in 1989.

In the absence of severe stem rust in 1989, 15 fungicide treatments to 'Bonanza' tall fescue did not statistically increase seed yield (P=0.10). In 1987 and 1988 ("Seed Production Research," Ext/CrS 70 and Ext/CrS 74), several of these same fungicides were applied to 'Fawn' tall fescue, with no significant increase in seed yield observed. After three years of field tests, fungicides applied for reducing foliar disease damage in tall fescue have not resulted in statistically significant increases in seed yields compared with nontreated controls.

"Large" plot study. Seed yields in fungicide-treated versus nontreated plots were statistically different (P=0.001) for 'Delray' and 'Linn' (Table 2). These differences were 45% and 42% larger than the nontreated controls for 'Delray' and 'Linn', respectively.

Table 2. Seed yield (g/plot) of perennial ryegrass cultivars Delray and Linn treated with five applications (tank mix) of Bravo (1 pt/A) + Tilt (4 oz/A), Hyslop Field Laboratory, Corvallis, Oregon, 1989.

	Grams cleaned seed	
Cultivar	Control	Treated
Delray	4596	6677***
Linn	4226	6011***

*** Seed yields between treated and control were significantly different at P=0.001.

Fungicides applied: April 19, May 3, May 19, June 3, June 16.

Seed harvested: 'Delray', June 25; 'Linn', June 26.

Throughout the growing season, plants were examined for foliar diseases. Fungus-induced leafspots were found in April and May; by June and July natural senescence of the flag leaf, second leaf, and third leaf occurred, and no disease differences were observed on these leaves due to fungicide treatment.

In June and July, the principal disease in the nontreated controls was stem rust and was rated as severe on leaves and seed heads. No stem rust was found in the fungicide-treated plots. Fungicide treatments provided 100% control of stem rust.

Five applications of fungicides for control of foliar diseases are not practical nor economical. It may also be unrealistic to expect a similar difference in seed yield for different cultivars or with fewer applications of fungicide. Moreover, incidence and severity of different diseases often change from year to year. However, the study reveals the magnitude of increase in seed yield that could be expected when primarily stem rust is controlled in perennial ryegrass by fungicides.

SUMMARY

In field plot research, many treatment combinations of host, cultivar, fungicide, fungicide rates, and fungicide application dates are possible. The task of testing all combinations of these variables is enormous. However, based on several years of field testing, several general conclusions are possible.

Fungicide applications to perennial ryegrass to control stem rust result in seed yield increases. In years when weather in April and May is wetter and cooler than normal, applications of Bravo may reduce damage caused by leafspot diseases.

For tall fescue, data obtained so far indicate that fungicide treatments do not increase seed yields, even when the crop is treated with up to five fungicide applications. In some years and for some treatments, seed yields in plots treated with fungicides have seed yields higher than the nontreated controls; however, these differences are not statistically different (P=0.10). Likewise, some fungicide treatments in some years result in seed yields less than nonsprayed controls (NS, P=0.10).

Leafspot diseases occur regularly in fields of tall fescue in Oregon, and leafspot fungal pathogens have been isolated in the laboratory in pure culture from infected tissue. Leafspot diseases are reproduced when healthy plants are inoculated with the pathogens. However, these diseases were not severe enough in 1987, 1988, and 1989 to reduce seed yields. It may be recalled that the growing season and weather conditions in 1988 were conducive to leafspot disease development in other grass crops (e.g., orchardgrass) grown for seed. In three years of testing, fungicide applications to tall fescue have not resulted in consistent increases in seed yield.

Fungicide applications to tall fescue to evaluate the benefits of stem rust control will continue until more is known about the effect of this disease on seed yield.

Although fungicide programs are available for controlling leaf diseases in orchardgrass and stem rust in perennial ryegrass, no standard fungicide spray program has evolved for leafspot disease control in perennial ryegrass and tall fescue. It is generally known that disease severity changes yearly and varies by location, host, and cultivar. Thus, a decision to apply fungicides involves several interacting variables, including host resistance, the stage of crop maturity in a growing season, flowering date of the grass species or cultivar, and weather conditions when the flag leaf and head are emerging. Since no routine fungicide spray system was found to be satisfactory for leafspot control in perennial ryegrass or tall fescue, it remains an individual decision to apply fungicides based on the interacting variables described above.

EVALUATION OF TILT FUNGICIDE APPLICATIONS FOR CONTROL OF STEM RUST ON 'LINN' PERENNIAL RYEGRASS

Ronald E. Welty

In 1986 a three-year study was initiated with 'Linn' perennial ryegrass to evaluate seed yield in field plots treated with Tilt, a fungicide that controls stem rust. The two objectives of the study were to 1) measure seed yield and relate it to the most effective fungicide applications, and 2) provide field plots of plants with varying percentages of stem rust so disease incidence could be related to seed yields.

To accomplish these objectives, 'Linn' perennial ryegrass was established at Hyslop Field Laboratory and field plots (8' x 10' or 8' x 20') to receive up to six applications of Tilt. Annual results from this study were reported in earlier issues (1986 and 1988) in this series of annual publications. The study was completed in 1989, and this report summarizes three years of testing.

MATERIALS AND METHODS

Fungicide applications. In 1986 Tilt was applied at 8 oz/A; in 1988 and 1989 the rate for Tilt was reduced to 4 oz/A. The annual date for the first application of Tilt varied by the maturity of the crop and the stage of plant development. First applications were made when 75-100% of the plants had developed first or second nodes in the seed tiller on April 2, 1986, April 16, 1988, or April 18, 1989. Subsequent applications (up to six) were made at 12-14 day intervals as plant stages changed.

Seed yield. Seeds were harvested with a small plot harvester on July 4, 1986, July 1, 1988, and June 26, 1989, threshed, cleaned, dried, and weighed. Seed yields are expressed as grams of seed per plot.

Stem rust severity. Stem rust was scored July 3, 1986, June 30, 1988, and June 22, 1989, as the percentage of the panicle (head and stem) with stem rust.

Experimental design. Tilt treatments were arranged in a randomized completed block design with four replications in 1986 and 1988 and five replications in 1989. Seed yield and stem rust scores were averaged for replication, and the results were analyzed for statistically significant differences.

RESULTS

Stem rust was more severe in 1986 and 1988 than in 1989; the results will be discussed on the basis of 1986 and 1988 data (Table 1). In both years, stem rust developed in nontreated control plots. In in plots receiving one or two late-season applications of Tilt, stem rust was significantly less (P=0.05) than the control. Stem rust in plots treated with 3 to 6 late-season applications of Tilt were not significantly different from plots receiving two late-season applications. Stem rust developed in plots receiving one late-season or 1 to 3 early-season applications of Tilt.

Table 1. Stem rust severity and seed yield in 'Linn' perennial ryegrass treated with 1-6 applications of Tilt (Propiconazole), Hyslop Field Laboratory, Corvallis, Oregon, 1986, 1988, 1989.

Number of applications	Percentage disease (stem and head)			Seed yield (percentage control)		
	1986[a]	1988[b]	1989[c]	1986[d]	1988[e]	1989[f]
0	57	50	Trace	100	100	100
1	26	34	0	96	98	99
1, 2	63	20	0	118	104	97
1, 2, 3	47	22	Trace	107	97	96
1, 2, 3, 4	24	5	0	102	111	105
1, 2, 3, 4, 5	0	0	0	120	97	107
1, 2, 3, 4, 5, 6	0	0	0	118	123	104
2, 3, 4, 5, 6	0	0	0	118	117	104
3, 4, 5, 6	0	0	0	109	111	104
4, 5, 6	0	0	0	115	87	100
5, 6	2	0	Trace	107	105	99
6	17	28	-	110	91	-
LSD 0.05	15.1	14.7	-	NS	NS	NS

[a] 1986 - 8 oz. Tilt/A: 1st appl. 04/02; scored 07/03/86; harvested 07/04/86.
[b] 1988 - 4 oz. Tilt/A: 1st appl. 04/16; scored 06/30/88; harvested 07/01/88.
[c] 1989 - 4 oz. Tilt/A: 1st appl. 04/18; scored 06/22/89; harvested 06/26/89. Appl. 6 omitted due to shortened growing season.
[d] 1986 - Seed yield, 4 reps; control = 188 g/plot.
[e] 1988 - Seed yield, 4 reps; control = 353 g/plot.
[f] 1989 - Seed yield, 5 reps; control - 459 g/plot.

Seed yields for all three years in plots treated with Tilt were generally larger than the nontreated control; however, the differences were not significantly different (P = 0.10). Seed yields were also generally larger in plots treated with late-season or 4 to 6 applications of Tilt, and were smaller in plots treated early with Tilt.

SUMMARY

One or two applications of Tilt in May and June significantly reduces stem rust in 'Linn' perennial ryegrass;

however, rust control and total seed yield were not related. Two other components of seed yield (1000 seed weight and tiller number) were not measured in these studies.

The second objective of this three-year experiment was to evaluate seed yield loss with varying amounts of stem rust. It was hoped the experimental design (series/omission spray treatments) would provide data to resolve this question. The design provided plots with different percentages of stem rust, but the second objective was not attained because seed yields were not statistically different. It is concluded that in small plot tests it remains unclear how the amount of stem rust influences seed yields in perennial ryegrass. In cereals, stem rust is known to reduce seed size and number.

FUNGICIDE APPLICATIONS IN BURNED VERSUS NONBURNED ORCHARDGRASS

Ronald E. Welty

Orchardgrass fields are often burned after seed harvest to remove straw residue, control weeds and insects, and reduce disease inoculum. In April and May 1983, burned and nonburned fields of orchardgrass were surveyed for scald, eyespot, and streak to relate prior-year burning to incidence and severity of these leaf diseases. At the end of the survey, prior-year burning appeared unrelated to leafspot disease severity, and efforts were directed toward evaluating fungicides for leaf spot control. The results of these studies have been reported in earlier issues of this publication series.

MATERIALS AND METHODS

In 1988 a field of 'Potomac' orchardgrass was used to evaluate burning versus nonburning, with and without fungicide treatments for leafspot disease control (scald, eyespot, streak). The experiment was arranged in a split plot design, with the main plot effect (factor a) burn versus nonburn; the subplot effect (factor b) was four fungicide treatments and a nontreated control. Variables measured were seed yield per plot and percent disease severity on the flag, second, and third leaf on tillers. The field was limed and fertilized according to soil tests to maintain vigorous growth. Experimental plots (8' x 20') were rows planted on 1-foot centers. This field was originally used for evaluating fungicides (1984-1988) for leaf disease control and was established September 12, 1983. Each year after seed harvest, straw was removed with a flail chopper. Remaining plant stubble (3-4 inches) and some leaf residue on soil surface provided inoculum carry-over for the next growing season.

After seed harvest in 1988, half the plots in each replication were burned with a propane burner to simulate open field burning. Subplot treatments the following spring (1989) were two applications of fungicide at flag leaf emergence (April 20, 1989) and after seed heads were fully emerged (May 1, 1989). Fungicide treatments were Bravo 720 (1 pt/A), Folicur (12 oz/A), Bravo 720 (1 pt/A) + Tilt (4 oz/A), or Bravo 720 (1 pt/A) + Bayleton (4 oz/A). A nontreated plot served as a control. Treatments were randomly assigned to plots, and the experiment contained six replications. Leaf area damaged by disease (0-100%), primarily scald, was estimated May 26, 1989, using a whole-leaf blade scoring system. Ten tillers were scored from each plot. Disease scores were averaged by leaf position on the tiller (flag, second, third) and mean disease scores computed for each treatment. Seeds were harvested June 18, 1989, with a small plot harvester and dried, threshed, and cleaned before weighing. Seed yields and mean disease scores were statistically analyzed and compared for significant differences.

RESULTS

Average seed yield (Table 1) from plants in the nonburned plots was slightly higher than the seed yield from plants in the burned plots, but the difference was not statistically significant (F value = 0.12). Average leaf area diseased (%) in the flag leaf, second, and third leaf were 12, 18, and 48% in the burned plots and 12, 18, and 41% in the nonburned plots, respectively. Leaf area diseased (%) in the top three leaves on a tiller due to burning versus nonburning treatments were not statistically different (P=0.1).

Two applications of Bravo or Bravo + Tilt at boot (April 20, 1989) and heading (May 1, 1989) resulted in a significantly (P=0.1) higher seed yield than the nontreated control (F value = 2.17). Leaf area diseased (%) in the top three leaves in tillers from plants treated with fungicides was less than for the same leaves on a tiller from the nontreated control, but the differences were not statistically significant (P=0.1). There was no statistically significant interaction between burning and fungicide treatments for seed yield (F value = 0.66).

Table 1. Seed yield (g/plot) and disease severity (%) of 'Potomac' orchardgrass burned and nonburned and treated with two applications of four fungicide treatments.

	Seed[1] Yield	Leaf Area Diseased (%)[2] Flag	Second	Third
Main plots				
Burn	416	12	18	48
Nonburn	425	12	18	41
LSD 0.10	NS	NS	NS	NS
Subplots				
Check	402	14	20	50
Bravo[3]	438	12	17	46
Folicur	406	11	18	38
Bravo + Tilt	440	10	17	44
Bravo + Bayleton	418	11	18	43
LSD 0.10	28.4	NS	NS	NS
LSD 0.05	NS	NS	NS	NS

[1] Harvested: June 18, 1989
[2] Leaf area diseased (scald) was scored May 26, 1989.
[3] Fungicide rates: Bravo 720 = 1 pt/A; Folicur = 12 oz/A; Bravo + Tilt = 1 pt + 4 oz/A; and Bravo + Bayleton = 1 pt + 4 oz/A.

SUMMARY

Leaf diseases in orchardgrass were less severe in plots treated with Bravo. This supports previous results when this fungicide was applied to orchardgrass. Burning orchardgrass plots the previous year did not significantly change seed yield, nor did it reduce the severity of leaf spot diseases in the top three leaves on a tiller. It is concluded, based on these data, that propane burning has little effect on leafspot disease severity in the following crop year. Weather conditions (rainfall and temperature) during late April and May have a greater influence on leaf disease severity, an observation supported and reported in other studies.

STRIPE RUST OF ORCHARDGRASS

Ronald E. Welty

In spring and early summer, stripe rust in orchardgrass occurs sporadically and can be serious in certain fields in certain years. The disease was first reported in the Willamette Valley in 1984 and is being closely monitored. During the past five years, there have been no widespread epidemics of the disease. Based on what is known of stripe rust on other grass hosts, environmental factors have a greater influence on development of stripe rust than they do for either stem rust or crown rust.

Optimum temperatures for germination of urediospores (yellow-orange spores) of stripe rust were studied in England in the 1960's. Whereas the urediospores of most races of stripe rust from other hosts (e.g., wheat, Kentucky bluegrass) germinate best at 50-55 F, urediospores of stripe rust on orchardgrass germinate best at 70-75 F. Because of this temperature difference, stripe rust in orchardgrass generally occurs in warmer weather, whereas stripe rust in Kentucky bluegrass occurs in cooler weather. Once the fungus invades the plant, temperature also affects the length of time it takes for the fungus to produce pustules that rupture through the leaf surface.

Stripe rust overwinters on infected plants in fields where temperatures are not extreme. In spring, if conditions become favorable for infection, secondary spread can be aggressive. However, in most years (in the spring), stripe rust does not develop into an epidemic; many growers never see the disease. Often infected plants are scattered in a field, and the crop is harvested before inoculum increases to a level to cause much damage. There are exceptions, however, and the disease may be serious in low areas in a field or poorly drained sites.

In September 1989, weather conditions (primarily rainfall and high temperatures in mid-August) favored development of stripe rust in orchardgrass. The disease was widespread and uniform in many fields. Pustules were narrow, yellow, linear stripes, mainly on leaves and spikelets. If seed heads were present, pustules were also found on stems, secondary branches, glumes, and lemmas. An optimum time to evaluate cultivars for disease resistance is in the middle of an epidemic.

MATERIALS AND METHODS

On September 7, 1989, 10 cultivars of orchardgrass at Hyslop Field Laboratory (planted in 1984) (Table 1) were rated for stripe rust resistance. Ten clusters of leaves (10-15 leaves per cluster) were removed from each cultivar, and the most severely rusted leaves in each cluster were scored by a Modified Cobb Scale for rating rusts: 0-5% = highly resistant; 5-10% = resistant; 10-25% = moderately resistant; 25-40% = moderately susceptible; 40-65% = susceptible; 65-99% = highly susceptible. Scores were averaged for each cultivar, and results were statisticallly analyzed. The study contained eight replications of each cultivar.

RESULTS

Stripe rust severity in these cultivars ranged from 15% to 83% (Table 1). Of the cultivars, Cambria was the most resistant and Latar the most susceptible to stripe rust. Average stripe rust scores among cultivars were statistically different (F value = 10.99; P = <0.01; LSD 0.05 = 17.4%; LSD 0.01 = 23.1%).

Table 1. Average stripe rust scores of 10 cultivars of orchardgrass, September 1989, Hyslop Field Laboratory, Corvallis, Oregon.

Orchardgrass cultivar	Stripe rust rating %
Cambria	15
Potomac	34
Hallmark	34
Pennlate	37
Aonami	48
Able	58
Sterling	58
Juno	63
Frontier	63
Latar	83
LSD 0.05	17.4
LSD 0.01	23.1

SUMMARY

Cultivars rated as highly susceptible to stripe rust should be examined carefully beginning in early May and continuing to harvest. If stripe rust is found, the level of resistance of a cultivar and an "estimated days-to-harvest" may help decide whether to apply fungicides. In most situations, growers can consider none, one, or two applications of Tilt or Bayleton, according to labeled instructions, depending on disease severity. Limited benefits will be obtained from applications made at flowering or after plants flower.

A relationship between the amount of rust inoculum in the fall and severity of rust in the following growing season has not been found. Based on this information, fall applications of fungicides to reduce rust inoculum is unlikely to provide protection for the next year's crop. Inoculum that has overwintered and weather conditions during the growing season have the greatest influence on development of a rust epidemic.

Orchardgrass is an open-pollinated species, and a cultivar is a combination of several clones. Resistance is based on the number or frequency of resistant genes in a plant, number of resistant plants in a cultivar, and the number of virulence genes in a culture of rust (i.e., race). As cultivars change or as new cultivars are developed (i.e., clones combined and recombined in a population of plants), races of stripe rust may be selected by clones within a cultivar, and a new or different race may become the dominant strain present. Because of this, a rust rating for a cultivar could be expected to change, as with cereals, including wheat and barley, where pathogenic races of stripe rust are known to occur.

Stripe rust occurs in orchardgrass grown for seed in the Willamette Valley; however, the disease is not widespread and regular enough for meaningful field tests. It is, however, important to remain vigilant for a change or increase in disease severity.

DISTRIBUTION OF ERGOT, BLIND SEED, AND SEED GALL NEMATODE IN THE WILLAMETTE VALLEY

S.C. Alderman

During the summer of 1988 and 1989, a survey was initiated to determine the distribution and severity of the grass seed diseases ergot (*Claviceps purpurea*), blind seed (*Gloeotinia temulenta*), and seed gall nematode (*Anguina agrostis*) in the Willamette Valley. The grasses included were bentgrass (*Agrostis tenuis* Sibth. 'Highland'), Kentucky bluegrass (*Poa pratensis* L.), chewings fescue (*Festuca rubra* subsp. *commutata* Gaud.), tall fescue (*Festuca arundinaceae* Schreb.), annual ryegrass (*Lolium multiflorum* Lam.), perennial ryegrass (*L. perenne* L.), and orchardgrass (*Dactylis glomerata* L.). A total of 492 fields were examined in 1988 and 477 in 1989. Summaries for 1989 are preliminary since a few remaining samples have not yet been processed.

Ergot was detected in all grasses except orchardgrass. The percentages of fields infested with ergot in 1988 were 52% in Kentucky bluegrass; 13% in bentgrass; and 1-3% in tall fescue, perennial ryegrass, and annual ryegrass. In 1989 percentages of fields with ergot were 6% in Kentucky bluegrass; 13% in bentgrass; 8% in chewings fescue; and 1% in tall fescue. A survey of weed grasses in 1988 and 1989 indicated that ergot was widespread throughout the Willamette Valley and that tall fescue, annual ryegrass, and quackgrass (*Agropyron repens* (L>) Beauv.) were the most common weed grasses infested with ergot.

In 1988 blind seed was detected in 26-30% of the tall fescue, annual ryegrass and perennial ryegrass fields; and in 3% of the Kentucky bluegrass fields. In 1989 blind seed was detected in 8-12% of tall fescue, annual and perennial ryegrass fields, and in 3% of Kentucky bluegrass fields. In both years severity of blind seed was less than 0.3% infected seed. A survey of blind seed in annual ryegrass growing as a weed grass, outside of production fields, was conducted in 1989. Annual ryegrass was found at 47 out of 103 randomly selected sites within the valley and blind seed was detected at 4 sites, widely distributed in the lower two thirds of the valley.

The seed gall nematode was found in 9% of bentgrass fields in 1988 and 5% of bentgrass fields in 1989. The nematode was not detected in other grasses.

Previous surveys for blind seed in the Willamette Valley indicated that trace levels of disease were present between 1960 and 1979. In the present survey trace levels were also detected. However, low levels of disease were detected in about 30% of the fields of tall fescue and perennial and annual ryegrass. The large number of fescue and ryegrass fields infected suggest that under favorable environmental conditions for disease and in the absence of control measures, a general epidemic may be possible. Although it is not quantitatively known how current disease levels are influenced by environmental conditions, higher disease levels would be expected if rainy, wet weather occurs during flowering. In addition, it is also not understood how changes in cultivars or production practices might influence disease levels.

EFFECT OF FIELD BURNING ON VIABILITY OF ERGOT AND SEED GALL NEMATODE

S.C. Alderman and W.C. Young, III

During September of 1989 the effect of open or propane field burning on viability of ergot (*Claviceps purpurea*) or seed gall nematode (*Anguina agrostis*) was examined. Ergot sclerotia were removed from an infested seed lot of Kentucky bluegrass and seed galls were removed from seed heads collected from an infested bentgrass field.

Sclerotia or galls were placed between two layers of 38 mesh stainless steel screening (20 sclerotia or 10 galls per screen). The edges were crimped to contain the propagules. Four screened packets were uniformly distributed in each of four plots of the open burn treatment and in each of four plots of the propane treatment. Open burn plots were ignited after distributing baled straw uniformly over perennial ryegrass stubble in an amount equivalent to 2.0 tons/a. A propane burner, operating at 3 mph and 25 psi, was used to burn back stubble and regrowth in the propane treatment. A control set of sclerotia or seed galls was placed in field plots which were not burned.

Following treatment, seed galls were removed from the screens, broken open, placed in 2 ml of water, and incubated at 5 C overnight. Viable nematodes were counted using a dissecting microscope. Ergot sclerotia were placed on moistened perlite and incubated at 5 C. After 12 weeks of conditioning, each sclerotium was examined. Sclerotia bearing apothecial stalks were considered viable.

Nematodes per 40 galls were reduced 99 and 98% in the open and propane treatments, respectively, relative to control levels. Germination of ergot sclerotia was 64% in the control treatment. No sclerotia germinated in the open or propane burned treatments.

AGRONOMIC STUDIES ON TURF-TYPE TALL FESCUE VARIETIES

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

Investigation continued during the 1988-89 crop year to determine the effect of various management practices on seed yield of turf-type tall fescue. Four varieties of tall fescue (Falcon, Rebel, Bonanza turf-types and Fawn forage type) were seeded in August 1985 for a long-term study investigation row spacing, time and rate of spring nitrogen fertilizer, and post-harvest residue management. The 1989 harvest was the fouth year of seed yield data collected from these trials.

Each variety was seeded separately in 200-ft x 150-ft blocks planted in alternating strips 24-ft x 150-ft at either 12-inch or 24-inch inter-row spacing. Intra-row density was held constant in both 12-inch and 24-inch plantings by using a seeding rate of 7.0 lb/a and 3.5 lb/a, respectively. Plots were fertilized in the spring at either vegetative development, reproductive development or split equally between the two growth stages with urea applied rates equivalent to 90, 130 or 170 lb N/a. Actual calendar dates for spring N application have been mid-February (vegetative growth stage) and late-March (early reproductive growth stage).

At crop maturity (optimum seed moisture content for swathing) a 3.25 x 16 ft section of each plot was harvested using a small plot harvester incorporating a sickle bar cutter and draper designed for efficient bagging of plant biomass. The bagged material was air-dried, threshed, cleaned and weighed to determine seed yield. Since harvest of the first year seed crop, half of the plots have been burned two times with a propane flamer to simulate open field burning. Straw was removed from unburned plots with a flail chopper, leaving 3 to 4 inches of stubble, to simulate baling of post-harvest residue. All plots have received annual applications of 16-20-0 fertilizer in mid-October, and 3.0 lb/a Karmex herbicide in November.

Tall fescue seed yields reported by growers varied widely in 1989, but were generally lower than in the previous year. Information on tall fescue production made available from the OSU Economic Information Office showed a state-wide average reduction in seed yield (lb/a) of 7% (1988 vs. 1989). However, in the South Willamette Valley (Benton, Lane and Linn counties) a 15% reduction was reported. Simalarly, average seed yield data observed in our research plots (Hyslop Crop Science Field Laboratory, Benton county) were 20% less in 1989 when compared to 1988.

Seed yield data for the main treatment effects in 1989 are shown in Table 1. As noted in previous years, many significant interactions make the interpretation of these data less straight forward than the simple single-factor approach presented in this table. Recall that interaction occurs when main factors do not act independently of each other; thus, changing the level of one factor does not produce the same effect at all levels of another factor. In addition, not all varieties respond the same to every treatment, and, being perennial crops, it is likely that growth may be influenced over time by the various treatments they have recieved; thus, older crops may respond differently to the same treatment when measured over time.

Data shown in Table 2 are the average seed yields of each main factor through four seed harvests (1986-89). Note that burning residue after harvest has resulted in greater seed yield for all varieties. Also, very little variation in seed yield has occurred due to row spacing or time of spring N application. Finally, high rates of spring N have not increase seed yield, indicating that rates between 90-130 lb N/a may be adequate.

Table 3 presents a comparison of grand mean seed yield data from four seed harvests (1986-89) of four varieties of tall fescue. The grand mean is an average of all treatment combinations for a given variety in a specific year. Comparison of the grand means for each variety in 1986 and 1987 show that the second year seed crop, with the exception of Rebel, averaged 40% greater than the first year harvest seed harvest. Thus, when fall-establishment is used, maximum yield potential may not be achieved in the first crop year. Seed yield in 1988 was about 82% of the 1987 crop, with both Bonanza and Rebel down about 25%, while Falcon and Fawn fell by 7 and 15%, respectively. In 1989 turf-type varieties (Falcon, Rebel, and Bonanza) averaged 26% lower seed yield than in 1988. Fawn, a forage variety, was only 3% lower in 1989 than the previous year.

The trends discussed above support the grower observations that seed yield of turf-type tall fescues decline during the third and fourth year of production when compared with forage varieties. However, the intent of this report is not to judge the benefit of one management practice over another, but to only highlight the general direction of seed yield data. The final seed harvest will be taken in 1990.

Table 1. Effects of residue management, row spacing, and time and rate of spring nitrogen application on seed yield of four varieties of tall fescue, 1989.

Treatment	Seed yield (lb/a)			
	Bonanza	Rebel	Falcon	Fawn
Residue Management				
Burn	1292	864	1240	1403
Flail chop	1127	585	923	1224
LSD .05	*	196	*	*
Row Spacing (inch)				
12	1189	718	1085	1286
24	1230	731	1078	1342
LSD .05	*	NS	*	*
Nitrogen Time				
Vegetative	1148	712	1097	1297
Split (50/50)	1245	740	1082	1328
Reproductive	1235	722	1065	1318
LSD .05	*	*	NS	NS
Rate of N (lb/a)				
90	1092	686	1029	1441
130	1260	732	1126	1358
170	1277	755	1088	1143
LSD .05	49	*	*	104
Grand mean	1210	725	1081	1314

*Interaction with other treatments significant at the $P<0.05$ level.

Table 2. Average seed yield through four seed harvests (1986-89) of four varieties of tall fescue as effected by residue management, row spacing, and time and rate of spring nitrogen application.

Treatment	Seed yield (lb/a)			
	Bonanza	Rebel	Falcon	Fawn
Residue Management[1]				
Burn	1646	1143	1596	1513
Flail chop	1500	874	1317	1337
Row Spacing (inch)				
12	1537	1070	1472	1341
24	1518	1104	1323	1370
Nitrogen Time				
Vegetative	1521	1101	1427	1349
Split (50/50)	1560	1128	1394	1373
Reproductive	1501	1033	1370	1346
Rate of N (lb/a)				
90	1478	1142	1430	1549
130	1590	1091	1376	1343
170	1515	1029	1385	1177
Grand mean	1537	1071	1409	1370

[1] Residue management data are the average of three seed harvests (1987-89).

Table 3. Comparison of grand mean (average of all treatment combinations) seed yield data from four seed harvests (1986-89) of four varieties of tall fescue.

Year	Seed yield (lb/a)			
	Bonanza	Rebel	Falcon	Fawn
1986	1390	1324	1219	1148
1987	2021	1314	1706	1604
1988	1489	987	1582	1358
1989	1210	725	1081	1314

Acknowledgement: This research was supported by a grant from Oregon Tall Fescue Commission.

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

Straw removal by baling instead of burning causes alterations in many aspects of grass seed crop management. Various stubble management techniques are presently used where annual open field burning is not possible; however, current OSU Extension Fertilizer Guides are based on a system where the grass straw and stubble were burned. The ability to predict nutrient response for different species as stands age, over several post-harvest residue management systems is desired. This study, began in 1988, is a long-term investigation of the interaction between post-harvest residue management and nitrogen (N) fertilization on perennial ryegrass and tall fescue.

The conversion from burning to non-burn management of grass seed fields has potential advantages and disadvantages for fertility management of grass seed fields. A non-burning system could reduce N volatilization loss but residual straw and stubble in the field may reduce N fertilizer efficiency due to N immobilization. Immobilization of N is a result of the utilization of ammonium and nitrate by soil microbes during stubble decomposition. Thus, the addition of low nitrogen crop residue can result in a marked depression of N uptake by the plant and a consequent decrease in crop yield. Production systems resulting in the inclusion of increased crop residue may require additional N fertilizer.

Two locations for both perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*) were selected for study in fields established by Willamette Valley seed growers in the 1987.

Post-harvest residue management treatments were made following harvest of the first seed crop in 1988. Straw residue was baled during mid-August at all four locations and straw weight estimates (ton/acre) were recorded. Straw was then returned in an equal weight to main plots receiving an open-field burn treatment. In addition, four other stubble management treatments have been 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) Annual open-field 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

Open-field burn, propane burn, and flail chop treatments were completed between the last week of August and the first week of September. However, because only 0.87 inch of rain was recorded during September-October 1988 (second driest ever), Enquik application was delayed until mid- to late-November due to the limited sprout of volunteer seedlings. Enquik was applied at a rate of 15 gallons per acre, with an equal volume of water, plus 0.250% 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.

Single-spring N applications were applied in early-April 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.

At crop maturity (optimum seed moisture content for swathing) a 3.25 x 20 ft. section of each plot was harvested using a small plot harvester incorporating a sickle bar cutter and draper designed for efficient bagging of plant biomass. The bagged material was air-dried, threshed, cleaned and weighed to determine seed yield.

Visual observations of the main plots in the late-November provided evidence as to effectiveness of open-field burning on volunteer seedling control. Only shattered seed protected in cracks in the soil 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." In early-December standard soil-active herbicides were applied to all plots.

Enquik was applied to both propane burned and flail chopped plots, and initially resulted in visibly better seedling control. In general, seedling control appeared less effective in the flail chopped treatments due to the greater number of volunteer seedlings that emerge from the crop residue remaining on the soil surface. Where there is little or no residue, few seedlings are able to become established. However, by late-winter there was no visible difference in seedling density between the Enquik and the non-Enquik treated plots, regardless of whether propane burn or flail chop post-harvest management was used. In addition, Enquik appeared to have more affect on established plants of tall fescue than perennial ryegrass. This effect was still noticeable at the Martin tall fescue site in late-spring.

Post-harvest residue management had no significant effect on seed yield of perennial ryegrass (Table 1). Seed yield data for the variety Regal was very consistent across all treatments, however, the variety Pleasure showed some treatment variation.

Seed yield of both varieties of tall fescue was significantly affected by residue management treatment (Table 1). Martin tall fescue seed yield was greatest when stubble was flail chopped following baling. There was no significant difference between open burn and propane burn treatments. However, seed yield of both propane burn and flail chop treatments was reduced when followed with an application of Enquik.

Table 1. Effect of residue management and rate of spring nitrogen application on seed yield of two varieties of perennial ryegrass and two varieties of tall fescue, 1989.

Treatment: Residue x Nitrogen	Perennial ryegrass		Tall fescue	
	Regal	Pleasure	Martin	Rebel II
	(lb/a)			
Residue Management				
Open burn	1161	1431	1072	726
Propane burn	1214	1532	1108	1208
Flail chop	1175	1429	1200	1078
Propane burn + Enquik	1145	1401	861	920
Flail chop + Enquik	1146	1263	1010	879
LSD 0.05	NS	NS	98	185
Spring Rate (lb/a)				
60	1173	1350	1083	980
100	1167	1365	1035	953
140	1163	1519	1033	954
LSD 0.05	NS	NS[1]	NS	NS

[1]P-value: 0.09

The open-field burn treatment on the tall fescue variety Rebel II was adversely affected by a significant reduction in stand. An exceptionally high straw dry weight (6.0 ton/a) and dry conditions prior to burning likely contributed to this result. There was no significant difference in seed yield between propane burn treatment and flail chop treatments. And, as at the Martin tall fescue site, Enquik reduced seed yield of both treatments when compared with untreated plots.

Seed yield of tall fescue was not affected by rate of spring N application for either variety. In perennial ryegrass a trend was seen for a higher yield response where 140 lb N/a was applied to the variety Pleasure; no affect was observed on Regal perennial ryegrass. In addition, the residue management x spring N interaction was not significant at any location, suggesting that unburned grass seed fields may not require additional N fertilizer to maintain seed yield. This conclusion is from one treatment year. Conclusions may change with time.

Acknowledgements: This research was initiated by a grant from the State of Oregon Department of Environmental Quality, and has been continued with the support of the Oregon Ryegrass Growers Seed Commission and the Oregon Tall Fescue Commission.

NITROGEN AND SULFUR UPTAKE FOR COOL SEASON FORAGE AND TURF GRASS GROWN FOR SEED

J.M. Hart, D. Horneck, D. Peek, and W.C. Young III

Forage and turf grasses have been grown for seed in the Willamette Valley for several decades. Open field burning was the standard management practice for field sanitation and straw removal. Fertilizer recommendations for burned fields were generated from field experiments and experience. Air quality regulations curtailing burning created the need for alternate methods of field sanitation and straw disposal. Growers began to bale and remove straw. Questions about rate and timing of fertilization accompanied the change in straw removal method. Characteristics of nutrient and dry matter accumulation would be helpful for an initial assessment of fertilizer timing.

The objective of this project was to determine dry matter and nutrient uptake for cool season forage and turf grasses grown for seed. Several varieties from five perennial grass species were selected in an established variety seed yield trial and sampled throughout the growing season. Varieties selected were: Linn and Pennfine perennial ryegrass (*Lolium perenne*); Fawn and Rebel tall fescue (*Festuca arundinacea*); Newport bluegrass (*Poa pratensis*); Potomac orchardgrass (*Dactylis glomerata*); and Pennlawn fine fescue (*Festuca ruba*).

Nutrient uptake is a function of dry matter and nutrient concentration in the plant. Comparisons of cultivars producing a wide range of dry matter produced variation in nutrient uptake. Comparison between cultivars would be difficult without a standard basis. So that dry matter comparisons to nutrient uptake and comparisons among cultivars would be possible, the data for dry matter and nutrient accumulation were normalized. Uptake for the last sampling date was considered 100% of the total amount. Earlier sampling dates were a proportion of the last sampling date. These data, expressed as percent, are plotted on the Y axis of Figure 1. The shape of the normalized dry matter accumulation curve was similar for all cultivars. Average dry matter values are used for comparisons with nutrient accumulation.

To make these data useful from year to year or area to area, a method comparing plant growth seasonally in various locals was needed. Calendar date is not the best indicator of plant growth or a basis for comparison. Some grasses such as corn and wheat are defined by growth stages. No growth stages are defined for grass grown for seed. Growth degree days, or heat units, were used to describe growth of the grass plant. The basis for the heat units was 32^{O}F and the accumulated growth degree days, or heat units, were plotted on the X axis of Figure 1.

N accumulation for cultivars was similar. The single line for accumulation plotted in Figure 1 is an average showing N accumulation accelerated compared to dry matter, early in the season. N accumulated at the same rate as dry matter from mid to late growth of the grass.

The greatest difference between dry matter and N accumulation occurred when 550 to 600 heat units accumulated. The calendar occurrence for this in the Willamette Valley is late March to Early April. The grasses produced 20% of the total dry matter and have accumulated approximately 35 % of the total N. This accelerated N uptake requires adequate soil N prior to the N accumulation by the grass plant. A portion or all of the spring fertilizer N should be applied prior to this time.

Timing of N application is important for grass grown for seed but not critical as in wheat production. When wheat has produced 20% of the total dry matter, 70% of the total N is in the aerial portion of the plant making early N supply critical.

In contrast to N, the average S accumulation is markedly advanced compared to dry matter (Figure 1). All cultivars averaged 80% S accumulation by the time 45% of the dry matter was produced. Earlier in the growing season, 50% of the S had been accumulated when 20% of the dry matter was produced. The amount of S uptake is not large, between 10 and 25 lb S/a. The important fact is that the majority of cultivars accumulated S at an accelerated rate compared to dry matter and nitrogen. Growers and fertilizer dealers should ensure adequate S is supplied by the soil or through early season fertilization.

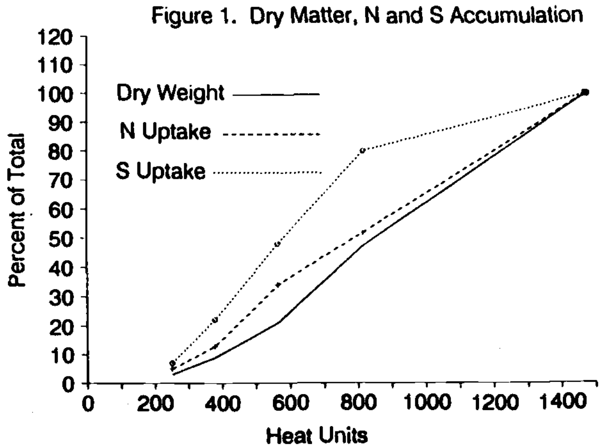


Figure 1 Comparison of dry matter, N and S accumulation in cool season grasses grown for seed. Normalized values for all varieties are averaged in this comparison.

RESPONSE OF TALL FESCUE TO THE PLANT GROWTH RETARDANT CERONE

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

Cerone is foliar applied slow ethylene-releasing plant growth retardant that is used to reduce lodging in barley and wheat. The primary growth retardant 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.

Grower interest in lodging control on grasses grown for seed encouraged us to establish research plots in 1988 to test the effect of Cerone on tall fescue grown for seed under Oregon conditions. Additional trials were established in 1989 by Rhone-Poulenc Ag Company to further evaluate the potential of their product in tall fescue seed production. Results from the two trials are presented below.

1988

Cerone was applied to an established stand of "Bonanza" turf-type tall fescue at the Hyslop Crop Science Farm on May 12, 1988, when the panicle-inflorescence was still in the boot stage. Three rates of Cerone (0.25, 0.50 and 0.75 lb a.i./a) and an untreated control plot were arranged in a randomized complete block. Treatments were replicated three times. All fertilizer and herbicides were applied according to standard production practices.

One-foot row samples were taken just after peak anthesis to evaluate treatment effects on tiller growth and yield components. These data showed no significant difference in spikelets per spike, mean number of florets per spikelet, or fertile tiller number at peak anthesis. In addition, no significant difference was observed for the length of individual internodes, panicle length, or the combined total length.

No visual indication of altered maturity due to treatment was observed and plots were harvested July 8, 1988, at 38.5% seed moisture (determined from samples taken in untreated border plots). Most of the above ground plant biomass was cut and bagged using a small plot harvester. The bagged material was air-dried, threshed, cleaned and weighed for seed yield estimates.

Total dry weight at harvest and individual seed weight was not significantly affected, however, seed yield was increased over the check plot at all rates of Cerone (Table 1). An explanation for the increased seed yield is unclear as there was no difference in the potential number of seeds on a unit area basis, or in the percent floret site utilization. The check plots produced the lowest yield in all three replicates. Coefficient of variation (C.V.) was 6.2%.

Table 1. Response of dry weight, seed yield, and 1000 seed weight to varying Cerone application rates on Bonanza tall fescue, 1988.

Cerone application rate	Plot dry weight	Seed yield	1000 seed weight
(lb a.i./a)	(ton/a)	(lb/a)	(g)
check	3.6	1278	1.98
0.25	4.5	1845	1.99
0.50	4.5	1882	1.99
0.75	3.7	1799	2.06
LSD 0.05	NS	210	NS

1989

Cerone plots were established in a commercial production field of "Clemfine" forage-type tall fescue approximately 4 miles south of Albany, Oregon. Applications were made on April 24, April 27, and May 1, 1989 (early, medium and late dates, respectively) at rates between 0.6 and 1.6 lb a.i./a. The "early" treatment was made after the flag leaf was visible, but before it had fully emerged; "medium" treatment date was coincident with boot-stage; and "late" treatment was when about 20% of the panicles were starting to emerge. All treatments plus an untreated control plot were arranged in a randomized complete block design with four replications. All fertilizer and herbicides were applied according to standard production practices.

Yield component data and seed yield estimates were collected as discussed above. These data showed no significant difference in spikelets per spike, mean number of florets per spikelet, or fertile tiller number at peak anthesis. In addition, replicated seed moisture samples were taken from all plots to assess maturity on June 27 and June 30, 1989. No significant difference in seed moisture (maturity) was observed. All plots were harvested on June 30. No significant differences in seed yield resulted from Cerone treatments in 1989.

Table 2. Effect of date and rate of Cerone application on seed moisture content and seed yield in Clemfine tall fescue, 1989.

Treatment Date			Seed Moisture		Seed
4/24	4/27	5/1	6/27	6/30	Yield
(lb ai/a)			------- (%) -------		(lb/a)
--	check	--	50.43	40.10	1555
0.6	0.6	--	53.30	45.15	1432
0.6	--	--	56.25	46.93	1670
1.6	--	--	52.85	44.75	1478
--	0.6	--	51.90	47.15	1420
--	1.2	--	52.75	42.72	1518
--	--	0.6	49.70	46.95	1540
--	--	1.2	52.63	45.05	1571
			NS[1]	NS	NS

[1]P-level 0.06

Results from these trials do not provide conclusive evidence of a consistent benefit from Cerone application on tall fescue. Although the result of treatment varied between the two years, severe lodging was not a problem in either 1988 or 1989. Further study will be required to determine the exact nature of the product's effect on grasses grown for seed.

Cerone received a federal registration for use in "Grass Seed Production" from EPA in December 1989. Labeled rates are 0.5 to 1.0 lb a.i./a, applied between late boot to 50% panicle emergence, for reduced lodging. Label restrictions include: no grazing treated fields, and no feeding of seed screenings.

Acknowledgement: This research was partially supported by a grant from Rhone-Poulenc Ag Company.

OREGON FORAGE AND TURF GRASS VARIETY SEED YIELD, 1989

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

A fee-supported seed yield evaluation has been conducted at Oregon State University since 1981. In the most recent planting, 41 perennial varieties and 6 annual ryegrass varieties were planted in May 1987, and September 1988, respectively, at the Hyslop Crop Field Laboratory. Selected data from all varieties harvested in 1989 are shown in Table 1. A complete report of results, including management practices, is available on request from the authors.

Author's note: Due to staff and budget reductions the regular scheduled planting of perennial grass species was not established during the spring of 1989. Continuation of this program in later years will depend upon interest and financial resources.

Table 1. Seed yield and maturity estimates of annual ryegrass, perennial ryegrass, bluegrass, orchardgrass, tall fescue, and fine fescue, 1989.

Species and variety	Seed yield	Heading date	Anthesis date	Harvest date
	(lb/a)			
Annual ryegrass				
Marshall (Std.)	1877	5/17	6/02	7/01
Mississippi	1510	5/10	5/28	7/01
Bartolini	934	5/16	5/31	7/01
Bartissimo	566	5/15	5/31	7/01
BAR LM 4990	542	5/21	5/31	7/01
BAR LM 411	354	5/15	5/26	7/01
Mean	964	5/16	5/30	7/01
LSD 0.05	281	--	--	--
Perennial ryegrass				
Chief	1298	5/04	5/22	7/01
Linn (Std.)	1251	5/04	5/20	7/01
Sheriff	1083	5/13	6/02	7/01
Bargold	1046	5/26	6/11	7/18
BAR DK 4GEL	878	5/23	6/02	7/01
BAR ER 6K	706	6/01	6/12	7/18
Opinion	651	5/31	6/11	7/18
Boston	635	6/01	6/12	7/18
Barcolte	586	5/26	6/07	7/01
Bar LP 82-LO	470	6/06	6/12	7/27
Barcredo	273	5/31	6/12	7/27
Mean	807	5/24	6/06	7/12
LSD 0.05	201	--	--	--
Bluegrass				
BAR VB 534	1308	5/04	5/08	7/05
BAR VB 577	1140	5/04	5/12	7/05
Caroline	1025	5/04	5/10	7/05
Miranda	889	5/10	5/15	7/05
BAR VB 7251	857	5/01	5/15	7/05
Lucia	656	5/09	5/10	7/05
Newport (Std.)	544	5/04	5/12	7/05
BAR LP 6611	471	5/15	5/22	7/05
BAR VB 7034	427	5/05	5/22	7/05
Mean	813	5/06	5/14	7/05
LSD 0.05	326	--	--	--

Species and variety	Seed yield	Heading date	Anthesis date	Harvest date
	(lb/a)			
Orchardgrass				
Hallmark	1743	4/25	5/10	6/21
Syn 8501	1695	4/25	5/10	6/21
Paiute	1679	4/25	5/10	6/21
Potomac (Std.)	1562	4/25	5/11	6/21
BAR DGL 71	1077	5/15	5/31	7/01
DS-7	1044	5/15	5/30	7/01
Mean	1460	5/02	5/17	6/24
LSD 0.05	227	--	--	--
Tall Fescue				
BAR FA 7851	1857	5/04	5/28	7/01
Fawn (Std.)	1470	4/21	5/12	6/21
Barcel	1393	5/04	5/30	7/01
Syn W	1328	4/27	5/27	6/21
Trbl	1140	5/04	5/30	7/01
Mean	1437	4/30	5/25	6/27
LSD 0.05	262	--	--	--
Fine Fescue				
Hector	1460	4/21	5/10	6/23
Victor	1294	4/19	5/08	6/23
Flemo	1183	4/19	5/08	6/23
Molinda	936	4/21	5/12	6/23
Camaro	867	4/25	5/12	6/23
Barnica	738	4/29	5/12	6/23
Koket	719	4/25	5/12	6/23
Pennlawn (Std.)	631	5/01	5/26	6/23
Baruba	553	4/29	5/12	6/23
Barcrown	435	5/10	5/26	6/27
Mean	882	4/26	5/13	5/23
LSD 0.05	183	--	--	--

TESTING LEGUME SEEDS FOR MOISTURE CONTENT

D.F. Grabe and C. Garbacik

Moisture content is intimately associated with all aspects of physiological seed quality. Moisture is related to seed maturity; seed shattering and optimum harvest time; longevity in storage; economies in artificial drying; injuries due to heat, frost, fumigation, insects and pathogens; mechanical damage; and seed weight. Therefore, appropriate moisture testing procedures are needed for marketing, quality control, and research.

There is no single method of seed moisture determination that is satisfactory for all situations. The optimum method will depend on the chemical composition and structure of the seed, level of moisture content, degree of accuracy and precision required, and constraints of time, technical expertise, and cost.

Because of these considerations, three general types of moisture tests are required: (a) an oven method for general laboratory use where a high level of accuracy is required, (b) a less accurate practical method for field use, and (c) a basic reference method for calibrating the first two methods.

Incredibly, there are no standard methods for seed moisture testing in the United States. Different laboratories use different test conditions when using the common oven drying method. These conditions range from drying the seed 24 hours at 100°C to drying for 1 hour at 130°C. Although drying to constant weight is often thought to establish the amount of moisture present in the seed, drying to constant weight at different temperatures unfortunately gives different apparent moisture contents. To compound the problem, electric moisture meters used in the seed trade are calibrated against these variable oven methods. Discrepancies in moisture tests go undetected because it is not common for different laboratories to conduct moisture tests on the same seed lot.

The International Rules for Seed Testing contain recommendations for oven moisture testing methods for a number of seed crops and these procedures are followed by many countries. It is now recognized, however, that the ISTA methods produce incorrect results for many crops because they were not developed in conjunction with basic reference methods.

Emphasis this year was placed on development of accurate oven methods for moisture testing of small-seeded legumes. The ISTA moisture testing method for small-seeded legumes is to dry intact seed 1 hour at 130°C. However, it was questioned whether all the moisture is removed by this method. The Karl Fischer titration method was used as a standard reference method for calibrating oven methods to give accurate results. The moisture-extraction procedure developed consisted of grinding the seed in a Wiley Mill through a 20-mesh screen, and extracting 1 gram of the ground seed in 50 mL methanol for 24 hours. An aliquot was used for titration in the Karl Fischer apparatus.

Oven tests were then conducted with several samples of each species at 103°C, 110°C, and 130°C for various time periods and compared with Karl Fischer results. Drying temperatures of 103°C and 110°C did not remove all the moisture during the 16-hour test period. Drying periods at 130° C that provide moisture contents equivalent to the Karl Fischer reference method are indicated in Table 1.

Table 1. Recommended drying periods at 130°C for testing moisture content of small-seeded legumes.

Species	Drying period
	h
Red clover	5
White clover	5
Crimson clover	4
Sub clover	12
Alfalfa	5

Moisture loss from ground seed occurs faster than in intact seeds, suggesting that hard seed coats may prevent moisture loss from these seeds. Grinding shortened the drying periods for legume seeds to as little as 0.5 hour, but results were somewhat erratic, possibly due to changes in moisture content during grinding and handling. As of now, it appears that moisture testing of small-seeded legumes will be more reliable on whole seed than on ground seeds.

TOUGH AND PURSUIT FOR BROADLEAF WEED CONTROL IN CLOVER

Bill D. Brewster, Don L. Kloft, and John Leffel

Tough (pyridate) and Pursuit (imazethapyr) were evaluated in several trials in growers' fields and at the Hyslop research farm near Corvallis during the 1988-89 season. Both crop safety and broadleaf weed control were evaluated. Trials at several locations during the previous season indicated that these two herbicides were relatively safe on small-seeded legumes such as clover, alfalfa, and trefoil. Because dinoseb has been banned from agricultural use by the Environmental Protection Agency, no herbicide is registered for use in seedling clover that will control such composite-family weeds as mayweed chamomile (*Anthemis cotula*) or common groundsel (*Senecio vulgaris*). No herbicides that are effective on broadleaf weeds are registered in crimson clover at any growth stage.

Tough controls weeds through the foliage and has a very short soil life, so crop rotations will not be affected by its use. Pursuit acts through the foliage and the soil and remains active for several months, which is a concern for certain sensitive crops grown in rotation with clover. Neither herbicide alone will control all broadleaf weeds in a typical Willamette Valley clover field. Pursuit is effective on many weeds including those in the mustard family such as shepherdspurse (*Capsella bursa-pastoris*), but is weak on most weeds in the composite family.

Research to date has concentrated on developing rates and timings of application that are safe to the crop and effective on the weeds. Older plants, whether weeds or crops, tend to be more tolerant of these materials, so early application is necessary to obtain weed control, but the crop must be old enough to escape serious injury. In general, weed control was best in plots treated with both herbicides, depending on the weed spectrum at a given site. Seed yield also tended to be highest in plots treated with both herbicides, but only in those treatments where the two materials were applied in two separate timings. Tank-mix applications produced lower seed yields because the herbicide treatment was relatively ineffective since treatment had to be delayed to avoid crop injury.

CONTROL OF CLOVER APHID IN RED CLOVER SEED PRODUCTION

John Leffel, Glenn C. Fisher and Ken West

Six trials were conducted over a period of three years in commercial red clover (*Trifolium repens*) fields in the North Willamette Valley. Lorsban 4E at 1.0 and 0.5 lb ai/a and Metasystox-R at 0.5 lb ai/a were evaluated for clover aphid (*Nearctaphis bakeri*) control. Plot size varied from one-half acre to nearly three acres and was replicated from one to three times per trial. Individual growers applied the insecticides with their equipment at rates varying from 10 to 15 GPA at from 35 to 40 PSI. Applications were made from prebloom to about 10 percent bloom.

Treatments were evaluated at approximately one-week intervals post spray by collecting ten clover heads per plot and recording the numbers of live aphids. In 1987 both clover heads and the first three-leaf sheaths below the heads were inspected for aphids. Clover heads only were inspected in 1988 and 1989. However, in 1989 clover heads were placed in Berlese funnels within three hours of field collection and all aphids, thrips, nitidulid beetles and minute pirate bugs were recorded per ten heads.

Both insecticides generally provided satisfactory aphid control through three to four weeks post spray. Little impact was noticed on populations of nitidulid beetles, thrips, and minute pirate bugs (see 1989 data). Lygus populations were not monitored. Increase in seed yield compared with untreated control plots is shown in Table 1.

Table 1. Percent increase in seed yield over untreated check plots.

Treatment	1987[1]	1988[2]	1989[2]	Average[3]
Lorsban 1.0 lb ai/a	8	30	22	22.2
Lorsban 0.5 lb ai/a	16	21	22	20.0
MSR 0.5 lb ai/a	6	5	9	6.6

[1]Data from one location.
[2]Data averaged from two locations.
[3]Average at all locations in each year.

1989 Red Clover Insect Trials

In 1989 separate trials were conducted at the Tim Dierickx farm and the Mike Cropp farm. At both locations treatments were replicated three times (Table 2). However, the two fields had significantly different aphid populations and thus must be considered separately.

At the Dierickx location, MSR at 0.5 lb ai/a provided control equivalent to Lorsban rates through the fourth week (Figure 1). Lorsban provided significantly better control than MSR beginning four weeks post-treatment. Lorsban rates had significantly fewer aphids than the check throughout the evaluation. Evaluation was discontinued when clover foliage dried out and was no longer able to support aphids. At week four in the Dierickx field, the sampler got out of the check plot giving the rapid drop in aphids.

Mike Cropp's field had a much higher aphid population than Dierickx's (Figure 2). Lorsban at both rates provided highly significant reductions in aphid population levels at Dierickx's throughout the evaluations. MSR reduced aphid populations only slightly below the check after week four and was inferior to the Lorsban treatments.

The treatments appeared to have no effect on nitidulid adult numbers or on Lygus abundance at either site. Predators were present in greater numbers in check plots but this was due to the higher aphid numbers. Predators started giving good control at the Cropp's after week five, which is what we hoped would happen.

Both honey and bumble bee activities were observed, and counts made. The first aphid counts were made one week following pesticide application and bees were actively flying and working the blooms. There was no difference in bee activity observed in any of the treatments.

Table 2. Seed yield of red clover at two locations following treatment for control of clover aphids, 1989.

Treatment	Dierickx	Cropp
	------------(lb/a)--------	
Lorsban 1.0 lb ai/a	856	651
Lorsban 0.5 lb/ai/a	803	680
MSR 0.5 lb ai/a	748	592
Untreated check	744	505

THE EFFECT OF DATE OF PLANTING, ROW SPACING, AND SEEDING RATE ON SEED YIELD OF RED CLOVER (*TRIFOLIUM PRATENSE* L.)

William C. Young III and Eduardo M. Echeverria

The effect of various planting dates, row spacings and seeding rates on seed yield and seed yield components were studied for Kenland red clover. These studies were established at Hyslop Crop Science Farm near Corvallis, Oregon. Plots were seeded in the fall of 1987 and spring of 1988; data reported here are from the first year seed crop harvested in August 1988.

Results indicated that optimum seed yield under the growing conditions of this study was obtain by seeding between the end of August (645 lb/a) and the end of September (664 lb/a) for the fall planting (Table 1). Irrigation was applied after the first and second fall seeding dates; natural rainfall was sufficient for emergence on the rest of the plantings. Late fall and spring seeding produced lower yields. The highest seed yield for the spring planting was 233 lb/a, which was seeded on March 15 (Table 2). Late fall and spring plantings (October and May) resulted in lower plant number per unit area and a lesser number of reproductive stems than earlier seeding dates.

Both fall and spring date of planting studies were established at two seeding rates, 1.8 and 3.6 lb/a. Seeding rate had virtually no effect on seed yield or yield components (Tables 1 and 2).

In addition, a study was established on September 23, 1987, which evaluated five row spacings sown at two seeding rates. The effects of row spacing indicated that narrow rows (6, 12 and 18 in) tended to increase yield (Table 3). No significant interaction between row spacing and seeding rate was observed, although the lower seeding rate (1.8 lb/a) generally resulted in higher yields. There were highly significant differences in plant number at the different row spacing. An increase in plant density was associated with a negative effect upon inflorescences per unit area.

Differences in seed yield for both planting date and row spacing studies were attributed to the total production of inflorescences per unit area. A positive correlation between plant height and seed yield was observed; plant height decreased with delayed date of planting and increased row distance. Certain components of yield, such as florets per inflorescence, seeds per inflorescence, and percent of seed set, were not affected at the different planting dates and row spacing. Weight of 1000-seed decreased as planting date was delayed.

Table 1. Seed yield (lb/a) of Kenland red clover established at different fall planting dates and seeding rates. Row spacing: 12 inch.

Seeding Rate	Planting date					
(lb/a)	8/30	9/15	9/30	10/15	10/30	Mean
1.8	674	668	707	540	402	598
3.6	616	627	620	525	466	570
Mean	645	647	664	533	434	

Table 2. Seed yield (lb/a) of Kenland red clover established at different spring planting dates and seeding rates. Row spacing: 12 inch.

Seeding Rate	Planting date			
(lb/a)	3/15	4/1	4/15	Mean
1.8	252	156	121	177
3.6	212	156	102	157
Mean	233	156	112	

Table 3. Seed yield (lb/a) of Kenland red clover established at different row spacings and seeding rates. Date of planting: Sept. 23.

Seeding rate	Row spacing (in)					
(lb/a)	6	12	18	24	30	Mean
1.8	782	754	660	583	577	671
3.6	641	648	674	596	502	612
Mean	711	700	667	588	539	

Figure 1

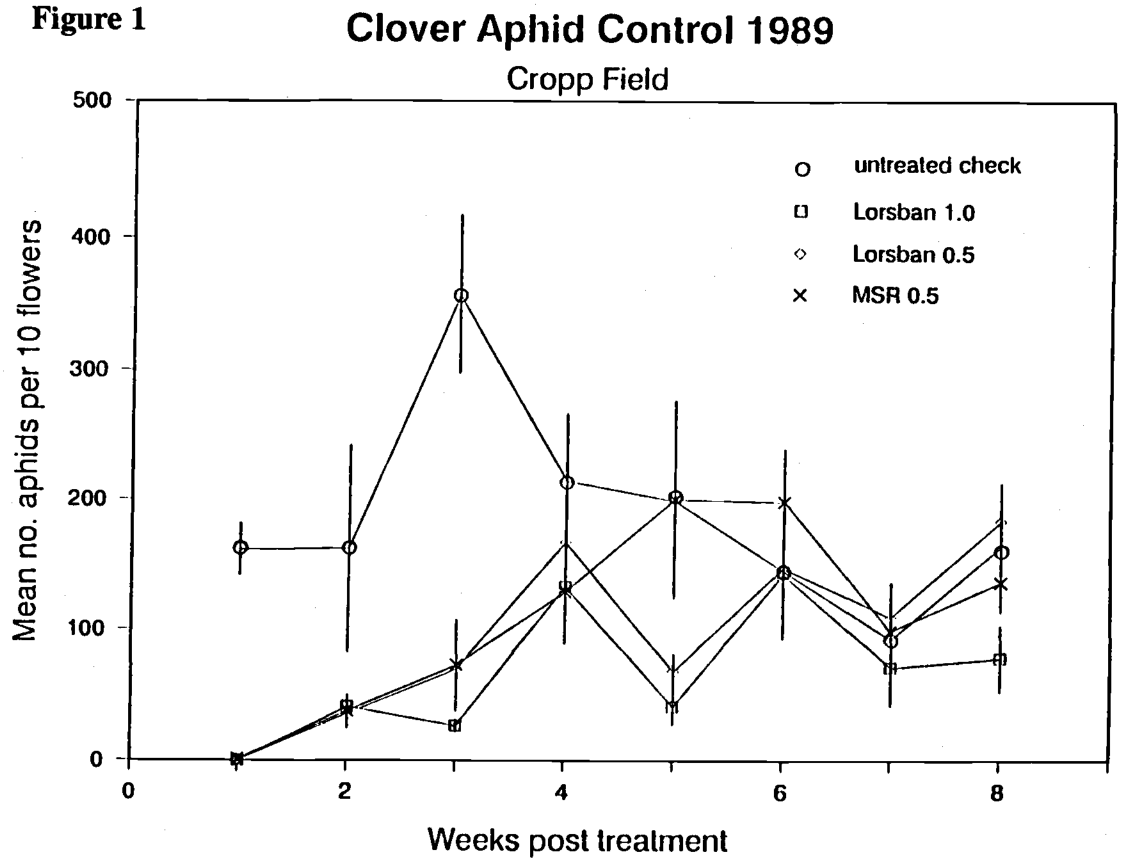
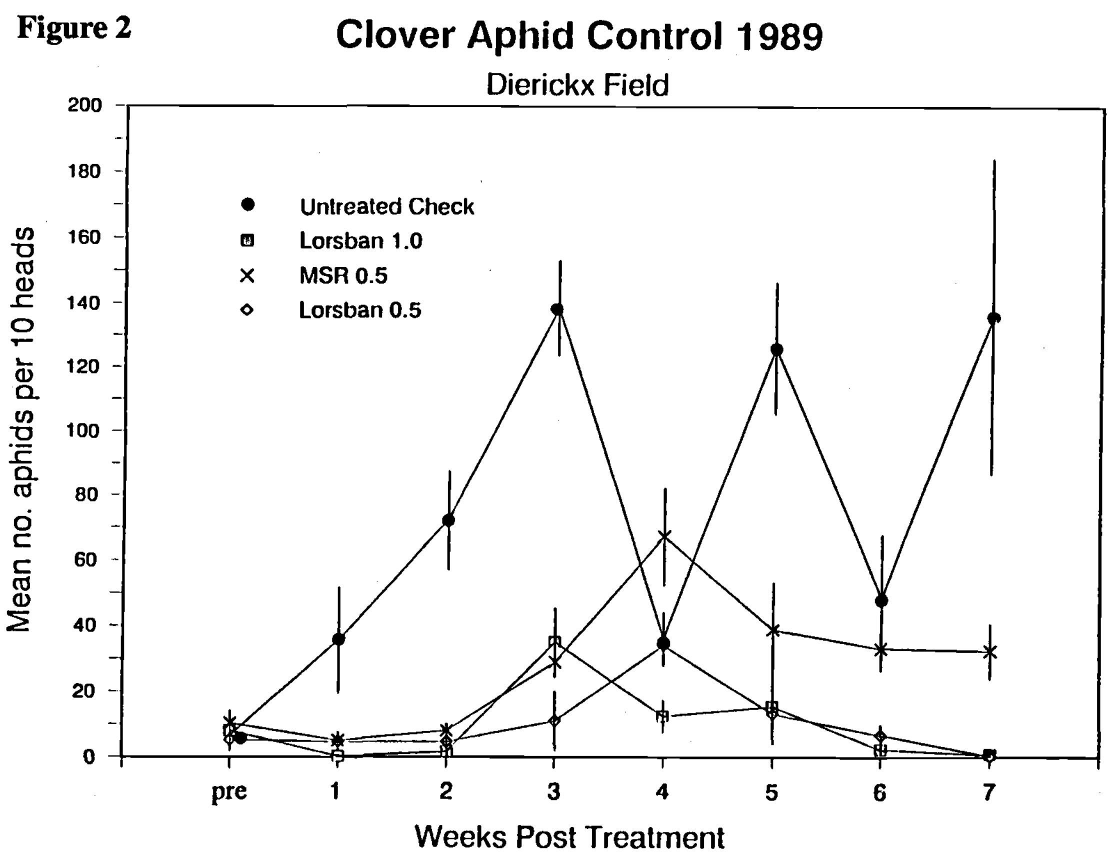


Figure 2



HARVEST METHODS STUDY IN MEADOWFOAM

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

Introduction

The conventional harvesting method used by meadowfoam growers is to use a swather to cut and windrow the crop for drying in the field and then combine using a pickup attachment. The harvesting method used in the experimental plots involved a "Carter" harvester, originally designed for harvesting forage plots. The "Carter" harvesting method requires that the meadowfoam crop remain in the field until most of the moisture in the plant has evaporated and then the entire plant is flailed into a burlap bag and hung in the open air to dry or dried in a forced air oven. The "Carter" method is very complete in that it literally sweeps the plot clean of all plant material. This method requires a laborious threshing technique because of all the plant material being handled. The "Carter" method is impractical for commercial growers.

Direct combine harvesting of meadowfoam has been tried on a limited basis by growers, but because of weed problems in the crop, swathing, drying in the field, and combining with a pickup attachment is the preferred method. Meadowfoam grower yields have been considerably lower than the reported experimental seed yields. Some preliminary studies have indicated that harvesting losses during the swathing and pickup operation may be a significant factor. In addition, losses during the combine threshing operation may be a factor.

The purpose of this trial was to identify a harvesting method that is practical for the growers and results in minimal harvest losses. To accomplish this task, it was first necessary to develop plot-size equipment that would duplicate the growers field-size equipment to use in experimental trials both on the experiment station and in growers fields.

A plot-size swather has been developed which very closely duplicates field-size equipment used by growers. An experimental plot combine (Wintersteiger) was fitted with a pickup attachment and accessory equipment to duplicate threshing by commercial machines. The same plot combine can also be used for the direct combining method. The results from the 1989 experimental trials on the experiment station are very encouraging and several trials on growers' fields are planted for the 1990 season.

Results and Discussion

Seed and oil yields and seed losses are shown in Table 1. The most surprising result in this trial is that direct combining yielded significantly higher in seed and oil yield than the swathing and combine-pickup method. Direct combining was significantly lower in seed and oil yield than the "Carter" method for the early and mid dates but not for the late (7/12) date. The 1000 seed weight and percent oil content were not significantly different for any harvest method in Mermaid or 83-545 and only slightly so in 85-765. This again confirms that maximum dry weight and oil content is reached at about 40% seed moisture content and is constant for all three lines or varieties.

Seed losses from each harvesting method were measured and percentages of total yield calculated (Table 1). Total yield is the harvest yield plus the seed loss determined from each operation in the harvest methods. For example, in the swathing and combine-pickup method, seeds on the ground after swathing are called "cutting loss". The additional seeds dropped by the pickup attachment is the "pickup loss" and the seeds that came through the combine during threshing is the "combine loss". Direct combining has cutting losses at the sickle at harvesting and combine loss through the threshing operation.

The swathing-pickup method averaged about 10% seed loss for each of the three harvesting operations. Direct combining averaged about 6.7% cutting loss and 16.1% combine loss. The late direct combine treatment (7/12) averaged 6.0% cutting loss and 12.6% combine loss over the three lines. The past year's experience shows that the moisture content of the stems, leaves, and seeds must be very low to successfully direct combine. With careful attention to harvesting conditions and threshing adjustments, the losses in the direct combine method could be reduced by half.

Modifications in both the swathing-pickup and direct combining methods are being made as a result of the past year's experience.

The data presented graphically in Figure 1 shows the effect of harvest method on oil yield. The results are similar for all three meadowfoam lines. The superiority of the 85-765 line is again apparent in this trial. With adjustments in equipment and timing for both the swathing and direct combining methods it should be possible to substantially reduce seed losses in future trials.

Table 1. 1988-89 Meadowfoam Harvest Methods Study -- Seed Loss

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)	42.2	10.5	11.1	11.0	32.5	23.1	9.3	8.3	42.4	13.1	12.7	10.1
Swathed - mid (6/23)	17.6	13.0	6.3	11.5	11.5	22.1	11.1	8.4	11.9	21.6	5.9	10.1
Swathed - late (6/26)	8.5	16.3	6.1	10.4	7.3	17.2	12.8	9.1	8.1	14.4	12.8	10.2
Combined - early (6/27)		5.7		17.5		8.3		17.6		7.9		18.3
Combined - mid (7/6)		5.7		17.3		7.9		18.4		7.2		18.2
Combined - late (7/12)		4.7		11.6		7.4		12.6		6.0		13.9
Carter - early (6/20)	42.2	4.1			32.5	8.0			42.4	5.0		
Carter - mid (6/23)	17.6	4.0			11.5	8.0			11.9	5.5		
Carter - late (6/26)	8.5	3.8			7.3	8.1			8.1	4.7		
LSD 0.05		2.1	NS	2.1		4.6	NS	1.7		3.7	NS	1.9

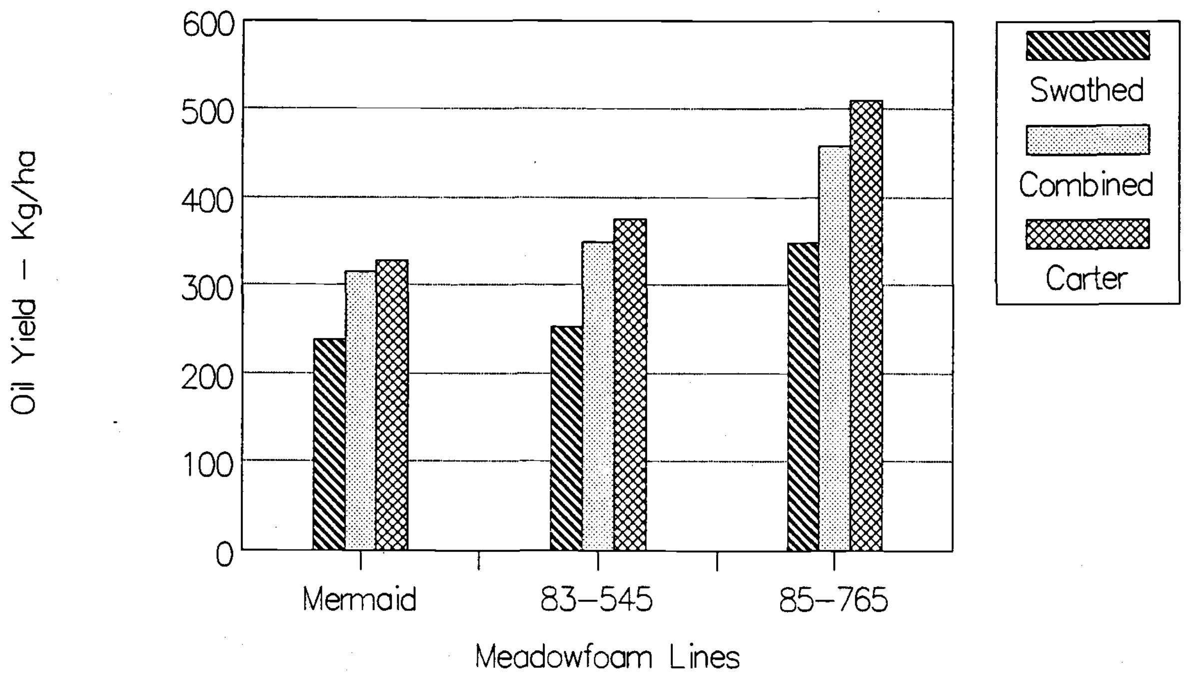


Figure 1. 1988-89 Meadowfoam Harvest Methods Study -- Oil Yield.

OPTIMUM HARVEST TIME FOR MEADOWFOAM

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

Meadowfoam is being considered as an alternate crop for Oregon, particularly on poorly-drained Willamette Valley soils. As part of the overall research effort on maximizing yields, studies were conducted on the proper timing of harvest operations. The objectives of this study are (1) to develop a seed maturity index to determine when maximum dry weight and oil content are reached, and (2) to determine when to harvest to minimize shattering and obtain maximum harvestable yield.

Two experimental lines (85-765, and 83-545) and the variety Mermaid, were planted in Fall, 1988 at Hyslop Farm on Woodburn silt loam soil. Plots were seeded in 6-in rows at the rate of 20 seed/ft. Plot size was 7.5 by 20 ft. Experimental design was a randomized block with four replications.

Seed Development and Maturation

Seed development studies were conducted to determine when meadowfoam seed reaches maturity (maximum seed dry weight and oil content). Seeds were hand-harvested daily from June 9 to June 27 and measurements made of moisture and oil percentage, and seed dry weight.

Peak flowering occurred on May 13, 14, and 15 for 83-545, 85-765, and Mermaid, respectively.

The development of Mermaid is shown in Table 1. The development rate of the other two lines was similar.

The first sampling date (June 9) was 25 days after peak flowering for Mermaid, 26 days for 85-765, and 27 days for 84-545. Since flowering occurred over about a 28-day period, overall plot maturity was approached gradually, making it difficult to pinpoint a precise date when maximum dry weight was reached.

Seed moisture content decreased gradually from about 60% to about 42%, averaging 2.0% daily loss in moisture for the three varieties during this period. Thereafter, moisture dropped rapidly during the next 5 days, averaging 6.1% moisture loss per day for the three varieties. Seed maturity was considered to be the point where the rate of moisture loss suddenly accelerated, which averaged 42.3% moisture content for these three varieties.

Maturity (42% moisture) was reached 35 days after peak flowering in 83-545, 36 days in Mermaid, and 37 days in 85-765. At this stage, weight per thousand seeds was 9.2, 10.8, and 10.3 g for Mermaid, 85-765, and 83-545, respectively. Oil contents for the three varieties were 30.9, 26.6, and 30.5% for Mermaid, 85-765, and 83-545, respectively.

Table 1. Seed development and maturation of Mermaid meadowfoam in 1989.

Date	Days after peak flowering	1000-seed weight	Seed moisture content	Seed oil content
June	(d)	(g)	---------(%)--------	
9	25	8.4	63.5	23.7
10	26	8.5	61.7	25.3
11	27	9.2	59.6	26.3
12	28	9.1	58.6	27.3
13	29	9.5	57.7	25.7
14	30	9.2	61.5	26.8
15	31	9.5	59.7	27.0
16	32	10.2	54.9	27.2
17	33	9.9	50.3	28.6
18	34	10.0	47.6	25.9
19	35	9.4	44.6	32.0
20	36	9.1	42.2	30.9
21	37	9.6	33.9	28.4
22	38	9.4	23.4	29.4
23	39	9.1	17.7	28.0
24	40	8.9	13.8	27.7
25	41	9.3	9.7	27.8
26	42	9.3	8.6	28.8
27	43	9.4	8.2	28.6
LSD .05		0.6	2.8	1.8

We concluded that seed maturation patterns for the three varieties were very similar, with 85-765 maturing a day later than Mermaid.

Optimum Harvest Time

Four plots of each variety were windrowed each day between June 20 and 28. The moisture content on June 20 was about 42% for Mermaid and 85-765 and 32% for 83-545. The windrowed area was 5x20 ft. All plots were combined on July 10.

The harvested yield data are shown in Table 2. Seed and oil yield did not increase after the first windrowing date. A small but significant decrease in yield with late windrowing occurred only in 85-765. The 85-765 line was superior in yield to Mermaid and 83-545.

This trial will be repeated in the 1989-90 season with windrowing dates at seed moisture contents at 50% or greater to determine the earliest possible date for windrowing.

Table 2. Effect of time of windrowing on yield and seed quality of three varieties and lines of meadowfoam.

Windrowing date	Mermaid Seed yield	Mermaid Moisture content	Mermaid 1000-seed wt	Mermaid Oil content	Mermaid Oil yield	83-545 Seed yield	83-545 Moisture content	83-545 1000-seed wt	83-545 Oil content	83-545 Oil yield	85-765 Seed yield	85-765 Moisture content	85-765 1000-seed wt	85-765 Oil content	85-765 Oil yield
June	(lb/a)	(%)	(g)	(%)	(lb/a)	(lb/a)	(%)	(g)	(%)	(lb/a)	(lb/a)	(%)	(g)	(%)	(lb/a)
20	657	42.2	9.53	29.7	196	693	32.5	9.91	32.1	222	972	42.4	10.83	31.3	305
21	Swather repairs														
22	659	23.4	9.60	20.4	194	733	16.0	9.90	32.0	234	913	22.3	11.01	31.7	289
23	629	17.6	9.68	28.6	179	717	11.5	9.80	31.9	228	949	11.9	10.75	32.2	305
24	622	13.8	9.57	29.3	183	707	9.5	9.75	31.1	220	996	10.7	10.63	31.9	317
25	663	9.6	9.41	29.8	198	730	7.5	10.04	32.4	237	999	8.8	10.88	31.0	309
26	622	8.5	9.35	29.4	183	748	7.3	9.81	31.6	238	997	8.1	10.52	32.2	320
27	629	8.4	9.31	30.3	190	681	7.1	9.95	32.9	223	941	7.5	10.76	31.8	299
28	563	8.8	9.65	29.1	164	687	7.6	9.75	31.9	219	914	8.1	11.07	31.1	284
LSD 0.05	NS		NS	NS	NS	NS		NS	NS	NS	60		0.32	NS	21

RESPONSE OF MEADOWFOAM TO NITROGEN FERTILITY AND SEEDING RATE

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

In previous micro-plot trials there was some evidence that seeding rate or plant populations may be interacting with response to nitrogen fertility. Therefore, the 1988-89 trial was conducted with 3 levels of spring-applied nitrogen (35, 55, and 75 lb N/A) and 3 seeding rates (10, 20, 30 seed/ft) in a 3 by 3 factorial design. Soil tests showed 50 lb N/A in the top 6 inches of soil at planting, and 25 lb N/A was fall-applied. Total nitrogen levels (soil + fall + spring) were 110, 130, and 150 lb N/A. since the 85-765 line has shown increased yield in previous trials, it was the only variety in this study.

Insect damage to the stems and buds of meadowfoam plants was first reported in 1988. Damage occurred again this year in the nitrogen fertility experiment. The most severe damage was recorded in the high nitrogen treatment (150 lb/A), some damage was reported in the 130 lb/A treatment, and very little damage was found in the 110 lb/A treatment. The insect was identified by the OSU Entomology Department as a small fruit fly in the *Drosophilidae* family. The larva of this fly destroys the flower bud or the growing point of the stem, depending on where the eggs are laid.

The most significant result of this trial is the lack of response to increased nitrogen levels in seed yield, oil yield, and percent oil content. Part of this lack of response was due to increased insect damage at the higher rates of nitrogen. The lowest nitrogen rate produced the highest values in these 3 yield components. Seed weights were significantly increased at the higher nitrogen level, especially at the lower seed rates.

The recommended seeding rate for meadowfoam is 20 seed/ft. When the seeding rate was reduced to 10 seed/ft the seed yield, oil yield, and percent oil content were significantly reduced at all three levels of nitrogen. Increasing the seeding rate to 30 seed/ft increased the seed and oil yields only at the higher nitrogen rate.

In summary, the results presented graphically in Figure 1 show that 20 seeds/ft (standard seeding rate) is equal to or superior to the lower or higher seed rates at all levels of nitrogen with the one exception of 30 seeds/ft at the highest nitrogen rate. The mean oil yield of the low fertilizer rate at the 20 seeds/ft seeding is still significantly higher than the 30 seeds/ft at the highest nitrogen rate.

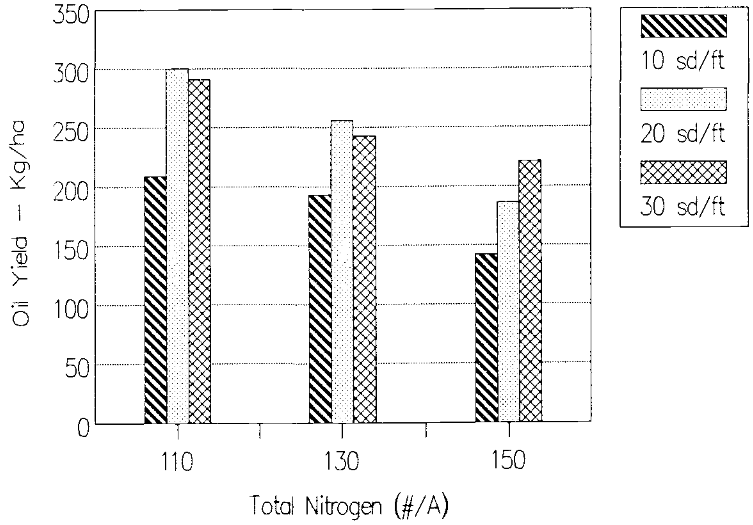


Figure 1. Meadowfoam oil yield response to N fertilization and seeding rates.

SEED CONDITIONING RESEARCH

A. G. Berlage, D. B. Churchill, T. M. Cooper, and D. M. Bilsland

Seeds harvested with conventional equipment contain various types and quantities of contaminants that are picked up and mixed with the crop. Contaminants such as weed seeds, inert material, seeds of other crops, and nongerminable seeds from the intended crop must be removed to meet required standards before the seed lot can be sold. The Federal Seed Act requires that seed sold and transported meet certain minimum standards for purity and germination, and contain no noxious weed seed. Extensive conditioning, including threshing, debearding and cleaning, is often required to meet legal or contractual standards.

Conditioning Wildflowers. Many wildflower seeds have appendages that must be removed to improve the seed's ability to flow and to allow complete cleaning. Seed lot weights ranging from a few grams to more than 100-kg are possible. Cleaning of seed lots requires conditioning the seed with machines that separate particles by physical property differences between the intended crop seed and other contaminants.

Seeds of seven species of hand-harvested wildflowers were acquired from a commercial source. The lots contained large amounts of inert material, mostly pieces of leaf, stem and nongerminable seed. The seeds of most of these species had appendages that would reduce the efficiency of conditioning. Two methods for conditioning, hand and machine separation, were investigated. The hand separation was used to determine the exact initial and final purity percentages without loss of any seeds, along with germination results. Machine separation was conducted with commercially available laboratory-sized equipment. Because of the limited supply of seeds, a replicated machine separation test could not be conducted.

Assuming that hand separation returns nearly 100% of the seed and causes no damage, machine tests can be compared to determine loss and damage. Since machine threshing and separation usually results in some loss, it was expected that the quantity of seed saved in machine separation would be lower. The original weights were slightly higher than the sum of the fraction weights due to fine particles not collected.

For three species, germination of the machine-separated seed was slightly lower than that of the hand-separated seed. This suggests that some damage occurred during the process, probably the threshing. For the other four species, germination of the machine-separated seed was higher than the hand-separated seed. For one specie, a very large increase in the quantity of germinable seed occurred. Further investigation is required to determine if this was the result of damage to the hand-separated seed, making the germination of the machine-separated seed appear greater, the result of dormancy being broken during machine threshing causing a higher germination level, or some other factor.

In general, smaller seed is more difficult to condition. Species with small seed resulted in relatively large losses and lower final purities than the larger species. Static charge created problems with seed adhering to separating devices. Threshing of species that are retained inside of the threshing cylinder require careful monitoring since free seed is more susceptible to damage. On a continuous basis, some adjustment of feed rate would be necessary to ensure the proper level of threshing.

In most cases, the required purities of 95 to 98% were achieved. The air separation portion of these sequences tended to be the least precise procedure, resulting in greater loss than other machines. Adjustment of the velocity gives the conditioner the option of improving purity at the expense of more crop seed or saving greater amounts of crop seed with lower purity.

Decision-Support Systems. The development of decision-support or expert systems rely upon an established base of knowledge. For seed-conditioning, this includes knowledge about the physical properties of crop seeds and their contaminants and the separating principles of the conditioning machines. Computer databases are used as the repository of such knowledge. Currently, data are not readily available to predict whether a seed mixture can be successfully and economically separated. A database of seed physical properties is being developed. One method of collecting data uses the Machine Vision System (MVS) to gather certain visually sensed physical properties of seeds. Length, width, and shape data are being collected for database storage. The MVS database of seed physical properties will eventually contain thousands of records. For this reason, a compact data structure is required.

Many decisions are required throughout the seed-conditioning process. Since the decision to use a particular machine depends partly upon what contaminants are present, more accurate knowledge of the composition of a seed lot gives a more reliable recommendation of machine selection. For example, a scalping operation is usually the initial process used to reduce the amount of foreign material in uncleaned seed lots. Some crops such as wheat and corn however, come from the combine relatively clean due to their high density and regular shapes. Cleaning of such crops is often simple and well established in the industry. In these cases the scalping step might be eliminated in favor of other cleaning methods. Yet, with other types of seed crops such as grasses and flowers, the actual seed comprises very little of the bulk material harvested and requires extensive cleaning.

Seed-conditioning equipment of all types exploit differences in the physical properties of seed. The greater the difference in these properties, the easier it is to remove contaminants. When a physical property of a contaminant is the same as that of a portion of the crop seed, that portion must be discarded to accomplish the removal of the contaminant. During the cleaning process, greater seed lot purity results from larger amounts of crop seed being discarded. Conversely, less cleanout results in lower purity.

Determining exactly which properties a machine is acting upon is often difficult. Many machines act upon a combination of properties to accomplish separations. Additionally, the relative importance of these properties will change with different seed types, seed lot composition, and machine operating parameters.

The MVS is an appropriate sensor of seed dimensional data for inclusion in a computer database of seed physical properties. All measurable physical properties for both crop seeds and their contaminants must be catalogued in a form usable by a computer database. New sensors and systems to quantify currently unmeasured physical properties such as density, elasticity, surface texture, and shape will be needed.

Appreciation is expressed to the Officers of the
1989-90 Oregon Seed Council:

Mike McCarthy, President
Ralph Fisher, First Vice President
Mike Baker, Second Vice President
Don Hector, Treasurer
David S. Nelson, Executive Secretary

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Appreciation is also expressed to Mrs. Barbara Reed for her conscientious attention to detail in formatting this manuscript for publication.