Factors affecting weeping lovegrass seedling vigor on shinnery oak range

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Abstract

Low vigor of seedlings and stand failures plague many revegetation efforts in semiarid and arid rangelands. Phototoxicity, sandbur (Cenchrus incertus M.A. Curtis) competition, seedbed preparation (plowing vs. disking), and nitrogen (N) fertilization were studied as reasons for low vigor of Ermelo weeping lovegrass [*Eragrostis curvula* Schrad.) Nees] seedlings on sand shinnery oak (*Quercus havardii* Rydb.) range in west Texas. Oak leaf residue and sandbur-dominated grass residue extracts did not affect seed germination and initial shoot growth of lovegrass seedlings. However, these residue extracts reduced root length 92% and 21%, respectively. Survival of weeping lovegrass seedlings was not affected by even 65 sandbur plants/m². But, herbage yield was reduced 65, 72, and 79% with 30, 45, and 65 sandbur plants/m². Early in the growing season, unfertilized plowed (P) plots had 5.6 ppm N in the 10–20 cm soil layer compared to a maximum of 3.9 ppm on other seedbed treatments. In the surface 10 cm, the P plots had less N than the disked plots. Surface-applied N fertilizer accumulated in the upper 10 cm of soil and promoted weed growth without improving weeping lovegrass stands or seedling vigor. Weeping lovegrass seedling vigor was greatest on P and least on disked plots. Thus, plowing buried weed seeds better, put resident N more deeply into the soil for better root uptake, removed allelopathic residues from seedling contact better, and provided for much higher seedling vigor than the disked seedbeds.

Key Words: seedling vigor, allelopathy, seedbed preparation, weeping lovegrass, sandbur, seedling fertilization

Weeping lovegrass [*Eragrostis curvula* (Schrad.) Nees], an introduced species from southern Africa, is becoming an important forage on seeded ranges of west Texas. Relative to native range, this grass has been shown to increase forage and beef production (Shoop et al. 1976). However, establishing vigorous stands of weeping lovegrass is a big challenge on semiarid West Texas rangeland.

The major purpose of seedbed preparation is to control weed competition (Vallentine 1980). Previous experience on semiarid sand shinnery oak (*Quercus havardii* Rydb.) range (Cotter and Dahl 1982, Cotter et al. 1984) showed that 'Ermelo' weeping lovegrass growing in moldboard plowed plots had better stands and was more vigorous than in nontilled or tandem disked plots. Further, seedbed preparation can influence nutrient availability and distribution in the soil profile (Groffman 1985, Webster et al. 1985, Kovacic et al. 1986). Grass seedling response to nitrogen (N) fertilization has not been readily predictable and much debated (Welch et al. 1962, McKell 1972, Howe and Snaydon 1986, Benner and Bazzaz 1987). Phytotoxic suppression of seedling development has been reported by several authors (Dalrymple and Rogers 1983, Rice 1984, Harrington 1987, Karachi and Pieper 1987, Roder et al. 1988), but no record of the phytotoxic suppression of weeping lovegrass establishment on sand shinnery oak range could be found.

Vigorous grass seedlings have improved winter (White 1984) drought (Bovey et al. 1986) survival. In addition, high seedling vigor would be expected to have other benefits such as speeding up stand development, soil stabilization, and reducing the time a stand takes to be ready for the first grazing. The purpose of this study was to examine reasons for poor stands and low vigor of 'Ermelo' weeping lovegrass seedlings on a semiarid sand shinnery oak range in west Texas.

Materials and Methods

Laboratory Phytoxicity Study

Allelopathic effects of plant residues on 'Ermelo' weeping lovegrass was tested for in the laboratory. Air-dry residues were collected in March 1987 from a sand shinnery oak range on the Double U ranch near Post, Texas. Residues were separated into sand shinnery oak leaves and grass material predominantly composed of sandbur (*Cenchrus incertus* M.A. Curtis). The residues were ground to pass a 40-mesh screen. Extracts were prepared from 10 grams of ground material agitated for 2 hours by a magnetic stirrer in 175 ml of cold distilled water. The extracts were filtered through No. 2 filter paper, placed in a perforated ceramic funnel under vacuum, and stored in a refrigerator. In each of fifteen 9-cm diameter petri dishes, weeping lovegrass seeds were placed on filter paper to which either distilled water, oak leaf residue extract, or grass residue extract were applied. Dishes were arranged at random. The seeds were incubated under saturated conditions at 25° C in a dark growth chamber for 10 days. Germination was determined at 7 days while root and shoot lengths of 8 randomly picked seedlings per petri dish were measured at 10 days of incubation (Rice 1984).

Field Studies

The effects of sandbur infestation, seedbed type, and N fertilization on weeping lovegrass basal cover and vigor were studied on Double U Ranch near Post, in semiarid Garza County. Weeds other than sandbur did occur in the study plots. However, sandbur was the dominant competitive influence, and its competitive role influencing weeping lovegrass seedling is emphasized in this study. Soil at the site is a Brownfield series (loamy, mixed, thermic, Arenic Aridic Paleustalf) which had pre-trial levels of available N, P, and K at 3.4, 3.1, and 93.8 ppm, respectively, and a pH of 8.4 at 0 to 6 in depth. The climate is warm, temperate, subtropical with an average growing season of 216 days (Richardson et al. 1965). About 75% of the 478 mm average annual precipitation occurs during the warm season of May through October. May and June are the wettest months. Summer droughts of 2 to 3 weeks, or longer, are common. Although the maximum temperatures average 35° C during July, they can fall to 0° C or less in winter. Climax vegetation for the site is a tall grass prairie with scattered clumps of scrub oak (Richardson et al. 1965). Permanent vegetative cover is essential for soil stabilization. Study plots were located on converted rangeland dominated by sandbur and shinnery oak.

Sandbur Competition Study

The impact of sandbur interference on survival and vigor of first season weeping lovegrass was determined on four 2.3 × 20 m blocks prepared by plowing with a turning-disk plow on 1 May

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Contribution from the College of Agricultural Sciences, Texas Tech University published as paper No. T-9-588.
Manuscript accepted 22 July 1990.

1987. On 4 May, weeping lovegrass was seeded into dry soil at a row spacing of 46 cm and a seeding rate of 1.8 kg pure live seeds per hectare. Lovegrass and sandbur seedlings emerged on 18 May after 58 mm of rain on 16 May. Forty-five days later, sandbur seedlings on 2 × 1-m plots were thinned on either 0, 30, 45, or 65 plants per m^2 to attain as even a distribution as possible. Any additional sandbur or other weed seedlings emerging thereafter were removed. Also, weeping lovegrass seedlings in each plot were thinned to 20 plants per m^2 (1 plant/20 cm). Survival, seedhead numbers, and herbage yield of weeping lovegrass were measured in November 1987.

Seedbed Preparation and N Fertilization Study

The effects of seedbed preparation and N fertilization on first year stand and vigor of weeping lovegrass, and on availability and distribution of N in the soil profile, were parameters measured. On each of 4 blocks, seedbeds were prepared on 8.5 × 20-m main plots by plowing with a turning-disk plow (P), burning plus late tandem-disking (BD), early tandem-disking (ED), and late tandem-disking (LD). Experimental design of field plots was a randomized complete block.

The BD plots were burned on 25 March 1987 before grass started to green and the seedbed was prepared by tandem-disking on 1 May. The ED treatment comprised 3 passes with a tandem disk-harrow on 13 March 1987. The late tandem-disking operation was similar to ED except that it was delayed to 1 May 1987. Depth of disking was 10–14 cm. The P comprised one, 21-cm deep pass on 1 May 1987. Weeping lovegrass was planted 0.5 to 2.0 cm into dry soil on 4 May using a seed drill equipped with double-disk openers and depth-regulator bands. Seeding rate was 1.8 kg pure live seeds per hectare on 46-cm wide rows. Seedlings emerged on 18 May following 58 mm of rain on 16 May. Four soil samples were collected from each plot at 0 to 10 and 10 to 20 cm depths. The 4 samples from each depth were composited and placed in air-tight plastic bags and preserved under dry ice before deep freezing them in the laboratory. Plant-available N (NH_4^+ and NO_3^-) was determined by the specific-ion electrode methods (Keeney and Nelson 1982; Orion Research, Inc. 1979, 1986). On 10 June, ammonium nitrate fertilizer treatments were applied to the soil surface of three, 2.3 × 20-m subplots (5 rows) of weeping lovegrass seedlings in each main plot. Each subplot received either 0, 30, or 60 kg N per hectare. Soil samples were collected from each subplot on 7 July and 28 September 1987. All soil samples were collected at least 5 days after a rainfall event so that nitrate leaching would not vitiate the results of soil analysis (Bremner 1965). Rainfall and weekly minimum and maximum temperatures were measured on site. Measured monthly amounts in mm were: 230, 20, 135, 14, 57, and 4 for May through October.

Data on sandbur and other weed infestation and weeping lovegrass response were collected in November 1987 from randomly placed quadrats, or row segments, on the center 3 rows of each subplot. Sandbur and other weed infestation were measured by ocular estimate of canopy cover. Weeping lovegrass stand was measured as percent of basal cover along a row, a gap greater than 2.5 cm being considered unoccupied. The vigor of weeping lovegrass was assessed by measuring plant height, seedhead numbers, and herbage yield (Hull 1954, McKell 1972, Cook and Stubbendieck 1986).

Weeping lovegrass stand and seedhead counts were transformed before statistical analysis by $(100 - Y)^{0.5}$ and $(Y + 0.5)^{0.5}$, respectively, where Y was the value as measured in the original scale. For presentation, however, the data were converted to the original scale, but it was inappropriate to convert standard errors (SE) of means (Steel and Torrie 1980). All data were subjected to analysis of variance, and means were separated by Fisher's protected least significant difference (L.S.D.) test (SAS 1984, 1986). Simple effects were examined for significant interactions according to Steel and Torrie (1980). A regression equation of herbage yield on sandbur infestation was established.

Results and Discussion

Laboratory Phytotoxicity Study

Neither oak leaf nor grass residue extracts significantly affected germination and shoot growth of weeping lovegrass (Table 1). Root length, however, was significantly reduced 21% by grass residue extract and 92% by oak leaf residue extract ($P<0.05$). In a similar study by Roder et al. (1988), leachates from sandbur [(*Cenchrus longispinus* (Hack.)] plants, composited over phenological stages, reduced initial root growth and increased shoot growth of switchgrass (*Panicum virgatum* L.) seedlings without affecting germination. Leachates from Gambel oak (*Quercus gambelii* Nutt.) litter reduced radicle growth and speed of germination of ponderosa pine (*Pinus ponderosa* Laws) but not total germination (Harrington 1987). Osmotic concentrations of extracts which are too high may confound allelopathic effects (Anderson and Loucks 1966, McWilliams et al. 1970). McDonough (1977) recommended extracts with osmotic potentials less than 0.05 MPa. For some forage species, however, osmotic potentials up to 0.6 to 1.0 MPa may not affect germination (Knipe 1968, Young et al. 1970). Osmotic potentials were not measured in this study, but the water:residue ratio was comparable to, or greater than, those used by some authors (Dalrymple and Rogers 1983, Harrington 1987). Further, osmotic concentrations apparently have not confounded phytotoxic effects because germination and shoot growth were unaffected by the extracts. Residue effects on early root growth of weeping lovegrass were not, but need to be, confirmed in the field.

Table 1. Allelopathic effects of range litter (predominantly sandburs) and sand shinnery oak leaf residue on germination and root and shoot growth of Ermelo weeping lovegrass.

	Means[1]		
Treatment	Germination (%)	Shoot length (mm)	Root length (mm)
Distilled water (control)	48a	30a	31a
Grass litter extract	43a	39a	24b
Oak leaf extract	40a	31a	3c
S.E. of means (12 DF)	6	2	2

[1]Means within a column followed by the same letter are not significantly different (Protected L.S.D. test) ($P>0.05$).

Field Studies

The 461 mm of rainfall received from May through October 1987 was above average for Garza County, and good stands of weeping lovegrass resulted. Rainfall amount and distribution in May 1987 were far above the minimum requirements for high rates of weeping lovegrass germination (Wester et al. 1986).

Sandbur Competition Study

Sandbur infestation up to 65 plants/m^2 did not affect weeping lovegrass survival (all lovegrass plants survived) on unfertilized plots. Herbage and seedhead production, however, were drastically reduced by competing sandbur seedlings ($P<0.05$) (Table 2). Relative to sandbur-free plots, herbage yield was reduced 65, 72, and 79%, while seedhead production was reduced 89, 92, and 94%, at 30, 45, and 65 sandbur plants per m^2, respectively ($P<0.05$). The regression equation of herbage yield on sandbur infestation, and the associated coefficient of determination, were:

$$Y = 194 - 7.9X + 0.16X^2;\ r^2 = 0.84,$$

where Y is grams of lovegrass herbage dry matter/m^2 and X is the

Table 2. **Mean herbage and seedhead production of Ermelo weeping lovegrass at 4 densities of sandbur.**[1]

Sandbur plants/m²	Herbage yield (g/m²)	Seedhead (Number/m²)
0	194a	8.0a
30	68b	0.8b
45	55b	0.6b
65	41b	0.5b
SE of means (9df)	21	

[1]Means within a column followed by the same letter are not significantly different (Protected L.S.D. test) ($P > 0.05$).

number of sandbur plants/m². Bryan and McMurphy (1968) reported that weeds drastically reduced seedling stature of 5 grasses which included weeping lovegrass. Their grasses failed to produce seedheads in the first year of planting. Most perennial grasses are particularly susceptible to competition in the seedling stage because of low seedling vigor and slow early growth compared to annual species (Evans and Young 1972). These findings are consistent with results of this study. Sandbur effect on weeping lovegrass could be a combination of phytotoxicity and competition for nutrients, especially N and water.

Seedbed Preparation and N Studies

Seedbed strongly affected ($P = 0.001$) weeping lovegrass seedlings' vigor. Herbage yield, plant height, and seedhead number of weeping lovegrass were much greater on P plots than on any other seedbed treatment (Table 3). Trends in seedling vigor corresponded to trends in N content in the 10 to 20-cm soil layer as determined early in the growing season (Fig. 1). Seedlings grew better on seedbeds where soil N was higher below 10 cm and where favorable moisture conditions and root growth occurred most of the growing season. Early in the growing season P plots had a higher content of N in the 10 to 20-cm layer and a lower content in the surface 10-cm layer compared to other seedbed treatments (Fig. 1). Groffman (1985) and Webster et al. (1985) reported plowed soils also had more plant-available N in lower layers than no-tillage or conservation-tillage soils. Webster et al. (1985) speculated that the supply of N to plants was more restricted in no-tillage or conservation-tillage, than in plowed soils because undecomposed residue in the top 7.6 cm of unplowed soils tied up the N.

Table 3. Effect of seedbed treatments and nitrogen fertilizer on first season weed canopy and on Ermelo weeping lovegrass herbage production, plant height, and seedhead production.

	Variable[1]			
	Herbage yield	Plant height	Seedheads per meter of row	Weed cover[2]
	(g/m²)	(cm)	(no)	(%)
Seedbed treatments				
Plowed	145a	41a	2 a	46b
Burned & disked	73b	32b	0.5b	60a
Early disked	52bc	29bc	0 b	56ab
Late disked	45c	28c	0.4b	66a
S.E. of Means (9 d.f.)	30	4		12
Nitrogen fertilizer treatments (kg N/ha)				
0	70a	32a	0 a	53b
30	83a	33a	0.9a	57ab
60	83a	32a	0.8a	60a
S.E. of Means (6 d.f.)	21	2		6

[1]Means within a column followed by the same letter are not different (Protected L.S.D. test) ($P > 0.05$).
[2]Weed cover included sandbur and other weeds.

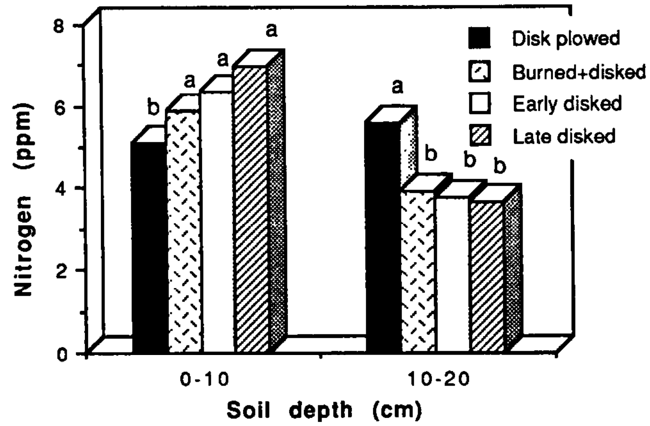

Fig. 1. Interaction of seedbed type and soil depth for plant-available nitrogen in soil samples collected from unfertilized Ermelo weeping lovegrass plots on 3 June 1987. Seedlings emerged 18 May 1987.

a,b Means at a depth followed by the same small letter are not significantly different (Protected L.S.D. test) ($P > 0.05$); S.E.=0.66.

Means within a seedbed type were not significantly different (Protected L.S.D. test) ($P > 0.05$); S.E. = 1.74.

Nitrogen fertilization had no effect ($P > 0.05$) on weeping lovegrass seedling vigor (Table 3). Twenty-seven days after N fertilization, the concentration of N in both the 0 to 10 and the 10 to 20-cm layers increased with the rate of N fertilization, but the increase was greater in the upper layer (Fig. 2). Thus, more of the surface-applied fertilizer accumulated in the surface 10 cm of soil and may

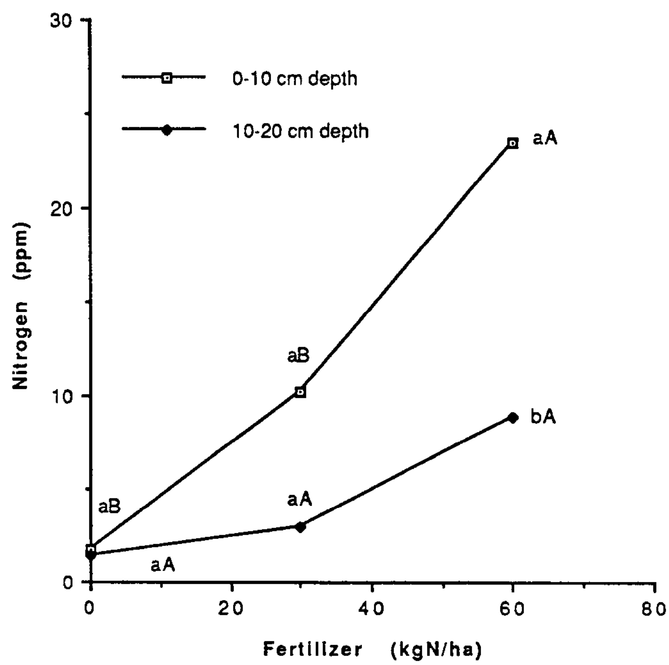

Fig. 2. Interaction of soil depth and fertilizer rate for plant-available nitrogen in soil samples collected from Ermelo weeping lovegrass plots on 7 July 1987. Seedlings emerged 18 May, and fertilizer was applied on 10 June 1987.

a,b Means at the same level of fertilizer followed by the same small letter are not significantly different (Protected L.S.D. test) ($P > 0.05$); S.E. = 3.89.

A,B Means within a depth followed by the same capital letter are not significantly different (Protected L.S.D. test) $P > 0.05$); S.E. = 5.25.

not have been readily available to weeping lovegrass seedlings whose roots extended into deeper soil horizons. Summer rainfall in semiarid areas rarely results in deep movement of available N (Stoddart et al. 1975). Only 62 mm of rain was received between N application and 7 July 1987, the soil sampling date. By 28 September 1987, 110 days after fertilizaton, any differences in N content between seedbed treatments, fertilizer rates, or soil layers had disappeared. The drastic decline in the level of N on fertilized plots is attributable primarily to a flush of growth of the annual weeds (including sandbur), induced by favorable moisture and high N fertility. Also, the literature reveals that N fertilization does not improve grass establishment in semiarid climates (Welch et al. 1962, Bryan and McMurphy 1968, Warnes and Newell 1969, Valentine 1980). Instead, N fertilization usually reduces perennial grass stands because of increased competition from annual weeds (Evans and Young 1972). In our study, sandbur and other weeds, as well as dead weeping lovegrass seedlings, were most numerous on LD plots receiving 60 kg N/ha. Welch et al. (1962) found that N fertilizer increased the growth of species with medium and high seedling vigor but seedling development of species with low seedling vigor was so slow that fertilizer was of no benefit. For N fertilizer to benefit seedlings of planted grass species in semiarid climates, it will probably have to be placed at a 10 cm depth or greater in the soil.

Our lab studies of phytotoxicity from vegetation litter indicated that oak and sandbur litter reduced and, in some cases, eliminated, radicle and root development in weeping lovegrass seedlings. Because tandem disking primarily mixes plant litter with the surface 10 to 12 cm of soil and does not bury it, it is probable that plant litter (particularly oak litter), inhibited seedling root development. Plowing, on the other hand, buried the plant residues away from seedling root development.

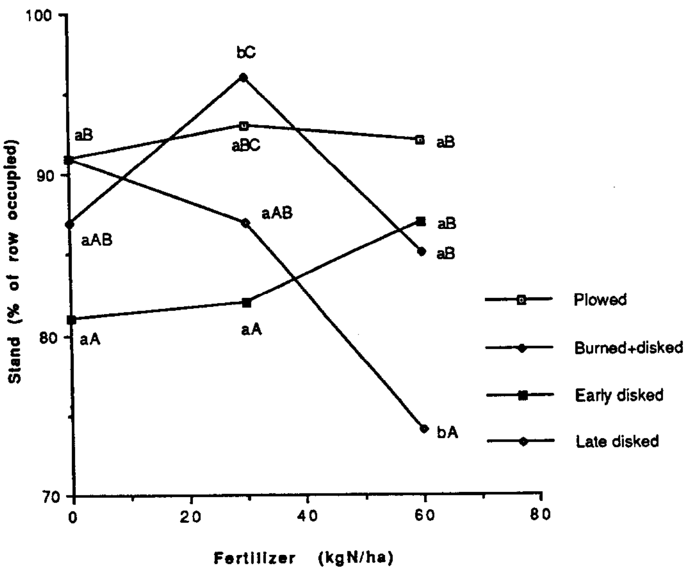

Fig. 3. Interaction of seedbed and fertilizer treatments for first year Ermelo weeping lovegrass stand.
a,b Means within a seedbed treatment followed by the same small letter are not significantly different (Protected L.S.D. test) ($P > 0.05$).
A,B,C Means at the same level of fertilizer followed by the same capital letters are not significantly different (Protected L.S.D. test) ($P > 0.05$).

Conclusions

In field seedings, weeping lovegrass stand and vigor were apparently reduced by phytotoxic inhibition of early root growth by oak leaf and sandbur-dominated grass residues. Sandbur infestations strongly competed with first season weeping lovegrass seedlings. The P plots which controlled sandbur the best had the most vigorous seedlings and the most consistently good stands. Also, P plots were richer in N in the 10 to 20 cm soil layer and poorer in the upper (0 to 10 cm) layer than the BD, ED, and LD plots. Thus, we believe the more vigorous weeping lovegrass seedlings obtained from plowing vs. disking resulted in better weed control, provided greater residue decomposition, eliminated phytotoxic seedling root inhibition, and increased N availability in the deeper soil horizon. Broadcast fertilization with N did not benefit weeping lovegrass basal cover and did not improve vigor; the surface-dressed N accumulated in the upper 10 cm of the soil and promoted sandbur growth rather than weeping lovegrass vigor.

Our results indicate the preferable seedbed for weeping lovegrass plantings is plowing to bury undesirable plant seeds and to eliminate potential phytotoxic plant residues.

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