Effects of Herbicide and Liquid Nitrogen Fertilizer Application on the Establishment of Wheatgrass Pastures in the Texas Rolling Plains

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ABSTRACT

Introduced wheatgrasses selected for improved productivity, quality, and drought tolerance may be a complementary forage to winter wheat and perennial warm-season grasses, filling a gap in spring forage availability in the semi-arid regions of the Texas Rolling Plains. In this experiment, the effects of herbicides applied with water or liquid nitrogen (N) fertilizer on the establishment of crested wheatgrass cv. Hycrest, hybrid wheatgrass cv. NewHy, intermediate wheatgrass cv. Oahe, pubescent wheatgrass cv. Luna and cv. Manska, and tall wheatgrass cv. Jose were investigated. Wheatgrasses were sown at a location near Guthrie, TX in November 1998. Five months after seeding, 2,4-D (2.0 lb ai/A), metsulfuron (Ally; 0.011 lb ai/A), triasulfuron (Amber; 0.026 lb ai/A), dicamba (Banvel; 0.5 lb ai/A), and picloram (Tordon 22K; 0.5 lb ai/A) were applied in an aqueous solution or with liquid N fertilizer carrier (28% N, ammonium nitrate + urea, UAN). One month after herbicide application, plants were evaluated for chlorosis, necrosis, stunting, and stand coverage. Thirty days later herbage dry matter (DM) yield was determined. Wheatgrasses differed in their responses to individual herbicides; however, the use of sulfonylurea herbicides triasulfuron and metsulfuron, and auxin-type herbicides picloram and dicamba increased or did not affect DM yield when compared to control. Application of UAN in a mixture with these herbicides improved establishment of wheatgrasses compared with herbicides applied in an aqueous solution by reducing leaf and plant injury and increasing DM yield. In contrast, application of the auxin-type herbicide 2,4-D reduced growth of most wheatgrasses when compared to control plants, regardless the carrier type. When compared to untreated plants, application of auxin-like herbicides resulted in a greater incidence of leaf injury and reduction in DM yield than application of sulfonylurea herbicides.

KEYWORDS: Herbicide, Pasture establishment, Wheatgrasses, Cool-season grasses.

Increasing costs, lower crop value, and increased risk associated with dual-purpose or forage wheat (*Triticum* spp.) have led to interest in finding alternative winter forage crops in the Texas Rolling Plains (Redmon, 1997). An alternative source of forage during winter and spring may be cool-season perennial grasses (Reuter et al., 1999). Although winter conditions are favorable for growth and herbage production of most cool-season perennial grass species in this region, water deficits and high temperatures during summer months reduce their survival potential and significantly limit the number of species in consideration (Redmon, 1997). One class of suitable cool-season grasses is the wheatgrasses. Over the past 20 years, the nutritional quality of introduced wheatgrass species has been significantly improved (Vogel and Moore, 1998; Moore et al., 1995), offering an alternate and potentially less expensive forage than winter wheat.

Management practices maximizing production and survival rate of wheatgrasses in the Texas Rolling Plains are not well understood. One of the most important management practices is proper weed control to ensure successful pasture establishment. Little is known about wheatgrass species and variety responses to herbicides used to control weeds in grass pastures, especially when applied in a mixture with liquid nitrogen (N) fertilizer, a common practice to reduce operational costs of pasture management.

The objectives of this experiment were: 1) to test wheatgrass species and variety responses to selected herbicides commonly used for weed control in grasslands; and 2) to determine the effects of liquid N fertilizer/herbicide combinations on plant growth during the establishment year.

MATERIALS AND METHODS

Study Area

This experiment was established 12 miles north of Guthrie, TX (Midway Church, 33° 48' 43" N latitude, 100° 19' 39" W longitude) on Sagerton loam soil (fine mixed thermic Typic Paleustolls) in November 1998. The precipitation and temperature data for 1998 - 2000 at

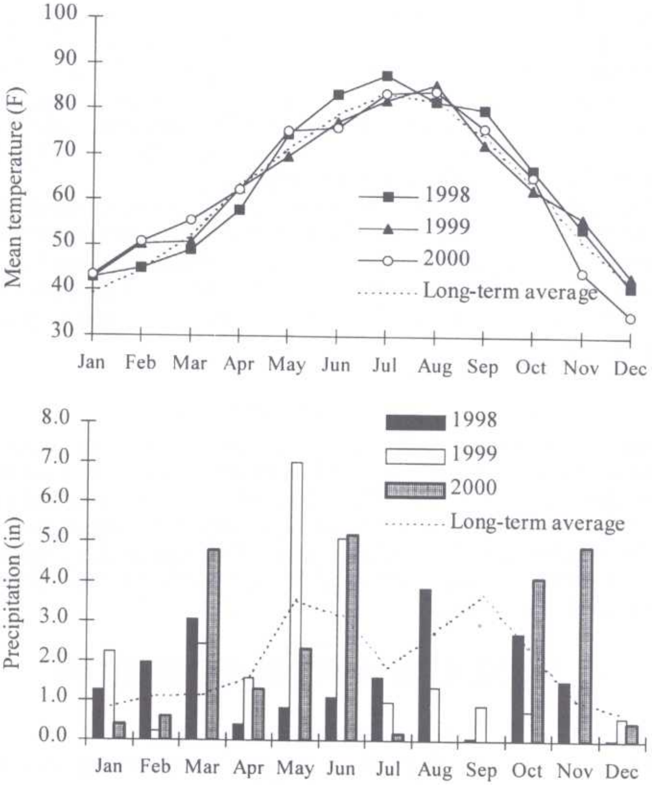

Fig. 1. Mean temperature and precipitation at Guthrie, TX during 1998 - 2000.

this location (N.O.A.A., 1998, 1999, 2000) are presented in Fig. 1. The mean (high + low for 24-hr period) monthly air temperatures were 1.5 F and 0.8 F higher than the long-term average in 1998 and 1999, respectively. In the first half of 2000, the mean air temperature was 2.5 F higher than the long-term average. In 1998 and 1999, precipitation deficits were 5.5 in and 0.7 in, respectively. A severe precipitation deficit (0.7 in) in December 1998 delayed plant germination; however, above normal (156%) rainfall in January - March 1999 resulted in a relatively good plant establishment.

Experimental Design

Wheatgrass species investigated in this experiment included crested wheatgrass [*Agropyron cristatum* (L.) Gaertn. X *A. desertorum* (Fisch. ex Link) J.A. Schultes] cv. Hycrest, hybrid wheatgrass [*Elytrigia repens* var. *repens* (L.) Desv. ex B.D. Jackson X *Pseudoroegneria spicata* (Pursh) Löve] cv. NewHy, intermediate wheatgrass [*Thinopyrum intermedium* (Host) Barkworth & Dewey] cv. Oahe, pubescent wheatgrass [*Thinopyrum intermedium* ssp. *barbulatum* (Schur) Barkworth & Dewey] cv. Luna and cv. Manska, and tall wheatgrass [*Thinopyrum ponticum* (Podp.) Barkworth & Dewey] cv. Jose.

The experiment was established as a randomized complete block design replicated four times. Each wheatgrass entry within a block (replication) was planted as a single strip (7 ft by 120 ft) at the seeding rate of 15 lb/A using a Tye Pasture Pleaser double disk drill (AgEquipment Group LP, Lockney, TX). Each strip was divided in six plots (7 ft by 20 ft). Subsequently, each plot was split in half. Half of the plot was treated with herbicide in an aqueous solution and 0.25% nonionic surfactant (NIS), and the other half was treated with herbicide mixed with liquid N fertilizer carrier [UAN, 28% N (ammonium nitrate + urea)] and NIS on April 9, 1999. The herbicide untreated control plots were sprayed with water or UAN fertilizer. Herbicide treatments included 2,4-D [4-(2,4-dichlorophenoxy)butanoic acid, 2.0 lb ai/A], picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid, 0.5 lb ai/A), dicamba (3-,6-dichloro-2-methoxybenzoic acid, 0.5 lb ai/A), metsulfuron {methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoate, 0.011 lb ai/A} or triasulfuron{2-(2-chloroethoxy)-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide, 0.026 lb ai/A}.

On May 13, 1999 chlorosis, necrosis, stunted plants, and stand coverage were visually determined based on scale from 0 to 100 (0 = no symptoms or no stand coverage, 100 = severe symptoms or complete stand coverage). Herbage biomass was determined by harvesting plots at a 2-in stubble height on June 19, 1999 (year of establishment) and June 29, 2000 (second growing season). Dry matter (DM) yield was determined after drying samples in a forced-air oven at 149 F for 72 hr.

Statistical Analysis

Before statistical analysis, percentage values describing the occurrence of chlorotic, necrotic, stunted plants, and stand coverage were transformed by the arcsin transformation to ensure normal distribution. Actual data are presented with statistical separation based on transformations. Detailed comparison of means for wheatgrass type and herbicide treatments was performed by using a protected Duncan multiple range test ($P = 0.05$), and the pairwise multiple comparison test (LSD, $P = 0.05$) was applied for comparison of UAN fertilizer application effects.

RESULTS AND DISCUSSION

Leaf and Plant Injuries

Chlorosis. The incidence of chlorosis was significantly affected by herbicide, UAN fertilizer, wheatgrass entry, and an interaction between wheatgrass entry and UAN fertilizer (Table 1). The interaction of wheatgrass entry with UAN on the incidence of chlorosis indicated that wheatgrasses fertilized with N did not significantly differ in chlorosis among each other (Table 2). In contrast, not fertilized pubescent wheatgrass cv. Luna and cv. Manska, and intermediate wheatgrass cv. Oahe had more chlorosis than tall wheatgrass cv. Jose, hybrid wheatgrass cv. NewHy, and crested wheatgrass cv. Hycrest.

Table 1. Analysis of variance summary of herbicide, nitrogen fertilization, wheatgrass entry effects upon developmental and physiological features of wheatgrass.

Source	Chlorosis	Necrosis	Stunted Plants	Stand Coverage	Herbage DM 1999	Herbage DM 2000
Herbicide (H)	*	*	*	*	*	NS
Nitrogen (N)	*	*	*	*	*	NS
Wheatgrass (W)	*	*	*	*	*	*
HxN	NS	NS	NS	NS	NS	NS
WxH	NS	NS	*	NS	NS	NS
WxN	*	NS	NS	NS	*	NS
WxHxN	NS	NS	NS	NS	*	NS

*Significant at the 0.05 probability level.

Table 2. Incidence of chlorosis on Wheatgrass plants in relation to N fertilization, averaged over herbicide treatments (percentage of plants chlorosis syptoms).

N level	cv. NewHy	cv. Luna	cv. Jose	cv. Manska	cv. Oahe	cv. Hycrest
O lb/A	5.0 A c	13.7 A a	7.7 A bc	11.0 A bc	10.5A ab	4.8 A c
28 lb/A	2.9 B a	1.7 B a	0.8 B a	1.9 B a	0.8 B a	1.2 B a

[1] In columns, means followed by the same capital letter are not significatnly different ($P<0.05$).

[2] In rows,means followed by the same common lettter are not significantly different ($P<0.05$).

As a main effect, application of UAN reduced chlorosis (1.6%) when compared to not fertilized plants (8.8%). Regardless of herbicide and UAN treatments, chlorosis was most pronounced in pubescent wheatgrass cv. Luna, followed by cv. Manska, intermediate wheatgrass cv. Oahe, tall wheatgrass cv. Jose, hybrid wheatgrass cv. NewHy, and crested wheatgrass cv. Hycrest (Table 3). When averaged over UAN fertilizer and wheatgrass entry treatments, the greatest frequency of chlorosis was observed on plants treated with picloram, whereas plants treated with 2,4-D, metsulfuron, triasulfuron, and dicamba did not differ from control plants (Table 4). Picloram was applied in this experiment at the highest labeled rate (0.5 lb ai/A) recommended for pastures (Ahrens, 1994). At high doses (0.5 - 1.5 lb ai/A) picloram caused leaf injuries in several cool-season grasses including western wheatgrass (*Pascopyrum smithii* [Rydb.] Löve) and smooth bromegrass (*Bromus inermis* Leyss.) (Gesink et al., 1972), orchardgrass (*Dactylis glomerata* L.), crested wheatgrass and red fescue (*Festuca rubra* L.) (Canode, 1974). Such leaf injuries involved chlorosis as well as twisted flag leaves and leaf rolling (Gunsolus, 1999).

Table 3. Incidence of cholorosis, necrosis, and stunting (percentage of plants with symptoms), and stand coverage (percentage of area covered by plants) on wheat grass entries across herbicide and UAN treatments.

Parameter	cv. Hycrest	cv. Jose	cv. Luna	cv. Manska	cv. NewHy	cv. Oahe
Cholorsis	3.0 d[1]	4.3cd	7.7 a	6.4b	4.0cd	5.7abc
Necrosis	6.0 ab	7.8a	2.7c	3.3c	4.0bc	3.7c
Stunting	49.1 a	25.6c	19.5c	20.2c	40.5b	23.1c
Coverage	80.1 c	87.7b	91.5a	83.5bc	79.4c	81.6c

[1] In rows, means followed by the same common letter are not significantly different ($P<0.05$).

Table 4. Herbicide effects on chlorosis, necrosis, stunting (percentage of plants with symptoms), and stand coverage (percentage of are covered by plants) across wheatgrass entries and UAN fertilizer treatments.

Parameter	Control	2,4-D	Dicamba	Metsulfuron	Picloram	Triasulfuron
Cholorsis	4.6 b[1]	4.3 b	5.5 b	4.6 b	7.4 a	4.8 b
Necrosis	1.3 c	5.9 ab	4.3 b	3.7 c	8.1 a	3.8 bc
Stunting	15.6 d	35.6 ab	32.7 bc	27.3 c	40.1 a	27.3 c
Coverage	85.8 c	80.4 b	85.0 a	85.5 a	80.7 b	86.2 a

[1] In rows, means followed by the same common letter are not significantly different ($P<0.05$).

Necrosis. The incidence of necrotic leaves was significantly influenced by herbicide, UAN fertilizer, and wheatgrass entry (Table 1). Most necrotic plants occurred in response to treatment with auxin-type herbicides 2,4-D, dicamba, and picloram (Table 4). The incidence of necrosis on plants treated with sulfonylurea herbicides metsulfuron and triasulfuron was not significantly different from that on control plants (Table 4). Some cool-season grasses, i.e., tall fescue (*Festuca arundinacea* Schreb.), might develop leaf injury such as necrosis after application of picloram at 1.25 lb ai/A (Berry and Buchanan, 1975). Wheatgrasses fertilized with UAN had less necrosis (3.6%) than not fertilized plants (5.5%), regardless of herbicide treatment. Averaged over herbicide and UAN fertilization treatments, tall wheatgrass cv. Jose and crested wheatgrass cv. Hycrest had more necrosis than hybrid wheatgrass cv. NewHy, intermediate wheatgrass cv. Oahe, pubescent wheatgrass cv. Manska, and cv. Luna (Table 3). A greater occurrence of necrosis in tall wheatgrass cv. Jose and crested wheatgrass cv. Hycrest, however, might also be related to their development stage; they were more matured than the other wheatgrasses at the time of herbicide application.

Stunted plants. Stunting was influenced by herbicide, UAN fertilizer, wheatgrass entry, and an interaction between herbicide and wheatgrass entry (Table 1). Averaged over wheatgrass entries and UAN fertilization treatments, stunting rate was higher in all herbicide treatments when compared to control (Table 4). A greater number of stunted plants would be expected in grasses treated with sulfonylurea herbicides rather than auxin-type herbicides (Gunsolus, 1999). However, McLain and Evans (1988) reported a higher incidence of plant injuries on dryland cool-season grasses only when metsulfuron was applied at a rate higher than 0.012 lb ai/A, thus higher than that in our experiment (0.011 lb ai/A). Nitrogen fertilization reduced the number of stunted plants (19.4%) when compared with not fertilized plants (40.1%), regardless of herbicide treatment. Among the wheatgrass entries, stunting occurred mostly in crested wheatgrass cv. Hycrest and hybrid wheatgrass cv. NewHy, and the least number of stunted plants were observed in tall wheatgrass cv. Jose, intermediate wheatgrass cv. Oahe, pubescent wheatgrass cv. Manska, and cv. Luna (Table 3).

The interaction between herbicide and wheatgrass entry (Table 4) indicated that the frequency of stunted plants, compared to untreated control, was greater for hybrid wheatgrass cv. NewHy, intermediate wheatgrass cv. Oahe, and crested wheatgrass cv. Hycrest when 2,4-D, dicamba or picloram were applied. Cultivar NewHy and cv. Oahe had also a greater number of stunted plants in response to treatment with sulfonylurea herbicides. The herbicide 2,4-D was not suitable for pubescent wheatgrass cv. Manska nor was dicamba for tall wheatgrass cv. Jose. In contrast, the frequency of stunted plants was not significantly affected by herbicide treatment in pubescent wheatgrass cv. Luna.

Stand coverage. Stand coverage was influenced by herbicide, UAN fertilizer, and wheatgrass entry. Plots treated with dicamba, metsulfuron or triasulfuron did not differ in stand coverage from control plots; however, a reduction in stand coverage resulted from application of 2,4-D and picloram (Table 4). Wheatgrasses fertilized with UAN generally had better stand coverage (86.5%) than not fertilized plots (80.1%), regardless of herbicide application. The best stand coverage was observed in plots with pubescent wheatgrass cv. Luna, followed by tall wheatgrass cv. Jose and pubescent wheatgrass cv. Manska, intermediate wheatgrass cv. Oahe, crested wheatgrass cv. Hycrest, and hybrid wheatgrass cv. NewHy (Table 3).

Dry Matter Production In The Year Of Establishment

Dry matter yield responses of wheatgrasses to herbicide were modified by UAN fertilizer as shown by the complex interaction between these factors (Table 1). Application of 2,4-D in an aqueous solution increased DM yield of tall wheatgrass cv. Jose by 61% and tended ($P < 0.1$) to increase DM yield of hybrid wheatgrass cv. NewHy (27%) when compared to untreated control (Table 6). Yield DM, however, was reduced by application of 2,4-D in pubescent wheatgrass cv. Manska by 44%, intermediate wheatgrass cv. Oahe by 30%, and in crested wheatgrass cv. Hycrest by 24%, which agreed with results by Lym and Kirby (1991) and Beck et al. (1995). The basis for various DM yield responses of wheatgrasses to 2,4-D may be its translocation, which is generally slow in tolerant species, but it may vary among species due to formation of immobile complexes, reduced xylem transport, and anatomical differences (Ahston and Crafts, 1981). Application of 2,4-D with UAN fertilizer reduced DM yield of tall wheatgrass cv. Jose by 45% and tended to reduce DM yield of pubescent wheatgrass cv. Luna (37%) and cv. Manska (28%). The reason for that might be an increased uptake of 2,4-D by grass plants as often reported for some herbicides applied in a mixture with UAN fertilizer and surfactant (Gauvrit and Dufour, 1990).

Table 5. Percentage of stunted wheat grass plants in relation to herbicide treatments, averaged over UAN fertilizer treatments.

Wheatgrass	Control	2,4-D	Dicamba	Metsulfuron	Picloram	Triasulfuron
cv. Hycrest	3.06b	59.3a	57.5a	37.5b	72.5a	39.6b
cv. Jose	16.2b	31.2ab	35.6a	20.6ab	21.2ab	28.8ab
cv. Luna	17.5ab	17.5ab	21.2ab	20.0ab	28.1a	12.5b
cv. Manska	10.0b	27.5a	25.0ab	21.9ab	19.4ab	21.2ab
cv. NewHy	6.2d[1]	50.6b	31.9c	40.6c	77.5a	36.2c
cv. Oahe	13.1b	27.5a	25.0a	23.1a	21.9a	28.3a

[1] In rows, means followed by the same common letter are not significantly different ($P < 0.05$).

Table 6. Dry matter production (lb/A) of wheatgrasses in relation to nitrogen fertilization and herbicide type in the year of establishment.

Wheatgrass	Control	2,4-D	Dicamba	Picloram	Metsulfuron	Triasulfuron
0 lb N/A						
cv. Hycrest	255c[1]	193c	444ab	418ab	364abc	465a
cv. Jose	329bc	531a	241c	477ab	519a	514a
cv. Lunda	500b	554b	450b	811a	562b	577b
cv. Manska	494a	277b	479a	402ab	581a	561a
cv. NewHy	181a	230a	173a	59b	263a	214a
cv. Oahe	512a	359b	483ab	544a	418ab	545a
28 lb N/A						
cv. Hycrest	1383a	1321a	1326a	1481a	1253a	1702a
cv. Jose	1329a	727c	1830a	1440ab	1160bc	1364ab
cv. Luna	2110b	1337b	1640b	1876b	2160b	2939a
cv. Manskal	416ab	1019b	1822a	1862a	1889a	1586ab
cv. NewHy	465b	742a	474b	655ab	518b	495b
cv. Oahe	1763a	1643ab	1564ab	1510ab	1410b	1559ab

[1] In rows, means followed by the same common letter are not significantly different ($P<0.05$).

Picloram applied in an aqueous solution increased DM yield of crested wheatgrass cv. Hycrest by 64%, pubescent wheatgrass cv. Luna by 62%, and tall wheatgrass cv. Jose by 45%, but reduced DM yield of hybrid wheatgrass cv. NewHy by 67% (Table 6). Similar to 2,4-D, picloram mimics natural plant hormones, but it is translocated more rapidly in the plants and is active through both foliage and roots, thus being more toxic to some broadleaf weeds. Picloram may also cause plant injury in some cool-season grasses to a greater extent than 2,4-D when applied at early stages of their development (Gesink et al., 1972; Canode, 1974). A combined application of picloram and UAN fertilizer had no significant effect on DM yield when compared to plants treated only with UAN fertilizer.

Dry matter was not significantly affected by dicamba herbicide, either applied in an aqueous solution or in the mixture with UAN fertilizer, except for crested wheatgrass cv. Hycrest, which responded to application of dicamba with 74% increase in DM yield when compared to untreated control (Table 6). Grasses are generally tolerant to dicamba herbicide because of its rapid metabolism (Ashton and Crafts, 1981) and herbicide-related plant injuries and herbage biomass reduction are not common (Berry and Buchanan, 1975; Hall, 1976).

The effects of metsulfuron applied in an aqueous solution on DM yield of wheatgrasses were similar to those of triasulfuron (Table 6). When compared to control, both of these sulfonylurea herbicides increased DM yield of tall wheatgrass cv. Jose by 58% and 56%, and crested wheatgrass cv. Hycrest by 43% and 74%, respectively. Also hybrid wheatgrass cv. NewHy responded to the treatment with metsulfuron by increasing yield DM by 45%. Cool-season grasses are tolerant to sulfonylurea herbicides (Biljon et al., 1988; West and Standell, 1989), especially at doses lower than 0.04 lb ai/A (Warner et al., 1986; McLain and Evans, 1988) and at high temperature and soil moisture after application (Gillespie et al., 1985; Ferreira et al., 1990). Application of sulfonylurea herbicides in mixtures with UAN fertilizer did not affect DM yield when compared with control plants with the exception of intermediate wheatgrass cv. Oahe, which responded to the combined treatment of metsulfuron and UAN fertilizer with 18% reduction in DM yield. A lack of significant herbage biomass reduction due to combined application of sulfonylurea herbicides and UAN fertilizer might be related to relatively high temperature and adequate soil moisture after treatment (Stahlman et al., 1997).

Herbage Biomass Production In The Second Growing Season

Residual effects of herbicide treatment and UAN fertilizer application on DM yield of wheatgrasses were not observed in the second growing season (Table 1). Below average precipitation during fall 1999 and spring 2000 together with higher than normal temperatures during that period (Fig. 1) resulted in significantly less herbage biomass production in the second growing season when compared to that during the year of establishment (Table 7). Plants of hybrid wheatgrass cv. NewHy did not survive to the second growing season. Tall wheatgrass cv. Jose produced more herbage DM than other wheatgrasses.

Table 7. Dry matter production (lb/A) of wheatgrasses in the second growing season, averaged over herbicide and UAN fertilizer treatments.

cv. Hycrest	cv. Jose	cv. Luna	cv. Manska	cv. NewHy	cv. Oahe
485 b[1]	1469 a	457 b	553 b	no data	565 b

[1] In rows, means followed by the same common letter are not significantly different ($P<0.05$).

CONCLUSIONS

Results indicate that application of UAN fertilizer in a mixture with herbicides did not affect DM yield of wheatgrasses. In fact, application of UAN fertilizer combined with herbicides improved establishment of wheatgrasses compared with herbicides applied in an aqueous solution. This improvement involved less leaf injuries (chlorosis, necrosis) and fewer stunted plants, which resulted in a better stand coverage and greater herbage biomass production. Wheatgrasses varied in their responses to aparticular herbicide but, in general, sulfonylurea herbicides triasulfuron and metsulfuron, and auxin-type herbicides picloram and dicamba increased or did not affect DM yield when compared to control plants. In contrast, application of the auxin-type herbicide 2,4-D reduced growth of most wheatgrasses when compared to control plants, both when 2,4-D was applied in an aqueous solution or in combination with UAN fertilizer. Yield DM was considered in this experiment as the ultimate response criterion for herbicide efficacy. When compared to untreated plants, application of auxin-like herbicides resulted in a higher incidence of temporary leaf and plant injuries than application of sulfonylurea herbicides. Those leaf and plant injuries, however, did not affect DM yield (picloram) or had more permanent effects and reduced wheatgrass productivity (2,4-D). Residual effects of herbicide applied with UAN fertilizer on herbage production were not observed in the second growing season, most probably due to growth limiting weather conditions.

Based on the results of this experiment, weed control with herbicides (except for 2,4-D) commonly used in pasture and grassland management may be applied for wheatgrass stand establishment in semi-arid environments of the Texas Rolling Plains. Other management practices, however, require further research to improve herbage productivity and stand persistence of wheatgrass pastures.

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