Seeded wheatgrass yield and nutritive quality on New Mexico big sagebrush range

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Abstract

Establishment, yield, and nutritional quality of 'Nordan' crested wheatgrass (*Agropyron desertorum* [Fischer ex Link] Schultes), 'Fairway' crested wheatgrass (*Agropyron cristatum* [L.] Gaertner), 'Arriba' western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Löve), 'Luna' pubescent wheatgrass (*Thinopyrum intermedium* subsp. *barbulatum* [Schur.] Barkw. and D.R. Dewey), and 'Largo' tall wheatgrass (*T. ponticum* [Pod] Barkw. and D.R. Dewey) were evaluated on big sagebrush range *(Artemisia tridentata* Nutt. *tridentata)* in northcentral New Mexico during a 5-year study. All the above wheatgrasses showed high initial densities and long-term persistence. Wheatgrass yields across years and seasons during the last 2 years of study averaged 760 kg/ha compared to forage yields of 355 kg/ha on surrounding ungrazed native rangeland. There were no differences ($P>.05$) among wheatgrasses in standing crop of current year's growth during spring, summer, or fall. Crude protein concentrations did not differ ($P>.05$) among wheatgrasses with seasonal advance. However, all the wheatgrasses showed a consistent decline in nutritional quality from spring to summer to fall. All the wheatgrasses we studied will provide high-quality, spring (mid-April to mid-June) forage for livestock. During summer, use of native range is advantageous because it contains a high component of warm season grasses and forbs. Interseeding shrubs in wheatgrass seedings could reduce protein supplementation costs in winter.

Key Words: range improvement, revegetation, seeding, nutrition

The big sagebrush *(Artemisia tridentata* Nutt. *tridentata)* range type is of considerable importance in the western United States because of its large size (approximately 50 million hectares). Past heavy grazing by livestock has severely depleted this range type, particularly the southern portion in northern Arizona, northern New Mexico, and southern Colorado (Wooten 1908, Carlson 1969). After depletion, rest from grazing has showed little potential as a tool for range recovery of big sagebrush range in northcentral New Mexico (Holechek and Stephenson 1983), northwestern Arizona (Hughes 1980), and southwestern Idaho (Anderson and Holte 1980). These studies and others indicated sagebrush control is an important part of any program to increase forage production in this type.

Several studies have shown seeding of crested wheatgrass (*Agropyron desertorum* [Fischer ex Link] Schultes) can drastically increase forage production after brush control on big sagebrush range (Hull and Holmgren 1964, Springfield and Reid 1967, Frischknecht and Harris 1968). In northern New Mexico, Springfield and Reid (1967) reported crested wheatgrass is long-lived and productive when seeded on big sagebrush range. It provides succulent, nutritious forage earlier than most native grasses in the spring. This period is critical because nutritional needs of range cattle and sheep are highest then because of lactation. Other wheatgrasses may have potential for seeding in northern New Mexico. However, their use in range improvement programs depends largely on how their yield, persistence, and nutritional quality compares with the proven performance of crested wheatgrass. The objectives of our research were to compare the establishment, yield, and nutritional quality of 'Nordan' crested wheatgrass (*Agropyron desertorum* [Fischer ex Link] Schultes), 'Fairway' crested wheatgrass (*Agropyron cristatum* [L.] Gaertner), 'Largo' tall wheatgrass (*Thinopyrum ponticum* [Pod] *Barkw. and D.R. Dewey), Luna pubescent wheatgrass (T. intermedium* subsp. *barbulatum* [Schur.] Bark. and D.R. Dewey), and 'Arriba' western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Löve) on plowed big sagebrush range in northcentral New Mexico.

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Study Area and Methods

The study area is 38 km northwest of Taos, New Mexico, in a 25 to 35-cm precipitation zone at 1,900 m elevation. About 50% of the precipitation occurs in winter and spring, and 40% occurs in summer; July and August are months of peak rainfall. Annual precipitation during the study (1982–1986) averaged about 30 cm, and none of these years were extremely wet or dry. Soils on the study site are classified Cumulic Haplaustols in the Manzano series. They are well drained and clay loam in texture.

Vegetation on the study area before plowing was dominated by big sagebrush (*Artemisia tridentata* Nutt. *tridentata)* with a sparse understory of blue grama (*Bouteloua gracilis* [H.B.K.] Griffiths) and western wheatgrass. Other important species found on the study area include fourwing saltbush (*Atriplex canescens* [Purs] Nutt.), galleta (*Hilaria jamesii* [Torr.] Benth.), winterfat (*Eurotia lanata* [Pursh] Moq.), plains prickly pear cactus (*Opuntia polyacantha* Haw.), scarlet globemallow (*Sphaeralcea coccinea* [Pursh.] Rydb.), Russian thistle (*Salsola iberica* Sennen and Pau), fireweed summercypress (*Kochia scoparia Bornm.), buckwheat (Eriogonum* sp.), ring muhly (*Muhlenbergia torreyii* [Kunth] A. Hitchc. Ex Bush.), and crested wheatgrass.

The area selected for study is controlled by the Bureau of Land Management. We believe it is typical of big sagebrush ranges in northern New Mexico in terms of precipitation, soils, vegetation, and grazing management. During the past 15 years the study area has been grazed by cattle at a moderate stocking rate (30 to 40% use of current year's growth) during the winter from early November until late March.

The 1-ha study site was offset-disk plowed twice and fenced with rabbit-proof fencing in August 1980. In May 1981, 2 blocks of ten 100-m² experimental units were established within the fenced area. Five seeding treatments were randomly assigned to plots in each block and applied to one-half of each block (split block design) on 6 July 1982, and to the other half on 6 July 1983. Before application of seeding treatments, plots were hand weeded to remove competition. Seeding treatments included 'Nordan' crested wheatgrass, 'Fairway' crested wheatgrass, 'Largo' tall wheatgrass, 'Luna' pubescent wheatgrass, and 'Arriba' western wheatgrass. Seed for 'Fairway' crested wheatgrass and 'Nordan' crested wheatgrass was obtained from Sharp Brothers Seed, Greeley, Colo. Seed for 'Luna' pubescent wheatgrass, 'Largo' tall wheatgrass, and 'Arriba' western wheatgrass was donated to us by Wendall Oaks, manager, Soil Conservation Service Plant Materials Center in Los Lunas, New Mexico. All wheatgrasses were broadcast seeded at 508 pure live seeds per square meter, the recommended rate for broadcast seeding (Vallentine 1980). Seed was covered by hand raking immediately after broadcasting.

Plant density data were collected 5 October 1982 and 1983 to evaluate initial wheatgrass establishment. Ten randomly placed 400-cm² quadrats were evaluated on each experimental unit on each sampling date. A complete randomized block analysis of variance was used to analyze each year of seeding. The least significant difference test protected by a significant F-test was used to compare treatment means. Yield of seeded and non-seeded species was evaluated by harvesting to ground level 10 randomly placed 400-cm² quadrats per plot on 6 May (Spring), 8 July (Summer), and 4 November (Fall) of 1985 and 1986. Only current year's growth was used for yield estimation. Past year's growth was hand separated from new growth. All yield estimates are expressed on a dry matter basis. Although half of each plot was seeded in 1982 and 1983, yield data for 1982 and 1983 seedings were not separated. A factorial split plot analysis of variance was used to evaluate these data. Years (1985, 1986), seasons (spring, summer, fall), and seeding treatments were used as factors. The least significant difference test protected by a significant ($P<.05$) F-test was used to compare treatments. Samples used for yield were ground to pass through a 1-mm Wiley Mill screen after weighing, evaluated for total nitrogen by the Kjeldahl procedure, and analyzed for phosphorus by the Molybdovanadate method (AOAC 1984). Insoluble unavailable nitrogen (ADIN), neutral detergent fiber, acid detergent fiber, and acid detergent lignin were determined using the methods of Goering and Van Soest (1970). Silica was determined by AOAC (1984) procedures. The statistical analysis applied to these data was the same as that used for yield data.

Part of the north and south ends of the fenced area was left unplowed in 1980 so herbage yield on ungrazed, untreated native range could be evaluated. These 2 plots were 900 m² each. Forage yield was evaluated on 6 May, 8 July, and 4 November of 1985 and 1986 by harvesting to ground level twenty 400-cm² quadrats on each plot. Only current year's growth was used to evaluate yield.

Results and Discussion

Although the 5 wheatgrasses differed in initial seedling densities (Table 1), yield data indicate no differences in long term establishment (Table 2). Our data are consistent with those of Hull and Holmgren (1964) in Idaho and Springfield (1965) in New Mexico who found wheatgrass stands with widely varying numbers of initial seedlings all produced essentially the same yields, size of plants, and numbers of plants per unit area 5 years after planting.

Table 1. Density (#/m²) of wheatgrass at the end of the growing season on plots seeded on 6 July 1982 and 1983.

Treatment	1982[1] seeding	1983[1] seeding
'Fairway' crested wheatgrass	145	45
'Luna' pubescent wheatgrass	65	8
'Arriba' western wheatgrass	152	88
'Nordan' crested wheatgrass	172	79
'Largo' tall wheatgrass	188	68
SE	23	16
LSD.05	58	42

[1]Data were collected 6 October 1982 and 1983.

Table 2. Factorial split plot analysis of variance used to evaluate influences of species, season and year on wheatgrass yield.

	DF	Wheatgrass	Other grasses	Forbs	Total Yield
Species	4	NS	*	NS	NS
Season	2	**	NS	NS	**
Species × season	8	NS	NS	NS	NS
Year	1	NS	**	NS	**
Species × year	4	NS	*	NS	NS
Year × season	2	**	NS	NS	*
Species × season × year	8	NS	NS	NS	NS

*,**Significant at the 0.05 and 0.01 levels, respectively.
NS = Non-significant ($P>.05$).

These studies did indicate plant numbers differed greatly between treatments during the first 3 years after planting.

Wheatgrass yield or total forage yield did not differ among wheatgrass species plots ($P>.05$) (Table 2). When data were pooled across years and seasons, yields were 579, 838, 718, 866, and 796 kg ha^{-1} for 'Fairway' crested, 'Nordan' crested, 'Largo' tall, 'Arriba' western, and 'Luna' pubescent wheatgrass, respectively. Wheatgrass yield increased ($P<.05$) as season advanced from spring to summer in 1985. However in 1986 yield increased ($P<.05$) between summer and fall. Both 1985 and 1986 were years of slightly above-

Table 3. Yield (kg/ha) of wheatgrasses and total forage, averaged over wheatgrass species, as affected by the interaction of season and year.

Forage component	1985 Spring	1985 Summer	1985 Fall	1986 Spring	1986 Summer	1986 Fall	SE	LSD.05
	kg/ha							
Wheatgrasses	153	1026	1160	546	710	964	82	177
Total Forage	155	1100	1162	899	924	1296	146	315

average total precipitation. In 1985 much of the spring–summer rainfall occurred in May and June while in 1986 it was more evenly distributed throughout the period between early April and late August. Our observations and data indicate all the wheatgrasses we studied grow during both spring and summer in northern New Mexico.

Crude protein concentrations showed no differences (P>.05) among wheatgrass species (Table 4). Acid detergent insoluble nitrogen as a percentage of total nitrogen provides a measure of nitrogen that is unavailable to the animal. It did not differ (P<.05) among wheatgrass species (Table 4). Nutritional quality of all wheatgrasses declined with seasonal advance (Table 5).

All 5 wheatgrass species met the crude protein requirements (NRC 1984) for growing heifers and steers (minimum wt 255 kg) gaining 0.5 kg per day (8.5 – 9%, dry matter basis) and lactating cows (8 – 8.5%, dry matter basis) between mid-April and mid-June. Crude protein requirements of a dry, pregnant, mature cow (5.9%, dry matter basis) would probably not be met during fall and winter, even by selective grazing. Protein supplementation during this period is advised when wheatgrasses are used as winter feed.

An alternative to protein supplementation during winter would be to interseed shrubs such as fourwing saltbush and winterfat in wheatgrass stands. Current year's growth of these shrubs have crude protein levels well above 8% (dry matter basis) during winter (Otsyina et al. 1982, Jeffers 1985). Otsyina et al. (1982) reported, during a 20-day grazing trial, sheep on winter range in Utah lost about 5% of their body weight on a pure crested wheatgrass pasture, but only 1% on wheatgrass pastures containing the above shrubs. Gade and Provenza (1986), working in Utah, reported sheep grazing pure crested wheatgrass had winter diets averaging 5.7% crude protein, compared to 8.0% when grazing crested wheatgrass interspersed with shrubs. In southern Idaho, Monsen (1980) found interseeded fourwing saltbush did not reduce wheatgrass density or herbage yields, and was readily accepted as a winter forage species by cattle. Both fourwing saltbush and winterfat are common on big sagebrush ranges in northern New Mexico and appear well suited for interseeding with wheatgrasses. Unpublished studies we have conducted in northern New Mexico on similar sites have shown poor establishment of fourwing saltbush and winterfat when seeded in mixtures with wheatgrasses. In the big sagebrush type it appears shrubs are best established in grass stands by interseeding rather than direct seeding (Plummer et al. 1968, Giunta et al. 1973, Van Epps and McKell 1977).

Native big sagebrush range in northern New Mexico typically

Table 4. Factorial split plot analysis of variance used to evaluate influences of species, season and year on wheatgrass chemical composition.

	DF	Crude Protein	Acid detergent insoluble Nitrogen	Neutral detergent Fiber	Acid detergent Fiber	Acid detergent Lignin	Phosphorus	Silica
Species	4	NS	NS	NS	NS	NS	**	NS
Season	4	**	**	*	*	**	**	*
Species × season	8	NS	NS	NS	NS	NS	NS	*
Year	1	NS	NS	NS	*	NS	NS	NS
Species × year	4	NS	NS	NS	NS	NS	NS	NS
Year × season	2	**	**	**	**	**	**	**
Species × season × year	8	NS	NS	**	**	NS	NS	NS

*,** Significant at the 0.05 and 0.01 levels, respectively.
NS = Non-significant (P>.05).

Table 5. Chemical composition (dry matter basis) averaged over wheatgrass species, as affected by the interaction of season and year.

Forage component	1985 Spring	1985 Summer	1985 Fall	1986 Spring	1986 Summer	1986 Fall	SE	LSD.05
	%							
Crude protein	14.5	7.2	5.5	12.3	9.3	5.6	0.35	0.75
Acid detergent insoluble nitrogen[1]	4.8	8.0	12.6	5.4	8.0	17.0	0.79	1.69
Neutral detergent fiber	60.3	67.5	71.6	62.1	64.7	67.0	0.58	1.24
Acid detergent fiber	29.8	35.1	38.6	37.5	38.5	45.7	0.82	1.76
Acid detergent lignin	3.7	6.4	6.9	3.9	5.1	5.3	0.21	0.45
Phosphorus	0.25	0.15	0.09	0.21	0.16	0.10	0.005	0.01
Silica	7.0	5.9	6.9	8.1	7.2	11.9	0.40	0.86

[1]% of total nitrogen.

has a high component of blue grama and galleta. These grasses have crude protein concentrations above 9% (dry matter basis) during July and August (Pieper et al. 1978, Jeffers 1985). Native range also contains several palatable forbs (e.g., scarlet globemallow) with crude protein levels above 12% (dry matter basis) during summer (Jeffers 1985). Thus, when native big sagebrush range and wheatgrass seedings are available, the native range is best used during the months of July, August, and September.

'Luna' pubescent wheatgrass was superior to other wheatgrass species in phosphorus concentration (Tables 4, 5). Phosphorus values for data pooled across seasons and years for 'Fairway' crested, 'Luna' pubescent, 'Arriba' western, 'Nordan' crested, and 'Largo' tall wheatgrass were 0.17, 0.18, 0.14, 0.15, and 0.16%, respectively. The least significant difference value ($P<.05$) was 0.01%.

Lactating beef cows, growing heifers, and growing steers require about 0.20 to 0.25% phosphorus (dry matter basis) (NRC 1984). This requirement was met by all the wheatgrasses in spring. However, during summer (June through September), phosphorus was below NRC recommendations. During fall and winter, phosphorus concentrations were below those required for maintenance (.15%) (NRC 1984). The use of a phosphorus supplement appears advisable if these wheatgrasses are grazed in fall and winter. Cook (1946) found that cattle and sheep showed no response to phosphorus supplements in late spring when grazed on crested, tall, and pubescent wheatgrass pastures, although analyses of forage samples showed phosphorus was deficient. Apparently, livestock in his study used the phosphorus they stored during early spring to carry them over the deficient period in late spring.

Both neutral and acid detergent fiber concentrations showed wheatgrass species year by season interactions ($P<.05$) (Table 4). The erratic and inconsistent nature of fiber differences among wheatgrass species with seasonal advance and between years prevents drawing any meaningful conclusions about the superiority of particular wheatgrass species. Fiber data do reflect the decline in forage quality with seasonal advance (Table 5). Neutral detergent fiber concentration shows a high negative association with forage intake (Van Soest 1982). Forage digestiblity is negatively associated with acid detergent fiber concentration (Van Soest 1982).

Total forage yield on the native range plots across seasons and years averaged 355 kg/ha. Yield of western wheatgrass, blue grama, other grasses, and forbs were 275, 43, 15, and 22 kg/ha, respectively. In contrast, average total yield for seeded wheatgrass plots were 923 kg/ha. Wheatgrasses, other grasses, and forbs averaged 760, 133, and 30 kg/ha, respectively. These data show wheatgrass seeding nearly tripled forage yields, compared to those of native range.

Studies from nearby locations by McDaniel and Balliette (1986) show chemical control of big sagebrush using tebuthiuron pellets resulted in forage yields after 3 years similar to those on plots seeded to wheatgrasses in our study. They also found blue grama production was similar on treated and untreated plots. Forb production was low (less than 50 kg/ha) and little influenced by herbicide application.

In central Utah, Cook (1966) evaluated the long-term effectiveness of converting big sagebrush ranges to wheatgrasses. He found both crested and pubescent had good initial establishment and long-term persistence. During spring, cattle and sheep had superior gains on rangelands seeded to these grasses, compared to native range. During summer after mid-July, gains dropped off sharply on wheatgrass seedings, presumably caused by lower nutritive quality as the wheatgrass matured.

Tall wheatgrass was also evaluated in the Cook (1966) study. During spring, cattle had higher gains on crested and pubescent wheatgrasses than on tall wheatgrass. However, after mid-July, cattle performed better on tall wheatgrass. Crested wheatgrass yields were highest, tall wheatgrass yields were intermediate, and pubescent wheatgrass yields were lowest. Results from Cook (1966) cannot be completely applied to our study because central Utah has more spring precipitation and less summer precipitation than northcentral New Mexico. However, average total annual precipitation in both studies was nearly the same.

Conclusions

Our 5-year study of 'Nordan' crested wheatgrass, 'Fairway' crested wheatgrass, 'Arriba' western wheatgrass, 'Largo' tall wheatgrass, and 'Luna' pubescent wheatgrass shows all these wheatgrasses have good establishment, yield, and nutritive quality in northcentral New Mexico. None of the wheatgrasses showed any definite superiority in productivity or nutritional quality during any season. All these wheatgrasses are well suited to spring grazing. A limitation of our study is that only 1 location was evaluated. However, empirical observations show all 5 wheatgrasses grow well in northcentral New Mexico and are palatable to livestock in spring. During summer, native range will better meet the nutritional needs of livestock than wheatgrass seedings because of a high component of blue grama and galleta. In winter, including interseeded shrubs in wheatgrass stands could reduce supplemental feed costs.

Literature Cited

Anderson, J.A., and K.E. Holte. 1980. Vegetation development over 25 years without grazing on sagebrush-dominated rangeland in southeastern Idaho. J. Range Manage. 34:25-29.

AOAC. 1984. Official methods of analysis (13th ed.). Association of Official Analytical Chemists. Washington, D.C.

Carlson, A.W. 1969. New Mexico sheep industry, 1850-1900: its role in the history of the territory. New Mexico Historical Review XLIV:1.

Cook, C.W. 1966. Development use of foothill ranges in Utah. Utah Agr. Exp. Sta. Bull. 461.

Frischknecht, N.C., and L.E. Harris. 1968. Grazing intensities and systems on crested wheatgrass in central Utah: response of vegetation and cattle. USDA Tech Bull. 1388.

Gade, A.E., and F.D. Provenza. 1986. Nutrition of sheep grazing crested wheatgrass versus crested wheatgrass-shrub pastures during winter. J. Range Manage. 39:527-530.

Giunta, B.C., D.R. Christensen, and S.R. Monsen. 1975. Interseeding shrubs in wheatgrass with a browse seeder-scalper. J. Range Manage. 28:398-402.

Goering, K.K., and P.J. Van Soest. 1970. Forage fiber analysis. USDA-ARS Handbook No. 379.

Holechek, J.L., and T. Stephenson. 1983. Comparison of big sagebrush vegetation in northcentral New Mexico under moderately grazed and grazing excluded conditions. J. Range Manage. 36:455-456.

Hughes, L.H. 1980. Six exclosures with a message. Rangelands 2:17-18.

Hull, A.C., Jr., and R.C. Holmgren. 1964. Seeding southern Idaho rangelands. USDA Forest Serv. Res. Pap. INT-10.

Jeffers, J. 1985. Botanical composition and nutritional quality of pronghorn, cattle and sheep diets in northcentral New Mexico. M.S. Thesis. New Mexico State Univ., Las Cruces.

McDaniel, K., and J. Balliette. 1986. Control of big sagebrush with pelleted tebuthiuron. Weed Sci. 34:276-280.

Monsen, S.B. 1980. Interseeding fourwing saltbush with crested wheatgrass on southern Idaho rangelands. Abstr. Annu. Meeting Soc. Range Manage. 33:51.

NRC. 1984. Nutrient requirements of beef cattle (6th ed.). Nat. Acad. Sci.—Nat. Res. Counc., Washington, D.C.

Otsyina, R., C.M. McKell, and G. Van Epps. 1982. Use of shrubs to meet nutrient requirements of sheep grazing on crested wheatgrass during fall and early winter. J. Range Manage. 35:751-754.

Pieper, R.D., A.B. Nelson, G.S. Smith, E.E. Pakre, E.J. Boggino, and S.L. Hatch. 1978. Chemical composition and digestibility of important range grass species in southcentral New Mexico. New Mexico Agr. Exp. Sta. Bull. 662.

Plummer, A.P., D.R. Christensen, and S. Monsen. 1968. Restoring big game range in Utah. Utah Div. Fish and Game Pub. 68-3.

Springfield, H.W. 1965. Rate and spacing in seeding crested wheatgrass in New Mexico. USDA Forest Serv. Res. Note RM-42.

Springfield, H.W., and E.H. Reid. 1967. Crested wheatgrass for spring grazing in northern New Mexico. J. Range Manage. 20:406-408.

Vallentine, J.F. 1980. Range development and improvements. Second Edition. Brigham Young Univ. Press, Provo, Utah.

Van Epps, G.A., and C.M. McKell. 1977. Shrubs plus grass for livestock forage: a possibility. Utah Sci. 38:75-78.

Van Soest, P.J. 1982. Nutritional ecology of the ruminant. O & B Books, Inc. Corvallis, Ore.

Wooten, E.O. 1908. The range problem in New Mexico. New Mexico State Univ. Bull. 60.