Plant Science Pamphlet 6
Annual Progress Report
February 2002

Progress Report 2001

Central Crops and Soils Research Station Highmore, South Dakota

SDSU

SOUTH DAKOTA STATE UNIVERSITY • PLANT SCIENCE DEPARTMENT • BROOKINGS, SD 57007

Contents

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Highmore, South Dakota

Welcome

Robin Bortnem
Manager

Approximately 75 people attended the annual twilight tour on 28 June 2001. Dinner was followed by tours of the various ongoing research projects. Dixie Volek and daughters Shandra and Sherise prepared the desserts and helped serve the meal. Pioneer Garage of Highmore provided the pickups and trailers used for the tour. I'd like to thank all that were involved in helping to make this twilight tour a success.

A new addition to the tour this year was a guided stroll through the tree and shrub nurseries. The nurseries are a cooperative study for evaluation of woody plant material for potential use in windbreaks, wildlife habitat, etc. in the Northern Great Plains. As you go through this report you will notice that in addition to Plant Science personnel, the Highmore Station hosts cooperative research on woody plants with USDA/NRCS in Bismarck, N.D., on arthropod infestations with USDA-ARS in Brookings, S.D., on switchgrass establishment and biomass production with USDA-ARS in Lincoln, Neb., and proso millet evaluation with the University of Nebraska at Lincoln, Neb.

The research conducted each year and included in this report involves long hours by staff from many disciplines at SDSU and the Highmore Research Farm. Their efforts in contributing to this publication each year are greatly appreciated. The support and input from area producers, ranchers, Advisory Board members, and county Extension educators is also greatly appreciated.

A special thanks to Nancy Kleinjan for her assistance in preparing this report.

Greetings

Dale Gallenberg
Head, Plant Science Department

On behalf of the Plant Science Department, let me extend my greetings and best wishes to each of you. This Annual Progress Report marks the passing of another year. Summarized within the following pages are the research and Extension activities during 2001 at the Highmore Research Farm. Once again, Mother Nature played a role in determining the outcome of studies at the farm. But then, climate and weather are stresses that have been dealt with at this site for over 100 years.

I would like to thank Mike Volek for his continued hard work and dedication to the Highmore Research Farm. He continues to manage the day-to-day, on-site activities in an efficient and effective manner. The farm is always neat and organized, and researchers and Extension specialists from Brookings know that they have a competent and knowledgeable staff member waiting to help them. I would also like to thank Robin Bortnem for her continued efforts as Station Manager, to all the faculty and staff in the Plant Science Department at SDSU for their work at the farm, and to the NRCS personnel for their continued evaluation studies.

The biggest thanks, though, goes to each one of you for taking the time to read this report, and for giving us input into what research needs to be done here in Highmore. You have questions —we try to find answers. As always, your comments and suggestions are more than welcome.

If you have comments or suggestions pertaining to research on the farm or questions or input on any other matter, please write or call.

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2001
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Monthly temperature and precipitation data for the station during 2001.

	Temperature (F)			*Precipitation*
Month	*Maximum*	*Minimum*	*Mean*	*(inches)*
January	29.4	10.7	20.0	1.20
February	20.4	1.1	10.7	*
March	34.9	18.6	26.7	*
April	59.0	34.1	46.6	4.23
May	70.8	46.8	58.8	3.06
June	79.1	55.7	67.4	3.22
July	88.7	62.2	75.5	3.42
August	89.4	58.7	74.0	0.20
September	77.3	51.0	64.2	2.00
October	62.9	36.3	49.6	0.75
November	54.2	29.4	41.8	1.18 rain and 11.5 snow
December	33.8	15.7	24.7	Trace rain and snow

* Missing data

On the cover:

This past summer a split planting-date (early June and early July) proso millet plot was seeded at the Highmore Experiment Station. Seeds of over 15 varieties (provided by Dr. David Baltensperger, millet breeder, UN-L) were planted in replicated plots. The project was a cooperative effort between the forage breeding project (Robin Bortnem), the oat breeding project (Lon Hall), and the seed testing lab (Brent Turnipseed). All of the proso varieties planted grew well, produced seed, and matured, even from the July planting date. Sufficient rainfall encouraged many of the varieties to grow 4 to 5 1/2 feet tall. There was sufficient interest in the plot so that next year it will be planted again and harvested for seed yield trials. (*Photo by Brent Turnipseed.*)

2001 Report
Field Evaluation of Woody Plant Materials
Highmore, South Dakota

Dwight Tober
Plant Materials Specialist, USDA/NRCS
Bismarck, N.D.

Objectives

1. Evaluation of the adaptation and performance of selected woody plant material for field and farmstead windbreaks, wildlife habitat, and streambank and lakeshore plantings in the Northern Great Plains.
2. Select and cooperatively release superior cultivars for increase by commercial nurseries.

Activities in 2001

A total of 140 accessions of 87 different species are currently being evaluated. Four new entries planted on May 14, 2001, included black currant (*Ribes americanum*), redleaf rose (*Rosa rubrifolia*), rugosa rose (*Rosa rugosa*), and Meyer's spruce (*Picea* spp.).

Weed control and maintenance were good. A major renovation effort in 2000 included removal of broken branches and limbs resulting from snow damage, removal and pruning of natural dieback of some species (primarily shrubs), and cutting and removal of contaminant species (primarily Siberian elm and mulberry). All of the apricot (8 entries) and some entries of crabapple, poplar, Russian olive, and other species were removed at various times during the summer by staff at the station.

Selected trees and shrubs were evaluated on September 4, 2001. Measurements and notes were taken on crown spread and plant height, disease and insect damage, drought and cold tolerance, fruit production, survival, vigor, and snow and animal damage.

The following accessions were noted to have superior performance:
- ND-1134 hybrid plum
- 908041 false indigo
- 9035212 sandbar willow (some winter dieback noted spring 2001)
- 323957 chokeberry

These selections have also performed well at other locations and are tentatively scheduled for cooperative release pending further data summary and analysis.

The winter of 2000/2001 was characterized by heavy snow and below average temperatures. Some of the entries which had previously been rated quite high showed moderate to severe signs of winter injury and dieback:
- ND-3773 willow
- Mich-433 laurel willow
- Roselow sargent crabapple
- ND-1567 hawthorn
- ND-995 prairie willow
- 9063142 Japanese cherry
- Streamco purpleosier willow
- ND-3902 sandbar willow (moderate damage)

Summary of accomplishments

Selected accessions/cultivars which have performed well at the Highmore site and show promise for additional testing and/or promotion for conservation use include the following:

'Cardan' green ash
'Oahe' hackberry
'Centennial' cotoneaster
'Scarlet' Mongolian cherry
'Sakakawea' silver buffaloberry
'McDermand' Ussurian pear
'Indigo' silky dogwood
'Regal' Russian almond
ND-1134 hybrid plum
ND-21 nannyberry
ND-3902 sandbar willow
9047238 sea buckthorn
ND-1879 honeylocust
9008041 false indigo
'Legacy' late lilac
ND-1863 honeylocust
9058862 tamarack
'Meadowlark' forsythia
ND-170 cotoneaster
'Midwest' Manchurian crabapple
'Bighorn' skunkbush sumac
323957 chokeberry
14272 hybrid poplar
ND-2103 highbush cranberry
9069081 littleleaf linden
hybrid poplar 9069086 (Theves)
9063130 river birch
9047228 pygmy caragana
9016318 Siberian elm
ND-46 Timm's juneberry
Arnold's Red honeysuckle
ND-3744 Korean barberry
9057409 American hazel
Siberian larch (SL–383, ND-1765)
ponderosa pine (ND-1763, 9067413)
9057411 lodgepole pine
Scot's pine (9063156, 9063154)
9057410 hackberry
9063148 corktree
9063116 black ash

This field evaluation planting site was established in 1978. Data from this planting have been used to document the cooperative release of the cultivars listed below. These cultivars are currently in large-scale production and use in conservation plantings throughout the Northern Great Plains. Several more releases are anticipated in the near future. Information gathered concerning plant performance assists cooperating nurserymen and plant researchers in determining the range of adaptation of many other accessions/cultivars also included in the test planting.

Cultivars tested at Highmore and released to public:

- 'Cardan' green ash (1979)
- 'Oahe' hackberry (1982)
- 'Sakakawea' silver buffaloberry (1984)
- 'Scarlet' Mongolian cherry (1984)
- 'Centennial' cotoneaster (1987)
- 'McDermand' Ussurian pear (1990)
- 'Homestead' Arnold hawthorn (1993)
- 'CanAm' hybrid poplar (1995)
- 'Regal' Russian almond (1997)
- 'Legacy' late lilac (1999)

2001 Report
Assessment of Herbicides for Switchgrass Establishment in the Northern Great Plains

K.P. Vogel and *R.A. Masters*

Cooperators:
USDA Agricultural Research Service
U.S. Department of Energy
South Dakota State University
University of Nebraska

Rationale

Switchgrass has been identified by the U.S. Department of Energy (DOE) as a potential biofuel crop. This native warm-season tallgrass is broadly adapted to environments that extend from the eastern Great Plains to the east coast.

Weed interference is an important factor that limits establishment of switchgrass from seed. Severe weed infestations can cause complete stand failures. Weed control during the seeding year has ben shown to improve switchgrass establishment. Preemergence herbicides provide a means to control weeds during switchgrass establishment.

Atrazine has been used to improve switchgrass establishment (Martin et al. 1982, Bahler et al. 1984). Vogel (1987) found that acceptable stands of switchgrass could be established at a reduced seeding rate of 107 pure live seed m^{-2} when weed interference was reduced following atrazine application at time of planting.

Imazethapyr, applied at 70 g ai ha^{-1} before planted grasses emerged, provided excellent weed control and enabled establishment of excellent stands of switchgrass within 1 year after planting (Masters et al. 1996).

Recent research conducted in eastern Nebraska demonstrated that switchgrass establishment was improved following application of imazapic (PLATEAU) at 35 g ai ha^{-1} or atrazine (AATREX 4L) at 2.2 kg ai ha^{-1} + quinclorac (PARAMOUNT) at 1.1 kg ai ha^{-1}.

Additional research is needed to determine the influence of environment on efficacy of the herbicides and switchgrass tolerance to them.

Objectives

The objectives of this study were to determine the effect of selected herbicides applied at the time of seeding on stand establishment and subsequent biomass yields of switchgrass in the Northern Great Plains.

Materials and Methods

Field experiments were conducted near Mead, Neb., Highmore, S.D., and Mandan, N.D., in 2000 to assess the influence of selected herbicides on switchgrass cultivar establishment.

Switchgrass cultivars were planted at a rate of 330 pure live seed m^{-2} in 8 X 5-m plots on May 16, 24, and 25, 2000, at Mead, Highmore, and Mandan, respectively. 'Cave-In-Rock' and 'Trailblazer' were planted at all locations. In additional, 'Sunburst' and 'Forestberg' were planted at Highmore and Mandan, respectively.

Switchgrass plots were planted into a clean, firm seedbed that was disked, harrowed, and culti-packed within 14 days of planting. The experimental design at all locations was a randomized complete split block with herbicide treatments and replications as main plot treatments and cultivars as subplot treatments.

Herbicides applied immediately after planting were AATREX 4L at 1.1 or 2.2 kg ai ha^{-1}, PARAMOUNT at 280 or 560 g ai ha^{-1}, PLATEAU at 35 g ai ha^{-1}, AATREX at 1.1 kg ai ha^{-1} + PARAMOUNT 280 or 560 g ai ha^{-1}, and PLATEAU 35 g ai ha^{-1} + PARAMOUNT 280 g ai ha^{-1}. At Mead, an additional treatment of PLATEAU 35 g ai ha^{-1} + PARAMOUNT 560 g ai ha^{-1} was included.

Herbicide spray solutions were applied with a tractor-mounted sprayer to deliver 190 L ha^{-1} (20 gallons $acre^{-1}$). There were four replications per treatment combination. No additional treatments were applied to plots the establishment year.

In the spring of 2001, plots at Mandan were burned prior to spring greenup to remove the previous year's growth. Plots at Mead were mowed and raked to remove the previous year's growth. Previous year biomass at Highmore was insufficient to warrant burning or removal by mowing and raking because of drought conditions at Highmore during the 2000 growing season. At Highmore, previous year biomass was shredded with a rotary mower.

Within 14 d after burning or mowing a mixture of 1.1 kg a.i. ha^{-1} of 2,4-D low volatile ester and 2.2 kg a.i. ha^{-1} of atrazine and metolachlor was broadcast in a total spray volume of 187 L ha^{-1} (20 gallons per acre) over the entire plot area at the three locations. The 2001 spring herbicide application was applied to suppress weed growth that would have interfered with stand counts and yield harvests in 2001. Established switchgrass is tolerant of the herbicides used in the spring of 2001.

The effectiveness of the herbicides in improving switchgrass establishment was determined by measuring stand frequency of occurrence and herbage dry matter yield. In late May or early June 2001, frequency measurements were made using a frequency grid (Vogel and Masters 2001).

Prior to harvest in late fall after a killing frost, the plots at each location were trimmed to a uniform length of 3 m. The percentage of the total biomass that was weeds in each plot was estimated visually by two independent observors prior to harvest. Switchgrass biomass yield was determined by cutting and weighing a 0.91m-wide swath the length of each subplot using a flail type plot harvester with a cutting height of 10 cm. The outer edges of the subplots were not harvested for yield to reduce border effects. Four plots of each cultivar at each location were subsampled for biomass which was used to determine dry matter concentration of the biomass. Mean dry matter concentration of the subsamples was used to adjust biomass yields to oven-dry weights.

The data were analyzed separately for each location using a split-split-plot design with herbicides treatments as the whole-plot and switchgrass cultivars as the subplot using the GLM procedure in SAS (SAS Institute, Inc. 1990).

Results

A visual evaluation of the experiments was made in August 2000. Herbicide effectiveness and switchgrass establishment appeared to be adversely affected by the drought conditions at Highmore during June and July 2000.

At Mandan, dominant weeds were annual grasses, primarily stinkgrass and foxtails. At Mead, broadleaf weeds dominated, primarily velvetleaf, common waterhemp, and annual sunflower.

At all sites, control of broadleaf weeds and annual grasses appeared to be greatest where PLATEAU was applied alone or where PARAMOUNT was applied with PLATEAU or AATREX.

Switchgrass stands appeared to be poor at Highmore, regardless of herbicide treatments. Switchgrass stands appeared to be fair to good at Mandan and excellent at Mead where PARAMOUNT was applied with AATREX.

In the year following establishment (2001), there were significant differences in stands due to herbicide treatments only at Mandan (Table 1 and Table 2). PLATEAU or treatments in which PLATEAU was a component significantly reduced switchgrass stands at Mandan in comparison to other herbicide treatments. At the other locations, PLATEAU did not have an adverse effect on switchgrass stands. Because PLATEAU can have adverse effects on switchgrass stands under field conditions and because of unpredictable micro-environmental effects, the manufacturer does not recommend it for use in switchgrass establishment.

The other herbicide treatments did not have an adverse effect on stands at any of the three locations.

In the Great Plains, stands with frequency grid percentages of 50% or higher can be classified as fully successful, stands at 25 to 50% indicate adequate stands, while frequencies of less than 25% could be regarded as marginal or unacceptable and may require re-establishment (Vogel and Masters 2001).

Stands at Highmore were marginal due to the drought of the previous year. However, the plots did produce adequate levels of biomass the year following establishment, likely made feasible by the herbicide treatment in the spring of 2001, which allowed the thin stands to increase in density with reduced weed competition.

At the end of the second growing season, there were significant differences due to herbicide treatments on the percentage of biomass that was weeds. This was due to the effect the herbicide had on first year stands and on the weeds that were controlled in the establishment year.

Herbicide treatments that controlled both broadleaf and grassy weeds in the establishment year such as quinclorac plus atrazine tended to have smaller percentages of weeds the year after establishment. Untreated plots tended to have the highest weed percentages the year after establishment, even though a combination grass-broadleaf weed herbicide was applied in the spring of the year after establishment.

Herbicide treatments had a significant effect on post-establishment-year biomass yields only at Mead. Untreated plots had significantly lower biomass yields than plots treated with herbicides. Plots treated with combinations of herbicides that controlled broadleaf and grassy weeds had higher yields than herbicides that controlled only broadleaf weeds. The atrazine plus quinclorac treatments had significantly higher yields than the plots that received only atrazine.

The herbicide treatment of A1Q2 (atrazine 1.12 kg ha^{-1} + quinclorac 580 g ha^{-1}) resulted in acceptable stands, high biomass yields, and low weed percentages at all three locations. Of the herbicides and herbicide concentrations and combinations evaluated, this treatment is an excellent herbicide combination for establishing switchgrass for biomass production in the Northern Great Plains.

Two or three cultivars were evaluated at each location to determine if there were any herbicide by treatment interaction effects that would be of concern. Herbicide by cultivar interaction effects were not significant for stands or biomass yields. They were significant for weed percentages at Mead and Highmore, but the mean squares for the interaction were substantially smaller than those for the main treatment effects.

The cultivars that were evaluated represent the diversity of cultivars available for use in the Northern Great Plains. These results indicate that the effects of herbicides on switchgrass stands and biomass yields are consistent over cultivars.

Different switchgrass cultivars were included in this study primarily to determine if there were signficant herbicide x cultivar interaction effects. There were significant cultivar effects for switchgrass stands at Mead and Highmore, but because only a single seed lot of each cultivar was used, it is not possible from the results of this study to determine if the difference was due to genetic differences among cultivars for establishment capability or to differences in quality among the seed lots.

Although there were differences in cultivars for stands at Mead, all cultivars had excellent stands. At Highmore, all cultivars had marginal stands due to drought conditions the establishment year.

There were significant differences in biomass yields due to cultivar differences at all three locations. This was to be expected. Cave-in-Rock has more yield potential when grown in USDA Plant Hardiness zones 5 and 6 than cultivars of more northern origin such as Forestburg and Sunburst, but it also has less yield potential when moved north of its area of adaptation. In general, the different switchgrass cultivars performed as expected.

In summary, the combined use of atrazine and quinclorac should be acceptable for weed control for establishment of adapted switchgrass cultivars in the Northern Great Plains. This herbicide combination results in good weed control and hence establishment of switchgrass without any apparent deleterious effects. As a result of the reduced weed competition and improved establishment, switchgrass biomass yields are enhanced the year after establishment in comparison to untreated checks.

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Table 1. Analysis of variance of the switchgrass stands and biomass yields the year following establishment in response to herbicide applications the year of establishment in the Northern Great Plains.

Source of variation	df	Mean squares			
		Yield tons/acre	Yield Mg ha^{-1}	Grass stands %	Weeds %
Mead, Neb.					
Replicates	3	1.91	9.60	555	3670
Herbicides	9	3.02**	15.17**	848	760*
Error a	27	0.84	4.24	401	265
Cultivar	1	2.86**	14.37**	3217**	9336**
Cultivar x herbicide	9	0.44	2.20	51	784*
Error b	68	0.31	1.57	172	321
Highmore, S.D.					
Replicates	3	1.01	5.10	211	1647
Herbicides	8	1.65	8.30	261	5035**
Error a	24	1.40	7.05	216	652
Cultivar	2	2.84**	14.26**	424**	952*
Cultivar x herbicide	16	0.31	1.54	37	408*
Error b	54	0.23	1.15	52	219
Mandan, N.D.					
Replicates	3	0.15	0.75	413	256
Herbicides	8	1.79	8.98	6656**	915**
Error a	24	1.04	5.22	352	200
Cultivar	2	10.12**	50.86**	315	60
Cultivar x herbicide	16	0.38	1.91	331	134
Error b	54	0.44	2.20	245	125

*,** Indicates significance at the 0.05 and 0.01 levels of probability, respectively.

Table 2. Switchgrass biomass yields and switchgrass and weed percentage means the year following establishment in response to herbicide treatments the year of establishment in the Northern Great Plains.

Treatment+	Biomass yield			Grass stands			Weeds		
	Mead	Highmore	Mandan	Mead	Highmore	Mandan	Mead	Highmore	Mandan
		Tons/acre			%			%	
				Herbicide					
A1	1.9	1.6	2.4	81	9	67	32	60	0
A1Q1	2.8	2.8	2.8	81	20	66	9	10	0
A1Q2	3.3	2.6	2.5	77	19	66	12	4	1
A2	2.5	2.0	2.3	80	16	55	6	34	4
Q1	3.0	2.3	3.0	77	11	74	16	5	1
Q2	3.3	2.2	2.8	66	15	49	20	5	3
P2	2.7	2.2	1.6	70	19	8	2	13	28
P2Q1	3.1	2.5	2.3	60	19	20	5	12	5
P2Q2	2.8			54			6		
Untreated	1.7	1.8	2.3	72	8	73	33	46	2
LSD 0.05	0.3	ns	ns	ns	ns	5	4	6	7
				Cultivar					
Cave-in-Rock	2.9	2.5	2.5	80	18	56	2	15	6
Trailblazer	2.6	2.3	2.9	68	11	50	20	24	4
Sunburst		1.9			16			24	
Forestburg			1.9			53			4
LSD 0.05	0.1	0.1	0.1	1	1	ns	1	1	ns

+ Herbicide treatment abbreviations are: A1 = atrazine 1.12 kg ha^{-1}; A2 = atrazine 2.2 kg ha^{-1}; Q1 = quinclorac or Paramount 280 g ha^{-1}; Q2 = quinclorac 580 g ha^{-1}; P2 = Plateau 36 g ha^{-1}; or a combination of two of the herbicide treatments such as A1Q1 = A1 + Q1.

2001 Report
Alfalfa and Grass Breeding

Arvid Boe and *Robin Bortnem*

Pasture/Rangeland Alfalfa

There has been a long-time need/demand for a grazing-type alfalfa to persist and reseed in depleted pastures and rangelands in the semiarid northern Great Plains.

Recently we observed the natural spread of a population of predominantly yellow-flowered alfalfa on the Grand River National Grassland (GRNG) near Lodgepole, S.D. Based on data collected by the USDA Forest Service at Lemmon, S.D., we estimate the initial invasion of the GRNG by alfalfa occurred less than 20 years ago. Since then, the population has spread by seed across an area of more than 2 square miles. It occurs in highest densities in swales, but scattered plants also occur on slopes and rocky uplands.

During early August 2000, we collected seed from about 250 alfalfa plants on the GRNG and planted seeds from each plant in the greenhouse in February 2001. During May-June 2001, we transplanted seedlings from about 220 of the parent plants and four check cultivars/populations into replicated single-row-plot nurseries at Highmore, S.D., Brandon and Miami, Manitoba, and Ames, Iowa. Similar nurseries will be established at Mandan, N.D., and Huntley, Mont., during 2002. Over the next 3-4 years, data will be collected on forage yield, seed yield, vegetative spread, growth habit, and resistance to diseases and insects at all locations. The expected outcome of this research is the development of new cultivars that can persist and improve forage production and quality in depleted grazing lands throughout the northern Great Plains.

Preliminary observations at Highmore and other locations during the transplant year (2001) indicated substantial variability among families (a family is comprised of plants derived from the seeds of a single plant) for flower color, growth habit, and vigor.

Switchgrass for Biomass

Central South Dakota has been identified by the U.S. Department of Energy (USDOE) as an area with excellent potential for the profitable production of biofuel crops. We are currently receiving support from the USDOE Bioenergy Feedstocks Development Program to develop new cultivars capable of producing high amounts of biomass under conditions suboptimal for the production of conventional grain and forage crops.

During May 2000, we transplanted seedlings of 100 families of switchgrass from cultivars/breeding populations with origins in southeastern South Dakota, southeastern Nebraska, southern Illinois, and northern Oklahoma to replicated single-row-plot nurseries at Highmore, Kimball, and Aurora, S.D. The Highmore nursery was planted into a stand of alfalfa to provide a high-stress environment (competition for light, moisture, and nutrients). Because alfalfa begins growth about a month earlier than switchgrass during the spring, the alfalfa is mowed periodically between the switchgrass rows during the early part of the growing season.

For the next 3 years, we will harvest the nurseries annually shortly after a killing frost in the fall (generally early October) to determine biomass yield. Based on biomass yield and persistence data, we will, at the end of the 3-year evaluation period, select the best plants for development of a new cultivar.

Results from the October 2001 harvest at Highmore indicated significant differences among families for survival and biomass yield. So far, the populations of northern origin (i.e., southeastern South Dakota) seem better adapted than those of more southern origin to the high-stress environment at Highmore.

2001 Report
Weed Control

L. Wrage, D. Deneke, D. Vos, S. Wagner, and *B. Rook*

The Highmore experiment station provides a strategic location for several weed control field evaluation and demonstration trials. The plots provide data for the statewide weed control Extension program and are used for field tours.

The station has been the primary site for evaluating downy brome (cheatgrass) control in winter wheat. A block is devoted to maintaining the weed infestation and provides the winter wheat crop for comparing herbicides, including experimental products.

2001 Projects

Projects initiated included winter wheat, experimental Clearfield wheat, sunflower, herbicide-resistant sunflower, edible bean, soybean, grain sorghum, proso millet, oats, and safflower.

Fall precipitation was very limited; fall-seeded wheat and winter-annual weed emergence was reduced. Cheatgrass emergence was primarily in the spring.

There were considerable dry periods during the 2001 season. Crop emergence and early growth were generally favorable. Weed pressure in plots was light; however, there was significant competition during stress periods.

The cooperation and assistance of station personnel is acknowledged. Extension educators identify needs, assist with tours, and utilize the data in producer programs.

NOTE: Data reported in this publication are results from field tests that include labeled product uses, experimental products or experimental rates, combinations or other unlabeled uses for herbicide products. Tradenames of products used are listed; there frequently are other brand products available in the market. Refer to the appropriate weed control fact sheet available from county Extension offices for herbicide recommendations.

Table 1. Weed control in sunflower.

RCB; 3 reps	Precipitation:		
Planting Date: 5/25/01	PRE:	1st week	0.60 inches
Variety: See comments		2nd week	0.75 inches
PRE: 5/25/01	EPOST:	1st week	0.35 inches
EPOST: 6/19/01		2nd week	1.65 inches
POST: 7/12/01	POST:	1st week	0.47 inches
Soil: Clay loam; 2.1% OM; 6.5 pH		2nd week	1.00 inches

VCRR=Visual Crop Response Rating (0=no injury; 100=complete kill)

Grft=Green foxtail

COMMENTS: Varieties planted: Pioneer 63M80, Mycogen CAMS - IMI, and 01RL004 - SU. Evaluation includes experimental herbicide-resistant sunflowers. Some variability in weed density in plot area. Note lack of cross tolerance in Express sunflowers. Roundup, 2,4-D, dicamba at low levels caused severe crop injury.

Treatment		*Rate/A*	*Sunflower % VCRR 8/30/01*	*% Grft 8/30/01*
	Check		0	0
Herbicide Comparison				
Preplant Incorporated				
	Treflan	1.5 pt	0	93
	Sonalan	2.67 pt	0	96
	Prowl	3.6 pt	0	93
	Treflan+Spartan	1.5 pt+4 oz	0	90
Preemergence				
	Prowl+Spartan	3.6 pt+4 oz	0	82
	Prowl	3.6 pt	0	75
	Spartan	3.5 oz	0	37
	Spartan	5.33 oz	0	53
	Dual II Magnum	1.67 pt	0	73
	Lasso	2.5 qt	0	84
Preemergence & Postemergence				
	Spartan&Poast+COC	3.5 oz&1 pt+1%	0	87
	Spartan&Select+COC	3.5 oz&6 oz+1%	0	89
	Aim+Spartan&Poast+COC	.33 oz+3.5 oz&1 pt+1%	0	86
"Express" Sunflower				
Postemergence				
	Express+COC	.25 oz+1%	0	3
	Raptor+COC	4 oz+1%	25	53
	FirstRate+COC	.31 oz+1%	83	23
	Ally+NIS	.1 oz+.25%	20	27
	Harmony GT+NIS	.4 oz+.25%	32	0

Table 1 (cont.) Weed control in sunflower

Treatment	Rate/A	Sunflower % VCRR 8/30/01	% Grft 8/30/01
"IMI" Sunflower			
Preemergence & Postemergence			
Prowl&Raptor+COC+28% N	3 pt&4 oz+1 qt+2 qt	0	90
Postemergence			
Raptor+COC+28% N	4 oz+1 qt+2 qt	0	73
Raptor+Arsenal+COC+28% N	4 oz+1 oz+1 qt+2 qt	0	77
Simulated Contamination/Drift			
Preemergence & Early Postemergence			
Spartan&Poast+COC+2,4-D ester	3.5 oz&1 pt+1%+.5 oz	32	93
Spartan&Poast+COC+Banvel	3.5 oz&1 pt+1%+.05 oz	8	98
Spartan&Poast+COC+Tordon	3.5 oz&1 pt+1%+.1 oz	2	98
Spartan&Poast+COC+ Roundup Ultra+AMS	3.5 oz&1 pt+1%+ 1.6 oz+2 lb	28	97
Spartan&Poast+COC+ Ally+X-77	3.5 oz&1 pt+1%+ .01 oz+.025%	5	71
Preemergence & Postemergence			
Spartan&Poast+COC+2,4-D ester	3.5 oz&1 pt+1%+.5 oz	32	87
Spartan&Poast+COC+Banvel	3.5 oz&1 pt+1%+.05 oz	43	97
Spartan&Poast+COC+ Roundup Ultra+AMS	3.5 oz&1 pt+1%+ 1.6 oz+2 lb	58	89
LSD (.05)		10	18

Table 2. Weed control in safflower demonstration.

RCB; 3 reps	Precipitation:			
Planting Date: 5/2/01	PPI/PRE:	1st week	1.60 inches	
PPI/PRE: 5/2/01		2nd week	0.30 inches	
POST: 6/19/01	POST:	1st week	0.35 inches	
Soil: Clay loam; 2.8% OM; 6.3 pH		2nd week	1.65 inches	

Grft=Green foxtail
KOCZ=Kochia

COMMENTS: Very light weed pressure. Primarily evaluation for crop tolerance with labeled and experimental herbicides. Crop tolerance appears adequate for treatments tested. Valor, 2X Spartan, and 2X Pinnacle appeared to have adequate tolerance under 2001 conditions. Multi-year averages are useful.

Treatment		*Rate/A*	*% Grft 8/2/01*	*% KOCZ 8/2/01*	*Safflower Yield lbs/A*
	Check		0	0	1195
Preplant Incorporated					
	Treflan	1 qt	92	96	1245
	Sonalan	1.5 qt	95	97	1153
Prememergence					
	Dual II Magnum	2 pt	93	88	1301
	Prowl	3.3 pt	84	97	1310
Preemergence & Postemergence					
	Valor&Poast Plus+COC	3 oz&1 pt+1 qt	97	96	1104
	Spartan&Poast Plus+COC	4 oz&1 pt+1 qt	98	99	1197
	Spartan&Poast Plus+COC	8 oz&1 pt+1 qt	99	99	1105
Postemergence					
	Poast Plus+COC	1 pt+1 qt	99	0	1184
	Assure II+COC	8 oz+1 qt	96	0	1205
	Select+COC	7 oz+1 qt	99	0	1229
	Pinnacle+NIS	.25 oz+.25%	0	95	1171
	Pinnacle+NIS	.5 oz+.25%	0	98	1267
	LSD (.05)		5	4	244

Table 3. Weed control in soybean.

RCB; 3 reps	Precipitation:		
Planting Date: 5/25/01	PRE:	1st week	0.60 inches
Variety: NK S14-M7		2nd week	0.75 inches
PRE: 5/25/01	EPOST:	1st week	0.85 inches
EPOST: 6/19/01		2nd week	1.65 inches
POST: 7/12/01	POST:	1st week	0.47 inches
Soil: Clay loam; 2.8% OM; 6.3 pH		2nd week	1.00 inches

COMMENTS: Uniform plot area. Moderate grass pressure. Very good weed control. Some variability in yield across plot area.

Treatment	*Rate/A*	*% Grft 9/11/01*	*% Rrpw 9/11/01*	*Soybean Yield bu/A*
Check		0	0	11
Early Postemergence				
Roundup Ultramax+AMS	.8 qt+2 lb	98	91	25
Early Postemergence & Postemergence				
Roundup Ultramax+AMS& Roundup Ultramax+AMS	.8 qt+2 lb& .8 qt+2 lb	98	89	26
Early Postemergence				
Extreme+NIS+AMS	1.5 qt+.25%+2 lb	98	98	25
Preemergence & Postemergence				
Boundary&Roundup Ultramax+AMS	1.5 pt&1.2 pt+2 lb	97	91	22
Authority&Poast+COC	4 oz&.5 pt+1 qt	98	73	22
Postemergence				
Ultra Blazer+Poast+COC	1.5 pt+.5 pt+1 qt	82	59	19
LSD (.05)		2	8	4

Table 4. Sorghum herbicide demonstration.

RCB; 3 reps	Precipitation:		
Planting Date: 5/25/01	PRE:	1st week	0.60 inches
Variety: Legend LM4335		2nd week	0.75 inches
PRE: 5/25/01	POST:	1st week	0.35 inches
POST: 6/19/01		2nd week	1.65 inches
POST1: 7/12/01	POST1:	1st week	0.47 inches
Soil: Clay loam; 2.8% OM; 6.3 pH		2nd week	1.00 inches

VCRR=Visual Crop Response Rating (0=no injury; 100=complete kill)

Grft=Green foxtail
Rrpw=Redroot pigweed

COMMENTS: Excellent test area. Moderate foxtail and pigweed pressure. Crop response noted as delay at heading.

Treatment	Rate/A	Sorghum % VCRR Delay 9/11/01	% Grft 9/11/01	% Rrpw 9/11/01	Sorghum Yield bu/A
Check		0	0	0	24
Preemergence					
Outlook	20 oz	7	95	92	58
Bicep Lite II Magnum	1.9 qt	0	98	97	65
Preemergence & Postemergence					
Dual II Magnum&Permit	1.5 pt&.67 oz	2	97	97	73
Dual II Magnum&Aim+NIS	1.5 pt&.33 oz+.25%	30	98	97	60
Dual II Magnum&Paramount+ COC+28% N	1.5 pt&5.33 oz+ 1 qt+2 qt	33	98	97	48
Dual II Magnum&Peak+COC	1.5 pt&1 oz+1 qt	2	98	96	59
Dual II Magnum&2,4-D amine	1.5 pt&1 pt	0	96	98	51
Dual II Magnum&Clarity	1.5 pt&.5 pt	0	99	98	67
Dual II Magnum&Starane+LI-700	1.5 pt&.67 pt+.25%	0	95	98	60
Dual II Magnum&Shotgun	1.5 pt&3 pt	2	98	98	57
Dual II Magnum&Basagran+ Atrazine+COC+28% N	1.5 pt&1.25 pt+ 1.25 pt+1 qt+2 qt	0	95	98	52
Dual II Magnum&Buctril/Atrazine	1.5 pt&2 pt	0	94	98	53
Postemergence					
Atrazine+COC	1.25 qt+1 qt	3	71	96	58
Paramount+Atrazine+COC	5.33 oz+1 qt+1 qt	30	99	98	57
Paramount+Starane+ Atrazine+COC	5.33 oz+.5 pt+ 1 qt+1 qt	28	98	98	59
Preemergence & Postemergence 1					
Dual II Magnum&Buctril/Atrazine	1.5 pt&2 pt	5	91	98	64
Dual II Magnum&Marksman	1.5 pt&2 pt	8	86	97	36
Dual II Magnum&2,4-D amine	1.5 pt&1 pt	5	90	95	61
Dual II Magnum&Starane+ Atrazine+LI700	1.5 pt&.5 pt+ 1 qt+.25%	0	72	97	52
LSD (.05)		8	2	1	12

Table 5. Weed control in dry beans.

RCB: 3 reps	Precipitation:		
Planting Date: 5/25/01	PRE:	1st week	0.60 inches
Variety: Navy		2nd week	0.75 inches
PRE: 5/25/01	POST:	1st week	0.35 inches
POST: 6/19/01		2nd week	1.65 inches
Soil: Clay loam; 2.8% OM; 6.3 pH			

Grft=Green foxtail
Rrpw=Redroot pigweed

COMMENTS: Uniform plot area; moderate foxtail and light broadleaf pressure. Poast and Raptor provided excellent foxtail control.

Treatment		*Rate/A*	*% Grft 9/11/01*	*% Rrpw 9/11/01*
	Check		0	0
Preemergence				
	Dual II Magnum	1.67 pt	69	77
	Outlook	21 oz	78	72
	Lasso	2.5 qt	77	73
Preemergence & Postemergence				
	Command 3ME+Poast+COC	2 pt&1.5 pt+1 qt	89	95
	Spartan&Poast+COC	4 oz&1.5 pt+1 qt	91	95
	Spartan&Poast+COC	5.33 oz&1.5 pt+1 qt	95	97
Postemergence				
	Basagran+Poast+COC	1 qt+1.5 pt+1 qt	93	90
	Pursuit 2L	2 oz	84	77
	Raptor	4 oz	90	94
LSD (.05)			10	6

Table 6. Proso millet herbicide demonstration.

RCB; 3 reps
Planting Date: 5/24/01
Variety: SunUp
POST: 6/19/01
Soil: Clay loam; 2.1% OM; 6.5 pH

Precipitation:
POST: 1st week 0.35 inches
2nd week 1.65 inches

VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

COMMENTS: Primary objective crop tolerance. Crop response indicates slight delay for several treatments. No early-season response noted.

Treatment		Rate/A	Millet % VCRR 9/8/01	Millet Yield bu/A
Postemergence				
	2,4-D amine	.5 pt	8	22
	2,4-D amine	1 pt	13	24
	Clarity	2 oz	12	21
	Clarity	4 oz	12	21
	Peak+NIS	.5 oz+.25%	2	20
	Buctril	1 pt	0	21
	Check	----	7	28
	LSD (.05)		7	7

Table 7. Soybean herbicides to oats follow crop.

RCB; 3 reps
Planting Date: 5/25/00
Variety: NK S14-M7
POST: 6/22/00
Soil: Clay loam; 2.1% OM; 6.4 pH

VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

COMMENTS: Purpose to evaluate carryover effects from 2000 herbicides in soybeans. Check and Roundup treatment had highest yields. Pursuit carryover caused the greatest yield reduction. All treatments were treated with Roundup at 1 qt/A as a late post treatment to reduce effect of weed control differences.

Treatment		*Rate/A*	*Oat % VCRR 7/29/01*	*Oat Yield bu/A*
	Check		0	43
Preplant Incorporated				
	Treflan	1.5 pt	3	31
	Prowl	3 pt	0	31
Early Postemergence & Postemergence & Postemergence 1				
	Roundup Ultra+AMS&	1 pt+2 lb&		
	Roundup Ultra+AMS&	1 pt+2 lb&		
	Roundup Ultra+AMS	1 pt+2 lb	0	47
Postemergence				
	Pursuit DG+MSO+28% N	1.44 oz+1 qt+1 qt	70	1
	Raptor+MSO+28% N	5 oz+1 qt+1 qt	30	15
	LSD (.05)		16	13

Table 8. Cheatgrass control in winter wheat.

RCB; 3 reps
Planting Date: 9/26/00
PRE: 9/26/00
SPRING: 4/18/01
SPOST: 5/2/01
Clay loam; 2.5% OM; 6.2 pH

Precipitation:		
SPRING:	1st week	1.38 inches
	2nd week	0.00 inches
SPOST:	1st week	1.60 inches
	2nd week	0.30 inches

Dobr=Downy brome
Tamu=Tansy mustard

COMMENTS: Light cheat pressure. Very dry fall, limited fall emergence. Stand improved in spring; downy brome primarily spring development.

Treatment	*Rate/A*	*% Dobr 7/29/01*	*% Tamu 7/29/01*
Check		0	0
Preemergence			
Amber	.56 oz	0	98
Finesse	.4 oz	15	98
Treflan	1.5 pt	15	0
Maverick	.5 oz	81	98
Maverick	.67 oz	87	98
Maverick	1 oz	84	98
Spring			
Maverick+NIS	.5 oz+.5%	91	98
Maverick+NIS	.67 oz+.5%	91	98
Maverick+NIS	1 oz+.5%	93	98
Maverick+2,4-D ester+NIS	.67 oz+1 pt+.5%	95	98
Olympus+NIS	.6 oz+.25%	91	98
Olympus+NIS	.9 oz+.25%	90	98
Amber+NIS	.56 oz+.5%	15	98
Olympus+Sencor+NIS	.6 oz+4 oz+.25%	90	98
Spring Postemergence			
Maverick+NIS	.67 oz+.5%	79	98
Maverick+Harmony GT+NIS	.67 oz+.3 oz+.5%	81	98
Maverick+Clarity+NIS	.67 oz+4 oz+.5%	88	98
Maverick+Starane+NIS	.67 oz+.33 pt+.5%	75	98
Maverick+2,4-D ester+NIS	.67 oz+1 pt+.5%	83	98
Olympus+NIS	.6 oz+.25%	83	98
Olympus+2,4-D ester+NIS	.6 oz+1 pt+.25%	83	98
LSD (.05)		8	0

Table 9. Weed control in Clearfield wheat.

RCB; 3 reps
Planting Date: 9/26/00
Variety: Clearfield
E. SPRING: 5/2/01
Soil: Clay loam; 2.9% OM; 6.7 pH

Precipitation:
E. SPRING: 1st week 1.60 inches
2nd week 0.30 inches

VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Dobr=Downy brome
Wibw=Wild buckwheat
Tamu=Tansy mustard

COMMENTS: Experimental wheat; weed control evaluation. Dry fall conditions. Limited fall emergence; stand improved in spring. Good downy brome control.

Treatment	*Rate/A*	*W.Wheat % VCRR 7/29/01*	*% Dobr 7/29/01*	*% Wibw 7/29/01*	*% Tamu 7/29/01*
Check		0	0	0	0
Early Spring					
Raptor+MSO+28% N	4 oz+1 qt+1 qt	0	98	85	98
Raptor+MSO+28% N	5 oz+1 qt+1 qt	0	98	78	98
Raptor+MSO+28% N	6 oz+1 qt+1 qt	7	98	87	98
Raptor+MSO+28% N	10 oz+1 qt+1 qt	13	98	88	98
LSD (.05)		6	0	10	0

2001 Report
Suppressing Alternaria Blight of Safflower with Foliar Fungicides

M. Draper, L. Wrage, K. Ruden, D. Vos, S. Wagner, and *B. Rook*

Safflower is a relatively pest-free crop under a semi-arid production environment. The crop was showing great promise as a rotational alternative to wheat in western South Dakota. It has shown good yield potential and crops with high test weight can be paid a bonus for oil content.

However, as moisture and humidity increase, Alternaria blight caused by the fungus *Alternaria carthami* can become a serious disease. Alternaria blight typically appears late in the season and may lead to premature death of the crop. Test weight of the seed can be reduced, reflecting lower oil content, and infections of the head can lead to discoloration of the seed.

In 1997 and 1998, Alternaria blight was devastating, preventing the harvest of safflower fields near Wall and Kadoka, S.D. Disease pressure was greatly reduced in 1999 due to a drier and less humid environment than in the previous 2 years.

Materials and Methods

Trials were planted at a single location at the Highmore Research Farm. A widely planted variety, SF797, was used in the study. The crop was planted May 2, treated July 12, rated August 3, and harvested September 11, 2001.

Four fungicide treatments with three rates each were applied to the crop at early bud and compared with an untreated check (Table 1). Products and rates are listed in Table 1. Each treatment was replicated four times.

Results and Discussion

Most treatments led to a numerical increase in yield and test weight (Table 1), but significant differences were not observed among the fungicide combinations tested. Yields were lower than in 1998 and 1999 but greater than in 2000, ranging from 34 to 39 bu/A and 1373 to 1547 lb/A.

Folicur at 4 fl oz/A produced the best numeric yield response, followed by Quadris at 0.1 lb a.i./A and Folicur at 6 fl oz/A. Quadris at 0.1 lb a.i./A produced the greatest reduction in disease, with Folicur at 4 fl oz/A and Quadris at 0.125 lb a.i./A following close behind.

Alternaria leafspot was locally severe in 2001, but dry conditions prevented the disease from becoming more severe over a wide area. Dry conditions also prevented producers from achieving high yields.

Acknowledgements

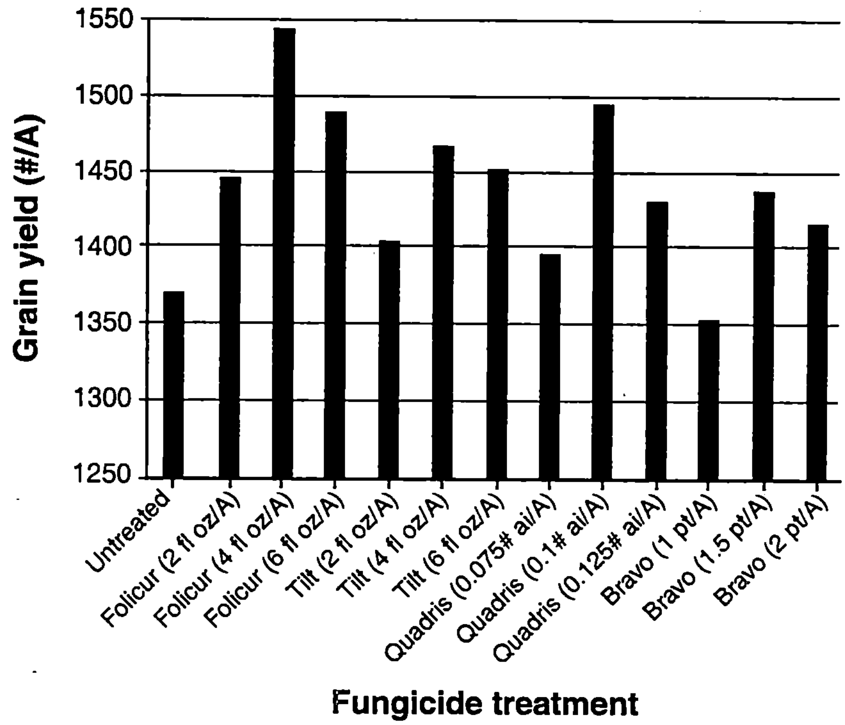
Costs for this research were offset in part by grants from the South Dakota Oilseeds Council.

Table 1: Yield and test weight response of safflower to various fungicide treatments.

Treatment	Rate	Crop stage	Whole Plot Disease Rating	Yield (bu/A)	Test Weight (#/bu)	Actual Yield (#/A)
Untreated	n/a	n/a	4.00	34.10	40.35	1372.97
Folicur	2 fl oz/A	Early bud	2.75	36.92	38.82	1447.55
Folicur	4 fl oz/A	Early bud	2.00	39.12	39.54	1547.26
Folicur	6 fl oz/A	Early bud	3.00	38.24	39.03	1493.42
Tilt	2 fl oz/A	Early bud	2.75	36.69	38.28	1406.57
Tilt	4 fl oz/A	Early bud	2.50	37.54	39.09	1469.14
Tilt	6 fl oz/A	Early bud	2.25	37.09	39.11	1454.20
Quadris	0.075 lb ai/A	Early bud	2.25	36.54	38.31	1397.21
Quadris	0.1 lb ai/A	Early bud	1.50	37.54	39.86	1498.37
Quadris	0.125 lb ai/A	Early bud	2.00	36.28	39.35	1434.39
Bravo WeatherStik	1 pt/A	Early bud	3.25	34.58	39.15	1355.49
Bravo WeatherStik	1.5 pt/A	Early bud	3.50	36.40	39.63	1440.28
Bravo WeatherStik	2 pt/A	Early bud	3.25	35.36	40.18	1420.34
$LSD_{(0.05)}$			NS*	NS	NS	NS

* Indicates means are not significantly different than the untreated control ($P_{0.05}$)

Figure 1: Safflower yields associated with various 2001 fungicide treatments.



2001 Report
Fertilizer and Soil Test Effects on Soybean Yield

Jim Gerwing, Ron Gelderman, Anthony Bly, and *Mike Volek*

Knowledge of soil test levels can improve the profitability of fertilizer use. Profits increase if more fertilizer is used when soil test levels are low or if little or no fertilizer is used when test levels are high. Frequently, however, the major nutrients (N P K) and sometimes zinc and sulfur are applied without a current soil test.

This experiment was initiated to demonstrate the effects of applying phosphorus, potassium, zinc, and sulfur regardless of soil test. The intent is to continue the experiment on the same location at the Highmore experiment station for a number of years. The planned rotation is soybean and wheat. The objective is to demonstrate soil testing's ability to predict crop response to fertilizer and fertilizer influence on soil tests.

Materials and Methods

The experiment was established on a Glenham loam soil series on the Highmore Station in 1997. Glenham soils are deep, well drained soils formed in friable glacial till.

Fertilizer treatments consisted of a check where no fertilizer was applied, 50 lb/a nitrogen and 50 lb/a nitrogen plus either 35 lb phosphorus (0-46-0), 50 lb/a potassium (0-0-60), 25 lb sulfur (21-0-0-24) or 5 lb Zn/a ($ZnSO_4$ – 35%). The nitrogen source was urea. The urea rate was adjusted in the sulfur treatment to give credit for the N in the ammonium sulfate.

All fertilizer treatments were broadcast by hand into the previous crop (wheat) residue on May 18 and incorporated by disking. Roundup Ready soybeans (Pioneer 91b33 RR) were drilled on May 19.

Plot size was 25 by 50 feet. Each treatment was replicated four times in a randomized complete block design. Yields were measured with a small plot combine.

Results and Discussion

Soil analysis on samples taken on May 18 is reported in Table 1. The 70 lbs of nitrogen applied to the previous wheat crop resulted in only an 11-lb-per-acre increase in soil residual nitrate over the check where no nitrogen had been applied since the start of the study in 1997. No nitrogen would have been recommended for soybeans. For this study, however, 50 lbs of N was applied to determine its influence on soybean yield.

The sulfur soil test was high and no sulfur would have been recommended. Previous application of sulfur did not result in increased sulfur soil test. The 25 lbs of phosphorus and 50 lbs of potassium applied each year since 1997 increased the phosphorus soil test from 10 ppm in this check to 19 ppm and the potassium soil test from 553 to 705 ppm. The phosphorus test (10 ppm) was in the medium range and 10 lbs of phosphorus fertilizer would have been recommended. The potassium soil test was very high and none would have been recommended.

The zinc soil test was raised from 1.08 ppm to 4.85 ppm by the annual addition of 5 lbs of zinc for 4 years. The check zinc soil test (1.08 ppm) was in the very high soil test range. No zinc would have been recommended regardless of soil test since soybean is usually not responsive to zinc.

Soybean yield, oil, and protein content are reported in Table 2. Yields were limited by very dry conditions in late July and August and were not affected by fertilizer treatment. The lack of response to fertilizer treatment was expected since soybeans do not normally respond to nitrogen and other soil tests were adequate for soybeans. Phosphorus was in the medium range but soybeans frequently do not respond to phosphorus in medium and higher testing soils.

Soybean seed protein was not influenced by the fertilizer treatments but there was a trend (Pr > .05) for increased oil content in the phosphorus and potassium treatments (Table 2).

This site will be rotated back to wheat in 2002. Similar fertilizer treatments (N rate will change) will be applied to the same plots.

Yields and soil tests from the previous 4 years of this study can be found in the 1997 - 2000 Highmore annual reports or in the 1997 - 2000 SDSU Plant Science Department Soil/Water Science Research Annual Report, TB No. 99.

Table 1. Soil test levels, Highmore, 2001.

Soil Test[1]	Check	Treated
Nitrate-N, lb/a		
0 – 6 inches	12	10
6 – 24 inches	30	43
Sulfate-S, lb/a		
0 – 6 inches	9	9
6 – 24 inches	28	19
Phosphorus, ppm	10	19
Potassium, ppm	553	705
Zinc, ppm	1.08	4.85
OM, %	3.5	
pH	6.4	
Salts, mmho/cm	0.4	

[1] Sampled 5/18/01

Table 2. Soybean yield, protein, and oil content, fertilizer trial, Highmore, 2001.

Fertilizer Treatment	Yield	Protein	Oil
lb/a	bu/a	%	%
0	22	30.1	15.5
50 N	20	28.6	16.7
50 N + 35 phosphorus	20	28.8	16.3
50 N + 50 potassium	19	29.3	16.4
50 N + 25 sulfur	21	29.0	16.0
50 N + 5 zinc	21	29.7	15.1
Pr. > F	0.58	0.10	0.05
CV %	12.6	2.6	4.4
LSD	NS	NS	0.9

2001 Report
Small Grain Variety Performance Trials

R. G. Hall, K. K. Kirby, and *L. Hall*

This reports the 2001 Highmore Research Farm performance trials for hard red spring wheat, spring oat, spring barley, and winter wheat varieties conducted by the SDSU Crop Performance Testing (CPT) program. The spring grain trials were seeded and harvested by L. Hall, Research Associate, SDSU Oat Breeding Project, and the winter wheat trial was conducted by the SDSU Winter Wheat Breeding Project led by Dr. Amir Ibrahim.

Experimental procedures

Four replicates of each entry were seeded into plots measuring 5 X 20 feet and later cut back to a uniform dimension prior to harvest. Either a cone-drill seeder (spring grain trials) or a no-till seeder (winter wheat trial) with a spinner directing seed to seven seed tubes spaced on 7-inch rows was used to seed the trials. The pure-live-seed (PLS) for each entry was determined and all plots were seeded at 1.2 million PLS per acre.

The spring trials were seeded on April 30, 2001, into a Trent silt loam previously cropped to soybeans. The winter wheat trial was seeded on September 25, 2001.

Measurements of performance

Yield (bu/a) and bushel weight (lb) values are an average of four replicates. Yields are adjusted to 13.5% grain moisture (dry matter basis) and bushel weights of 60 lbs (wheat), 32 lbs (oat), or 48 lbs (barley). Grain protein values are obtained from one sample per entry. Yield, bushel weight, and grain protein values are reported for year 2001 and for 3 years (1999-2001).

Performance results

Hard red spring wheat yields in 2001 (Table 1a) averaged 39 bu/a at Highmore, 46 bu/a at Spink County, 37 bu/a at Selby, and 62 bu/a at Brown County.

There were 5 entries in the top-yield-group (TYG) at Highmore, 11 at Spink County, 4 at Selby, and 5 at Brown County in 2001. There were also a number of entries in the TYG at Highmore, Selby, and Brown County for the longer 3-year term.

In 2001 the entries Alsen, Butte 86, Chris, Hanna, Ingot, Parshall, Reeder, SD3348, SD3367, SD3506, and ND722 were above average in protein on a statewide basis (Table 1b). In 2001, the entries Alsen, Ingot, Keystone, Knudson, SD3506, SD3546, and ND722 were above average in bushel weight statewide.

As indicated by top-yield percentages, the entries Knudson, Norpro, Reeder, and SD3546 were in the top-yield group 50% or more of the time on a statewide basis in 2001. Over the longer 3-year period, the entries Alsen, Butte 86, Ember, Forge, HJ98, Ingot, Ivan, Norpro, Oxen Parshall, Reeder, Russ, Saxon, Walworth, and SD3367 were in the top-yield group 50% or more of the time.

Oat yields in 2001 (Table 2a) averaged 39 bu/a at Highmore, 37 bu/a at Selby, and 62 bu/a at Brown County. There were 5 entries in the top-yield group (TYG) at Highmore, 8 at Selby, and 4 at Brown County in 2001. There were a number of entries in the TYG at Selby for the longer 3-year term.

In 2001 the entries Hytest, Loyal, Paul (hulless), Riser, Settler, SD97039, SD97525, and SD97839 (hulless) were above average in protein on a statewide basis (Table 2b). In 2001, the entries Paul (hulless), Hytest, and SD97839 (hulless) were above average in bushel weight statewide.

As indicated by 2001 top-yield percentages, Ebeltoft, Killdeer, SD96024, SD97039, SD97250, and MN97239 were in the top-yield group 50% or more of the time. Over the longer 3-year period, Don, Ebelftoft, Jerry, Loyal, Richard, Troy, and Youngs were in the top-yield group 50% or more of the time.

Barley yields in 2001 (Table 3a) averaged 84 bu/a at Highmore, 83 bu/a at Selby, and 97 bu/a at Brown County. There were 7 entries in the top-yield-group (TYG) at Highmore, 6 at Selby, and all 10 entries at Brown County in 2001. There were a number of entries in the TYG at Highmore, Selby, and Brown County for the longer 3-year term.

In 2001 entries differed by 1.5% in protein on a statewide basis (Table 3b). In 2001, the entries Conlon and Logan, both two-row types, were above average in bushel weight statewide.

As indicated by 2001 top-yield percentages, the entries Conlon, Logan, Drummond, Excel, Lacey, Legacy, and Stander were in the top-yield group 50% or more of the time on a statewide basis. Over the longer 3-year period, the entries Conlon, Logan, Drummond, Excel, Foster, Lacey, Robust, and Stander were in the top-yield group 50% or more of the time.

Hard red winter wheat yields in 2001 (Table 4a) averaged 29 bu/a at Highmore and 30 bu/a at Selby. At both locations the coefficients of variations (CV's) were 20% or higher. This indicated the amount of experimental error associated with test trials was above the acceptable upper limit of 15%. Consequently, no statistical analyses were done and valid variety yield differences could not be determined.

Although variety yield differences could not be obtained at these two locations, an examination of statewide variety performance can help to identify some of the better performing varieties (Table 4b). Although variety yield differences could not be identified at these two locations, 20 entries were above average in yield on a statewide basis in 2001. Likewise, 10 entries were above average in yield statewide over the longer 3-year term.

In 2001 the entries Crimson, Harding, Hondo, Jagger, Jerry, NuHorizon~W, Quantum 7588~H, Rose, Scout 66, Tandem, Wahoo, Wesley, SD92107-3, SD92107-5, SD97049, and SD97W604~W were above average in protein on a statewide basis (Table 4b). In 2001, the entries Avalance~W, Crimson, Harding, Hondo, Millennium, Nekota, NuPlains~W, Rose, Scout 66, Tandem, Trego~W, SD92107-3, SD92107-5, and SD97457 were above average in bushel weight statewide. As indicated by the winter survival percentages, 20 of the entries were above average in winter survival when averaged over seven locations.

Table 1a. HRS wheat variety test yield averages, 1999-2001 at four locations.

Variety	Highmore '01	Highmore 3-yr	Spink Co. '01	Spink Co. 3-yr	Selby '01	Selby 3-yr	Brown Co. '01	Brown Co. 3-yr
	bu/acre							
Alsen	37	30+	45	.	32	46	71+	48+
Butte 86	38	31+	44	.	30	45	64	45+
Chris,CK	38	26+	30	.	26	34	53	33
Ember	41	34+	37	.	40	54+	66	48+
Forge	46+	36+	46	.	37	50+	69+	50+
GM40002	34	.	41	.	33	.	47	.
GM40016	33	.	37	.	32	.	52	.
GM40019	39	.	51+	.	40	.	65	.
Hanna	35	.	48+	.	35	.	61	.
HJ98	35	28+	43	.	35	46	66	45+
Ingot	39	31+	42	.	38	50+	60	45+
Ivan	42+	33+	44	.	45+	53+	54	42+
Keystone	39	.	46	.	37	.	63	.
Knudson	45+	.	49+	.	41+	.	59	.
Norpro	50+	33+	55+	.	42+	48	57	41
Oxen	44+	33+	51+	.	35	49+	61	45+
Parshall	36	33+	43	.	33	51+	63	45+
Reeder	37	32+	54+	.	45+	54+	63	47+
Russ	37	32+	49+	.	39	50+	65	50+
Saxon	41	31+	48+	.	34	47	62	41
Walworth	37	33+	40	.	37	51+	50	46+
Experimental lines:								
SD3367	38	34+	47	.	34	50+	60	50+
SD3496	39	.	49+	.	37	.	65	.
SD3506	38	.	47	.	39	.	65	.
SD3540	41	.	52+	.	37	.	68+	.
SD3546	42+	.	50+	.	38	.	68+	.
ND722	40	.	46	.	37	.	68+	.
Test avg.:	39	32	46	.	37	49	62	45
LSD (5%) $:	8	ns$$	7	.	4	5	4	8
CV (%) #:	14	14	11	.	7	5	4	7

+ Entry is in top-yield group.
$ LSD (5%) - how much two values must differ to be sigificantly different.
$$ Differences within a column are not significant.
A measure of experimental error; a value of 15% or less is best.

Table 1b. Statewide performance averages for HRS wheat entries - 2001.

	Relative Heading day	2001 Protein pct	2001 Bushel Weight lb	2001 Height inches	Yield, bu/a '01	Yield, bu/a 3-yr	Top Yield Percentage* Variety '01	Top Yield Percentage* Variety 3-yr
Alsen	3	14.9+	62+	34	45	41	33	63+
Butte 86	0	14.1+	60	37	44	41	22	50+
Chris,CK	3	14.9+	59	41	36	31	0	13
Ember	1	13.1	61	35	49	45	22	100+
Forge	-1	13.4	61	37	50	46	44	100+
GM40002	-	13.5	59	33	39	.	0	-
GM40016	-	14.0	59	33	41	.	0	-
GM40019	-	13.4	60	30	48	.	33	-
Hanna	2	14.4+	60	39	44	.	11	-
HJ98	4	13.8	60	33	46	41	22	63+
Ingot	-1	14.3+	63+	38	45	43	22	88+
Ivan	5	13.3	61	32	47	44	44	100+
Keystone	2	13.5	62+	36	45	.	0	-
Knudson	2	13.6	62+	33	49	.	67+	-
Norpro	5	13.8	60	33	50	44	55+	75+
Oxen	2	13.9	60	33	46	44	44	100+
Parshall	4	14.4	61	38	45	44	0	88+
Reeder	3	14.3	61	36	50	45	67+	100+
Russ	2	13.8	60	38	48	45	22	100+
Saxon	5	13.9	59	35	47	42	44	75+
Walworth	3	14.0	60	35	44	45	11	100+
Experimental lines:								
SD3367	-	14.2+	61	36	45	45	11	88+
SD3496	-	13.8	61	36	45	.	22	-
SD3506	-	14.1+	62+	38	47	.	22	-
SD3540	-	13.7	61	36	49	.	44	-
SD3546	-	13.9	62+	37	49	.	55+	-
ND722	-	14.5+	62+	38	46	.	11	-
State test avg.:	-	14.0	61	36	46	43	-	-

+ Above average performance.

* Percent of time a variety appears in the top-yield group across nine (2001) or eight (1999-2001) test sites when experimental error was low as indicated by C.V. values of 15% or less.

Table 2a. Oat variety test yield averages (1999-2001) at three locations.

Variety	*Highmore* '01	*Highmore* 3-yr	*Selby* '01	*Selby* 3-yr	*Brown Co.* '01	*Brown Co.* 3-yr
			bu/acre			
Don	58	.	90	121	106	.
Ebeltoft	71+	.	111+	146+	133	.
Hytest	50	.	80	106	101	.
Jerry	55	.	85	132+	116	.
Killdeer	74+	.	115+	.	143+	.
Loyal	56	.	103	133+	147+	.
Paul Hls	41	.	53	73	85	.
Richard	84+	.	115+	129+	131	.
Riser	46	.	74	97	94	.
Settler	56	.	86	130+	108	.
Troy	62	.	121+	147+	118	.
Youngs	64	.	101	144+	129	.
Experimental lines:						
SD96024	66	.	116+	.	150+	.
SD97039	61	.	116+	.	138	.
SD97250	80+	.	114+	.	140	.
SD97525	55	.	86	.	111	.
SD97839-Hls	37	.	85	.	95	.
MN97239	80+	.	117+	.	148+	.
Test avg.:	61	.	98	123	122	.
LSD (5%) $:	13	.	12	18	9	.
CV (%) #:	15	.	9	7	5	.

+ Entry is in top-yield group.
$ LSD (5%) - how much two values must differ to be significantly different.
# A measure of experimental error; a value of 15% or less is best.

Table 2b. Statewide performance averages for oat entries - 2001.

	Relative Heading day	Protein pct	2001 Bushel Weight lb	Height inches	Yield, bu/a '01	Yield, bu/a 3-yr	Top Yield Percentage* Variety '01	Top Yield Percentage* Variety 3-yr
Don	0	14.8	36	31	92	100+	0	60+
Ebeltoft	8	15.1	32L	32	100+	114+	50+	100+
Hytest	3	18.3+	39+	36	81	83	0	0
Jerry	4	16.2	37	34	94	105+	0	80+
Killdeer	5	14.2	35	32	110+	.	75+	-
Loyal	7	17.2+	36	37	104+	109+	13	100+
Paul Hls	6	21.0+	43+	37	59	66	0	0
Richard	3	15.8	34	36	99+	102+	25	60+
Riser	0	18.6+	37	31	83	88	13	20
Settler	4	17.3+	36	35	91	100+	0	40
Troy	6	16.4	35	36	97+	105+	13	80+
Youngs	8	15.7	33L	36	99+	109+	0	60+
Experimental lines:								
SD96024	-	16.7	36	36	113+	.	75+	-
SD97039	-	17.2+	37	36	103+	.	25	-
SD97250	-	15.0	37	33	109+	.	50+	-
SD97525	-	17.8+	37	36	92	.	0	-
SD97839 Hls	-	18.9+	43+	33	75	.	0	-
MN97239	-	15.5	34	35	104+	.	50+	-
State test avg.:	-	16.8	37	34	95	98	-	-

+ Above average performance.
L One of the lowest bushel weight varieties under test.
* Percent of time a variety appears in the top-yield group across eight (2001) or five (1999-2001) test sites when experimental error was low as indicated by C.V. values of 15% or less.

Table 3a. Barley variety test yield averages (1999-2001) at three locations.

Variety	Highmore '01	Highmore 3-yr	Selby '01	Selby 3-yr	Brown Co. '01	Brown Co. 3-yr
	bu/acre					
Two-row types:						
Conlon	77	63+	85+	85+	94+	76+
Logan	93+	71+	84+	82+	96+	75+
Six-row types:						
Drummond	86+	60	83+	82+	96+	76+
Excel	89+	66+	80	81	98+	78+
Foster	83+	63+	79	80	98+	78+
Lacey	80+	65+	88+	87+	101+	77+
Legacy	87+	.	84+	.	96+	.
Mnbrite	82	60	79	76	94+	73+
Robust	75	59	80	77	92+	72+
Stander	91+	62+	86+	86+	101+	78+
Test avg.:	84	63	83	82	97	76
LSD (5%) $:	10	10	6	5	ns$$	ns
CV (%) #:	9	8	5	5	6	7

+ Entry is in top-yield group.
$ LSD (5%) - how much two values must differ to be significantly different.
$$ Differences within a column are not significant.
A measure of experimental error; a value of 15% or less is best.

Table 3b. Statewide performance averages for barley entries - 2001.

	Relative Heading day	2001 Protein pct	2001 Bushel Weight lb	Height inches	Yield, bu/a '01	Yield, bu/a 3-yr	Top Yield Percentage* Variety '01	Top Yield Percentage* Variety 3-yr
Two-row types:								
Conlon	0	12.1	50+	28	72	65	63+	88+
Logan	2	11.9	49+	29	76+	68+	88+	100+
Six-row types:								
Drummond	2	12.2	47	31	70	62	50+	50+
Excel	3	11.6	47	30	74+	67+	50+	75+
Foster	2	11.4	47	31	71	66	38	88+
Lacey	0	12.2	48	30	74+	69+	75+	100+
Legacy	2	12.0	47	31	74+	.	88+	-
Mnbrite	2	12.8	48	32	67	61	13	38
Robust	3	12.6	48	32	67	63	13	75+
Stander	3	12.0	47	30	72	64	63+	75+
State test avg.:	-	12.1	48	30	72	66	-	-

+ Above average performance.
* Percent of time a variety appears in the top-yield group across eight (2001) or eight (1999-2001) test sites when experimental error was low as indicated by C.V. values of 15% or less.

Table 4a. HRW wheat variety test yield averages (1999-2001) at Highmore and Selby.

Variety	Highmore '01	Highmore 3-yr	Selby '01	Selby 3-yr
		bu/acre		
Alliance	36	61	35	58
Arapahoe	40	56	32	50
Avalanche~W	23	.	29	.
CDC Falcon	39	.	30	.
Crimson	31	51	28	46
Culver	29	58	40	50
Golden Spike~W	25	.	24	.
Harding	29	50	39	50
Hondo	27	55	25	46
Jagger	18	52	24	42
Jerry	37	.	31	.
Millennium	34	61	36	54
Nekota	31	54	40	50
NuFrontier~W	26	.	26	.
NuHorizon~W	23	.	31	.
NuPlains~W	30	59	28	51
Quant.7588~H	19	59	37	61
Ransom	37	52	29	47
Rose	29	47	30	42
Scout 66	30	44	30	39
Stanton	24	.	21	.
Tam-107	14	50	31	47
Tandem	34	52	38	52
Trego~W	26	.	29	.
Vista	31	58	37	49
Wahoo	35	.	30	.
Wesley	33	62	30	54
Windstar	31	54	31	43
2137	22	59	31	52
Experimental lines:				
SD92107-3	33	.	30	.
SD92107-5	34	.	38	.
SD97049	29	.	22	.
SD97250	39	.	30	.
SD97457	30	.	32	.
SD97W604~W	24	.	19	.
SD97W609~W	27	.	32	.
SD97W650~W	23	.	23	.
Test avg. :	29	55	30	49
LSD (5%) :	.	ns$	.	.
CV (%) #:	20	11	22	18

~ A hard white (W) winter wheat.
$ Differences within a column are not significant (ns).
# A measure of experimental error; a value of 15% or less is best.

Table 4b. Statewide performance averages for HRW wheat entries - 2001.

Variety	Heading Diff. days	Yield, bu/a 2001	Yield, bu/a 3-yr	2001 Bushel Weight lb	2001 Protein pct	2001 Coleoptile length, inches*	2001 Winter Survival pct#
Alliance	2	50+	60+	58	11.4	2.1	64+
Arapahoe	3	52+	59+	58	12.7	2.4	60+
Avalanche~W	2	38	.	59+	12.6	2.6	40
CDC Falcon	4	52+	.	58	12.5	2.6	64+
Crimson	5	47+	53	61+	13.0+	3.4	64+
Culver	3	47+	56+	57	12.5	3.4	53
Golden Spike~W	7	38	.	54	12.2	3.2	48
Harding	5	49+	54	59+	13.0+	3.2	59+
Hondo	3	44	54	60+	12.9+	2.9	45
Jagger	0	36	53	56	13.9+	2.4	40
Jerry	6	53+	.	58	13.2+	2.9	58+
Millennium	4	52+	60+	60+	12.5	2.6	59+
Nekota	2	49+	56+	59+	12.5	2.9	62+
NuFrontier~W	4	42	.	57	12.4	3.4	41
NuHorizon~W	3	43	.	58	13.0+	3.4	46
NuPlains~W	3	43	55	60+	12.6	2.4	48
Quant.7588~H	2	49+	65+	56	13.0+	3.4	49
Ransom	5	53+	53	58	12.6	3.4	64+
Rose	5	43	50	60+	13.1+	3.4	50
Scout 66	2	42	46	59+	13.0+	3.7	54+
Stanton	1	40	.	58	12.6	3.2	43
Tam-107	0	38	53	56	12.7	3.2	45
Tandem	4	50+	55	60+	13.2+	3.4	61+
Trego~W	3	46	.	60+	12.1	2.4	54+
Vista	2	50+	57+	58	12.7	2.9	58+
Wahoo	3	48+	.	56	12.9+	3.2	54+
Wesley	2	51+	61+	58	13.7+	2.4	61+
Windstar	5	51+	57+	58	12.7	2.4	55+
2137	3	38	57+	57	12.0	2.1	37
Experimental lines:							
SD92107-3	4	50+	.	59+	12.9+	2.6	58+
SD92107-5	5	51+	.	59+	13.0+	3.4	63+
SD97049	3	46	.	57	12.8+	2.6	48
SD97250	3	50+	.	58	12.7	2.6	62+
SD97457	0	47+	.	59+	12.6	2.4	61+
SD97W604~W	1	40	.	58	13.1+	1.9	41
SD97W609~W	2	44	.	58	12.7	1.9	52
SD97W650~W	2	39	.	57	12.5	3.2	40
State test avg.:		46	55	58	12.7		53

+ Above average performance.
* Coleoptile length to nearest 0.1 inch.
# Average of seven locations: Brookings, Watertown, Highmore, Wall, Selby, Britton, and Winner.

2001 Report
Alfalfa Production

Vance Owens and *Eva Omdahl*

Alfalfa cultivars are tested at several South Dakota research stations. Our objective is to provide producers with yield data from currently available alfalfa cultivars to aid in cultivar selection. Even though our yield trial does not contain all available cultivars, it should be a helpful tool in identifying cultivars suitable for specific needs.

Table 1 provides forage production data from 14 different cultivars currently tested at Highmore. Tons of dry matter yield are shown for two individual cuttings in 2001, total production for 2000, total production for 1999, and a cumulative total for 1999 through 2001. Cultivars are ranked from highest to lowest based on the 3-year total. The least significant difference (LSD) at the bottom of the table is used to identify significant differences between cultivars. If the difference in yield between two cultivars exceeds the given LSD, then they are significantly different.

Alfalfa was planted in May 1998 at a seeding rate of 15 lbs pure live seed (PLS) per acre. Experimental design consists of six replications in a randomized complete block. Fifty pounds of super phosphate (P_2O_5) was applied preplant, as was Treflan for weed control. Later fertilizer application was made when necessary as recommended by the SDSU Soil Testing Laboratory.

Plots were harvested once in the establishment year, three times in 1999, and twice in 2000 and 2001. Forage was harvested with a sickle-type harvester equipped with a weigh bin for obtaining fresh plot weights. Random subsamples from the fresh herbage were taken to determine percent dry matter. Alfalfa cultivars were evaluated for maturity prior to harvest. Yield differences among cultivars were tested using the LSD at the 0.05 level of probability when significant F-tests were detected by analysis of variance (Table 1).

Table 1. Forage yield of 14 alfalfa cultivars entered in the SDSU alfalfa testing program. Trial is located at the Central Research Station at Highmore, S.D.

Entries	2001 1 June	2001 12 July	2001 Total	2000 Total	1999 Total	99-01 Total
	Tons Dry Matter/Acre					
WL 324	1.77	1.37	3.14	2.00	4.24	9.37
MagnumV	1.88	1.15	3.02	1.70	4.31	9.04
WL 232HQ	1.91	1.36	3.26	1.69	3.98	8.94
Pioneer Brand 53Q60	1.76	1.13	2.88	1.93	4.07	8.89
WL 325HQ	1.68	1.27	2.95	1.78	4.09	8.82
Goldrush 747	1.91	1.13	3.04	1.76	3.95	8.74
Vernal	1.92	1.05	2.97	1.46	4.13	8.56
Garst 620	1.72	1.14	2.86	1.56	4.11	8.53
Pioneer Brand 53V63	2.00	1.10	3.11	1.58	3.83	8.52
Husky Supreme	1.76	1.00	2.75	1.59	4.17	8.51
TMF 421	1.79	0.99	2.78	1.49	4.18	8.46
DK140	1.64	0.83	2.46	1.65	4.07	8.19
TMF Multiplier II	1.88	0.91	2.78	1.52	3.83	8.13
Frontier 2000	1.60	1.02	2.62	1.61	3.56	7.79
Mean	1.78	1.10	2.88	1.63	4.03	8.54
Maturity (Kalu & Fick)	4.0	6.0				
LSD (P=0.05)	NS	NS	NS	NS	0.37	NS
CV (%)	18.3	38.1	20.8	26.4	8.0	12.8

NS = not significant at 0.05 level of probability

2001 Report
Influence of Planting Date on Arthropod Infestations, Plant Growth, and Yield, Winter Wheat, 2000-2001 Growing Season

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Summary

1. Cereal aphid infestations and damage from chewing insects were light in winter wheat plots across all planting dates. These insects could not have affected yield directly.

2. The number of plants with symptoms of WSM or BYD was relatively low. The early planting had a greater number of plants with BYD symptoms than the intermediate planting.

3. Early- and middle-planted winter wheat tended to have the thickest crop canopies when measured at heading. There were no statistical differences in yield among planting date treatments. However, test weights for middle and late plantings were greater than that of the early planting.

Introduction

Yield of winter wheat can be reduced following fall infestation by arthropod pests such as cereal aphids and grasshoppers. Some wheat diseases, such as barley yellow dwarf (BYD) and wheat streak mosaic (WSM), also become prevalent when cereal aphids and curl mites are abundant in the fall.

Severity of arthropod infestations is generally affected by planting date, but specific differences in infestation levels have not been determined for various planting dates of winter wheat. Our objective was to measure arthropod population levels and damage, incidence of viral diseases, plant growth, and yield in winter wheat planted over a range of three dates.

Winter wheat plots

'Crimson' winter wheat was sown at three different planting dates ("early," August 31; "middle," September 11; and "late," September 25, 2000) at the Central Research Station at Highmore. Seed was sown about 1 inch deep using a Kirschman drill in furrows about 12 inches apart. Seed was treated with fungicides (mixture of 10% AI carboxin and 10% AI thiram, 6.8 fl oz (total product)/cwt) to limit several seed- and soil-borne diseases of wheat. Treatment plots (30 by 60 ft) were arranged in a RCB with four replications. Fertilizer (46-0-0 (N-P-K), 100 lb ac^{-1}) was applied at planting.

Insect sampling. We sampled 25 tillers (from five groups of five plants) per wheat plot for arthropod infestations and chewing insect damage on September 15 (early plots only), October 12 (early and intermediate plots), and October 25 (all plots). For each 25-tiller sample, we counted the number of cereal aphids per tiller and the number of plants damaged by insects with chewing mouthparts (e.g., grasshoppers, wireworms, and cutworms).

Viral diseases. We sampled for the incidence of viral diseases in wheat by walking through plots in a W-pattern and classifying 300 randomly selected plants per plot as either having or not having symptoms of BYD disease or WSM disease.

Leaf area measurements. The ratio of wheat-leaf area to the ground area upon which the wheat was grown was measured using the leaf-area index (LAI) feature of the LAI-2000 crop canopy analyzer on June 5, 2001. An above-canopy reference measurement was used as a benchmark for four within-canopy measurements per plot. Data were averaged across treatments and standard error of data means calculated using SAS software.

Yield data. Plots were harvested by hand and by a Massey-Ferguson 8XP combine on July 30. Hand-harvest yield was derived by taking three 1-foot sections of row per plot. Plants were cut at the ground level using scissors. Leaves, stems, and grain heads were placed into paper bags and dried to ambient humidity in a greenhouse. The number of heads was determined, and the grain was manually separated from the chaff. Total grain weight and 100-kernel weight was then measured. Data for grain yield in bushels per acre was extrapolated from the 1-foot grain-harvest samples.

Combine yield was taken from two 6-ft-wide combine strips within each plot; exact measurements of strips were made immediately after each pass. Moisture was measured for each combine strip sample, and yield data were adjusted to the equivalent weight at 13.5% moisture. Test weight and moisture content of combined grain were measured using a Dickey-John seed tester.

Results

Insects. Cereal aphids were virtually absent in the wheat plots, and we estimated that only 5% of the leaf area of wheat seedlings was defoliated. These insects could not have meaningfully limited plant growth or yield.

Viral diseases. The number of plants with symptoms of WSM was relatively low and did not differ among planting date treatments. The number of plants with symptoms of BYD was also relatively low, but the early planting had a greater number of symptomatic plants than the intermediate planting (Table 1).

Leaf area. At the time of leaf-area measurements, wheat in the early-, middle-, and late-planted treatments was in the early boot to full boot, late flag to early boot, and late flag stages of development, respectively. LAI readings showed that early- and middle-planted treatments had similar canopy densities (Table 2). Late-planted wheat had a thinner canopy than wheat grown in the early- and middle-planted treatments.

Yield. Results of hand-harvesting revealed that the numbers of seed heads and seeds per foot of row were less in the middle-planted treatment than in the early- and late-planted treatments (Table 2). Individual seed weight was greatest in the middle-planted wheat when compared with early- and late-planted treatments.

Results from combine-harvest samples showed no statistical differences in yield among plantings, even though the average for the early planting was over 4 bu less than that of the middle and late plantings (Table 3). Test weights for the middle and late plantings were greater than that of the early planting.

Acknowledgment

We thank Mike Volek and Kurt Dagel for help in establishing winter wheat. Dave Schneider, Cecil Tharp, Connie Cihlar, Toby Bryant, Julie Marler, and Malissa Mayer assisted in sampling the wheat plots.

Table 1. Percentage of winter wheat plants showing symptoms of wheat streak mosaic (WSM) and barley yellow dwarf (BYD), Central Research Station, Highmore.

Planting	*Plants with WSM symptoms (percent)*	*Plants with BYD symptoms (percent)*
Early	2.3 ± 0.4	3.2 ± 0.9 a
Middle	2.2 ± 0.4	0.6 ± 0.3 b
Late	1.8 ± 0.1	1.3 ± 0.6 ab

Values represent average ± standard error for 4 replicates of winter wheat planting date treatments (early = Aug 31, middle = Sep 11, and late = Sep 25, 2000). For BYD symptom averages, percentages followed by different letters have a probability less than 1 in 20 that they are similar statistically.

Table 2. Yield results from hand harvest of 'Crimson' winter wheat, July 30, 2001, Central Research Station, Highmore.

Planting[a]	*Crop canopy*[b] *(LAI)*	*Total heads (per foot of row)*	*Total seeds (per foot of row)*	*Seed weight (g per 100 seeds)*
Early	0.73±0.11	46±2	1236±72	2.78±0.06
Middle	0.73±0.04	41±4	1077±102	2.83±0.03
Late	0.63±0.03	44±3	1122±56	2.82±0.05

[a] Values represent average ± standard error for 4 replicates of winter wheat planting date treatments (early = Aug 31, middle = Sep 11, and late = Sep 25, 2000).

[b] Crop canopy characteristics were measured with a LAI-2000 leaf area index (LAI) meter on June 5, 2001.

Table 3. Yield results from combine harvest of 'Crimson' winter wheat, July 30, 2001, Central Research Station, Highmore.

Planting	*Yield bu acre^{-1}*	*Test weight lb bu^{-1}*
Early	29.0 ± 2.6	61.2 ± 0.4 a
Middle	34.8 ± 2.0	61.9 ± 0.2 b
Late	34.7 ± 1.3	62.2 ± 0.1 b

Values represent an average ± standard error for 4 replicates per planting of winter wheat (early = Aug 31, middle = Sep 11, and late = Sep 25, 2000). Test weights followed by different letters have a probability less than 1 in 20 that they are similar statistically.

2001 Report
Influence of Planting Date on Arthropod Infestations, Plant Growth, and Yield of Spring Wheat

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Summary

1. Cereal aphid infestations and damage from chewing insects were light in spring wheat plots regardless of planting date. These insects could not have directly limited plant growth or yield.

2. The percentage of plants with symptoms of WSM or BYD was low. However, the percentage of plants with WSM symptoms was greatest in the late planting, and the percentage of plants with BYD symptoms was greater in the late planting than in early planting.

3. Late-planted spring wheat tended to have a less dense canopy, fewer total seeds per foot of row, lighter seed weight, and less yield when compared with early- and middle-planted treatments. Combine yield and test weight were greatest in the early and middle plantings.

Introduction

Yield of spring wheat can be reduced following infestation by arthropod pests such as cereal aphids and infection with aphid-transmitted viral diseases such as barley yellow dwarf (BYD). Planting date can directly influence plant yield, but it may also influence infestation levels of insects, which may in turn affect plant growth and yield.

Specific differences in infestation levels have not been determined for various planting dates of spring wheat in South Dakota. Our objective was to measure insect infestation levels and damage, viral disease infection rates, plant growth, and yield in spring wheat planted over a range of three dates.

Spring wheat plots

'Ember' spring wheat was sown at three different planting dates ("early," April 27; "middle," May 8; and "late," May 16, 2001) at the Central Research Station. Seed was sown about 1 inch deep using a John Deere press drill in 7.5-inch wide rows. Seed was treated with fungicides to limit several seed- and soil-borne diseases of wheat. Treatment plots (30 by 60 ft) were arranged in a RCBD with four replications. Fertilizer (46-0-0 (N-P-K), 138 lb ac^{-1} and 14-36-13, 52 lb ac^{-1}) was applied at planting.

Insect sampling. We sampled 25 tillers (from five groups of five plants) per wheat plot for arthropod infestations and chewing insect damage several times in May and June. For each 25-tiller sample, we counted the number of cereal aphids per tiller and the number of plants damaged by insects with chewing mouthparts (e.g., grasshoppers, wireworms, and cutworms).

Viral diseases. We sampled for the incidence of viral diseases in wheat by walking along three transects and classifying 300 randomly selected plants per plot as either having or not having symptoms of barley yellow dwarf disease (BYD) or wheat streak mosaic disease (WSM).

Leaf area measurements. The ratio of wheat-leaf area to the ground area upon which the wheat was grown was measured using the leaf-area index (LAI) feature of the LAI-2000 crop canopy analyzer in the early, middle and late plantings on June 15, 22, and 29, respectively. An above-canopy reference measurement was used as a benchmark for four within-canopy measurements per plot. Data were averaged across treatments and standard error of data means calculated using SAS software.

Yield data. Plots were harvested by hand on August 7 and by a Massey-Ferguson 8XP combine on August 9. Hand-harvest yield was derived by taking three 1-ft sections of row per plot. Plants were cut at the ground level using scissors. Leaves, stems, and grain heads were placed into paper bags and dried to ambient humidity in a greenhouse. The number of heads was determined, and the grain was manually separated from the chaff. Total grain weight and 100-kernel weight was then measured. Data for grain yield in bushels per acre was extrapolated from the 1-foot grain-harvest samples.

Combine yield was taken from two 6-ft-wide combine strips within each plot; exact measurements of strips were made immediately after each pass. Moisture was measured for each combine strip sample, and yield data were adjusted to the equivalent weight at 13.5% moisture. Test weight and moisture content of grain combined over date of planting treatments were measured using a Dickey-John seed tester.

Results

Insects. Cereal aphid infestations and damage from chewing insects were both extremely low in spring wheat plots regardless of planting date. These insects could not have directly limited plant growth or yield.

Viral diseases. The percentage of plants with symptoms of WSM or BYD was low (Table 1). However, percentage of plants with WSM symptoms was greatest in the late planting, and the percentage of plants with BYD symptoms was greater in the late planting than in early planting.

Leaf area. At the times of leaf-area measurements in the early and middle planting, wheat was in the boot stage of development, whereas at the time of LAI measurements, the late-planted wheat was in the late boot stage to early heading. LAI readings showed that the early and middle planting dates had very similar canopy density measurements (Table 2). Late-planted spring wheat had the thinnest canopy.

Yield. Results of hand harvesting revealed a similar number of seed heads per row-foot across all treatments (Table 2). Number of seeds per row-foot, seed weight, and grain yield were much less for the late-planted treatment when compared with the middle- and early-planted treatments. Results of combine harvesting showed that yields and test weights were greater in the early and middle plantings than in the late planting (Table 3).

Acknowledgment

We thank Mike Volek for help in establishing the spring wheat. Dave Schneider, Cecil Tharp, Toby Bryant, Connie Cihlar, Julie Marler, and Malissa Mayer assisted in sampling the wheat plots.

Table 1. Percentage of spring wheat plants showing symptoms of wheat streak mosaic (WSM) and percentage showing symptoms of barley yellow dwarf (BYD), Central Research Station, Highmore.

Planting	*Plants with WSM symptoms (percent)*	*Plants with BYD symptoms (percent)*
Early	0.1 ± 0.1 a	0.7 ± 0.2 a
Middle	0.3 ± 0.2 a	0.8 ± 0.3 ab
Late	1.8 ± 0.5 b	1.7 ± 0.4 b

Values represent average ± standard error for 4 replicates of spring wheat planting date treatments (early = Apr 27, middle = May 8, and late = May 16, 2001). Within each column, percentages followed by different letters have a probability less than 1 in 20 that they are similar statistically.

Table 2. Yield results from hand harvest of 'Ember' spring wheat, August 7, 2001, Central Research Station, Highmore.

Planting[a]	*Crop canopy*[b] *(LAI)*	*Total heads (per row-foot)*	*Total seeds (per row-foot)*	*Seed weight (g per 100 seeds)*	*Yield (bu acre^{-1})*
Early	3.8±0.1	30±1	870±54	3.00±0.05	66±4
Middle	4.1±0.2	33±3	887±65	2.94±0.05	66±5
Late	3.2±0.1	29±2	785±51	2.29±0.05	46±3

[A] Values represent average (± standard error) for 4 replicates of spring wheat planting date treatments (early = Apr 27, middle = May 8, and late = May 16, 2001).

[b] Crop canopy characteristics were measured with a LAI-2000 leaf area index (LAI) meter on June 15, 22, and 29, 2001, for early, middle, and late planting treatments, respectively.

Table 3. Yield results from combine harvest of 'Ember' spring wheat, August 9, 2001, Central Research Station, Highmore.

Planting	*Yield bu acre^{-1}*	*Test weight lb bu^{-1}*
Early	55.0 ± 2.3 a	61.1 ± 0.3 a
Middle	48.0 ± 3.1 a	61.0 ± 0.3 a
Late	33.8 ± 2.1 b	59.1 ± 0.3 b

Values represent an average for 4 replicates per planting of spring wheat (early = April 27, middle = May 8, and late = May 16, 2001. Yields and test weights, respectively, followed by different letters have a probability less than 1 in 20 that they are similar statistically.

2001 Report
Winter Wheat Breeding and Genetics

Amir Ibrahim, Steve Kalsbeck, and *Rich Little*

Summary of Activities

The Winter Wheat Breeding and Genetics Program utilizes the Central Research Station at Highmore primarily for early-generation testing and evaluation of advanced-generation lines. Field trials at several other sites throughout South Dakota are also in the breeding program..

Central Research Station trials conducted in 2001 by the Winter Wheat Program included:
1. The CPT Variety Trial, under the overall coordination of Bob Hall. The trial included 37 entries, consisting of 26 released varieties (including new releases from other states), 8 advanced experimental lines from our program, 2 experimental lines from General Mills, and 1 experimental line from Colorado. This trial was also grown at 15 other sites in South Dakota.

Prior to cultivar release, promising elite lines must be grown in the CPT Variety Trial for 3 years to accurately measure potential performance across a range of environmental conditions. Yield and test-weight for the CPT entries are listed in Table 1.

2. The South Dakota Advanced Yield Trial (AYT), with separate nurseries for hard red and hard white lines. The AYT Red nursery included 35 entries, consisting of 28 advanced experimental lines and 7 checks. Ten of the experimental lines have the white bran color. The AYT nurseries were also grown at six other sites in South Dakota.

Each year, three to six superior experimental lines are selected from these nurseries and advanced to the CPT Variety Trial and the Northern Regional Testing Program. Performance data for the 2001 AYT nursery are listed in Table 2.

3. Early-generation F_2-bulk populations, consisting of 204 different cross combinations. Undesirable F_2 populations are eliminated from the program based largely on visual observations, pedigree and parental characteristics, and bulk yield. Desirable F_2 populations are advanced to the F_3 bulk nursery for further evaluation prior to head selection the following year.

Trial Conditions

The nurseries at Highmore were planted 1.5 inches deep into soybean cover with very dry top soil on September 25, 2000. Fall stand establishment was poor due to a combination of early fall cold temperatures and dry soil conditions. Due to the severe winterkill, spring stand also was poor. Plots were sprayed on April 26, 2001, with 5 quarts Ramrod per acre and in early May with 1.5 pints Bronate per acre. Yield and agronomic data are presented in Table 1 for the Crop Performance Trial and in Table 2 for the Advanced Yield Trials.

Acknowledgements

Each year, 600-800 new cross combinations are made and 600-800 new experimental lines are developed by the winter wheat breeding program. In addition to the excellent support of our wheat pathology programs (small grains pathology and virology), the solid and consistent financial support from the South Dakota Wheat Commission and the South Dakota Crop Improvement Association are vitally important to ensuring continued availability of improved winter wheat varieties for producers in South Dakota.

Table 1. Yield and testweight results of entries in the 2001 Crop Performance Testing (CPT) Nursery at Highmore and 2- and 3-year averages across selected locations.

	HIGHMORE				STATEWIDE†			
	2001		1999-2001		2000-2001		1999-2001	
ENTRY	YIELD bu/ac	TW lbs/bu	YIELD bu/ac	TW lbs/bu	YIELD bu/ac	TW lbs/bu	YIELD bu/ac	TW lbs/bu
ARAPAHOE	40	58	56	59	56	59	58	60
FALCON	39	59	--	--	--	--	--	--
SD97250	39	58	--	--	--	--	--	--
JERRY	37	58	--	--	--	--	--	--
RANSOM	37	56	52	57	51	58	51	58
ALLIANCE	36	58	61	59	58	59	60	59
WAHOO	35	55	--	--	56	58	--	--
SD92107-5	34	58	--	--	55	60	--	--
TANDEM	34	59	54	60	52	60	54	60
MILLENNIUM	34	60	62	60	55	60	59	60
WESLEY	33	58	63	59	59	58	62	59
SD92107-3	33	57	--	--	55	60	--	--
VISTA	31	59	58	60	56	59	56	59
CRIMSON	31	60	51	62	50	61	52	61
NEKOTA	31	60	56	60	54	60	56	60
WINDSTAR	31	58	55	58	52	58	56	58
NUPLAINS	30	61	60	61	52	61	55	61
SD97457	30	58	--	--	57	60	--	--
SCOUT66	30	60	45	60	47	60	45	60
ROSE	29	57	48	60	45	60	49	61
CULVER	29	57	58	59	53	58	56	59
SD97049	29	57	--	--	--	--	--	--
HARDING	29	55	50	58	52	60	53	60
SD97W609	27	58	--	--	50	59	--	--
HONDO	27	60	56	61	49	60	54	61
TREGO	26	60	--	--	53	61	--	--
NUFRONTIER	26	59	--	--	--	--	--	--
GOLDEN SPIKE	25	50	--	--	--	--	--	--
SD97W604	24	60	--	--	51	60	--	--
STANTON	24	58	--	--	--	--	--	--
AVALANCHE	23	59	--	--	--	--	--	--
NUHORIZON	23	59	--	--	--	--	--	--
SD97W650	23	57	--	--	--	--	--	--
2137	22	59	59	60	51	59	59	60
QUANTUM 7588	19	54	--	--	58	58	--	--
JAGGER	18	54	53	59	49	58	56	59
TAM 107	14	57	50	59	51	58	54	58
Mean	48	58						
LSD (.05)	6	2						
C.V. (%)	9	3						

† CPT Averages at selected locations throughout South Dakota: 2001--Britton, Highmore, Oelrichs, Wall, Winner; 2000--Dakota Lakes Pea Stubble, Dakota Lakes Spring Wheat Stubble, Highmore, Newell, Oelrichs, Platte, Wall, Winner; 1999--Dakota Lakes Pea Stubble, Dakota Lakes Spring Wheat Stubble, Highmore, Oelrichs, Platte, Wall, Winner.

Table 2. Advanced Yield Trials (AYT) agronomic results for the year 2001 at Highmore including averages with AYT nurseries at Wall, Winner, Selby and Brookings.

	Highmore		2 Locations		3 locations		4 locations		5 locations
ENTRY	Yield bu/ac	TW lb/bu	Height inches	Lodging (Scale 1-5, 1 is best)	Heading (Relative Days)	Yield bu/ac	Testweight lb/bu	Testweight Rank	Survival (Scale 1-9, 9 is best)
NW98S059**	24	57.8	28	4	2	59	57.8	9	5
SD96306**	27	57.3	29	3	3	59	58.1	7	6
SD97088**	28	57.1	30	3	4	59	57.2	15	6
SD98430*	35	55.9	26	2	2	58	55.8	28	6
Alliance	25	57.0	26	3	2	58	57.0	18	7
SD97432*	21	56.5	28	2	2	58	56.9	20	6
SD98102**	32	59.3	29	3	4	57	58.9	3	6
Wesley	26	57.8	24	2	2	56	58.5	5	7
SD98428*	19	58.2	25	3	2	56	56.7	24	6
SD97060*	29	56.4	31	3	6	55	56.8	23	6
SD97475	29	57.0	27	3	4	55	56.7	25	6
SD97538*	24	55.9	27	2	3	55	57.1	16	6
Crimson	28	60.7	30	5	5	54	60.3	1	7
SD98W198**	20	58.3	26	3	0	53	59.2	2	5
SD97007	12	55.1	27	3	1	52	56.5	26	6
SD92107-2*	25	56.3	31	2	6	51	57.6	11	6
SD98383	25	58.9	29	3	0	50	58.9	4	7
SD98226*	25	58.6	27	3	0	50	57.8	10	6
Trego	23	58.4	26	3	2	50	57.2	14	6
SD97W650**	25	58.8	23	2	1	48	57.3	13	5
CO980894	24	57.0	24	3	0	46	54.3	34	4
TAM 107	9	55.1	24	3	0	44	54.7	33	5
SD98243	16	56.2	27	2	1	44	57.3	12	6
Nuplains	31	59.9	27	3	6	43	58.1	6	5
SD98286	27	56.2	24	2	2	42	57.0	17	5
SD98W175	17	56.5	26	2	4	39	56.2	27	4
CO980889	13	52.9	23	3	0	39	54.1	35	5
SD98351	22	56.8	26	3	2	38	56.9	21	5
SD98W113	18	52.8	27	2	6	38	54.9	32	4
SD98W117	24	56.6	28	2	4	35	56.8	22	3
SD98W187	15	57.3	27	2	1	32	58.0	8	4
SD98W126	27	54.1	28	2	7	32	55.1	31	3
NW98S097	24	56.2	26	2	6	28	55.6	30	4
SD98W127	19	55.8	26	2	4	28	57.0	19	3
Estica	18		23	1	9	12			2
MEAN	23	55.3	27	2		47	57.0		5
LSD (P<.05)	10	3.6	2						1
C.V. (%)	26	3.8	7						31

* Selected for the 2002 AYT Nursery

** Selected for both the 2002 AYT and CPT (Crop Performance Testing) Nurseries

2001 Report
Oat Research

Lon Hall

The most important characteristics for varietal release are yield, yield stability, and test weight. However, there may be several factors that will contribute to the increase of these characteristics. Genetics, lodging resistance, barley yellow dwarf resistance, and crown and stem rust resistance all contribute to increased yield and test weight. Some other characteristics considered when releasing a variety are hull percent, high protein, high oil, low oil, plant height, maturity, hulled or hulless, and hull color.

Consumers require different characteristics for specific needs. Several millers want a high protein oat. The livestock producer wants a high oil, high protein, tall variety. The racehorse industry wants a white-hulled variety or high quality naked oat.

The Tri-State nursery is the only nursery grown at Highmore; its purpose is to add another environment for preliminary regional material. The Tri-State regional nursery is made up of 30 lines and 6 checks. The 30 lines consist of 10 advanced lines each from Minnesota, North Dakota, and South Dakota. The best lines will be entered in either the Uniform Early Nursery (UEO) or the Uniform Midseason Nursery (UMO) the following year.

The UEO is a regional nursery made up of 27 early maturing lines from breeding programs across the United States. We entered three lines this year; out of these three, one looks very promising for release in 2002. Compared to Don, SD97525 has better test weight, higher yield potential, better crown rust resistance, and a similar maturity.

The UMO is made up of 34 advanced medium and late maturing lines, usually one to three lines (we had three) from each of the participating state and Canadian breeding programs.

One of the South Dakota lines, SD96024, was the top yielder in the UMO (2000) and the South Dakota Standard Variety Oat Trials in 2000 and 2001.

The data collected from the regional nurseries provide valuable information needed for varietal release and germplasm selection for crossing in our program. The most advanced lines in the regional nurseries are simultaneously tested in the Standard Variety Oat trials across the state.

Plant breeding is a long, drawn-out process. The bulk breeding method takes, on average, at least 10 years from the initial cross to varietal release. This process can be speeded up a couple of years by using the single-seed descent method, which involves two extra generations in the greenhouse. Seeds are hand picked from bulk lines (segregating crosses) on basis of color, kernel size, and kernel shape, busted tip (thin hull), and, in the case of hulless oats, a large, hairless, white groat.

In the fall greenhouse, 500 selected seeds per cross (from 50 crosses) are planted in four 6-inch pots, the plants are then inoculated with several crown rust strains, and susceptible plants are discarded. The idea is to skew the population for desired characteristics before plants reach yield plots.

A single seed from each plant is harvested; about 1600 are selected based on hull color or naked groats and are planted, one to a pot, in the spring greenhouse. The seeds from these single plants are planted in a 5-ft by 5-ft yield plot about the first of May. It is possible to have yield plots 2 years after the initial cross is made using the single-seed descent method.

However, we don't want to put all our eggs in one basket, so a combination of the bulk and single-seed descent methods seems to work well.

For every oat variety released, approximately 40,000 non-segregating lines are evaluated.