Establishment of seven high yielding grasses on the Texas High Plains

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Abstract

The establishment of several high yielding grasses was examined on the Texas High Plains as an alternative to row crop agriculture. The species were Blackwell switchgrass (Panicum virgatum), El Reno sideoats grama (Bouteloua curtipendula), Morpa weeping lovegrass (Eragrostis curvula) and 4 old world bluestem selections including Caucasian (Bothriochloa caucasica), WW517 (B. intermedia var. indica), Ganada (B. ischaemum var. ischaemum), and WWspar (B. ischaemum var. ischaemum). Each species was seeded in mid-May 1981 and 1982 in Garza County on a fine sand and in Lubbock and Terry Counties on sandy loam soils. Number of seedlings 1 month after planting ranged from 129.7/m at Brownfield in 1981 to 7.5/m at Post in 1982. At the end of the first growing season, biomass ranged from 930 kg/ha at Lubbock in 1981 to 11 kg/ha at Post 1982. At the beginning of the second growing season, basal cover had increased, indicating these species were adapted to the winter conditions in the area. The seedings were successful, and adequate stands of all species were established the first year except for the 1982 Post planting. The year and location were the most important factors in establishment success during this study. There were differences among species, but no one species was superior over locations or years for all the characteristics measured. On the fine sand weeping lovegrass was superior.

Key Words: Panicum virgatum, Bouteloua curtipendula, Eragrostis curvula, Bothriochloa caucasica, Bothriochloa intermedia var. indica, Bothriochloa ischaemum var. ischaemum, germination, yield.

The most critical period in the establishment of a grass stand in semiarid regions is the first growing season following seeding. Establishment is often difficult due to insufficient moisture, high temperatures, high evaporation rates, damage to seedlings by windblown soil particles, and slow growth during the seedling stage (Welch et al. 1962). Many reseeding projects have been attempted throughout the Great Plains with varying degrees of success (Nixon 1949, Burnham 1955, Launchbaugh and Anderson 1963). The Great Plains Council (1966) surveyed grass plantings on the southern High Plains in 1961 and 1962 and reported 50% of the seedings were successful overall. However, on sandier sites only 20% were successful. Stuth and Dahl (1972) evaluated seedings following brush control on the Edwards Plateau and found an overall success rate of about 30%. With more intensive seedbed preparation, the success rate increased 65 to 100% depending on the seedbed and seeding method. Our study was initiated to determine differences among sites, years, and 7 improved grass species with respect to emergence and establishment characteristics.

Study Locations

Three study areas with course-textured soils were selected. The

Seed Company at Hereford, Texas, for providing seed for this study.

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first site was in Lubbock County. The soil is an Acuff loam, a fine loamy, mixed thermic Aridic Paleustolls (Blackstock 1979). The second site was in Terry County, 5 km north of Brownfield. The soil at this site is a loamy fine sand of the Amarillo series (Sanders 1962). It is a fine loamy, mixed thermic Aridic Paleustalfs. The third site was located on the Double U Ranch in Garza County. This site is off the Caprock and is more undulating and sandier than the other sites. The soil is fine sand of the Brownfield Series and is classified as a loamy, mixed thermic Arenic Aridic Paleustalfs (Richardson et al. 1975).

The climate of the southern High Plains is warm temperate, subtropical and characterized by dry winters, long summers, high winds, and high evaporation. The average freeze free period is 211 days from early April to early November (NOAA 1981). Precipitation averages about 460 mm annually. Three-fourths of the rainfall occurs during the warm season of April through October. However, monthly and annual totals vary greatly. In the 3 counties included in this study, annual precipitation has ranged from 81 to 1,100 mm.

Total soil nitrogen was measured using standard micro-Kjeldahl techniques (AOAC 1980). Average nitrogen levels varied among locations and ranged from 0.073% at Lubbock to 0.030% at Post for the 0-60 cm soil core. Brownfield was intermediate with 0.043% nitrogen in the soil.

Methods

Seven species were selected for evaluation and included 2 native and 5 introduced grasses. The native grasses were Blackwell switchgrass (*Panicum virgatum* L.) and El Reno sideoats grama [Bouteloua curtipendula (Michx.) Torr.]. Introduced grasses were Morpa weeping lovegrass [Eragrostis curvula (Schrad.) Nees.] and 4 old world bluestems (OWB) which included Caucasian [Bothriochloa caucasia (Trin.) C.E. Hubb.], WWspar [B. ischaemum (L.) King var. ischaemum], Ganada [B. Ischaemum (L.) Keng var. ischaemum], and WW 517 [B. intermedia (R.Br.) var. indica].

All species were seeded in 1981 and 1982. In 1981 a seedbed was prepared at all locations by disking early in the spring. The areas were disked again and cultipacked about 2 weeks before planting to remove the competing vegetation and to prepare a firm seedbed. In 1982 a litter mulch was used as the seedbed preparation technique in 1982. Wheat was drilled into freshly disked seedbeds at Lubbock and Brownfield and broadcast and cultipacked at Post in the late summer of 1981. Before planting in May 1982 the wheat and invading vegetation were sprayed with glyphosate (1%) to create a litter mulch.

A seeding rate of 215 PLS/m of row was used with a 1-m row spacing. The plots were planted 11-14 May 1981 and 1982 with a 1 row Almaco V-belt push planter. A seeding depth of about 1 cm was used for all species (Robertson and Box 1969, Cross 1983). Each plot consisted of 5 rows, 8 m in length. There were 6 replications of each species (treatments) at each location arranged in a randomized block design.

Soil moisture was randomly measured gravimetrically (Gardner 1965) over the area every 2 weeks during the growing season and

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monthly during the remainder of the year. Samples were taken at 0-5 and 5-60 cm depths.

Field data were collected to determine emergence, establishment, first year production, and overwintering ability. Each set of data included 5 randomly located samples from each plot. In mid-June, about 1 month after planting, the number of seedlings was determined per 0.5 m of row. In late September or October, measurements were taken to determine establishment and included basal cover in 1 m of row. Leaf canopy height and number of flowering culms were also measured for each basal cover segment.

In mid-September first-year production was measured by hand clipping all plants from 1 m of row to a 1-cm stubble height. The samples were dried at 50° C for 48 hr then weighed. Overwintering survival was determined by measuring basal cover of green culms during 1 May after planting. Basal cover information from September and the following May were compared using a *t*-test to determine if changes had occurred during winter.

Statistical analysis consisted of analysis of variance and LSD mean separation test (P=0.05) among species for each location and year. Analysis of variance across locations and years was performed with location as main plot, year as sub-plot, and species as sub-subplot in a split-split block design.



Fig. 2. Biweekly soil moisture at 2 depths (cm) for 3 study sites in west Texas.

Results

During this study, annual rainfall varied from 564 mm at Post in 1981 to 377 mm at Brownfield in 1982 (Fig. 1). These totals range from 86 mm above to 60 mm below the long-term average. Of the 2 years studied, 1981 had the highest total precipitation and more favorable distribution of rainfall during the growing season. This provided more beneficial conditions for plant growth than in 1982 or 1983. Late July and August rains resulted in increased growth late in the growing season. Soil moisture is presented in Figure 2.

Of the 6 plantings, (3 locations, 2 years), 5 were successful for all species based on 10 seedlings/m (Vallentine 1971) as the number needed for adequate stand establishment (Fig. 3). The 1982 seeding at Post failed.

The greatest difference in emergence, establishment, and overwintering characteristics was between planting years. Characteristics were also different for all locations. However, Brownfield and Lubbock were often similar and the difference was a result of reduced values at Post. Species responses were different for each measurement taken within years and locations except for dry weight at Brownfield in 1981 and 1982 and flower culm numbers at Lubbock and Post in 1982.



Fig. 3. Seedling number measured 1 month after planting for each species grouped by year and location. Within each year and location the bars with the same letter were not significantly different at P = 0.05 as determined by LSD test.

Emergence Characteristics

Seedling numbers differed within each location and year. However, no individual species were superior in numbers of seedling present 1 month after plantings (Fig. 3). In 1983, seedlings/m averaged across species were 129.7 at Brownfield, 124.4 at Lubbock, and 80.5 at Post. At all locations seedlings numbers were well above the number required for an adequate stand. In 1982, seedling numbers were reduced at all locations and averaged 53.2/m at Brownfield, 45.4/m at Lubbock, and 7.5/m at Post. In 1981 basal cover averaged 69% at Brownfield, 60% Lubbock, and 52% at Post, while in 1982 the averages were only 29, 25, and 5%, respectively (Marietta 1985).

Establishment Characteristics

Species responded differently for the characteristics measured at the end of the first growing season. The relative rank of locations changed with first year dry weight production (Fig. 4). Lubbock was the most productive site followed by Brownfield and Post. Averaged across species in 1981 and 1982, respectively, 45 and 34%, more dry weight was produced at Lubbock than Brownfield. The reduction between 1981 and 1982 averaged 60% at Lubbock, 52% at Brownfield, and 88% at Post. The only species that produced more dry weight in 1982 than in 1981 was switchgrass at Lubbock.

In 1981 first year production for all species averaged 520 kg/ha for Brownfield, 930 kg/ha for Lubbock, and 82 kg/ha for Post. At Post weeping lovegrass had significantly more production (340 kg/ha) than any other species. Average first-year production in

1982 was 376 kg/ha at Lubbock, 247 kg/ha at Brownfield, and 11 kg/ha at Post.

The other establishment characteristics measured included flower culm numbers and leaf canopy height (Table 1). Larger values were recorded in 1981 than 1982, and Lubbock ranked higher or the same as Brownfield. Post were lower. Similar trends were observed for dry weight. The differences among species can be attributed in part to individual growth form rather than seeding success, adaptability, or plant vigor.

Flower culm numbers were large for all of the OWBs (Table 1). At both Lubbock and Brownfield in 1981 all of the OWBs had higher flower culm numbers than the other species. However, the remaining species all produced flower culms. In 1982 a difference in flower culm numbers were recorded only at Brownfield where the OWBs and sideoats grama had higher numbers than weeping lovegrass and switchgrass. The leaf canoy height of weeping lovegrass was taller than the other species except at Lubbock and Post in 1982 when switchgrass was taller.

Overwintering Characteristics

Basal cover measurements were taken at the beginning of the second growing season to determine the effects of winter on newly established stands (Fig. 5). Basal cover increased for every species at all locations both in 1981 and 1982 except for sideoats grama at Lubbock in 1982 which decreased 3%. This indicates that all of the species were able to survive and continue to grow with the winter conditions in the area during the study.



Fig. 4. Establishment dry weight (kg/ha) for each species grouped by year and location. Within each year and location bars with the same letter were not significantly different at P = 0.05 as determined by LSD test.

Table 1. Establishment and overwintering characteristics for each location. These included the number of flowering culms and leaf canopy height.

Location characteristics	Date	Species						
		Switchgrass	Sideoats grama	Weeping lovegrass	WWspar OWB	WW517 OWB	Ganada OWB	Caucasain OWB
Brownfield		1. · · · · · · · ·				· · · · ·		······
Flower culm	Sep 81	9.2c*	75.5bc	4.3c	226.2a	71.0ab	202.0a	234.7a
(no./m)	Sep 82	3.2c	82.5b	6.8c	174.7a	92.2b	119.3b	160.7a
Leaf canopy	Sep 81	41.3a	23.5b	42.9a	22.7Ь	17.5Ь	31.2ab	41.2a
(cm)	Sep 82	25.3Ъ	19.7bc	33.7a	21.5bc	15.7c	19.2bc	24.2b
Lubbock								
Flower culm	Sep 81	27.3c	209.3bc	22.8c	852.5a	398.7Ъ	361.8b	437.8b
(no./m)	Sep 82	35.0bc	65.3abc	23.7c	106.5abc	118.5ab	146.8a	81.8abc
Leaf canopy	Sep 81	38.0b	28.8cd	50.3a	27.2cd	24.3cd	23.8d	31.0c
(cm)	Sep 82	46.2a	24.4c	33.9b	12.4e	14.2de	12.6e	16.4d
Post								
Flower culm	Sep 81	4.7bc	4.7bc	1.2c	34.7a	25.7ab	16.3abc	3.7bc
(no./m)	Sep 82	0.8a	0.2a	0.5a	1.5a	0.5a	0.3a	0.0
Leaf canopy	Sep 81	26.2b	11.2c	28.7a	10.3cd	11.3c	5.3d	7.3cd
(cm)	Sep 82	16.2a	7.5bcd	10.2b	8.9bc	8.1bc	5.5cd	3.9d

*Within each row the values followed by the same letter were not significantly different at P = 0.05 as determined by LSD test.

Discussion

The year and location were the most important factors in establishment success during this study. The rainfall amounts and patterns and the resulting soil moisture conditions were adequate for establishment in both years. However, the observed difference between years was probably a result of these environmental factors and soil and air temperatures which are considered the main environmental variables that contribute to successful stand establishment (Fults 1944, Moldenhauer 1959, Hudspeth and Taylor 1961). In addition, we used different seedbed preparation techniques. In 1981 cleaned, tilled seedbeds were used while in 1982 a stubble mulch and herbicide were used. When the danger of soil erosion is great and/or improvement of water and temperature conditions at the soil surface is needed, a stubble mulch is generally recommended (Launchbaugh and Owensby 1978). However, a clean,



Fig. 5. Overwintering basal cover (%) for each species grouped by year and location. Within each year and location the bars with the same letter were not significantly different at P = 0.05 as determined by LSD test.

tilled seedbed often gives as good or better results (Fults 1944, Dudley and Holt 1963) as in this study.

The failure at Post in 1982 apparently resulted from the method of seedbed preparation and the resulting competition from sandburs (*Cenchrus incertus* M.A. Curtis) that became established soon after planting. Abundant weeds often reduce grass establishment and first year production (Launchbaugh and Owensby 1978, Martin et al. 1982). Another factor indicating that the failure was due to seedbed preparation was seeding results obtained by Cotter and Dahl (1982) the same year and at the same location for weeping lovegrass. They reported that 38 to 41 plants/m were established at the end of the 1982 growing season with double disking and moldboard plowing as seedbed preparation techniques. However on the no-till plots no plants established.

General establishment success during our study was considerably higher than the success rates reported in the literature for the southern High Plains (Great Plains Council 1966). On sandy soils 20% of the seedlings were successful while on the tighter soils 49% had at least 10 seedlings/m. Sideoats grama, switchgrass, and weeping lovegrass produced successful stands 54, 30, and 57% of the time, respectively. In contrast, we achieved much better success for these species.

The seedling numbers were higher in our study than those previously reported for the same species (Pettit et al. 1976, Brock et al. 1984). The seedling counts for that work were generally made at the end of the first growing season rather than 1 month after planting. However, in our study individual plants could not be distinguished at the end of the first growing season. Since basal cover increased or was constant from June to September, except at Post, most of the seedlings probably survived or individual plants increased enough in size for basal cover to remain constant. At Post in 1981 basal cover was reduced about 50% overall as a result of seedling death. This reduction was probably the result of competition from weedy species and stress due to low soil moisture levels in July.

Seedling numbers for weeping lovegrass from other studies at the Post site range from 0 to 41 seedlings/m in 1982 and from 0 to 5 seedlings/m in 1983 (Cotter and Dahl 1982 and 1983). The range of values was probably the result of seedbed preparation techniques. Where weed competition was reduced, higher plant numbers were recorded. In comparison with our study, weeping lovegrass seedling numbers were 108.7/m in 1981 and 9.5/m in 1982. The 1982 values were less than those recorded with the moldboard plowing or double disking treatments the same year. At the Brownfield site in 1976 and 1977, weeping lovegrass was planted using various seeding equipment (Pettit et al. 1976). Seedling numbers averaged 9.5/m in 1976 and ranged from 2.7 to 6.9/m in 1977. During the present study, weeping lovegrass seedling numbers at Brownfield were 114.3/m in 1981 and 21.7/m in 1982.

Production values for the first growing season are generally not reported in conjunction with seeding trials. Values that have been reported are usually from fertilizer or herbicide trials. Depending on weed control methods and site, dry weight has ranged from no harvestable yield to 9,180 kg/ha for switchgrass and from 220 to 4,440 kg/ha for sideoats grama in Nebraska (Martin et al. 1982). Dalrymple (1970) stated that first year yields of weeping lovegrass in Oklahoma often reach 4,000 to 6,000 kg/ha, and that values presented from a fertilizer study ranged from 728 kg/ha to 2,105 kg/ha. These first year yields are higher than in our study. In summary, there were differences among species. However, they were not as important as the year and location effects. On the deep sandy land site at Post, weeping lovegrass was superior to the other species but on the sandy loam soils all of the species performed well.

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