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Contents

ALFALFA ESTABLISHMENT

ECONOMICS OF ESTABLISHING NO-TILL ALFALFA ON HIGH-ELEVATION MEADOWS

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Cooperating with River Meadow Ranch (Kurt Bucholz)
and CSU Beef Improvement Center (Mike Moon)

Alfalfa (Medicago sativa) is the most important crop in Wyoming, yet its use in high-elevation meadows has been limited. Although soil depth or drainage is not adequate on some fields, alfalfa could be grown on many others. Currently, very little alfalfa is seeded on high-elevation meadows due to the high costs of traditional methods, large amount of labor involved, inadequacy of equipment, and/or uncertainty of results.

Increasing the acreage of alfalfa would improve production and quality of winter feed, and could allow difficult-to-hay meadows to be converted to pasture.

With the availability of herbicides that control a broad spectrum of sod species, the no-till method of seeding is a reality. Alfalfa has been successfully no-till seeded on 20 or more fields across the state. With the recent decline in herbicide costs, this new opportunity for seeding alfalfa is very appealing.

The traditional method of seeding meadows includes plowing, additional tillage, and rough-leveling. Unless the soil is light, the seedbed probably will not be adequate for perennial seeding the first year. Therefore, oats (Avena sativa) are seeded the first year and harvested as hay. The meadow is replowed, tilled again, leveled, and planted the second year to oats-alfalfa or, if the seedbed is still rough, alfalfa seeding may be delayed until the next year. Depending on the toughness of the sod, the degree of leveling needed, and the ability to obtain a fine, firm seedbed, it may require as many as three years to establish alfalfa on the meadow.

Materials and Methods

With a Department of Energy grant, two studies were initiated in 1990. Kurt Bucholz with the River Meadow Ranch and Mike Moon at the John E. Rouse-CSU Beef Improvement Center cooperated. In the spring of 1990, cooperators tilled fields in the traditional manner and recorded time spent and fuel use for each operation. Adjacent to the tilled blocks, a no-till seeding block was established. Conventional and no-till blocks were seeded on May 31 and June 4, 1990 for the River Meadow and Rouse ranches, respectively. The River Meadow Ranch is at 6,700 feet. and the Rouse Ranch is at 7,300 feet. At both ranches the soil was a sandy loam. At each location there were single blocks of each seeding method.

At the River Meadow Ranch the meadow was flood irrigated. The sod was primarily smooth bromegrass (Bromus inermis), but bluegrass (Poa pratensis), quackgrass (Agropyron repens), and dandelions (Taraxacum officinale) were present. The field was moldboard plowed, disked, roller-harrowed, and leveled.

At the Rouse Ranch the sod was dominated by smooth bromegrass, but contained alfalfa that had thinned considerably since establishment nine years previously. The sod was roto-tilled and the seedbed roller-harrowed. This field was irrigated by center-pivot. Because neither field was rocky or native sod, a seedbed for alfalfa establishment was prepared in one year.

Results

Fuel and labor savings of the no-till method are shown in Table 1. Alfalfa was no-till seeded with about 1 gallon of fuel and one hour of labor per acre. The conventional tillage method of seeding required 15 to 16 gallons of fuel and three to over six hours of labor per acre. Fuel and time required for the traditional method would have been greater if the sod had never been turned or was a heavy or rocky.

During the establishment year on the River Meadow Ranch, no-till alfalfa yielded less than conventionally seeded alfalfa (about 1/2 vs 3/4 tons per acre of forage). However, yields in subsequent years were slightly greater for the no-till seeding. At the Rouse Ranch, alfalfa vigor with both methods was poor the year of seeding, with plant height no more than 6 inches for the year. This may have been the result of autotoxicity from the old alfalfa plants that recovered from the spring herbicide in the no-till treatment or from the decomposing alfalfa in the tilled treatment. Current research is directed toward the fall kill of old alfalfa and sod, with early spring no-till seeding of oats or alfalfa the next year.

Table 2 shows the comparative costs, based on custom rates, of establishing alfalfa in meadows by conventional and no-till methods. The cost of the herbicide glyphosate (Roundupß?ß), and now sulphosate (Touchdownß?ß), has declined in recent years, but costs of labor, fuel, and equipment, upon which the conventional method relies heavily, have continued to increase. Therefore, the cost advantage has swung in favor of the no-till technique. Costs of no-till seeding are 2/3 those of the traditional method. The costs do not include seed, fertilizer, or lost production the year of seeding, all of which would be similar for the two methods. Using the data in Table 1 and assuming $8 per hour for labor and $.98 per gallon for diesel fuel, the average savings on labor was $30.28 per acre and the average savings for fuel was $14.62 per acre with the no-till seeding method.

Table 1. Fuel and labor requirements for seeding alfalfa with and without tillage on high-elevation meadows at two locations in Wyoming.

Seeding method	River Meadows Ranch Fuel/A	Labor/A	Rouse Ranch Fuel/A	Labor/A
	(gal)	(hr)	(gal)	(hr)
Conventional till	16.3	6.4	15.5	3.2
No-till	1.0	0.9	1.0	1.1

Table 2. Comparative costs1 for no-till (sod seeding) and conventional seeding of alfalfa.

Operation	Conventional	No-till
	(dollars per acre)	

Plowing	$25.00	---
Disking (twice)	16.00	---
Roller-harrowing	7.50	---
Leveling	8.00	---
Drilling2	9.50	$17.00
Herbicide3	---	23.00
Herbicide application	---	3.50
Total	$66.00	$43.50

1 Average custom rates (information from Custom Rates for Farm-Ranch Operations in Wyoming, March 1991).

2 Assuming an eight-foot no-till drill costs $12,000, seeds 200 acres per year at 2-1/2 acres per hour with a 15-year life and requires a 70-horsepower tractor.

3 Glyphosate or sulphosate used at 1-1/2 pounds active ingredient per acre.

RESPONSE OF ALFALFA TO PESTICIDES IN NO-TILL ESTABLISHMENT OF ALFALFA

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The surface mulch of mountain meadow sod is maintained in no-till seeding of alfalfa (Medicago sativa L.). These conditions should favor the harboring and development of pests. In addition, the prolonged period of favorable surface soil moisture makes this an ideal habitat for many microorganisms including phycomycetous fungi such as Pythium and Phytophthora, as well as phytoparasitic nematodes. Therefore, a study was established to determine the need for and effect of various pesticides in relation to the no-till seeding of alfalfa in intermountain meadows. The site was located near Laramie, Wyoming at 6,700 feet elevation.

Materials and Methods

The field was a sod-bound smooth brome (Bromus inermis L.). The soil was high in phosphorus (34 parts per million PO4) and potassium (350 parts per million K) and had a pH of 6.9 and organic matter content of 9.5 percent. 'Ranger' alfalfa, which is susceptible to all major pests in Wyoming, was seeded at 10 pounds pure live seed per acre on June 10, 1986 with a John Deere Powrtillß?ß drill. At the time of seeding the sod was completely desiccated from the previous treatment with glyphosate. Glyphosate was applied 17 days prior to seeding except in the untreated check.

Treatments consisted of (1) Roundupß?ß (glyphosate) herbicide alone; (2) glyphosate + molluscicide; (3) glyphosate + insecticide/nematicide; (4) glyphosate + fungicide; (5) glyphosate + insecticide/nematicide + fungicide; and (6) untreated check. Glyphosate was broadcast-applied at 1.13 pounds acid equivalent per acre (1 1/2 quarts per acre) and 0.5 percent volume/volume X-77ß?ß surfactant on May 23, 1986 when sod was 4 to 6 inches tall. The molluscicide, Mesurolß?ß (2 percent methiocarb bait), was broadcast applied 1 pound per 1,000 square feet on June 11, 1986, the day after planting. The insecticide/nematicide, Furadan 10Gß?ß (carbofuran), was mixed with seed and applied at 10 pounds per acre on June 10, 1986. The fungicide, Ridomil 2Eß?ß (metalaxyl), was applied as a drench at 2.67 gallons per 100 square feet (4.9 ml product per gallon) on June 11, 1986.

The experimental design was a randomized complete block with four replications. Plot size was 20 by 20 feet. Row spacing was 8 inches. The seeding was flood irrigated on June 17 and July 7, 1986 and twice in 1987 and 1988. Data on seedling stand counts, nematode soil populations, insect injury, plant height (vigor), and forage yield was collected. Because no alfalfa seedlings were observed in untreated plots, 120 pounds per acre of N was applied in early spring 1987, so that alfalfa-seeded plots could be compared with N-fertilized grass.

Results

Excellent control of sod was obtained with the application of glyphosate. The primary invading weeds during the year of establishment were field pennycress (Thlaspi arvense L.) and common marestail (Hippuris vulgaris L.).

All pesticides increased alfalfa seedling numbers at five weeks after seeding (July 15) (Table 1).

By November, however, there were similar numbers of alfalfa seedlings on all pesticide-treated plots. The insecticide/nematicide, carbofuran, reduced damage from the sod webworm (Crambus spp.) and reduced nematode numbers, but this did not result in a denser alfalfa stand or greater production the following spring. The major parasitic nematode present was the stunt nematode. The molluscicide, methiocarb, reduced nematodes but had no lasting impact on stand or yield of alfalfa. All plots were monitored for slugs but none were found. Welty et al. (1983) reported increased alfalfa stand density and control of slug feeding from use of metaldehyde (molluscicide) in three seedings in Montana in 1979; however, yields of alfalfa the following year were not significantly greater than the untreated check. Glyphosate was applied one week before planting in their study. Perhaps, waiting until sod is completely desiccated following herbicide application, as in this study, reduces or eliminates slugs and possibly other pests as well.

Glyphosate was essential to establish alfalfa seedlings into smooth bromegrass sod (Table 1). This is in agreement with a previous study (Mueller-Warrant and Koch, 1980). In plots treated with herbicide (glyphosate), yield of alfalfa in June 1987 was nearly one-half ton of hay greater than for the smooth bromegrass fertilized with 120 pounds per acre of nitrogen (Table 2). The second harvest of bromegrass was 0.28 ton per acre. Alfalfa was not harvested a second time due to severe deer grazing. Similar yields and comparisons were obtained in 1988. With all herbicide-treated plots, alfalfa comprised greater than 90 percent of harvested forage in 1987 and 1988.

Conclusions

Glyphosate was the only pesticide used that was essential for no-till alfalfa establishment. Although there was some early benefit from other pesticide treatments during the establishment year, stands and yields the year after were not improved.

Table 1. No-till seeding of alfalfa with various pesticides at Exotex Ranch, Laramie, WY on June 10, 1986. Numbers are averaged over four replications.

Treatment	Alfalfa stand density 7/15/86	11/5/86	4/16/87	Nematode count 11/86	Plants with insect[1] damage
	------(no. ft2)------			(per 100 cm3 soil)	(no./ft row)
Untreated check[2]	0	0	0	26	-
Glyphosate only[3]	8	6	6	13	1.1
+ molluscicide[4]	15	8	7	7	2.2
+ insecticide/nematicide[5]	17	8	7	5	0.4
+ fungicide[6]	16	8	7	20	1.3
+ insecticide/nematicide and fungicide	18	8	7	6	0.4
LSD.05	3	4	3	5	0.6

1 Sod webworm was the only insect identified as damaging alfalfa seedlings.

2 Received none of the pesticides, but was seeded with alfalfa. Because no alfalfa seedlings were found in the spring of 1987, 120 pounds per acre of nitrogen fertilizer was applied.

3 Applied tank mix of 1 1/2 quarts per acre of Roundupß?ß and 1/2 percent volume/volume X-77ß?ß on May 23, 1986 to all but check treatments.

4 Applied as a 2 percent methiocarb bait of Mesurolß?ß at 1 pound per 1,000 square feet on June 11, 1986. No slugs were found.

5 Mixed with alfalfa seed at rate of 10 pounds per acre of Furadanß?ß 10 granular formulation.

6 Ridomilß?ß 2E was mixed at rate of 4.9 cubic centimeters per gallon water and applied as a drench at rate of 2.67 gallons per 100 square feet.

Table 2. Hay yields[1] and plant height following various pesticide treatments and no-till seeding of alfalfa at the Exotex Ranch, Laramie, WY.

Treatment	Hay yield, 12% moisture 6/26/87	7/1/88	Plant height (in) 7/15/86
Untreated check	2.44	2.23	-
Herbicide only	2.88	2.91	2.3
+ molluscicide	2.85	2.82	3.1
+ insecticide/nematicide	2.89	3.06	4.0
+ fungicide	3.01	3.03	2.5
+ insecticide/nematicide and fungicide	3.01	2.94	3.6
LSD.05	0.26	0.31	0.4

1 Yield of regrowth of untreated check (smooth bromegrass fertilized with 120 pounds per acre of nitrogen fertilizer) was 0.28 ton per acre in 1987 and 0.39 ton per acre in 1988. Alfalfa regrowth was not harvested due to extensive deer grazing. Alfalfa comprised at least 90 percent of hay on all treated plots.

References

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ALTERNATIVE ALFALFA SEEDING METHODS

David W. Koch and Thomas D. Whitson

Introduction

Although the most common method of seeding alfalfa is with a companion crop into a tilled seedbed, there are several alternatives. The most common companion crop is oats (Avena sativa L.). The general recommendation is to seed oats at 30 pounds per acre or less and with no more than 20 pounds nitrogen per acre. Less information is available regarding the optimum alfalfa seeding rate when planted with a companion crop. In contrast to the seeding of oats, care must be taken to avoid planting alfalfa more than 1/4 to 1/2 inch deep.

While companion crops compete with weeds, decrease soil crusting, protect against wind erosion and alfalfa seedling desiccation, and contribute to seeding year forage yield, they also compete with alfalfa for water, nutrients, and light.

An alternative companion crop is annual ryegrass (Lolium multiflorum). Annual ryegrass emerges quickly and provides rapid cover and may compete as effectively with weeds as oats. Because annual ryegrass does not grow as tall as oats, it should not compete as much with alfalfa for light.

One alternative to companion crop seeding is the use of a preplant incorporated herbicide. A broad spectrum of weeds can be controlled, allowing alfalfa seedlings to be more vigorous during the seeding year, which can improve chances of successful stand establishment. One disadvantage of this method is that alfalfa is more subject to wind erosion damage, particularly on sandy soils, than if a companion crop is used. Also, on high-clay soils there is greater likelihood of crusting without a companion crop.

Another alternative is to plant alfalfa into small grain stubble if the small grain crop is harvested for hay or silage or if straw is removed following grain harvest. Planting can be done in early August, during the winter (dormant) or in early spring. By not disturbing the soil, moisture is conserved, the soil is kept firm, yet easily seeded into; the stubble protects young seedlings against wind erosion and traps snow. It is less likely that seeding will be too deep. There are generally many fewer weeds if seeded in August. If weeds, volunteer, or regrowth of the grain crop are present at the time of seeding, they can be controlled chemically. Dormant and spring seedings may require weed control after seeding.

Methods

A field at the Torrington Research and Extension Center, which previously was infested with large numbers of weeds, was used. The previous crop was barley. The experimental design was a split plot with establishment methods as main plots and alfalfa seeding rates as subplots. Establishment methods consisted of spring seedings into tilled seedbeds: (1) without herbicide or companion crop; (2) with incorporated EPTC; (3) with oats as companion crop; and (4) with annual ryegrass as companion crop. Additional treatments (5 and 6) were alfalfa seeding in August into barley stubble and into a tilled seedbed without companion crop or herbicide.

Tilled seedbeds for spring seedings were plowed April 18 and disked twice before seeding. EPTC (Eptamß?ß) was applied at 3 1/2 pounds active ingredient per acre and incorporated with a roller harrow immediately before seeding. 'Hazen' oats and annual ryegrass were planted at 20 and 3 pounds per acre, respectively. These treatments were seeded on April 24, 1990. 'Arrow' alfalfa was seeded at 4, 8, 12, and 16 pounds pure live seed per acre as subplots with all establishment treatments. Alfalfa and companion crops were seeded in the same row with a Tye drill in 8-inch rows. Soil phosphorus was adequate. No nitrogen fertilizer was used.

Harvest dates in 1990 were July 10 and October 5. Because one replication of the tilled seedbed with incorporated EPTC treatment was severely stunted due to wind erosion, it was not included in 1990 harvest data.

Percentages of dry matter contributed by alfalfa, companion crop, and weeds were determined by clipping and separating two, 3-square feet quadrats per plot. Total dry matter was determined by flail harvesting 2 by 20 feet strips in each plot.

Results

Alfalfa seeding rates

The lowest rate (4 pounds per acre) of seeding with any of the seeding methods was not adequate for maximum alfalfa or forage yields the year of establishment. There was greater weed growth, in all cases, with the 4-pound per acre seeding rate. There was no difference between 8-, 12- and 16-pounds per acre alfalfa seeding rates, except with the annual ryegrass companion seeding. Alfalfa and total forage yield was best with 16-pounds per acre alfalfa seeding rate with the alfalfa-annual ryegrass seeding.

Companion species

There was less early growth with annual ryegrass than with oats and the annual ryegrass contributed less to establishment year forage yields than did oats. At the 4-pounds per acre alfalfa seeding rate alfalfa growth (total for 1990) was greater for oats than for annual ryegrass. At the 8- and 12-pounds per acre seeding rates alfalfa growth was similar for the two companion crops. At the 16-pounds per acre seeding rate alfalfa growth was better with annual ryegrass than with oats.

Weed control

Without control from herbicide or companion crop there was an average of nearly 2 tons per acre (dry matter) of seed growth the establishment year. There is some evidence, based on alfalfa seeding rates of 8 pounds per acre or greater, that alfalfa competed and reduced weed growth (i.e., alfalfa seeded at 8 vs. 4 pounds per acre with EPTC and 8 versus 4 versus with no herbicide or companion, particularly with the second harvest). Since there was no unseeded treatment, there is no way to know the total effect of alfalfa on weeds.

Best weed control was with EPTC (an average 60 percent reduction over no control). By comparison, the oat and annual ryegrass companion crops reduced weed growth an average 30 and 12 percent, respectively. However, with the annual ryegrass-alfalfa seeding there was a range of weed control from none with 4-8 pounds per acre alfalfa seeding rate to 63 percent with 16 pounds per acre. The best control of weeds was the combination of EPTC and alfalfa seeded at 8 pounds per acre (74 percent reduction in weed growth).

Seeding methods

Use of EPTC herbicide or seeding companion crops of oats and annual ryegrass with alfalfa each reduced weed competition and increased total forage yield for the establishment year. Use of EPTC allowed for a reduced alfalfa seeding rate for maximum forage yield, compared with the other methods. One significant problem with the use of EPTC is that the soil surface is bare for a longer period than if a companion crop is seeded. On light soils, such as in this study, alfalfa seedlings can be destroyed with a period of persistent wind. A previous seeding at this site was destroyed in this manner, while an adjacent seeding into barley stubble was preserved. With companion crop seedings, higher seeding rates of these crops, use of nitrogen fertilizer and/or delayed first harvest date will increase competitiveness of these crops with alfalfa seedlings.

Weed-free yields

Yields of alfalfa and/or companion crop for the establishment year were 2ß ß1/2 tons per acre (12 percent moisture) or greater with: (1) EPTC and alfalfa seeding rate of 8 pounds per acre or higher; (2) oat companion seeding and alfalfa seeding rate of 12 pounds per acre; and (3) annual ryegrass companion seeding and alfalfa seeding rate of 16 pounds per acre. The greatest weed-free yield of forage without herbicide or companion crop was with 16 pounds per acre of alfalfa seed (1.6 tons per acre).

Table 1. Yields of alfalfa, companion crop, total forage, and weeds the year of establishment for four methods and four alfalfa seeding rates at the Torrington Research and Extension Center.

	Alfalfa	Yield, July 10			Yield, Oct. 5		1990 yield total		
Seeding method	seeding rate	Alfalfa	Comp.*	Weeds	Alfalfa	Weeds	Alfalfa	Forage	Weeds
	lb/A	lb/A, dry matter							
Tilled, no herbicide or companion	4	553	-	2924	530	1702	1083	1083	4626
	8	1017	-	2981	1390	840	2407	2407	3821
	12	1105	-	3366	1456	889	2561	2561	4255
	16	1433	-	2461	1397	805	2830	2830	3266
Tilled, with EPTC	4	1930	-	2358	2167	244	4097	4097	2602
	8	2320	-	829	2370	214	4690	4690	1043
	12	2309	-	1452	2337	186	4646	4646	1638
	16	2269	-	980	2466	159	4735	4735	1139
Tilled, with oat companion	4	506	1212	1396	546	1688	1052	2264	3084
	8	815	1407	1508	1376	851	2191	3598	2359
	12	934	2173	1213	1497	1417	2431	4604	2630
	16	786	1945	1981	1178	1087	1964	3909	3068
Tilled, annual rye companion	4	295	663	3590	393	1944	633	1351	5534
	8	752	574	3739	1372	754	2124	2698	4493
	12	1184	1024	1988	1576	585	2760	3784	2573
	16	1381	1177	1147	1822	322	3203	4380	1469
	LSD.05	302	337	461	288	226	371	401	393

*Comp. = Companion Crop

FALL DORMANCY AND SEEDING RATE EFFECTS ON ALFALFA YIELDS IN WYOMING

L. S. Hicks and D. W. Koch

Alfalfa stops its growth due to shortening day length and decreasing temperatures. Cultivars vary in sensitivity to these environmental factors. Currently, cultivars are rated on the basis of relative fall growth (more growth corresponds to less dormancy) into dormancy classes 1 to 9. Fall dormancy is used as an indicator of the general region of adaptation of alfalfa cultivars. While less dormant cultivars have potentially greater annual yields, they are less likely to overwinter than more dormant cultivars.

Seeding rate effects on alfalfa yields have been variable (1,2). Planting dates might also influence the success of less dormant cultivars. There is little information on the influence of seeding rates and planting dates on cultivars of differing fall dormancy.

The objectives of this study were: (1) determine the minimum level of fall dormancy required for adequate winter survival and maximum yields in Wyoming; and (2) determine optimum seeding rate and seeding date of cultivars differing in fall dormancy with respect to long-term yield. A split-plot design with planting dates as main plots and cultivars and seeding rates as subplots was used. Treatments were replicated four times. Cultivars representing the eight dormancy classes available in 1987 (a ninth class was added in 1989) were: (1) Ladak 65, (2) Wrangler, (3) DK-120, (4) Apollo II, (5) WL-320, (6) DK 167R, (7) Pierce, and (8) WL-605. Planting dates were March 13 (dormant) and May 14, 1987. Seeding rates were 5, 10, 15, and 20 pounds per acre of pure live seed. The study was conducted at Powell, Wyoming, which is 4,360 feet in elevation and has a growing season of 150 days (based on minimum). The experiment was furrow irrigated. The soil was a Garland clay loam.

Yields of the May seeding in 1987 were greater than those of the dormant (March) seeding; however, due to an early snow, the third growth of the March seeding was not harvested (Table 1). In the second and third years (1988 and 1989) yields over all varieties were greater (+0.60 and +0.75 ton per acre) for the March seeding. Over the three-year period (1987-89) there was nearly a 1 ton per acre advantage for the dormant (March) seeding. Over the three years of production, cultivars with a fall dormancy rating of three to five (semi-dormants) produced the greater yields than dormant cultivars (1-2) and nondormant cultivars (6-8). The non-dormant varieties (6-8) winterkilled badly in 1987-88, resulting in greatly reduced yields in 1988 and 1989.

All cultivars except dormancy class 3 increased in yield with an increase in seeding rate from 5 to 10 pounds per acre over the three years of the study.(Table 3). There were no significant differences in establishment year yields (Table 2). Cultivars with fall dormancy rating of six to eight (non-dormants) had greater yields the third year with an increase in seeding rate to 15 pounds per acre. Cultivars varied considerably in the seasonal distribution of yield. Yields of the last harvest in the fall were closely associated with cultivar dormancy rating. These yields were greatest for non-dormants and least for dormant cultivars.

Table 1. Fall dormancy x planting date (March 13 and May 14) effects on alfalfa yields in the seeding year (1987), in 1988 and three-year (1987-89) total yield at the Powell Research and Extension Center.

Dormancy rating1	1987 Mar. 13	1987 May 14	1988 Mar. 13	1988 May 14	3-yr total Mar. 13	3-yr total May 14
	Planting date					
	tons/A, 12% moisture					
1	2.43	2.81	5.33	4.17	13.94	12.53
2	2.74	3.14	5.31	5.29	14.77	14.63
3	2.94	3.30	5.91	5.48	16.02	15.19
4	2.93	3.49	5.82	4.80	15.94	14.70
5	3.07	3.35	6.36	5.74	16.97	15.58
6	2.45	3.01	3.92	3.28	12.02	11.18
7	2.61	3.20	2.47	1.99	8.71	8.09
8	2.71	3.13	1.97	1.59	7.66	6.94
Seeding date mean	2.74	3.18	4.64	4.04	13.25	12.36
LSD.05	.38		.51		.90	

1 Cultivars with dormancy rating 1 and 2 are considered dormants; cultivars rated 3-5 are semi-dormant; and cultivars rated 6-8 are considered non-dormant.

Table 2. Yield the establishment year (1987) of alfalfa cultivars representing eight dormancy classes, seeded at four rates at the Powell Research and Extension Center. Yields are averaged over two planting dates and four replications.

Dormancy rating	Seeding rate (lb/A) 5.0	10.0	15.0	20.0	Mean
	ton/A, 12% moisture				
1	4.4	4.8	4.7	4.8	4.6
2	5.4	5.2	5.5	5.1	5.3
3	5.6	5.5	5.9	5.6	5.5
4	5.6	5.8	5.9	5.7	5.7
5	5.7	5.8	5.5	5.9	5.7
6	4.6	4.8	5.0	5.1	4.9
7	5.1	5.2	5.2	5.3	5.2
8	4.9	5.2	5.4	5.1	5.0
Seeding rate mean	5.2	5.3	5.4	5.4	

Seeding rates and dormancy ratings were not significant at P=.05.

Table 3. Yield over three years (1987-89) of alfalfa cultivars representing eight dormancy classes at Powell Research and Extension Center. Means are averaged over two seeding dates.

Seeding rate (lb/A)1

Dormancy

rating	5.0	10.0	15.0	20.0	Mean
			ton/A, 12% moisture		
1	9.7	11.1	10.4	10.3	10.4
2	10.9	12.1	11.8	11.5	11.6
3	12.2	11.9	12.0	12.2	12.1
4	11.3	12.3	12.1	12.1	12.0
5	11.5	12.8	12.9	12.7	12.5
6	7.4	9.0	10.4	10.4	9.3
7	3.7	6.3	7.0	6.3	5.8
8	2.5	4.1	6.2	5.7	4.6
Seeding rate mean	8.7	9.9	10.4	10.1	

1 Seeding LSD.05 = .07; dormancy rating LSD.05 = 1.4.

References

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ALFALFA STAND ESTABLISHMENT AND CUTTING MANAGEMENT STUDY: FIFTH YEAR FOLLOWING ESTABLISHMENT

James M. Krall and Jerry J. Nachtman

Introduction

This study was designed to assess the value of dormant and non-dormant alfalfa blends on first-year yields under irrigation at the Torrington Research and Extension Center. It was also intended to examine the effect of first-year cutting frequency on stand longevity and long-term productivity. Increasing the productive life of an alfalfa stand would have many economic benefits for producers.

Procedure

A split-block plot design was used for the study. Each treatment was replicated four times. Plots were 25 inches by 15 feet. The study was planted April 24, 1986. A non-dormant variety (ND), Pioneer variety 5929, and a dormant variety (D), Pioneer variety 526, were chosen to make the blends for planting. Five seed mixtures and four cutting treatments were designed into the study (Table 1). Three cutting frequencies and a no-harvest treatment were followed during the establishment year (1986). Three cuttings in 1987 and four cuttings in 1988-90 were obtained for all treatments.

Examination of stand establishment methods on production was continued in 1991. Four cuttings were obtained for each treatment during 1991, with each taken when the alfalfa reached the bud stage. The data were tested by analysis of variance with mean separation by LSD (by t) test. Differences referred to hereafter infer significance at $P < 0.05$.

Results and Discussion

During the establishment year, the three cutting systems yielded more than 6 tons of alfalfa, surpassing the one- and two-cutting systems. The two-cutting system was superior to the one-cutting system (1).

Increased harvest frequency during the establishment year did not adversely affect stand productivity at the beginning of second-year production (1987); however, total alfalfa forage yield the second year was higher in plots not harvested or harvested once compared to those harvested two and three times during the establishment year (Table 2). Yields in 1988-91 were not significantly different for any cutting method (Table 2), indicating that third- through sixth-year yields were not influenced by harvest management during the establishment year. Yields for the five seed mixtures were not significantly different for any treatment during the first three years following establishment (Figure 1). During the fourth and fifth year after establishment the two seed rates containing only the dormant variety yielded significantly higher. Establishment year cutting method had a significant effect on stand count after five years of production (Figure 2). Populations were the same for no harvest the establishment year and three harvests during the establishment year. Seed mixture at planting had no effect on alfalfa stand through four subsequent production years. However, in the spring of 1991, stand counts were significantly lower where non-dormant and dormant mixtures were used (Figure 3). It seems the number of dormant plants that established was less in this mixture. Then, when the non-dormant plants begin to die out after four subsequent production years, numbers declined. One, two and three harvests the first year resulted in somewhat higher weed production during the first harvest in 1991 (Figure 4). Dormant mixtures alone (S1 and S5) resulted in the lowest weed dry weight production in the first cutting. Weed production was not a factor in the subsequent harvest in 1991 (Figure 5).

The use of non-dormant mixtures did not increase establishment year yields as hoped, but the use of mixtures did adversely impact yield during the fourth and fifth year after the establishment year. Also of interest is that one, two, and three cuttings during the establishment year impacted yield the following year of production, but did not reduce production two, three, four, and five years following the establishment year.

Table 1. Establishment year seed mixtures and cutting systems.

1) Seeding rates:	S1 - 20 lb/A Dormant
	S2 - 15 lb/A (66% D + 34% ND)
	S3 - 17.5 lb/A (57% D + 43% ND)
	S4 - 20 lb/A (50% D + 50% ND)
	S5 - 10 lb/A Dormant
2) Cuttings:	C1 - No harvest the first year
	C2 - 1 cutting at 1/10th bloom
	C3 - 2 cuttings at 1/10th bloom
	C4 - 3 cuttings (bud stage, first flower, and first flower, respectively)

Table 2. Combined yield from harvests during the five years following establishment with various harvest methods.

Cutting	1987 yield1 (ton/A)	1988 yield (ton/A)	1989 yield (ton/A)	1990 yield (ton/A)	1991 yield (ton/A)
C1	7.35	4.36	6.11	5.03	5.28
C2	7.31	4.65	6.02	5.05	5.00
C3	6.77	4.38	6.06	5.05	4.82
C4	6.75	4.24	6.01	5.16	5.09
Dif. req. sign.	0 .50	NS	NS	NS	NS

1 Yields adjusted to 12 percent moisture basis.

Reference

1. Krall, J.M., J. Romsa, R. Hybner and D. Smith. 1986. Alfalfa Stand Establishment and Cutting Management Study. Annual Research and Extension Centers Progress Report. Wyoming Agric. Exp. Stn. B885: pp. 198-199.

Figure 1. Effectof seed mixture on combined yield following establishment year

Figure 2. Effect of various establishment year cutting methods on alfalfa population after five years.

Figure 3. Effect of various estalishment yearseeding methods on alfalfa population after five years.

Figure 4. Effect of establishment year cutting method on yeilds at first cutting in 1991.

Figure 5. Effect of establishment year seeding method on weed yields at first cutting in 1991.

SEED GERMINATION CHARACTERISTICS OF ALFALFA CULTIVARS DIFFERING IN FALL DORMANCY

L. S. Hicks and D. W. Koch

Alfalfa has been categorized as to level of fall dormancy, which is correlated with winter survival (1). Alfalfa dormancy has been used to predict adaptation of cultivars. For example, the system developed by Barnes, et al. (1) groups alfalfa into one of eight classes, with 1 the most dormant and 8 the least dormant cultivar. A ninth class was added in 1989. The ratings are based on relative regrowth of alfalfa (plant height) measured in mid-October following an early September harvest. Dormant cultivars (groups 1-3) make relatively little or no growth, semi-dormant cultivars (4-6) make more growth and non-dormant cultivars (7 and 8) make the most growth. Areas with cold winters require alfalfa cultivars with relatively more fall dormancy than areas with mild winters.

This experiment was conducted to determine the relationship of germination rate and total germination with alfalfa fall dormancy.

Methods

Alfalfa cultivars representing each of the eight fall dormancy levels recognized by the Certified Alfalfa Seed Council prior to 1989 were used. Two seed lots of each cultivar were selected to determine if seed germination characteristics varied with source. Seed used was field grown the previous year. Ten temperatures (0, 5.5, 10.5, 14.5, 18.5, 22.5, 26.5, 30, 35, and 40 C) were accomplished with the use of a thermogradient plate. One hundred seeds of each cultivar were placed on saturated blotter paper in the 10 locations, representing different temperatures. Cultivars were randomized in rows across the thermogradient plate. Each seedlot was replicated four times with a different randomization for each replication. Germination was counted periodically (11 days) over a 21-day period and represented one replication. Seeds were considered germinated when the radicle protruded the testa. Germination counts were adjusted for differences in hard seed. Total germination was calculated by combining adjusted germination of all counting days. Speed of germination indices were calculated by the method of MaGuire (2).

Results

There were no significant differences in total germination or rate of germination of seedlots. Alfalfa cultivars representing dormancy levels 1 to 8 differed significantly in total germination and speed of germination (Table 1). The dormant cultivars had the least and the non-dormant cultivars the greatest total germination. In general, total germination (percent) increased as cultivar dormancy decreased. Non-dormant cultivars germinated quicker than semi-dormant and dormant cultivars. The differences among cultivars were greater with speed of germination than with total germination. At the end of 21 days, total germination percentage (averaged over cultivars) was lowest at temperatures of 0 and 40 degrees Celcius. Germination was 90 percent or higher at temperatures of 10.5 to 30 degrees Celcius. Germination was less rapid at 0 or 40 degrees Celcius. Speed of germination increased from 0 to 22.5 degrees Celcius, then declined to 40 degrees Celcius, when averaged over cultivars. Speed of germination might be a method for characterizing alfalfa dormancy. This would be much faster and easier than the field method currently used.

Table 1. Relationship of cultivar dormancy to total germination and speed of germination of alfalfa seed. Data are combined over ten temperatures and four replications.

Dormancy	Total	Speed of

level	germination	germination
	-- % --	
1	70.8 a	35.6 a
2	70.6 a	37.6 a
3	73.6 bc	41.4 b
4	72.0 ab	38.0 a
5	75.6 de	45.7 c
6	74.5 cd	48.1 c
7	77.1 ef	51.8 d
8	78.7 f	55.1 e
LSD (0.05)	2.0	2.5

Means followed by the same letter within columns are not significantly different at P = 0.05, as determined by Newman-Kuels sequential studentized range test.

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ALFALFA DISEASE MANAGEMENT

FALL MANAGEMENT OF ALFALFA VARIETIES DIFFERING IN VERTICILLIUM WILT RESISTANCE

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University of Wyoming Sheridan Research and Extension Center,
Sheridan, Wyoming and the Padlock Ranch, Dayton, Wyoming

The rationale, objectives, procedures, and 1990 results are described in an earlier report (1). Plots were harvested in 1991 as indicated in previous years, except for the third cutting. First and second harvests were on June 27 and August 13, respectively. Due to irregular irrigation across the plots following the second harvest, growth was irregular and only one replication, in which growth was uniformly good, was harvested in the fall. Verticillium wilt was present in the plots to a limited degree in 1991 and disease ratings were not made. All plots were spray-inoculated with Verticillium albo-atrum following the first harvest in 1992 to ensure uniform infestation.

Harvests in 1992 were on June 10 and August 11. Fall growth was poor, as plots were not irrigated and there was minimal rainfall. The fall harvest was on October 9. Verticillium wilt was noted at each harvest in 1992.

Cows were released onto the grazed plots (Treatments 2 and 4) and surrounding field on October 20 and removed on October 25, 1991. Grazing intensity was 460 head on 220 acres, however, cattle were fed alfalfa hay about 1 mile from the plot area. Observations on October 25 indicated that grazing was nearly complete at that time.

The third (fall) growth was either not hayed or grazed (Treatment 1); grazed, but not hayed (Treatment 2); hayed, but not grazed (Treatment 3); or both hayed and grazed (Treatment 4) starting in 1990.

Results

'Arrow' tended to out-yield 'Apollo' in seasonal hay production, with most of the difference in the first harvest (Tables 1 and 2). At the first and second cuttings, Treatment 1 tended to be highest and Treatment 3 lowest in yield. The difference was that Treatment 3 was hayed the previous fall, while Treatment 1 was neither hayed or grazed.

Apollo, the Verticillium-susceptible variety, was adversely affected by both haying and grazing of fall growth. Arrow, the Verticillium-resistant variety, was adversely affected by haying of fall growth, but not by fall grazing (shown in Table 3 and illustrated in Figure 1).

Haying the fall growth in 1990 and 1991 resulted in a reduction of the vigor of the stand of both varieties, reducing total production for the first two harvests over the period of 1991-92 by 0.83 and 0.96 tons per acre for Apollo and Arrow, respectively (Table 3). This was determined by comparing plots which were hayed in the fall with control plots, which were left unharvested.

Grazing, on the other hand, reduced total production of Apollo 0.76 tons per acre and Arrow 0.09 tons per acre (Table 3). This would indicate that for the resistant variety, grazing, as practiced in this study, was less stressful to the stand than haying the fall growth of alfalfa. Haying more completely removed forage, and if plants are not completely dormant, may interfere with the storage of carbohydrate reserves in the roots; if mild weather follows haying, plants may somewhat deplete root reserves in an effort to initiate new growth.

Averaged over the season (1992), approximately 15 percent of Apollo and 3 percent of Arrow plants showed Verticillium wilt symptoms. By the end of 1992 plants showing symptoms early in the season had died. Evidently, fall grazing the previous two years accentuated the effect of Verticillium wilt on Apollo alfalfa.

Leaving fall growth unharvested would mean that the grower would leave approximately 1 1/4 to 1 1/2 tons per acre of hay in the field. Assuming that a Verticillium-resistant variety is grown, such as Arrow, what is the long-term effect of using the fall growth?

In spite of giving up 0.96 tons per acre of hay over the first two harvests (1991-92 total) for Arrow (Table 3), there was a gain of 1.06 tons per acre by haying the fall growth of alfalfa (Table 4 and Figure 2). It was advantageous, even with Apollo alfalfa, to hay the fall growth; however, because the stand thinned badly in 1992 it is not expected that this trend would continue in the future. As weeds and grasses fill in it is expected that forage quality would also suffer.

Grazing would be more practical than haying the fall growth, but use would be less due to loss of leaves before grazing, trampling, and the tendency of animals to leave stems. Grazing before alfalfa is dormant and for a longer time would increase use, but would likely be more detrimental to stand vigor. Assuming 50 percent of forage was used, fall growth of Arrow can be grazed with results similar to haying fall growth (Table 4).

Table 1. Yield data for the fall management - Verticillium wilt study, 1991, Padlock Ranch.

Treatment	Variety	First harvest	Second harvest	Third harvest	Total
		tons hay/acre, 12% moisture			
1 Two harvests (no haying or grazing of fall growth)					
	Apollo	2.38	2.61	-1	4.99
	Arrow	2.18	2.65	-1	4.83
	Average	2.28	2.63	-1	4.91
2 Two harvests with grazed fall growth					
	Apollo	1.89	2.54	-2	4.43
	Arrow	2.32	2.51	-2	4.83
	Average	2.11	2.53	-2	4.63
3 Three harvests with no fall grazing					
	Apollo	1.87	2.44	1.28	5.59
	Arrow	2.12	2.19	1.36	5.67
	Average	2.00	2.32	1.32	5.63
4 Three harvests, followed by grazing3					
	Apollo	2.06	2.37	1.12	5.55
	Arrow	2.19	2.50	0.96	5.65
	Average	2.12	2.43	1.04	5.60

1 Estimated amount of growth, which was left standing and ungrazed, for Apollo and Arrow was 1.29 and 1.35 tons per acre, respectively.

2 Estimated amount of growth available for grazing was 1.29 and 1.34 tons per acre for Apollo and Arrow, respectively.

3 There was no regrowth available for grazing.

4 Values are the average of three replicates, except for the third harvest, which is only replicate one.

5 Harvest 1 was June 27; Harvest 2 was August 13, and Harvest 3 was October 17.

6 Apollo is susceptible to Verticillium wilt and Arrow is resistant.

Table 2. Yield data for the fall management - Verticillium wilt study, 1992. Padlock Ranch.

Treatment Variety	First harvest	Second harvest	Third harvest	Total
		tons hay/acre, 12% moisture		
1 Two harvests (no haying or grazing of fall growth)				
Apollo	2.30	2.11	-1	4.41
Arrow	2.84	1.88	-1	4.72
Average	2.57	2.00	-1	4.56
2 Two harvests with grazed fall growth				
Apollo	2.35	1.86	-2	4.21
Arrow	2.65	1.98	-2	4.63
Average	2.50	1.92	-2	4.42
3 Three harvests with no fall grazing				
Apollo	2.35	1.91	0.84	5.10
Arrow	2.53	1.75	0.66	4.94
Average	2.44	1.83	0.75	5.02
4 Three harvests, followed by grazing[3]				
Apollo	2.32	2.11	0.77	5.20
Arrow	2.56	1.94	0.78	5.28
Average	2.44	2.03	0.78	5.25

1 Estimated amount of growth, which was left standing and ungrazed, for Apollo and Arrow was 0.87 and 0.81 tons per acre, respectively.

2 Estimated amount of growth available for grazing was 0.71 and 0.88 tons per acre for Apollo and Arrow, respectively.

3 There was no regrowth available for grazing.

4 Harvest 1 was June 10; Harvest 2 was Aug. 11 and Harvest 3 was Oct. 9, 1992.

5 Apollo is susceptible to Verticillium wilt and Arrow is resistant.

Table 3. Effect of haying and grazing of fall growth (1990-91) on subsequent vigor and productivity of alfalfa stands. Values are totals of first and second harvests for the 1991-92 period.

Variety	Control[1]	Fall haying	Fall grazing	Yield reduction due to fall: Haying[2]	Yield reduction due to fall: Grazing[2]
			------------------ tons/A, 12% ------------------		
Apollo	9.40	8.57	8.64	0.83	0.76
Arrow	9.55	8.59	9.46	0.96	0.09

1 Control plots were neither hayed nor grazed in the fall of 1990 or 1991.

2 Compared to control plots.

Table 4. Total yields, 1991-92, for fall haying and grazing treatments, compared with the control (fall growth left in the field).

Variety	Control[1]	Fall haying	Fall grazing	Yield advantage due to fall:[2] Haying	Grazing[3]
	------------------	tons/A, 12%	------------------		
Apollo	9.40	10.69	9.63	1.29	0.23
Arrow	9.55	10.61	10.57	1.06	1.02

1 Control plots were neither hayed nor grazed in the fall of 1990 or 1991.

2 Compared to control plots.

3 Assuming 50 percent use of fall growth by grazing animals.

Figure 1. Yield of first two harvests, totalled over 1991 and 1992 seasons.

Figure 2. Total yields over 1991 and 1992 seasons for unharvested (control), hayed and grazed fall growth.

Reference

1. Koch, David W., Fred A. Gray, Roger Hybner, and Ron Hossfeld. 1990. Fall management of alfalfa cultivars differing in Verticillium wilt resistance. pp 295-297. In Annual College of Agriculture Progress Report, 379 pp.

VERTICILLIUM WILT-FUNGICIDE LOSS ASSESSMENT STUDY

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Sheridan, Wyoming and the Padlock Ranch, Dayton, Wyoming

This study was established in 1989. Plots were cut twice in 1990, but no yield data were taken. In 1991, plots were harvested twice and the fungicide benomyl (Benlateß?ß) applied to stubble as a spray following each harvest. Verticillium wilt (VW) was present in plots on October 5, 1991. However, due to limited disease, severity ratings were not taken. In 1992, plots were harvested twice. Verticillium wilt was more prevalent in the plots in the spring of 1992 and disease ratings were taken. Plots were stubble sprayed with Verticillium albo-atrum inoculum following the second harvest in 1992 to ensure uniform infestation. A further description of this study has been given earlier (1).

Results

Verticillium wilt ratings are given in Table 1. Overall, Arrow had less disease than Apollo (1.1 vs. 6.2). Spraying with the fungicide benomyl reduced disease in the susceptible variety Apollo (6.7 vs. 5.7) but not in the resistant variety Arrow (1.2 vs. 1.0).

Forage yield for the two harvests in 1992 are presented in Table 2. The unsprayed control plot of Arrow out-yielded the Apollo control plot at the second harvest (2.0 vs. 1.6 tons per acre) but not at the first harvest (2.36 vs. 2.40 tons per acre). Stands in several Apollo plots showed signs of depletion by the fall of 1992, whereas those of Arrow did not.

Two-year total, 1991 and 1992, yields are shown in Table 3. Increase in yield from the fungicide spray was measured in 1992 only (after Verticillium wilt became established in the plots). Total yields of the control plots for Arrow and Apollo were 8.90 vs. 8.18 tons per acre, a difference of 0.72 tons per acre. The greater yield is attributed to the VW-resistance in Arrow. Further separation between these two varieties should occur in 1993. Applying a fungicide resulted in an increase of 0.54 tons per acre in Arrow and 0.32 tons per acre in Apollo. The increase in the VW-resistant variety Arrow indicates that a higher level of resistance is needed for maximum yield where Verticillium wilt is present.

Table 1. Verticillium ratings of plots in the spring of 1992.

	Apollo (susceptible)		Arrow (resistant)	
	Control	Fungicide sprayb	Control	Fungicide spray
	6.7a	5.7	1.2	1.0
Ave X(6.2)		6.2		1.1

a Ratings were taken on 6/10/92, prior to harvest. Ratings are the number of plants showing symptoms of Verticillium wilt in each plot (3 feet by 12 feet) and are the mean of six replications.
b Plots were stubble-sprayed following both harvests with the systemic fungicide benomyl in 1991 and 1992.

Reference

1. Koch, David W., Fred A. Gray, Roger Hybner, and Ron Hossfeld. 1990. Fall management of

alfalfa cultivars differing in Verticillium wilt resistance. pp 295-297. In Annual College of Agriculture Progress Report, 379 pp.

Table 2. Yields (tons per acre, 12 percent moisture) of the Verticillium wilt - fungicide loss assessment study located at the Padlock Ranch near Dayton, Wyoming in 1992.[a]

	Apollo (susceptible)			Arrow (resistant)		
	Control	Fungicide sprayed[b]	Increase	Control	Fungicide sprayed[b]	Increase
1st Harvest	2.40	2.54	0.14	2.36	2.98	0.62
2nd Harvest	1.60	1.78	0.18	2.00	1.92	0.00
Total	4.00	4.32	0.32	4.36	4.90	0.54

[a] Plots were harvested on 6/10/92 (1st harvest) and on 8/11/92 (2nd harvest). Plots were 7.5 feet by 12 feet in size.
[b] Plots were stubble-sprayed following harvest with the systemic fungicide benomyl in 1991 and 1992.

Table 3. Overall yields (tons per acre, 12 percent moisture) for 1991-92 in the Verticillium wilt-fungicide loss assessment study.[a]

	Apollo (susceptible)			Arrow (resistant)		
Year	Control	Fungicide sprayed[b]	Increase	Control	Fungicide sprayed[b]	Increase
1991	4.18	4.18	0.00	4.54	4.40	0.00
1992	4.00	4.32	0.32	4.36	4.90	0.54
Total	8.18	(8.50)	(0.32)	(8.90)	(9.30)	(0.54)

[a] Plots were harvested twice in 1991 and 1992. Plots size was 7.5 feet by 12 feet.
[b] Plots were stubble-sprayed following harvest with the systemic fungicide benomyl in 1991 and 1992.

INFECTION STATUS OF HEALTHY-APPEARING ALFALFA PLANTS OF RESISTANT CULTIVARS IN VERTICILLIUM WILT-INFESTED FIELDS

Margaret S. Page, Fred A. Gray, and Ron L. Hossfeld

Verticillium wilt (VW) incited by V. albo-atrum (Vaa), is a major disease of irrigated alfalfa in Wyoming (1). Although loss from VW has been reduced with the use of resistant cultivars, premature decline of stands still occurs in resistant cultivars. This is particularly noticeable during certain years under management practices involving late fall harvesting, followed by grazing of aftermath. Previous studies conducted in the greenhouse showed that a high percentage (>ß ß95 percent) of symptomless plants in resistant cultivars were infected seven months following stubble inoculation with Vaa (2). The authors also stated that the presence of Vaa in symptomless plants may adversely affect the performance and long-term field survival of the resistant cultivar.

Studies were initiated in the fall of 1989 on two separate fields planted to VW-resistant alfalfa cultivars to determine if healthy-appearing plants in VW-infested fields were in fact infected with Vaa. In addition, we also investigated the fate and infection status of plants having VW symptoms. Stands in both fields were still acceptable (>ß ß70 percent) and both had a moderate level of VW (estimated at 20-25 percent infestation). Both fields were located on the Padlock Ranch near Dayton, Wyoming and were watered with an overhead sprinkler irrigation system. Field #1 was seeded to 'Arrow' in 1986 and Field #2 to WL-316 in 1985. Both cultivars are rated as resistant (31-50 percent resistant plants) to Verticillium wilt.

Studies were initiated on both fields on November 15, 1989 when plants were in the 10-20 percent bloom stage. In Field #1, 27 plants with VW symptoms and 27 apparently healthy plants were tagged. All plants were randomly selected along a W-shaped pattern within a 5-acre section of a 60-acre field. Each plant was clipped, with stems counted, and dry weights determined. Hand clippers were soaked in a 10 percent chlorine bleach solution for five minutes between plants to avoid contamination of healthy plants. Prior to drying, a one-half inch segment, taken from near the base of each stem, was surface sterilized and placed in petri dishes containing water agar. After 48 hours, stems were observed at 100 magnifications for the presence of fruiting structures of Vaa. The procedure was repeated on June 19, 1990 and August 20, 1990 with the exception of plant shoot weight. Also, notes were taken as to the VW symptom status of each plant.

In Field #2, a total of 70 plants (10 with VW symptoms and 60 apparently healthy) were randomly selected within a 5-acre section of a 30-acre field. The shoots were removed and isolation made on lower stems. Methods were similar to those used in Field #1. Plants were not tagged and no further data collected after September 15, 1989.

Results indicated that an average of 10.3 percent of healthy-appearing plants in the two separate cultivars had one or more stems infected with Vaa. Arrow had an average of 10.9 percent infection (Figure 1), while WL-316 had 8.3 percent infection in healthy-appearing plants (Figure 2). Mortality of healthy-appearing plants was 0 percent compared to 51.9 percent for plants tagged as having visible VW symptoms (Figure 3). Twelve percent of the remaining plants tagged as being healthy had developed symptoms after 11 months (Figure 4). One the other hand, 61.5 percent of the remaining plants tagged with VW symptoms had recovered and showed no symptoms after the same time period. Of those plants

Figure 1.

Figure 2

Figure 3

Figure 4

showing symptoms, only 36.7 percent of the stems of a given plant were affected. Vaa was isolated from one or more stems from all plants showing VW symptoms. Healthy plants had more stems per plant (10.9) than plants with VW (8.5). The number of stems per plant decreased over time in both diseased and healthy plants. Number of stem per plant on September 15, 1989 and on August 20, 1990 were 14.1 and 8.2 for healthy-appearing plants and 11.0 and 7.5 for VW-diseased plants. Plants tagged as having VW yielded less than plants tagged as being healthy (4.3 grams per plant compared to 5.3 grams per plant, respectively). When plants tagged as being apparently healthy were separated relative to Vaa infection, plants free of Vaa out-yielded infected plants (5.3 grams per plant and 4.6 grams per plant, respectively).

In established fields infested with VW, a low percentage of healthy-appearing plants in the VW resistant cultivars Arrow and WL-316 were infected with Vaa. These findings are in agreement with those of Pennypacker, et al. The lower percentage of infected, symptomless plants found in the field as compared to that reported in the greenhouse studies (10.3 percent compared to 95-100 percent) may be due to lower inoculum potential, shorter plant infection period, or shorter period of optimum environmental conditions for infection, or a combination of one or more of these factors. As proposed by Pennypacker, et al., Vaa-infected, symptomless plants had fewer stems and yielded less than healthy-appearing Vaa uninfected plants. However, because none of the healthy plants (with or without Vaa infection) died during the 11 months, premature stand decline in VW resistant cultivars could not be attributed to death of Vaa-infected, symptomless plants in our study. A possible explanation may be that death of VW-symptomed plants is accelerated by the additional stresses provided by late fall harvest and grazing of aftermath. Both cultivars studied are rated as resistant (31-50 percent resistant plants); however, 50-69 percent of the plants are susceptible.

According to our study, 51.9 percent of these plants could die, assuming all are infected, and result in a 25 percent or greater stand reduction. The ability of plants to recover from Vaa infection and VW symptom expression may be a mechanism of resistance or it may be caused by adverse environmental conditions.

References

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2. Pennypacker, B.W., K.T. Leath and R.R. Hill, Jr. 1985. Resistant alfalfa plants as symptomless carriers of Verticillium albo-atrum. Plant Disease 69:510-511.

COMPARATIVE FORAGE YIELD, PLANT STAND, AND STEM NEMATODE INFECTION OF ALFALFA AND SAINFOIN GROWN IN THE LARAMIE VALLEY OF WYOMING

F. A. Gray and D. S. Wofford

The alfalfa stem nematode, Ditylenchus dipsaci (Kßüßhn) Filipjev, is a major cause of stand decline and yield loss in alfalfa in the western United States. It is particularly severe in the Rocky Mountain states where prolonged periods of cool temperatures favor its development and spread under irrigation. Under these conditions, parasitism by this nematode occurs rapidly, resulting in severe stunting and yield loss (6). Storage of nonstructural carbohydrates, essential for winter survival, is also reduced in stem nematode-infected plants, which may contribute to winterkill (2). A previous study in Wyoming reported the stem nematode to be widespread throughout the state (5). Injury to seedlings from stem nematode may occur in fields where alfalfa follows alfalfa. Control is obtained by a combination of cultural practices, including rotation with nonhost crops, the use of resistant cultivars, and irrigating fields during the mid-growth stage when stems are 6-10 inches tall.

Sainfoin, Onobrychis viciifolia Scop., has a long history as a forage legume crop in Europe. However, its cultivation in North America has had only limited success. Its main advantage over alfalfa is that it does not cause bloating in cattle (3). Its use as a high-quality, summer pasture has great potential in the western United States. However, rapid decline of stand, attributed to disease, appears to be the single limiting factor in its expanded use under irrigation (4,9,10). Earlier studies conducted in Wyoming found the northern root knot nematode, Meloidogyne hapla Chitwood, to be extremely damaging to stands of sainfoin under field conditions (11). Progress has been made in several agronomic traits but no disease-resistant variety has been released. The stem nematode has been shown to attack sainfoin seedlings under greenhouse conditions (7), but its reaction under field conditions has not been studied.

The objective of this experiment was to determine the comparative yield and reaction to the alfalfa stem nematode of alfalfa and sainfoin under field conditions.

Methods

The study was established in a six-year-old field of 'Ladak' alfalfa located on the University of Wyoming Agricultural Experiment Station in Laramie. The stand showed considerable thinning and plants infected with the stem nematode were present throughout the field. The field was plowed and disked in late May, and plots established on June 26, 1981. A random soil sample was collected from the top 6 inches in the field and the soil population of stem nematode determined. The soil was a silt clay of the Rock River Series (67 percent sand, 13 percent silt, 20 percent clay; pH 7.6; 2.1 percent organic matter). Plots were placed in a randomized complete block design with six replicates. Eptam was applied prior to seeding at 2 1/4 quarts per acre and incorporated. 'Remont' and 'Eski' sainfoin and 'Appalachee' and Ladak alfalfa were seeded at a rate of 36 pounds and 15 pounds pure live seed per acre, respectively. Eski was used as a standard one-cut type and Remont as a two-cut type. Both were developed (4) and extensively tested by Montana State University (8). Appalachee is rated as highly resistant (resistant plant >50 percent) and Ladak is rated as susceptible, (resistant plants <5 percent) to the stem nematode. Reaction of sainfoin under field conditions was unknown. Plots were furrow irrigated, although water was frequently unavailable in the latter part of the growing season during most years. Metal marker spikes (10 inches in length) were placed in a representative 6-feet section of row in each plot on October 20, 1981, and plant counts recorded. Plots were not cut in

1981. Laramie is located at 7,200 feet elevation and has a 90-day frost-free period. In the upper Laramie Valley, alfalfa is usually harvested twice, depending on weather conditions. Plots were harvested twice from 1982 to 1986 with the following exceptions: (1) the first harvest in 1984 was accidently made by the farm crew and yields were not recorded; and (2) Eski sainfoin did not have sufficient regrowth for a second harvest in 1983.

Symptoms, typical of the stem nematode (2), were first noticed in Ladak alfalfa in 1983. Following the second harvest in 1985, the remaining plants in the tagged 6-feet section of row in each plot were removed and final plant counts determined. Stem nematode infection status was determined by examining stem buds and lower stems for symptom expression. Plants were rated on a scale of 1-5 where 1 = healthy, 2 = slight infection, 3 = moderate, 4 = severe, and 5 = very severe infection. Stem bud and lower stem tissues of 10 random plants from Appalachee, Ladak, Remont, and Eski were chopped and placed on a Baermann funnel, and the stem nematodes were counted.

Results

Plants of Remont and Eski sainfoin removed October 3, 1985 were free of stem nematode symptoms. Plants of Ladak and Appalachee alfalfa had 40 and 39 percent infected plants, respectively, with typical symptoms of stem nematode. Average severity index for the stem nematode was significantly ($P < 0.05$) higher in susceptible Ladak than in resistant Appalachee (ASI = 1.4 and 3.1, respectively).

Initial stands of alfalfa and sainfoin cultivars were not different ($P>0.05$) (Table 1). However, when the study was concluded, stands were less dense ($P<0.05$) in the stem nematode-susceptible Ladak compared to the resistant Appalachee (16 plants per 6 feet of row and 30 plants per 6 feet of row, respectively). Although final stands of the two sainfoin cultivars were not significantly different, final stands were 20 percent greater in Remont than in Eski.

Remont had significantly higher total yields than did Eski. This was probably a combination of better stands and total harvests; Eski had sufficient growth for only one harvest in 1983. Appalachee out-yielded Ladak in two of the four years of the study. Total yield for Appalachee was 1.0 ton per acre more than Ladak. Remont sainfoin, selected for its regrowth ability, out-yielded Eski three of the four years in the two-cut system and produced a total yield similar to Appalachee and Ladak alfalfa. However, the density of plants required to obtain these similar yields was drastically different; 30 per six feet of row for Appalachee and seven per 6 feet of row for Remont.

Seedlings of Eski sainfoin previously were shown to be equally as susceptible as Ranger alfalfa to penetration and reproduction by stem nematode (7). However, seedlings of sainfoin that survived in our study had either escaped infection or had outgrown the infection and symptoms after 28 days. Although seedling infection may have occurred in this study, symptoms were not observed in either alfalfa or sainfoin. The four-week period between plow-down and seeding may have reduced nematode populations, particularly in the upper 2 inches of soil. Soil populations of stem nematode in the composite sample taken from the top 6 inches on the day of planting were relatively low (12 per 300 cubic inches of soil). Also, soil moisture may not have been favorable for a period of time necessary for infection (1).

At the end of the study, invasion and infection by stem nematode and typical symptoms had occurred in crown buds and stems of six-year-old plants of alfalfa, but not sainfoin. Although the number of crowns of the two alfalfa varieties having stem nematode infection were similar (40 percent vs. 39 percent), crowns of the susceptible variety Ladak were more severely infected. Plant tissues of 10 randomly selected Remont and Eski plants were free of D. dipsaci while those of Appalachee and Ladak had a mean of 220 and 4,200 D. dipsaci per gram dry stem bud tissue, respectively. From our study and a previous study conducted by Griffin (7), only tissue of very young seedlings of sainfoin appear to be susceptible to parasitism by stem nematode.

In summary, Remont sainfoin maintained sufficient plants, which resulted in yields comparable to those of alfalfa for five years. It appears that the stem nematode, a major stand decline disease of alfalfa, is not a threat to established stands of sainfoin.

Although sainfoin appears to be well-adapted to the Laramie Valley, plantings made under irrigation at two other locations in the state (Torrington and Dayton) have had different results. Research plots of sainfoin at the Torrington Research and Extension Center showed rapid stand decline attributed to high soil populations of the root-knot nematode Meloidogyne hapla Chitwood (11), not present at the Laramie site. Also, an experimental planting at Dayton resulted in similar stand decline, which was attributed to both a seedling disease, caused by Phytophthora megasperma f. sp. medicaginis Drechs. (10), and Verticillium wilt, V. albo-atrum Reinke and Berthier, both major diseases of alfalfa. Phytophthora root rot has been found in the Laramie Valley on alfalfa, but Verticillium wilt has not.

In Wyoming, plantings of sainfoin under dryland conditions, where disease pressure is low, have been more promising. If planting sainfoin under irrigation, a small strip should be planted for observation over several years before larger plantings are made. Also, planting sainfoin with a grass mix is another promising possibility currently being tested in Wyoming.

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Table 1. Comparative forage yield, plant stand, and stem nematode infection of alfalfa and sainfoin grown in a field naturally infested with the stem nematode.[a]

Crop cultivar	Reaction to SN[b]	Forage yield (tons/A) 2 cut 1982	2 cut 1983	1 cut 1984	2 cut 1985	Total yield Kg/plot	Plant stand: No. plants/6 ft of row 10/20/81	10/3/85	% reduction	Stem nematode[c]: % plants infected	ASI (1-5)	Nematodes /[e] g dry stem bud tissue
ALFALFA												
Appalachee	HR	3.9	2.0	1.3	3.7	10.9	88	30	66	39	1.4	220
Ladak	S	3.8	1.5	1.3	3.3	9.9	94	16	83	40	3.1	4,200
SAINFOIN												
Remont	U	5.0	1.8	1.2	2.7	10.7	81	7	91	0	1.0	0
Eski	U	4.6	1.1[d]	1.2	1.4	8.3	65	3	95	0	1.0	0
$LSD_{0.05}$		0.4	0.2	0.2	0.3	1.1	32	NS		12	1.1	

[a] The study was planted on 26 May 1981, near Laramie, Wyoming. Values are the mean of 6 replicates.
[b] HR = highly resistant to the stem nematode, S = susceptible, U = unknown.
[c] ASI = Average Severity Index for ASN-symptoms, 1 = none, 2 = slight, 3 = moderate, 4 = severe, 5 = very severe symptoms.
[d] Regrowth was insufficient for a second cut.
[e] Values are the average of nematodes recovered from 10 random plants from each cultivar at the end of the study.

MEADOW IMPROVEMENT
NITROGEN AND PHOSPHORUS FERTILIZATION OF GARRISON CREEPING FOXTAIL - YIELD RESPONSE AND ECONOMICS

D. W. Koch and D. Reynolds

One of the easiest and least expensive ways to increase hay production on meadows is to apply fertilizer. Garrison creeping foxtail is very responsive to nitrogen fertilizer, with yields often doubling with as little as 50 pounds per acre of nitrogen. If the soil test indicates 10 parts per million of phosphorus or less, there is likely to be an additional increase in hay yields when phosphorus fertilizer is added.

This study was conducted to determine the response of Garrison creeping foxtail on a low-fertility field to nitrogen and phosphorus fertilizer and the economics of various levels of fertilizer.

Methods

An established meadow dominated by Garrison creeping foxtail (Alopecurus arundinacea) located on the Kerbs' Farm near Saratoga was used to study responses to nitrogen (N) and phosphorus (P) fertilization. The soil is a sandy loam with a pH of 7.5. Initial soil analysis at 0-6 inch depth was as follows: nitrates, 4 parts per million; phosphorus, 3.5 parts per million; potassium 97 parts per million. These are all relatively low levels. This soil has a high lime level.

Fertilizer was applied as ammonium nitrate (34-0-0) and triple superphosphate (0-46-0). Treatments consisted of a control (no fertilizer), N rates of 0, 50, and 100 pounds per acre, P2O5 rates of 0, 15, 30, 45 pounds per acre applied yearly and a one-time rate of 135 pounds P2O5 per acre applied at the beginning of the study (1989 only). Potassium rates of 0 and 150 pounds per acre were also applied. Four replications of all treatments were applied. Fertilizer was applied on April 13, 1989, April 3, 1990, and on April 21, 1991.

The field was flood irrigated. In 1989 the first irrigation was on April 20. In 1990 and in 1991 irrigation was delayed several weeks following fertilizer application and there was less than optimum irrigation water applied, resulting in lower average yields than in 1989. Plots were harvested on July 7, 1989, July 12, 1990, and July 25, 1991. Amount of regrowth was not determined.

Results

Hay yield of the unfertilized meadow was only 0.71, 0.27 and 0.28 ton per acre in 1989, 1990, and 1991, respectively (Table 1). Over three years (1989-91), 50 pounds nitrogen per year, without P, increased three-year hay yield from 1.26 tons per acre for unfertilized control to 3.71 tons per acre (Table 1). Over the same period of time, applying 100 pounds N per year increased hay yield to 4.44 tons per acre. In addition to 100 pounds N, phosphorus fertilizer increased hay yield. The combination of 100 pounds N and 45 pounds P2O5 produced 5.56 tons per acre of hay over three. Applying 135 pounds of P2O5 at the beginning of the study (1989) was not as effective as applying 45 pounds of P2O5 yearly. In 1989, the 135-pound P2O5 rate may have caused a nutrient imbalance and reduced hay yields, compared with lower P rates of phosphorus fertilizer. Less response from the high initial rate may have been due to greater fixation. Residual P was not adequate to improve yields over the 4-5 pound rate in the second and third years of the study.

Even though the initial soil test indicated a low potassium (K) level, there was no difference in yield with application of 150 pounds K per acre, even at the high levels of N and P2O5.

Applying P with 50 pounds N per acre produced limited increases in yield. This indicates that N is most limiting and the need for N must be met before there is a response to P. Best return on the dollar for phosphorus was when phosphorus is applied with 100 pounds N per acre (2.02 to 2.15). Nitrogen and phosphorus can be blended so only one application is needed.

Best return on dollars spent on fertilizer was with 50 pounds N per acre, more than $3 return on the fertilizer dollar (Table 2). However, returns were greater than $2 for all levels of phosphorus fertilizer in combination with 100 pounds N per acre. Even better returns might have resulted, particularly in 1990 and 1991, if irrigation had been more timely and water more abundant. Also, there might be an economic return from potassium fertilization under these conditions. Single harvest hay yields of 3 tons per acre have been obtained from stands similar to the Garrison creeping foxtail in this study.

Soil test levels of phosphorus for the various fertilization rates in the spring of 1991 were:

P0 - 2.67 ppm
P15 - 3.00 ppm
P30 - 3.33 ppm
P45 - 3.67 ppm
P135 - 3.67 ppm

A phosphorus fertilization level of 45 pounds P2O5 per acre yearly was needed to maintain soil test P level, which was 3.5 parts per million at the start of the study.

Table 1. Yield of Garrison creeping foxtail and the increase over unfertilized control with various rates and combinations of nitrogen and phosphorus fertilizers. Kerbs Farm, Saratoga.

	Hay yield, tons/A (12%)					
Fertilizer	1989		1990		1991	
level1	N50	N100	N50	N100	N50	N100
P0	1.34	1.69	1.33	1.49	1.04	1.26
P15	1.45	1.84	1.29	1.57	1.04	1.35
P30	1.60	2.06	1.03	1.66	1.07	1.47
P45	1.76	2.21	0.91	1.81	0.99	1.54
P135	1.61	1.96	0.99	1.86	1.02	1.42
Unfertilized control	0.71		0.27		0.28	

Table 1. (Continued)

Increase Over Unfertilized Control, 3-Year Total		
Fertilizer level[1]	N50	N100
	tons hay/A	
P0	2.45	3.18
P15	2.52	3.50
P30	2.44	3.93
P45	2.40	4.30
P135	2.36	3.98

1 The 135 pounds per acre rate of phosphorus was applied in 1989 and no phosphorus was applied in 1990 or 1991.

Table 2. Costs and return on fertilizer dollar for various application rates of nitrogen and phosphorus. Numbers are totalled over three-year period (1989-91) at Kerbs Farm, Saratoga.

Nutrient level	Yield increase over control	Cost of increase[1]	Value of increase[2]	Return on fertilizer dollar
N50	2.45	46.05	147.00	3.19
N50 + P15	2.52	59.01	151.20	2.56
N50 + P30	2.44	71.97	146.40	2.03
N50 + P45	2.40	84.93	144.00	1.70
N50 + P135	2.36	84.93	141.60	1.67
N100	3.18	84.60	190.80	2.26
N100 + P15	3.50	97.56	210.00	2.15
N100 + P30	3.93	110.52	235.80	2.13
N100 + P45	4.30	123.48	258.00	2.09
N100 + P135	3.98	118.48	238.80	2.02

1 Based on N at \$0.257, P_2O_5 at \$0.288, and \$2.50 per acre for application.

2 Based on hay at \$60 per ton.

ALFALFA RESPONSE TO SURFACE-APPLIED PHOSPHORUS FERTILIZER

David W. Koch and James T. Pike
Cooperating with the Polo Ranch (John Morris)

Alfalfa requires more phosphorus (P) than other crops. Phosphorus incorporation is commonly recommended because P is generally immobile in the soil. Some studies have shown less than 3 inches movement from surface application over 10 years. What, then, can be done if a low P level is discovered after the stand is established?

Low P availability results from an inability of some soils to supply P as rapidly as it is removed by crops. The problem is accentuated by a high pH (greater than 7.5) and high lime content of the soil. The calcium in lime reacts with P and reduces availability, requiring a greater-than-normal application of fertilizer. Grass requires less P than alfalfa, but has a greater mass of roots closer to the surface and effectively competes with alfalfa. If a low P level is not corrected, alfalfa will not be vigorous and will decline prematurely. An adequate level of soil phosphorus will help sustain a productive stand of alfalfa.

Phosphorus is commonly topdressed on established alfalfa. Often a large application of P is incorporated when alfalfa is seeded in order to supply P for several years. Soils with a high P-fixing capacity or longer-term stands will need to be fertilized periodically. With a pure alfalfa stand, good responses have been obtained with surface broadcast of P fertilizer. With alfalfa-grass mixtures there is much less information (1).

For each ton of alfalfa hay harvested, about 10-12 pounds of P205 is removed (2). On low P-supplying soils, this amount of P fertilizer will need to be applied to maintain potential production of alfalfa. Phosphorus is not lost from the soil either by leaching or by volatilization; therefore, excess nutrients are stored until needed by the crop.

Mild deficiencies of P can reduce alfalfa yields without visible symptoms. More severe deficiency will cause stunting, which will not be evident unless compared to nearby healthy plants.

When phosphorus is deficient, fertilization with P will increase yield of the alfalfa component, improve P levels of the forage, and hasten maturity, allowing faster regrowth. It will probably have no effect on protein content or any other quality component.

Methods

In 1992 a soil test showed 7 pounds per acre of P205 (Olsen method) on a one-year-old alfalfa-grass stand that was irrigated with a center pivot. The field was on the Polo Ranch near Cheyenne. The soil was a fine loamy sand, deep and well-drained. The site was at 6,500 feet. The pH was 7.5 and the lime content was low. On May 18, 1992, a 50-feet wide strip was fertilized with a broadcast application of 100 pounds per acre of P205. This was the anticipated need for two to three years. Both alfalfa and grass were about 6-8 inches at the time. The first cutting was approximately 60 percent alfalfa. An adjacent four-year old stand was about 25 percent alfalfa and 75 percent bromegrass. On June 18 and August 12, 1992, yield of the P-fertilized strip and an adjacent unfertilized strip was determined on the day when the hay was windrowed. The samples were weighed, dried, and reweighed to determine dry matter content and to calculate yield of forage.

Results

Hay yield one month after topdressing with P fertilizer was 0.44 ton per acre greater (Table 1). This greater yield carried over into the second harvest, where there was a 0.36 ton per acre increase due to P. The total yield from two harvests (3.46 tons per acre) was still below the potential for the field. However, considering the cost of the fertilizer and its application and the increased value of the hay, there was approximately $1.55 return on the fertilizer dollar, just considering the first two harvests. The return (estimated at $26 of additional forage) one month after applying fertilizer was nearly adequate to pay the cost of fertilizing (an estimated $31 per acre). The response will be expected to continue into the next year, because only about 1/3 of the applied P was removed with these two harvests.

Table 1. Alfalfa response on a low phosphorus field to a surface application of phosphorus fertilizer.

	1992 harvests		2-cut	P content	Return on
	Jun 18	Aug 12	total	of forage[1]	fert $
	---------- tons/A ----------			------ % -----	
Unfertilized control	1.09	1.57	2.66	0.14	--
100 lb/A of P205 fert.	1.53	1.93	3.46	0.18	1.55

1 Determined on adjacent area.
2 Using $.28 per pound of P205, $3 per acre application cost, and $60 per ton of hay.

Additionally, there was an increase from 0.14 to 0.18 percent in P content of forage. For optimum production, alfalfa in early bloom should be in the range of .23 to .30 percent P. Greater than .20 percent, for example, is considered adequate for cows through the first four months postpartum.

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DRYLAND GRASS SEEDINGS AND EVALUATIONS

PRODUCTION AND QUALITY OF FORAGE GRASSES UNDER DRYLAND CONDITIONS

D. W. Koch, J. T. Pike, and F. Hruby

Improved grasses can be most effectively used if the seasonality of production and quality are known. These grasses can complement native range in several ways: (1) providing early green-up, enabling earlier grazing; (2) deferred grazing of range, allowing native grasses to reach a more advanced stage of maturity before grazing, thereby improving condition of range; (3) providing greater production in order to increase number of livestock; (4) providing higher-quality forage in late summer and fall, improving late-season weight gains and/or extending the grazing season; and (5) providing high-quality forage for breeding pasture, either in spring or in the fall. No one grass can be expected to provide all of these benefits.

In addition to production and quality, usefulness of a grass depends on ease of establishment, drought resistance, regrowth ability, and persistence. Recently, several improved cultivars have been released. Others have received little attention, particularly with respect to forage quality.

Methods

An old stand of crested wheatgrass was plowed in the spring of 1988 and summer fallowed. In early spring, 1989, the area was roller-harrowed to provide a firm seedbed. Thirty grasses were seeded with a Tye drill at recommended seeding rates in 3 1/2 by 412 feet plots on April 18. All grasses were planted at 8-inch row spacing, except Russian wildrye and Altai wildrye, which were seeded at 24-inch row spacing. All grasses produced good stands except little bluestem, which did not establish. Plots have been periodically rogued to maintain nearly pure stands. Additionally, grasses have been mowed and old growth raked off before start of growth in the spring. Banvel was applied in June 1992 to control broadleaf weeds.

'Bromar' mountain bromegrass and perennial rye winter-killed in the winter of 1991-92. 'Matua' prairie grass, a recent brome-related introduction from New Zealand, and 'Oahe' intermediate wheatgrass were seeded in their place.

On the dates shown in Table 1, which were approximately the 50 percent heading stage,ß ßhand-clipped samples were taken from 3-feet lengths of center rows of each grass. Grasses were oven-dried and dry matter production determined. These samples were saved for grinding and protein determination.

Rainfall was below normal for the fall of 1991, winter of 1991-92, and spring of 1992. The warmer than normal temperatures in April and May and dry conditions limited growth early and resulted in earlier heading of the early maturing grasses. In June and July rainfall was above normal and temperatures considerably below normal.

Results

1992

Relative maturity

Earliest grasses to green up were the wildryes, which had green leaves in early March. Grasses reaching the 50 percent heading stage in May were big bluegrass, orchardgrass, Russian wildrye, tall fescue, and green needlegrass. Grasses that did not reach the equivalent heading stage until July were Mammoth wildrye, beardless wildrye, intermediate wheatgrass, bluebunch wheatgrass, western wheatgrass, thickspike wheatgrass, streambank wheatgrass, and tall wheatgrass. 'Mandan' was 11 days later than 'Luna' pubescent wheatgrass and 'Revenue' was nearly a month later than 'Pryor' slender wheatgrass.

Forage production

Dry matter production at 50 percent headed stage, averaged over all grasses was 2333 pounds per acre. Grasses producing the most forage (more than 3,000 pounds per acre) were mammoth wildrye, Altai wildrye, tall wheatgrasses, and smooth bromegrass. Except for smooth bromegrass, these are later-maturing grasses. Grasses with the best regrowth were orchardgrass, tall fescue, and smooth bromegrass. Grasses with fair regrowth were big bluegrass, Russian wildrye, Altai wildrye, and mammoth wildrye. Regrowth was not measured in 1992, however. Among varieties of the same species, 'Mandan' produced more forage than 'Luna' pubescent wheatgrass and 'Pryor' produced more than 'Revenue' slender wheatgrass. 'Jose' and 'Alkar' tall wheatgrass produced similar yield.

Protein content

Average protein content among the grasses for mid-heading stage was 10.0 percent, but ranged from 15.6 percent for smooth bromegrass to 6.2 percent for switchgrass. Switchgrass is a warm-season grass. The warm-season grasses are notably inferior to the cool-season grasses in forage quality. Protein content of the wildryes was 9.1 to 10.9 percent. Equally important is the ability of a grass, once it has matured, to maintain nutritive value. Although subsequent samples were not taken in this study, the wildryes, for example, have been shown to maintain relatively good forage quality in late summer and fall.

1993

Forage production increased considerably from June 10 to July 12 (Table 2). Over all grasses, the increase was from about one-half ton to about 1 ton per acre. The increase was substantial for the later-maturing grasses such as intermediate and tall wheatgrasses; however, the earlier-maturing crested wheatgrass varieties, as a group, tripled in dry matter production over this period of time.

Average use in June and in July was the same (37 percent); however, preferences changed somewhat. No measurable use was found with basin or mammoth wildryes, big bluegrass, or 'Alkar' tall wheatgrass. Several grasses maintained palatability over time: Russian wildrye, orchardgrass, beardless wildrye, bluebunch and western wheatgrasses, and tall fescue. Other grasses were either low in acceptance or declined in acceptance over time. 'Fairway' and 'Ephraim' maintained palatability better than the other crested wheatgrass varieties.

Only two grasses averaged over 1,000 pounds dry matter per acre and over 50 percent use: 'Bozoisky' Russian wildrye and 'Fairway' crested wheatgrass. The relatively new release, 'Hycrest,' was much more productive than the most commonly used crested wheatgrass, 'Nordan,' and only slightly less palatable in July. The relatively new release, 'Ephraim,' however, was much less productive than 'Fairway' crested wheatgrass, but was nearly as palatable.

'Pryor' matured about one month earlier than 'Revenue' slender wheatgrass (Table 1), accounting for the greater amount of forage available in June and the substantial decline in palatability. The new release 'Matua' bromegrass, which was planted in 1992 in a plot that winterkilled, produced less than 'Manchar' smooth bromegrass, which was planted in 1989. Like 'Manchar,' 'Matua' brome was highly palatable. The drought resistance, persistence, and long-term production of Matua brome is not known.
Plans are to collect similar production and grazing information in 1994.

Table 1. Production and quality of 29 dryland grasses4 seeded in April 1989 at Archer Research and Extension Center. Evaluated in 1992.

Species and variety	50% heading date	Dry matter production	Crude protein3
		lb/A	%
Big bluegrass, 'Sherman'	May 20	2825	9.5
Orchardgrass, 'Paiute'	May 22	1607	9.9
Russian wildrye, 'Bozoisky'	May 21	1338	10.9
Altai wildrye, 'Prairieland'	July 3	3402	10.2
Beardless wildrye, 'Shoshone'	-1	1665	9.1
Basin wildrye, 'Magnar'	-1	1866	9.9
Mammoth wildrye, 'Volga'	July 25	4279	10.7
Crested wheatgrass, 'Nordan'	June 12	2135	12.8
Crested wheatgrass, 'Hycrest'	June 12	2619	10.2
Crested wheatgrass, 'Fairway'	June 14	2523	12.1
Crested wheatgrass, 'Ephraim'	June 17	1919	13.1
Pubescent wheatgrass, 'Luna'	June 21	2274	9.4
Pubescent wheatgrass, 'Mandan'	July 2	2703	8.6
Intermediate wheatgrass, 'Oahe'	July 3	2202	7.8
Bluebunch wheatgrass, 'Secar'	July 8	2187	8.4
Western wheatgrass, 'Rosana'	July 29	1424	11.0
Hybrid wheatgrass, 'Newhy'	June 23	2403	8.0
Thickspike wheatgrass, 'Critana'	July 7	1751	8.8
Streambank wheatgrass, 'Sodar'	July 29	1118	10.2
Slender wheatgrass, 'Revenue'	July 20	1693	8.3
Slender wheatgrass, 'Pryor'	June 19	3262	10.4
Tall wheatgrass, 'Jose'	July 3	3324	10.4
Tall wheatgrass, 'Alkar'	July 1	3511	7.4
Tall fescue, 'Alta'	May 24	1588	10.1
Smooth bromegrass, 'Manchar'	June 14	3137	15.6
Mountain brome, 'Bromar'	-2	-	-
Perennial rye	-2	-	-
Green needlegrass, 'Lodorm'	May 23	2225	12.1
Switchgrass	-1	2005	6.2

1 Produced few seed heads.
2 Winterkilled, 1991-92.
3 At 50 percent headed stage of growth.
4 Little bluestem was seeded, but did not establish.

Table 2

ESTABLISHMENT OF IMPROVED GRASSES ON RANGELAND

D. W. Koch, D. Reynolds and Silver Spur Ranch

A late fall or winter planting of improved range grasses is generally recommended. This so-called "dormant" seeding allows grasses to germinate and establish at the earliest opportunity when winter snow melts or spring rains are received.

Spring seedings have been successful, but, depending on soils and weather, seedings may be delayed due to wet fields, mechanical failure, or lack of time. This reduces the likelihood of grasses establishing well enough to survive an ensuing period of dry weather, which, in Wyoming, is a high probability.

The break out of sagebrush rangeland in the fall of 1989 at the Silver Spur Ranch provided an opportunity to evaluate spring seedings of 'Hycrest' crested wheatgrass (CWG), 'Luna' pubescent wheatgrass (PWG), and 'Bozoisky' Russian wildrye (RWR). Large-scale plantings were made in early-mid April 1990 on tilled strips alternating with untilled strips of sagebrush rangeland.

A 2-acre block was set aside for spring planting of the three grasses at three row spacings. Grasses were seeded April 26-27, 1990, following cultipacking of the seedbed.

Pubescent wheatgrass is the largest seed of the three grasses and is reported to have the most seedling vigor. Crested wheatgrass, the most widely used improved grass on rangeland, also has good seedling vigor. Russian wildrye is reported to have the poorest seedling vigor and this is the reason most often given for stand failures with this species. Hycrest CWG and Bozoisky RWR are recently released varieties.

Pubescent wheatgrass is a sod-former and the other two grasses are bunch type. In contrast to the normal spacing of 7-9 inches between rows, it has been recommended that RWR be spaced 21-24 inches. It has been difficult to convince producers to plug holes in the drill to accomplish the wider spacing, particularly because RWR does not fill in between rows as with a sod-forming grass.

Results

Periodic rainfall occurred in the spring of 1990 and good stands were obtained for all three grasses on both the large-block range seeding and on the 2-acre demonstration block. By mid-June 'Luna' PWG and 'Hycrest' CWG had produced more top growth than 'Bozoisky' RWR. An uncharacteristic heat wave occurred in late June and lasted for about a week, following which all of the grasses died back.

The following spring (1991) there was an excellent stand of Bozoisky RWR on both the large-scale and small block areas, but nearly a complete loss of Hycrest CWG and Luna PWG.

Why then does a grass that is supposed to have poor seedling vigor survive over two other grasses noted for relatively easy establishment?

Russian wildrye has the reputation of having excellent drought resistance, similar to that of CWG.

The reason it has excellent drought resistance is undoubtedly due, in part, to the fact that Russian wildrye develops a very extensive root system. In this study, root growth and development were not examined. It may be that RWR initially puts more energy into the development of roots, which allows it to better use diminishing soil moisture and to rejuvenate the plant when the tops die back.

In other studies, 'Bozoisky' has shown more seedling vigor than other varieties of RWR. Actually, seedling vigor should probably be measured by root growth as well as top growth.

RWR was more vigorous in wider rows. Production, on an area basis, was 60 percent greater with 16-inch rows over 8-inch rows and 75 percent greater with 24-inch rows than with 8-inch rows (Table 1). Combining the savings in seed cost and the value of increased forage production, with wider rows a producer could save $6 to $12 an acre at the outset. Additionally, the yearly increase in forage value is significant.

RWR has other desirable traits. It is long-lived, with productive stands having been reported after 30 years, has some tolerance to salinity, holds nutritive value well after curing, provids excellent fall grazing, and competes vigorously against invading species. It is not recommended on sandy soils. In addition to being difficult to establish on these soils, the wide rows and bunch growth habit lead to excessive wind erosion.

Table 1. Effect of row spacing on forage production of Russian wildrye and the economic advantage of wider row spacing.

Row spacing	Dry matter production	Seeding rate	Seed cost1	Increase in value of forage2
inches	lb/A	lb/A	$/A	$/A
8	500	7.2	18.00	-
16	800	4.8	12.00	6.00
24	875	2.4	6.00	7.50

1 Assuming $2.50 per pound. Cost per pound will vary.
2 Assuming value of $0.02 per pound.

ROLE OF GRASSES IN THE CONTROL OF LEAFY SPURGE

D.W. Koch, T.D. Whitson, M.A. Ferrell, and A.E. Gade

Leafy spurge is one of the most serious weeds in Wyoming. Most efforts for containing and controlling leafy spurge have been through use of herbicides. Herbicides currently available are expensive, do not provide long-term control with a single application, and may contaminate groundwater in some instances. Picloram, which is highly water-soluble, is the most effective treatment with a single application; however, retreatment is required within three years (1). In spite of millions of dollars spent on control each year, leafy spurge is still spreading. Other effective and less expensive methods of control must be integrated with chemical treatment.

Aside from the use of crested wheatgrass, there has been very little attention paid to the use of grasses for providing long-term competitive control of leafy spurge (2,3). Even with chemical treatment of leafy spurge and management to favor grasses, results are often not satisfactory because grasses are either not present in adequate stands or are not competitive enough to prevent reinvasion of the weed.

As part of the renovation process, it may be advisable to do a reseeding. Ideally, a grass needs to be adapted and long-lived to justify a seeding. Additionally, a grass should be relatively easy to establish, productive, palatable, and nutritious. Given these characteristics, the grass hopefully will provide long-term competitiveness and good value for livestock grazing. New varieties of tried and proven species, such as crested wheatgrass and Russian wildrye are now available.

The objective of these studies was to determine the potential of perennial grass competition as an alternative to repetitive herbicide treatment for long-term control of leafy spurge.

Methods and Materials

Study 1

The experimental design was a split plot with four replications. Main plots were seeding methods (conventionally tilled and no-till seeded). Subplots consisted of 11 grass species (see Table 1). Mountain rye has not survived and is not included in the five-year data shown in Table 1. This study was located on the D. Zimmerscheidt farm near Sundance, Wyoming.

The soil texture was a silt loam with a pH of 6.3 and organic matter of 1.8 percent. Initial control of leafy spurge was by application of Roundupß?ß (glyphosate) on June 2 and July 1, 1986 at 0.75 pound active ingredient per acre. A tank mix of pendimethalin at 2 pounds per acre and fluoxypyr at 0.50 pound per acre was applied May 16, 1988. Since then, no herbicides have been used. These grasses have not been subjected to grazing.

Conventionally seeded plots were rototilled August 11, 1986. No-till seeded plots were left untilled. Grasses were seeded with a no-till drill equipped with powered coulters spaced 8 inches on August 12, 1986.

Grass dry matter has been determined from 2, 2-square feet quadrats per plot each year since 1988. Leafy spurge control has been determined by visual evaluation each year.

Study 2

Based on three years of observation in the previous study, 'Bozoisky' Russian wildrye (RWR) and 'Luna' pubescent wheatgrass (PWG) were selected as two of the more promising grasses for long-term competitive ability. Large strips (66 by 200 feet) of each grass were seeded in a split-plot design with three replications. Main plots were either tilled or no-till (killed sod) seedbeds. Grasses were randomly seeded within these seeding method blocks. The study was set up for the evaluation of grasses under grazing and to determine economics of seeding these grasses.

Roundupß?ß (glyphosate) was applied at 1 1/2 quarts per acre (1.125 pounds active ingredient per acre) on May 18, 1989 when leafy spurge was 10-16 inches and in late bud-early flower stage. A second application of 1 quart per acre (0.75 pound active ingredient per acre) was on July 19, 1989. Plots seeded into bare soil were rototilled prior to seeding. No-till plots were left undisturbed until seeding. A no-till drill with 1/2-inch depth bands was used to seed all plots. Luna pubescent wheatgrass (PWG) was seeded at 11 pounds per acre of pure live seed (PLS) and Bozoisky Russian wildrye (RWR) was seeded at 7 pounds per acre of PLS. As in Study 1, Luna PWG was seeded in 8-inch rows; however, Bozoisky RWR was seeded in 24-inch rows in contrast to the 8-inch row seeding in Study 1. Plots were seeded on August 8, 1989.

Two 3-square feet quadrats were clipped on each grass strip immediately before grazing on September 1, 1992, and immediately after grazing on September 3, 1992, premarked adjacent quadrats were clipped. Thereby, initial amount of forage and use of existing forage were estimated. Adjacent untreated areas were sampled at the same time.

On September 1, 1992, 250 ewes and 60 lambs were placed on the entire area for 48 hours. Grazing animals had free choice of about 1.07 acres of each grass.

Results

Study 1

Pubescent wheatgrass, intermediate wheatgrass (IWG), big bluegrass (BBG), and crested wheatgrass (CWG) were the only grasses to establish adequately without tillage. The latter has thinned substantially since the year after seeding. Bluebunch wheatgrass (BBWG) and mountain rye were the only grasses failing to establish adequately in tilled plots. Intermediate wheatgrass had a thin stand initially in both tilled and no-till plots due to a seed lot with poor germination. It has thickened considerably in the past five years.

Five years after seeding (1992), with seeding into tilled seedbeds, there are still good stands of Bozoisky RWR, Luna PWG, Newhy hybrid wheatgrass (HWG), and Oahe IWG and fair stands for the other grasses. Under no-till seeding, Luna (PWG) has maintained the best stand. Sherman BBG and Oahe IWG have fair stands, but the other grasses have poor stands.

After five years, Bozoisky RWR, seeded into the tilled seedbed has maintained 95 percent leafy spurge control. Several other grasses have maintained good leafy spurge control. Bluebunch WG appears to be the poorest competitor. Under no-till seeding, none of the grasses have maintained acceptable leafy spurge control.

Tillage before seeding seemed to be important to vigor and production of grasses. Sherman BBG, Oahe IWG, Luna PWG, and Newhy HWG all produced over 1,000 pounds dry matter per acre in 1992. Bozoisky RWR, which had the purest stand five years after seeding and was most competitive, produced 696 pounds per acre. Although this study was not grazed, RWR is very palatable and very heavily used (see Study 2 results). Also, in this study, Bozoisky RWR was planted in 8-inch rows. In other studies the vigor and production of the grass is considerably greater in wider rows. Bozoisky RWR in Study 2 (Table 2) was seeded in an area near to Study 1 in 24-inch rows, although three years later. Grass production was 65 percent greater in the 24-inch rows of Study 2 than in the 8-inch rows of Study 1. Even though leafy spurge control is 98 percent in the 24-inch rows after two years (Study 2), the effect of row spacing over the long term is still not known. Manchar SBG established a good stand initially, but has not been very productive, particularly in dry summers. Rainfall in this area is apparently marginal for this grass.

Bozoisky RWR and Rosana western wheatgrass are superior among the grasses in this study for late summer and fall grazing; however, the former is much superior in leafy spurge control. Also, it is less expensive to establish.

Study 2

Results are shown in Table 2. Prior to grazing on September 1, 1992, Bozoisky RWR in no-till strips was greener in appearance than Bozoisky RWR in tilled strips. There was greater surface litter in the no-till seeding and this could have led to better conservation and/or use of moisture. Bozoisky RWR had more green leaves than Luna PWG, indicating greater ability to grow in late summer. There was an estimated 98 percent control of leafy spurge with both grasses at the time of grazing in 1992.

Luna PWG produced more forage than Bozoisky RWR, but because use by ewes/lambs was greater with the latter, the amount used (pounds per acre) was similar for the two grasses. Both were well past maturity when grazed; however, there was more new growth (basal leaves) with Bozoisky RWR. Bozoisky produced 50 percent more and Luna produced 114 percent more forage dry matter than an adjacent untreated leafy spurge-infested area. The untreated area was not grazed.

Grass yields for the two methods of establishment, no-till and tilled seedbed, were similar for the two grasses. Bozoisky RWR was favored by grazing sheep, with more than 90 percent use. Luna PWG was about 55 percent used. This is in agreement with other studies that show that Russian wildrye maintains palatability well after curing. Pubescent wheatgrass is very palatable in July and August and might be better used then.

Table 1. The control of leafy spurge and production of grasses seeded five years previously into tilled or non-tilled seedbeds. 1992 evaluations.

Grass variety	Grass stand Tilled	Grass stand No-till	Leafy spurge control Tilled	Leafy spurge control No-till	Grass production Tilled	Grass production No-till
	---------- % ----------				lb. d.m./A	
Pubescent wheatgrass, Luna	85	73	85	66	1365	1028
Crested wheatgrass, Hycrest	75	34	80	63	850	503
Big bluegrass, Sherman	75	55	81	48	1537	1030
Hybrid wheatgrass, Newhy	86	4	84	3	1297	279
Smooth bromegrass, Manchar	74	6	79	0	407	158
Intermediate wheatgrass, Oahe	84	48	84	40	1432	695
Bluebunch wheatgrass, Secar	64	11	65	16	1164	195
Western wheatgrass, Rosana	64	20	83	18	813	183
Russian wildrye, Bozoisky	90	19	95	25	696	183
Thickspike wheatgrass, Critana	65	26	80	43	592	451
LSD.05	20	20	26	26	307	307

Table 2. Study 2. Dry matter production and use of Luna PWG and Bozoisky RWR grazed September 1-3, 1992. Grasses were seeded August 8, 1989.

Grass	Seeding method	Dry matter Pregraze	Dry matter Postgraze	Use lb. d.m./A	Use %
		----- lb/A -----			
Bozoisky RWR	No-till	1350	114	1236	91.6
	Tilled	1063	0	1063	100.0
Luna PWG	No-till	1891	793	1098	58.4
	Tilled	2083	1063	1021	51.3

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PRODUCTION AND QUALITY OF RUSSIAN WILDRYE AND RUSSIAN WILDRYE-LEGUME MIXTURES

D. W. Koch, J. T. Pike, and F. Hruby

Seeding legumes with a perennial grass offers the possibility of increasing production, quality, and palatability of forage and, therefore, performance of livestock. Some legumes have greater seedling vigor and so, may compete excessively with grasses such as Russian wildrye. One way to reduce competition is to avoid the planting of both species in the same row. Drilling grass and legume in alternate rows or in opposite directions will help to ensure establishment of the grass.

Methods

A 7-acre field at the Archer Research and Extension Center was seeded to replicated blocks of 'Bozoisky' Russian wildrye (RWR) alone in 8-inch, 16-inch, 24-inch, and 32-inch rows and in 24-inch rows in mixtures with either 'Spredor II' alfalfa,'Monarch' cicer milkvetch, or 'Remont' sainfoin. Legumes were seeded after the RWR and in a perpendicular direction in 24-inch rows. Additionally, a block of 'Newhy' hybrid wheatgrass (HWG), which is a thickspike-quackgrass cross at 8-, 16-, 24-, and 32-inch spacings, without legume, was seeded.

Seeding rates (PLS) were:
- RWR and HWG - 8-inch rows, 9 lb/A; 16-inch rows, 6 lb/A; 24-inch rows, 5 lb/A; 32-inch rows, 4 lb/A
- alfalfa - 1 1/2 lb/A
- cicer milkvetch - 4 lb/A
- sainfoin - 22 lb/A

All legumes were inoculated with appropriate inoculum. Cicer milkvetch seed was scarified. All blocks were seeded on December 10, 1990.

On July 9, 1992, 5-feet sections of rows of each species on the 24-inch spacing were sampled. Dry matter production and crude protein were determined from these samples. At sampling the stage of maturity was: RWR, fully headed; alfalfa, 80-100 percent bloom; cicer milkvetch, vegetative; and sainfoin, early seed stage.

On May 27, 1993, 10 square feet quadrats of each species and mixture and each row spacing was clipped. Legume and grasses were separated and amounts of each determined.

Rainfall at the Archer Research and Extension Center was below normal for the period of September 1991 to May 1992. It was above normal in June of 1992. Average temperatures were above normal in the spring of 1992 and below normal in June and July.

In 1993, RWR, RWR-alfalfa, and RWR-sainfoin were grazed with lambs. Because estimated forage availability was similar for all three forages, the same stocking rate was used on all of them. Twelve lambs were introduced on one replication of each forage, without supplement, on June 21 and grazed for seven days before rotating to the next replication. Total grazing time was 21 days. At the initiation of grazing RWR was completely headed, alfalfa was 5 percent bloomed, and sainfoin was 20 percent bloomed.

Results

1992

'Bozoisky' Russian wildrye established without legume produced 768 pounds per acre of dry matter that contained 13.7 percent crude protein on July 9. This resulted in a total of 105 pounds per acre of protein produced (Figures 1 and 2).

Alfalfa, seeded in a mixture with RWR, suppressed grass growth by 91 percent; however, the total forage produced by the mixture was increased by 64 percent over the grass alone. Due to the alfalfa, average protein content increased to 15.1 percent and the protein produced per acre nearly doubled.

Cicer milkvetch suppressed grass growth by 43 percent and total forage produced by 27 percent. It also decreased the amount of protein produced per acre, although the average protein content was increased somewhat to 14.7 percent. Cicer milkvetch, a non-bloating legume, is slow to establish, but because it produces rhizomes, it has the ability to thicken as time passes.

Sainfoin suppressed grass production by 70 percent, but nearly doubled forage and protein produced per acre, compared to the straight grass seeding. The protein content of forage was affected little as the protein content of the overly mature sainfoin was similar to that of the grass.

Sainfoin appears to be the best legume in a mixture with RWR. It is less competitive than alfalfa with RWR, yet substantially increased production and protein. It is also non-bloating and is the most palatable of the three legumes. It retains leaves better than alfalfa with advancing maturity. It is also more frost tolerant than alfalfa in the fall and retains leaves longer.

Cicer milkvetch may require additional time before its contribution can be fully assessed. There were more weeds present in the grass seeding and in the cicer milkvetch-grass mixture than with the alfalfa and sainfoin mixtures.

1993

In 1993, Bozoisky RWR and Newhy HWG were nearly double the production of 1992, illustrating that it requires two full years before these grasses are at full production (Table 1).

RWR seeded alone was most productive in 24-inch rows and least productive in 8-inch rows (Fig. 3). There was a similar pattern for HWG.

In the mixtures, with 24-inch spacing, alfalfa-RWR and sainfoin-RWR were comparable in total production (Fig. 4). In the alfalfa-RWR mixture, there was only 13 percent grass, whereas, with the sainfoin-RWR mixture there was 42 percent grass. As in 1992, alfalfa was much more competitive and dominating than sainfoin.

Over the 21-day period, lambs gained on all forages (Table 2). Gain was about 1/4-pound per day on straight grass and 2/3-pound per day on alfalfa and sainfoin mixtures. This resulted in nearly three times as much lamb per acre with the legume mixtures.

Plans are to measure production and quality of grasses and grass-legume mixtures and to graze with lambs in 1994.

Table 1. Forage production (dry matter) in 24-inch rows in year two (1992) and year three (1993) and protein content of grass and grass-legume mixtures in 1992.

	1992 % protein		Grass	Legume	1992 Total			1993 Grass	Legume		Total		
Newhy				768	--		768		1518	--		1518	
RWR	13.5			815	--		815		1484	--		1484	
RWR-alfalfa			15.5		72	1338		1410		188	1316		1504
RWR-CMV			14.9		466	125		591		--1	--1		--1
RWR-sainfoin		12.8			240	1396		1636		624	878		1502

1 Not sampled in 1993.

Table 2. Lamb performance on Russian wildrye and Russian wildrye-legume mixtures in 1993.

Forage	Initial weight		Final weight		Average daily gain		Grazing days/acre		Lamb gain/acre	
					-------------- lb --------------					
RWR	84.2		88.5		0.24		156		38	
RWR-alfalfa		87.4		101.6		0.67		156		105
RWR-sainfoin		88.5		103.0		0.69		156		108

Twelve lambs grazed each forage from June 21 to July 12. They were rotated weekly over three pastures of each forage.

Figure 1. Forage production from 'Bozoisky' Russian wildrye (RWR) and 'Newhy' hybrid wheatgrass

(HWG) seeded alone and in mixtures with three legumes, 1992.

Figure 2. Protein content of 'Bozoisky' Russian wildrye and grass and legume components of three mixtures. Dashed lines indicate the weighted average protein content of grass-legume mixtures, 1992.

Figure 3. Effect of row spacing on production of two grasses in 1993.

Figure 4. Newhy hybrid wheatgrass (HWG) seeded alone and Bozoisky Russian wildrye (RWR) seeded alone and in mixtures with alfalfa and sainfoin, all in 24-inch rows, 1993.

FORAGE MILLET AS AN EMERGENCY FEED CROP DURING PERIODS OF DROUGHT

J. T. Pike and D. W. Koch

Due to the frequent occurrence of drought, early farmers and ranchers used foxtail-type millet for livestock feed. Foxtail-type millets include the varieties Siberian, Hungarian, and German. Pearl millet is a related millet used for hay as well as for grain. While millet is not drought tolerant, it has the ability to efficiently feete available soil moisture at planting and to mature in 60 days (2). Foxtail millet has been reported to produce more total dry matter than sudangrass in semiarid regions (1).

A number of negative traits of millet have also been reported. While the protein content of millet (up to 15 percent) is higher than crops such as sudangrass, protein of millet is not as efficiently used by livestock (3). Compared with timothy, millet hay is less palatable to horses and has a diuretic effect (7). It has also been reported to be unsuited for pasture because it is shallow rooted and easily uprooted. In addition, most varieties lack the ability to regrow after being grazed (7).

Situations where forage millet may have an economic value are: (1) where drought has reduced growth of perennial native and introduced forages, (2) where fall planted small grains have been lost to winterkill, (3) on land requiring a cover crop to protect a new seeding or prevent erosion, and (4) where an annual crop is needed to rotate with winter wheat in order to clean up winter annual grasses. The occurrence of abnormally low precipitation from September 1991 through May 1992 at the Archer Research and Extension Center resulted in reduced forage production. Because of its ability to mature rapidly, 54 acres of millet was grown to supply needed forage.

The objectives of the study were: (1) to determine the production potential of millet on land not allowed a fallow year for moisture accumulation and (2) evaluate its feed value both for grazing and as a harvested forage when feeted by sheep.

Methods

In June 1992 foxtail millet was planted in eight fields ranging from 5 to 10 acres in size. The soil type is an Albinas sandy loam. Seedbed preparation varied from no-till to conventional tillage. Soil tests for nitrogen and phosphorus were taken prior to planting. Due to dry conditions, no fertilizers were applied. Table 1 summarizes soil and cropping information for each seeding. Millet seed was drilled 1-inch deep at 13 pounds per acre with a John Deere 8000 double disk drill with 7-inch row spacing.

Plot 9 (Table 1) was planted to serve as a fallow comparison. All other plots were seeded into the stubble or the tilled seedbed of a 1991 crop. Either Siberian or Hungarian millet or both were seeded into non-fallow plots. In the fallow plot (no. 9) both Siberian and Hungarian, as well as pearl millet, were seeded. German millet seed was not available locally.

On July 5, Plots 1 through 5 were sprayed with 2,4-D at .38 pound active ingredient per acre to control broadleaf weeds. Yield was determined by clipping 8, 2.5-square feet quadrats of forage from each plot on September 5. Plot 1 was grazed with 151 ewe lambs (Rambouillet x Columbia) born during February and March 1992. Lambs were drenched with Ivomec, tagged, and weighed individually.

Average lamb weight at the start of the grazing period was 81 pounds. After grazing for 20 days lambs were weighed to obtain gain per animal per day. Lambs were supplemented with 1.0 pounds per day of grain composed equally of barley, wheat, and safflower. Prior to grazing, nitrate content of millet was 0.1 percent. Use was determined by estimating the amount of plant growth consumed.

Results

Forage production of millet

Average production of millet grown in fields not allowed a fallow year was 1,926 pounds per acre (Table 2). Yield ranged from 786 to 2,928 pounds per acre. Fields receiving conventional seedbed preparation averaged 2,291 pounds per acre, compared to 831 pounds per acre for the two fields which were no-till drilled either into sod (one field) or into stubble (one field). The check (fallowed) plot, averaged over Hungarian and Siberian varieties, produced 2,847 pounds per acre, which was 556 pounds per acre more forage than the non-fallowed fields receiving similar seedbed preparation. The hybrid pearl millet produced 2,127 pounds per acre, which was less than either Siberian or Hungarian varieties.

All fields exhibited vigorous growth from emergence until early July in response to 3.6 inches of rainfall during the last week of June. However, by mid July plants were severely stressed. Symptoms were wilting, abnormal heading, crinkling of leaves, and purple streaking of stems and leaves. Examination of plants revealed an infestation of corn leaf aphids (Rhopalosiphum maidis). Populations of aphids were highest in fields planted to Hungarian. The purple streaking may have been due to the low level of phosphorus (12 parts per million PO4) in these fields. Abnormal heading and crinkling of leaves was more noticeable in fields that had been sprayed with 2,4-D. A number of factors may have contributed to the symptoms, however.

Rainfall during June, July, and August was 7.3 inches above normal, preventing the observation of millet production under drought conditions. The average daily mean temperatures for June, July, and August were 1.2, 4.3, and 3.0 degrees Fahrenheit below normal. While the increased rainfall may have contributed to increased yield, the below-normal temperature most likely limited growth and production of millet, which is a warm-season crop. Millet yields in areas receiving 12 inches of rainfall have been reported as high as 4,500 pounds per acre (2).

Grazing study

Field Plot 1 was grazed with ewe lambs and provided 306 animal grazing days per acre and 130 pounds lamb per acre. The average daily gain was .40 pound per lamb. This compares favorably with feedlot gains of .60 pounds. The total gain per acre of 130 pounds would only provide $65 per acre gross income based on 1992 lamb prices. The low gain per acre was, in part, due to the low forage production but was further reduced by poor feetation. Daily observation of lambs revealed slow acceptance of millet and avoidance of plants that had headed. Use ranged from 30 to 90 percent with the highest rate occurring on the least mature plants. Use of Siberian was greater than Hungarian but was likely the result of a less mature Siberian, which reached the seed stage 12 days after Hungarian. Avoidance of mature millet raises the question of whether or not improved production will increase weight gain per acre. The results of this study are consistent with previous reports of low yield (6), and poor use due to low palatability (1). The low yields may be due to the altitude at Archer (6,000 feet) and cool summer temperatures, which have been found to limit millet growth (7).

Table 1. Plot description, varieties, previous crop and field preparation of millet seedings at Archer Research and Extension Center in 1992.

Plot No.	Acres	Planting date	Nitrogen/ phosphorus, ppm	Variety[1]	Previous crop	Field preparation
1	10	6-11	38 NO_3 26 PO_4	H,S	Triticale	Chiseled 2x, rod-weeded, harrowed
2	7.5	6-17	15 NO_3 12 PO_4	S	Native grass	Sprayed w/Roundup 5-91, no-till drilled
3	5	6-18	15 NO_3 12 PO_4	S	Sudan	Chiseled, disked, harrowed
4	7.5	6-18	15 NO_3 12 PO_4	S	Millet	Chiseled, disked, harrowed
5	5	6-18	15 NO_3 12 PO_4	H	Sudan	Chiseled, disked, harrowed
6	5	6-11	27 NO_3 16 PO_4	S	Barley hay	Stubble planting after applying Roundup
7	7.5	6-24	27 NO_3 16 PO_4	S	Winter wheat, sudan	Chiseled, disked, harrowed
8	7.5	6-13	27 NO_3 16 PO_4	H	Winter barley (winter-killed)	Chiseled, harrowed
9	0.25	6-22	27 NO_3	H,S,P	Fallow	Chiseled

1 H = Hungarian; S = Siberian; P = Hybrid Pearl Millet.

Table 2. Dry forage yield of millet grown under fallowed and non-fallowed conditions.

Plot No.	Variety	Forage yield
		--------- lb/A ----------
Non-fallowed		
1	Hungarian	2928
2	Siberian	786
3	Siberian	1981
4	Siberian	1921
5	Hungarian	2441
6	Hungarian	877
7	Siberian	2425
8	Hungarian	2050
	Average	1926
Fallowed		
9	Hungarian	2798
9	Siberian	2896
9	Hybrid Pearl	2127

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ALTERNATIVE FORAGES

BRASSICA FORAGE RESPONSE TO NITROGEN FERTILIZER

Aziz Karakaya and David W. Koch

Introduction

Brassica forage crops are high in nutrient content and palatability, grow rapidly and are cold tolerant. Because the grazing season is short in northern climates, Brassica forages can be used successfully to extend the grazing period. These crops can be planted as a break crop following plowdown of alfalfa. The Brassica species require large amounts of nitrogen. Nitrogen fertilizers are one of the major costs for production of these crops. Efficient use of residual N from alfalfa would reduce the cost of producing these crops. This study evaluated the growth of various Brassica forages as affected different nitrogen rates following plowdown of old alfalfa stands.

Materials and Methods

The experiments were conducted at the Powell Research and Extension Center and the Honor Farm at Riverton, Wyoming. Brassica forages were planted following the first and second harvests of alfalfa. Early plantings were June 13 at Powell and June 14 at Riverton. Late plantings were on August 2 at Powell and August 6 at Riverton. Four forage Brassica species, 'Premier' kale (B. oleracea L. var. acephala DC.), 'Emerald' rape (B. napus L.), Tyfon [B. rapa L. X B. pekinensis (Lour.) Rupr.], and 'Purple Top White Globe' turnip (B. rapa L.) were seeded. At Powell, seed was planted with a tractor-mounted cone planter. At Riverton, a Tyeß?ß drill was used. At Powell, Sonalanß?ß and Treflanß?ß wereß ßapplied at recommended rates for weed control before the early and late plantings, respectively. Seeding rate was 4 pounds per acre for Powell plantings. At Riverton, seeding rate for early plantings was 1.5, 1.5, 2.9, and 1.8 pounds per acre for kale, rape, Tyfon, and turnip, respectively. At the same location, seeding rate for late plantings was 2.7, 3.4, 6.0, and 1.8 pounds per acre for kale, rape, Tyfon, and turnip, respectively.

Ammonium nitrate (34-0-0) was broadcast applied four weeks after early plantings and on the same day as late plantings. Fertilizer treatments consisted of no fertilizer, 60 pounds per acre and 120 pounds per acre of nitrogen. In addition, at Powell before the late plantings, 100 pounds nitrogen per acre was applied to the entire experimental area. Harvest dates for early plantings were October 5 and 8 for Powell and Riverton, respectively. Late-planting harvest date was October 20 at Powell and plots were harvested at Riverton on October 21. Plots were flood irrigated at Powell and sprinkler irrigated at Riverton. The soil texture was sandy clay at both locations with a pH range of 7.8. The percentage of organic matter was between 1.5 and 1.9. Soil analyses results were as follows: early planting, Riverton: PO4P, 10 parts per million; N03N, 25 parts per million; K, 224 parts per million; late planting, Riverton: PO4P, 12 parts per million; NO3N, 18 parts per million; K, 206 parts per million; early planting, Powell: PO4P, 14 parts per million; NO3N, 14 parts per million; K, 166 parts per million; late planting, Powell: PO4P, 22 parts per million; NO3N, 11 parts per million; K, 224 parts per million.

Results

Early-planting yields were higher than late-planting yields at both locations (Tables 1 and 2). Some Tyfon plots exhibited poor and variable germination; therefore, Tyfon plots of early planting at Riverton and late planting at Powell were not harvested. Under early-planting conditions at Riverton some weeds were present in the plots (Table 2). Weed growth in late plantings was negligible and, therefore, not determined.

Heavy larvae and aphid damage to the leaves was observed at both locations with early planting. Kale, in particular, sustained heavy damage due to the pests. Because of the extensive pest damage, yields of early plantings were not much different than late plantings at Riverton. In terms of pest damage, turnip was the least affected crop.

All crops tested responded positively to the increase in nitrogen levels (Tables 1 and 2). This was more evident with early plantings and with turnips. Environmental conditions were more favorable to plant growth and there was a longer growing season with earlier planting. At Powell, early planting yields of kale, rape, and Tyfon were similar; however, turnip yields were greater. Tyfon and turnip yields were presented as combination of shoot and root yield (Tables 1 and 2). At Riverton, under early planting conditions, rape and turnip yields were greater than kale yields. At Riverton, yields were higher than at Powell (Tables 1 and 2). The root crops produced a greater proportion of shoot growth with increased nitrogen levels. Tyfon, and especially turnips, produced considerable root growth. Sometimes more than half of the yields of turnip consisted of roots (Tables 1 and 2). Increased nitrogen levels appear to favor more shoot growth. Especially at Riverton, root crops had low dry matter content. It is likely that low dry matter content of the fleshy roots of Tyfon and turnip was responsible for these low values.

Even though alfalfa stands were several years old at Powell and Riverton and a significant amount of residual N (see soil test results) was present, Brassica crops responded positively to nitrogen fertilization. Applying nitrogen can increase the yield of these crops; however, caution should be exercised since excessive nitrogen applications may cause environmental and potential livestock health problems.

Table 1. Dry matter (d.m.) yield response of forage *Brassica* species to nitrogen rate at the Powell Research and Extension Center, 1991.

Brassica sp.	Nitrogen level (lb/A)	Early planting: Brassica yield ton d.m./A	Early planting: % dry matter	Early planting: % shoot	Early planting: % root	Late planting[a]: Brassica yield ton d.m./A	Late planting[a]: % dry matter	Late planting[a]: % shoot	Late planting[a]: % root
Kale	N_0	1.23	16	100	-	0.50	15	100	-
	N_{60}	1.36	16	100	-	0.75	16	100	-
	N_{120}	1.82	14	100	-	1.05	13	100	-
Average		1.47				0.77			
Rape	N_0	1.12	1	100	-	0.44	13	100	-
	N_{60}	1.39	18	100	-	0.63	14	100	-
	N_{120}	2.12	18	100	-	0.61	13	100	-
Average		1.54				0.56			
Tyfon	N_0	0.96	13	71	29	-	-	-	-
	N_{60}	1.39	13	68	32	-	-	-	-
	N_{120}	2.02	12	74	26	-	-	-	-
Average		1.46							
Turnip	N_0	1.86	11	36	64	1.22	11	43	57
	N_{60}	2.60	11	39	61	1.62	11	46	54
	N_{120}	3.16	11	43	57	1.82	10	51	49
Average		2.54				1.55			

[a]In addition to the nitrogen levels listed above another 100 pounds per acre nitrogen was applied to entire plots before planting. Actual rates were 100, 160 and 220 pounds N per acre.

Table 2. Dry matter (d.m.) yield response of forage *Brassica* species to nitrogen rate at the Honor Farm, Riverton Wyoming, 1991.

Brassica sp.	Nitrogen level (lb/A)	Early planting: Brassica yield ton d.m./A	Early planting: % dry matter	Early planting: % shoot	Early planting: % root	Early planting: Weed lb d.m./A	Late planting: Brassica yield ton d.m./A	Late planting: % dry matter	Late planting: % shoot	Late planting: % root
Kale	N_0	1.89	39	100	-	375	1.89	12	100	-
	N_{60}	2.36	19	100	-	63	2.08	11	100	-
	N_{120}	3.25	19	100	-	379	2.42	10	100	-
Rape	N_0	2.69	19	100	-	322	1.42	12	100	-
	N_{60}	4.12	17	100	-	678	1.76	11	100	-
	N_{120}	5.34	16	100	-	433	1.97	10	100	-
Tyfon	N_0	-	-	-	-	-	1.63	10	80	20
	N_{60}	-	-	-	-	-	2.09	9	83	17
	N_{120}	-	-	-	-	-	2.15	8	84	16
Turnip	N_0	3.46	8	37	63	382	1.99	9	53	47
	N_{60}	3.43	8	47	53	179	2.76	9	58	42
	N_{120}	4.95	8	47	53	502	3.00	9	62	38

EVALUATION OF BRASSICA FORAGE SPECIES UNDER WYOMING CONDITIONS AND CHARACTERIZATION OF A PHYTOPHTHORA SP. ASSOCIATED WITH THESE CROPS

A. Karakaya, F. Gray, and D. W. Koch

Introduction

In previous Brassica trials at the Powell Research and Extension Center, kale and Tyfon plants showed wilting and root rot symptoms. From these roots a Phytophthora sp., similar to the fungus that causes root rot of alfalfa was isolated. In the spring and summer of 1991, experimental plots were established following plow down of old alfalfa stands at the Powell Research and Extension Center and at the Honor Farm, in Riverton, to evaluate the effect of disease under field conditions and to provide information on yield of various forage Brassica species under different environmental conditions and planting dates. At both locations soils are sandy clay.

Materials and Methods

Three forage Brassica species, 'Premier' kale, 'Emerald' rape, Tyfon, and 'Ranger' alfalfa were seeded. Experiments consisted of metalaxyl treated and untreated plots. For the treated plots, seeds were treated with Apronß?ß and approximately four weeks later Ridomilß?ß was applied. At Powell, Sonalanß?ß and Treflanß?ß were applied before the early and late plantings, respectively. Early-planting dates were June 13 and 14 for Powell and Riverton. Late plantings were August 2 and 6 for Powell and Riverton. At Powell seeding rate was 4 pounds per acre. At Riverton, seeding rate for treated plots was 1.5, 1.5, and 2.7 pound per acre for kale, rape, and Tyfon plants, respectively. The rate for untreated plots was 1.6, 1.6 and 3.0 pounds per acre for the same species. Second planting seeding rates at Riverton were slightly higher. Plots were flood irrigated at Powell and sprinkler irrigated at Riverton. Harvest dates for the first plantings were October 5 and 8 for Powell and Riverton, respectively. Harvest dates for the late plantings were October 20 and 21 for Powell and Riverton, respectively.

Results

Early planting. At Powell, treated and untreated plots had similar plant densities, with the exception of Tyfon. Variation was great in Tyfon plots (Table 1). Yields of untreated plots were slightly higher. Especially in the case of rape, the metalaxyl treatment might have been phytotoxic. There were a number of weeds not controlled by the herbicide. Dry matter content of the weeds were higher than dry matter of brassicas (Table 1). At Riverton, there was no difference in plant density or yield between treated and untreated plots (Table 2). Even though pest problems were present, yields were very high. Yields were much higher than at Powell (Tables 1 and 2).

Late planting. At Powell, even though treated plots had more plants, yields of treated and untreated plots were similar (Table 1). The yield of late-planted brassicas were lower than with early planting. Weeds, mainly wild brassicas, were present in the plots. At Riverton, density and yield of treated and untreated brassicas were similar (Table 2). The yields were considerably lower than early planting yields.

Throughout the experiments, larvae and aphid damage to the leaves of brassicas was noted. Larvae damage was highest in kale. Larvae damage to the rape and Tyfon leaves was medium. The caterpillars attacking the leaves were identified as Autographa californica (alfalfa looper), Pieris rapae (imported cabbageworm), and Melanchra picta (Zebra caterpillar). Alfalfa looper was not detected in Riverton. Larvae damage was heavier with early plantings. Heavy infestation of cabbage aphid (Brevicoryne brassica) was observed at both locations. Kale plants had heavy aphid infestation. Rape and Tyfon were moderately affected by the aphids. Aphid damage was greater with early plantings. Due to excessive pest problems, some kale plots at Riverton exhibited poor performance. The Phytophthora sp. isolated from brassicas was not detected this year. However, the alfalfa pathogen, P. megasperma f. sp. medicaginis was frequently isolated from diseased alfalfa plants at both locations and planting dates. In addition to the Phytophthora, some other pathogens attacking brassicas were observed. Powdery mildew of Tyfon caused by Erysiphe cruciferarum was detected at both locations. Soft rot of turnip roots caused by Erwinia carotovora was found at both locations. In addition, wire stem disease caused by Rhizoctonia solani was observed.

Based on microscopic observations, the kale and Tyfon isolates were identified as Phytophthora megasperma. However, these isolates differed from P. megasperma f. sp. medicaginis. It appears that P. megasperma has a broader host range; on the other hand, P. megasperma f. sp. medicaginis has a limited host range.

Acknowledgement

We would like to thank Michael Brewer for identifying larvae species and for confirming our aphid identification.

Table 1. Dry matter (d.m.) yields and plant density of *Brassica* forage species as affected by planting dates and metalaxyl treatment at the Powell Research and Extension Center, 1991.

	June 13 Planting							August 2 Planting				
	Brassica					Weeds		Brassica			Weeds	
Yield	Yield (lb/A)	% d.m.	% shoot	% root	Plant density[b]	Yield (lb/A)	% d.m.	Yield (lb/A)	% d.m.	Plant density[c]	Yield (lb/A)	% d.m.
Kale, treated[a]	2821	16	100	-	180	350	25	964	17	225	274	20
Kale, untreated	3235	16	100	-	178	313	25	903	14	180	177	19
Rape, treated	2421	15	100	-	150	307	25	982	14	139	146	19
Rape, untreated	3153	17	100	-	154	352	24	826	15	98	267	17
Tyfon, treated	1086	12	74	26	18	618	25	No	data	taken		
Tyfon, untreated	1402	13	65	35	34	472	24	No	data	taken		

[a]Seed treatment formulation, Apron®, used at planting and spray formulation of metalaxyl, applied 4 weeks later.
[b]~90 square feet
[c]20 square feet

Table 2. Dry matter (d.m.) yields and plant density of *Brassica* forage species as affected by planting dates and metalaxyl treatment (Honor Farm, Riverton, Wyoming, 1991).

Treatment	June 14 Planting		August 6 Planting				
	Yield (lb/A)	Plant density[b]	Yield (lb/A)	% d.m.	% shoot	% root	Plant density[c]
Kale, treated[a]	7691	29	2931	12	100	-	107
Kale, untreated	7712	28	2689	12	100	-	94
Rape, treated	11139	15	2388	11	100	-	37
Rape, untreated	11220	14	2315	12	100	-	34
Tyfon, treated	No data taken		2477	10	78	32	32
Tyfon, untreated	No data taken		2773	10	74	26	37

[a]Seed treatment formulation, Apron®, used at planting and spray formulation of metalaxyl, applied 4 weeks later.
[b]Two, 3-feet rows.
[c]10 square feet.

EVALUATION OF TRAP CROP 'MAXI' MUSTARD AND 'ADAGIO' RADISH BY GRAZING LAMBS

J. M. Krall, D. W. Koch, F. A. Gray, J. J. Nachtman, and R. Jones

Currently, there are several varieties of white mustard and radishes bred and selected for biological control of sugar beet nematode. Anticipated use of trap crops would be as a second crop following main crops in a sugar beet rotation.

As with turnips, these crops are fast-maturing and very cold hardy. Their potential for fall grazing in the United States has not been evaluated. A high seeding rate for nematode control is recommended and, therefore, seed costs would be greater than for turnips grown for grazing. Therefore, if these crops have grazing value, the returns may be used to offset the costs of growing the crops. Also, if sugar beets are to be grown in succeeding years, these crops might substitute for turnips for grazing. Turnips are a host to the sugar beet nematode and would be expected to increase the population of nematodes in the soil.

Methods

Torrington

'Maxi' mustard was planted on different dates and with different cultural practices following silage corn and dry beans at Torrington Research and Extension Center in 1992. Mustard was seeded at 19 pounds per acre. Prior to grazing, available forage was estimated by clipping random 2 1/2 square feet quadrats on October 16. Subsamples were analyzed for forage quality.

Ten lambs, previously on an alfalfa hay-corn grain diet were placed on 'Maxi' mustard on November 4, 1992. They were provided water, but given no additional feed or supplement. They were weighed initially and at two week intervals until removal on December 2. Average initial weight was 71 pounds and final weight was 88 pounds.

In 1993, a large-block seeding of 'Metex' mustard was established into barley stubble following grain harvest and removal of loose straw. Roundupß?ß was applied at 1 pint per acre directly before planting. There was no tillage prior to seeding.

The soil test showed a pH of 7.7, P04-P of 2 parts per million and NO3-N of 14 parts per million. On the basis of low P availability, 400 pounds per acre of 16-48-0 was applied (64 pounds N and 192 pounds P205 per acre).

On August 16, 19 pounds per acre of 'Metex' mustard was planted with a John Deereß?ß disk drill. Due to cooler than normal temperatures, barley was about two weeks late in maturing. The stand of mustard was somewhat uneven in growth. Volunteer barley growth was heavy. On September 2, 1 pint of Poastß?ß and 1 quart of crop oil was applied when volunteer barley and mustard was about 6 inches.

Dry matter production of mustard and volunteer barley and amount of straw were determined by quadrat sampling on October 28. On October 29, eight lambs were allocated to each of three mustard blocks. Grazing, without supplement, was completed on November 12.

About 16 percent of each mustard block was left ungrazed. Three unseeded (fallow blocks) were left between mustard blocks. In 1994, sugar beets will be planted to determine effect of grazed and ungrazed mustard, compared with unseeded controls on sugar beet yields. Plowdown of grazed and ungrazed mustard will be in the spring of 1994.

Powell

Two-acre blocks of 'Adagio' radish and 'Green Globe' turnip were planted on August 12, 1992, following the harvest of barley and removal of straw. Prior to seeding, 50 pounds per acre of N as ammonium nitrate was applied. A double-disk drill was used to drill the radishes and turnips into barley stubble. Turnips were seeded at 2 pounds per acre and radishes were seeded at 22 pounds per acre. No herbicide was used prior to seeding; however, a Poastß?ß and crop oil tank mix was applied for control of volunteer barley after radish and turnip emergence.

On October 23, eight, 3 square feet quadrats from radishes and turnips were clipped for dry matter production and forage quality estimates.

Twenty lambs averaging 87 pounds were turned on to turnips and twenty lambs averaging 84 pounds were turned on to radishes on November 19. They were given no supplemental feed. Lambs were removed on December 15.

Results

Torrington, 1992

The trap crop, 'Maxi' mustard, was very high in crude protein and digestibility (Table 1). Average lamb weight was 71.4 pounds at the beginning of grazing and 88.4 pounds at the end of the grazing period, an average daily gain of 0.60 pound per day. Average daily gain and gain over the 28-day grazing period would indicate that they can perform on mustard nearly as well as can be expected on a standard hay and grain ration. Using market lamb prices at the termination of grazing, the value of the lamb produced (224 pounds per acre) was $156 per acre.

Torrington, 1993

Control of volunteer barley was poor, as seen in Table 2. As a result, barley contributed about 24 percent of the feed available.

Average initial weight of lambs was 67 pounds (Table 3). Lambs readily ate mustard, along with the volunteer barley and some straw. Excellent performance (.676 pound gain per day) over the two-week grazing period was obtained.

Cost per pound of gain is greater than that for turnips. Seed cost, at the present, for trap crop mustard is about $30 pe r acre compared with $3-5 per acre for turnips. 'Metex' mustard or other trap crop varieties would probably be grown only if a sugar beet cyst nematode problem existed. In this situation there would be a possible supplemental benefit either from a reduction in need of nematicide or an increase in sugar beet yields.

Additional grazing studies on trap crops will be conducted in 1994, particularly with 'Adagio' radish on fields infested with sugar beet cyst nematode.

Powell, 1992

Although 50 pounds N per acre was broadcast, both turnips and radishes grew poorly and showed the chlorotic symptoms of nitrogen deficiency. This was further confirmed by the low protein content of the forage (Table 1). Typically, turnips at this location have tested 14 to 16 percent protein. In previous trials, over 200 pounds per lamb per acre have been obtained with similar planting dates in early August. The fact that radishes had a higher protein content and produced more lamb per acre may indicate that they are more tolerant than turnips of low soil fertility. Projected income per acre for turnips and radishes, based on this year's results, would be $49 and $69, respectively.

Radishes competed more effectively with volunteer barley than turnips. Barley comprised 14 percent of the estimated 1,318 pounds forage dry matter with the radish seeding, but 25 percent of the 1,313 pounds forage dry matter with the turnip seeding. Radish seed is more than double the size of turnips and appears to have superior seedling vigor. Both crops established adequate plant densities, 13.4 and 12.2 plants per square feet for radishes and turnips, respectively.

Table 1. Performance of lambs grazing 'Maxi' mustard and 'Adagio' radish in 1992.

Location	Crop grazed	Forage quality Crude protein	 IVDMD	Average daily gain	Grazing days per acre	Lamb produced per acre
		%	%	lb		lb
Torrington	mustard	21.6	81.3	.60	375	224
Powell	radish	12.3	83.7	.39	251	98
Powell	turnip	9.7	82.1	.31	251	77

Table 2. Forage production and composition of 'Metex' mustard seeded August 16, 1993 directly into barley stubble following grain harvest. Sampling was on October 28, immediately prior to initiation of grazing with lambs. Torrington R&E Center. Data are averages of three blocks.

Forage component	Production lb/A	% of total	Dry matter content, %
Mustard	1698	61.8	13.7
Volunteer barley	651	23.7	18.5
Straw, barley	397	14.5	--
TOTAL	2746		

Table 3. Performance of lambs grazing 'Metex' mustard at Torrington in the fall of 1993. Based on 24 lambs.

Grazed area, acres	.826
Initial grazing date	October 29
Final grazing date	November 12
Initial weight, lb.	67.00
Final weight, lb.	76.46
Average daily gain, lb.	.676
Gain/acre, lb.	275
Lamb grazing days/acre	407
Stocking rate (72-lb lambs):	
Lambs/A for 30 days	13.6
Lambs/A for 45 days	9.0
Lambs/A for 60 days	6.8
Per lamb costs:	
Cost/lamb/day, $	.36 (.35 to .38)1
Cost/lb. of gain, $	.53 (.51 to .56)1

1 Based on 5-year average lamb prices. Values in parentheses are based on low to high price variation over the past five years.