Yield and Chemical Composition of Coastal Bermudagrass, Rhodesgrass, and Volunteer Species Grown on Saline and Nonsaline Soils

C. L. GONZALEZ AND M. D. HEILMAN

Highlight: Yields and chemical composition of coastal Bermudagrass (*Cynodon dactylon* (L.) Pers.) and Rhodesgrass (*Chloris gayana* Kunth) grown on saline and nonsaline soils were investigated in the nonirrigated region of the Rio Grande Valley of south Texas. Forage production (3-years average) was 12.9 and 13.8 metric tons per hectare (MT/ha) for coastal Bermudagrass and 16.3 and 13.5 MT/ha for Rhodesgrass in nonsaline and saline soils, respectively, as compared with 7.7 and 7.2 MT/ha for voluntary grasses and forbs. The higher yields of coastal Bermudagrass in saline vs nonsaline soils indicates its greater salt tolerance. Soil salinity did not affect the chemical composition or crude protein content of either grass. Chemical composition of grasses varied yearly, but changes between saline and nonsaline soil treatments followed the same general trend. Growing grasses on saline soils established a mulch on the soil surface and reduced evaporation, but this was not a successful soil reclamation practice, because moisture extraction by roots from saline soil profile caused salt accumulation in the root zone.

Small, erratically distributed saline areas are common on cropland and rangeland of the Rio Grande Valley of south Texas (Hawker and Simmons 1926; Beck and Hendrickson 1928; Hawker et al. 1929; Fanning et al. 1965). In the intensely farmed area, because of their erratic distribution, saline soils are not treated differently from nonsaline soils. Salt intolerant crops fail to germinate in the saline spots, and cultivation keeps weed growth to a minimum. Thus, saline areas remain virtually barren year after year. A high water table and evaporation from the bare soil surface tends to perpetuate this saline system (Allen et al. 1966).

The areas with the most salt-affected soils are primarily on the Rio Grande River watersheds where climate is characterized by mild winters; long, hot growing seasons; and erratic rainfall distribution (generally, rainfall peaks in May and September).

We conducted this study to characterize forage quality and production of coastal Bermudagrass (*Cynodon dactylon* (L.) Pers.) and Rhodesgrass (*Chloris gayana* Kunth) on saline and nonsaline soils of the nonirrigated region of the Rio Grande Valley of south Texas. We also investigated the effects of grass mulches on saline soil reclamation.

Methods

The study was conducted 11 km east of Raymondville, Tex., in an area of interspersed saline and nonsaline alluvial soils that are underlaid by a high saline water table. Soil at the experimental site is a Raymondville clay loam. The Raymondville series is a member of the fine, mixed, hyperthermic family of Vertic Calciustolls. These are calcereous soils that have gray to dark gray A horizons, gray to light brownsih gray clayey B2 horizons, and limey clayey C horizons. The criterion for site selection and replication in the saline area was that the electrical conductivity (EC_e) of the saturation extract in the surface 60 cm of soil ranged between 6 and 16 mmhos/cm, with all replications as near as possible to the same EC_e value. Nonsaline plots had less than 4 mmhos/cm EC_e. Data were collected from 1963 to 1966.

Nonsaline and saline site experiments were designed as randomized complete blocks and installed in three replications. Treatments included coastal Bermudagrass, Rhodesgrass, and a control of voluntary grasses and forbs. Soil borders were maintained around each plot to induce water ponding. The plots (5.9 m × 15.5 m) were established about 1 month before planting. Fertilizer (34-0-0, NH_4NO_3) was hand broadcast yearly in early spring at 45 kg N/ha on all treatments. Rainfall record was obtained from a nonrecording raingage at the experimental site. Water table data were collected from piezometers placed around the experimental sites.

Herbage yield was determined by clippng each plot at ground level several times yearly when the forage crop was mature. Forage moisture samples were taken and green yield adjusted to oven-dried weights. Herbage yield data were analyzed by analysis of variance.

Vegetation samples, including leaves and stems of the grasses from each plot, were processed for chemical analysis. Samples from the control included grasses and forbs. Forage samples for each treatment were analyzed for nitrogen (N) by the Kjeldahl method (Peech et al. 1947). Percent N was multiplied by a factor, 6.25, for conversion to percent crude protein. Potassium (K) and sodium (Na) were determined from saturated extracts by flame photometry (U.S. Salinity Laboratory Staff 1954). Calcium (Ca) and magnesium (Mg) were determined by the EDTA method (U.S. Salinity Laboratory Staff 1954), as the difference between a Ca plus Mg titration and the Ca titration.

Soil samples were taken for salinity analysis in January 1963 and 3 or 4 times yearly. Plots were sampled at 15-cm increments to a 60-cm depth and by 30-cm increments from 60- to 180-cm. Soil salinity was determined on the saturated extract using a conductivity meter (U.S. Salinity Laboratory Staff 1954).

All treatment plots were listed into rows 96 cm apart; the grass was planted in the furrows to receive runoff from the lister ridges. Coastal Bermudagrass was sprigged in furrows, 30 cm apart, in early spring 1963 and again in June to assure a good stand. Rhodesgrass was broadcast seeded in September at 5 kg/ha.

Results

Figure 1 shows the study plots 2 years after treatment establishment and the effects of ridge furrow system of seeding for both saline and nonsaline soils. Grass seeded in the furrow

Authors are soil scientists, Southern Region, Agricultural Research Service, U.S. Department of Agriculture, Weslaco, Texas.

This study is a contribution from Soil and Water Conservation Research, Southern Region, Agr. Res. Serv., U.S. Dep. Agr., Weslaco, Tex.

Manuscript received July 2, 1976.

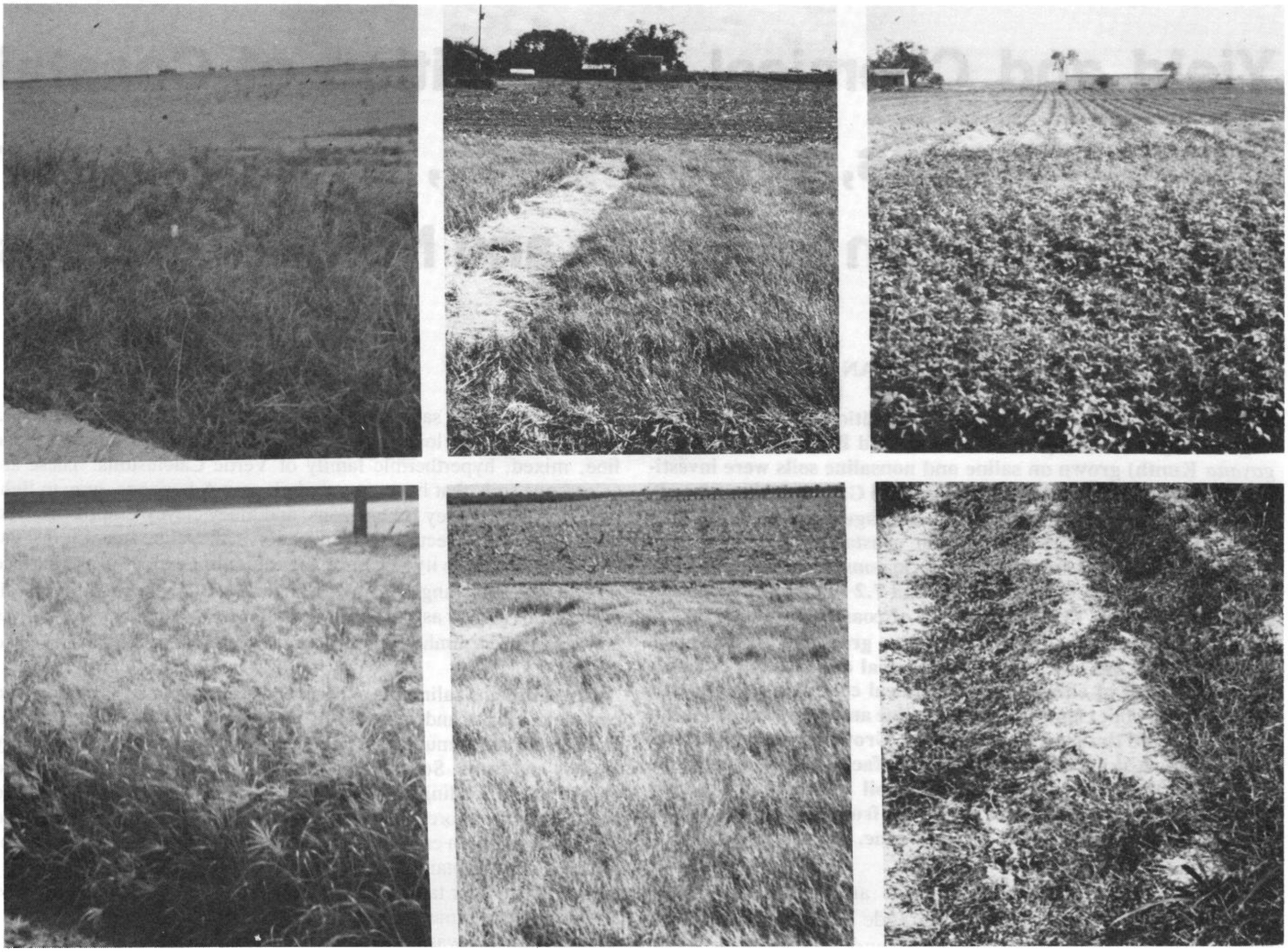

Fig. 1. *Study area showing nonsaline and saline grass plots 2 years after seeding. Top row (left to right) are Rhodesgrass, coastal Bermudagrass, and volunteer species (nonsaline). Bottom row (left to right) are Rhodesgrass, coastal Bermudagrass, and volunteer species (saline).*

effectively established and grew well because of greater salt leaching and increased soil moisture after rains. During periods of high rainfall, salts from the ridges were leached, and grasses were established on ridge tops. Both coastal Bermudagrass and Rhodesgrass provided 100% foliage cover on both saline and nonsaline soils. Voluntary grasses and forbs (control) provided 100% ground cover on nonsaline soil, but less than 50% on saline soil.

Forage Production

Production for Bermudagrass and Rhodesgrass was high the first year and decreased the next 2 years for both nonsaline and saline soil (Table 1). When year effects were compared, 1964 was significantly higher than 1965 and 1966 for both nonsaline and saline soils. Similar trend in forage yields (nonsaline and saline soils) reflects the effect of herbaceous mulches in temporarily reducing and maintaining a leached rooting zone under

Table 1. Total forage yields (metric tons/ha) for seeded and unseeded treatments on nonsaline and saline soils for 3 years.[1]

	Nonsaline				Saline			
Treatment	1964	1965	1966	Mean	1964	1965	1966	Mean
Coastal Bermudagrass	18.9b[2]	10.0b	9.8a	12.9b	16.7b	10.7b	14.1a	13.8b
Rhodesgrass	21.1b	14.0b	13.8a	16.3b	17.1b	11.2b	12.1a	13.5b
Control (unseeded)	10.0a	3.2a	9.9a	7.7a	8.5a	3.7a	9.4a	7.2a
Mean	16.7a[3]	9.1b	11.2b		14.1a	8.5b	11.9b	

[1] Oven dried basis, data are accumulated values each year of several harvests.
[2] Values in columns followed by the same letter do not differ significantly at the .01 probability level according to Duncan's multiple range test.
[3] Values in rows followed by the same letter do not differ significantly at the .01 probability level according to Duncan's multiple range test.

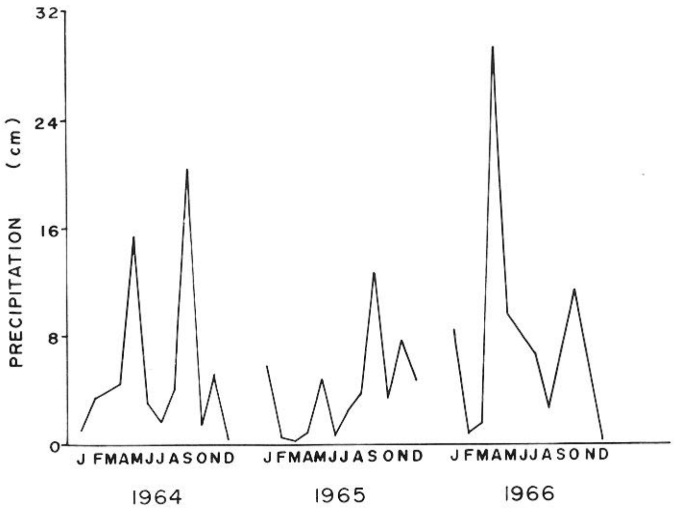

Fig. 2. *Monthly precipitation record in study area for 3 years.*

conditions of high water table and salinity. We observed a direct relationship between yield and total rainfall during the growing season (Fig. 2). Mean Bermudagrass yields (over 3 years) were greater on saline soil (13.8 MT/ha) than on nonsaline soils (12.9 MT/ha). Mean Rhodesgrass yield (over 3 years) on the other hand, was higher on nonsaline soil. Forage yield from the unseeded plots on the unsaline and saline soils showed more variation than the seeded plots, since the species composition was highly affected by salinity.

Major species on the saline control included carelessweed (*Amaranthus palmeri* Wats.), *Euphorbia* spp., *Eragrostis* spp., hooded windmillgrass (*Chloris cucullata* Bisch.), espanta vaqueros (*Tidestromia lanuginosa* (Nutt.) Standl.), and *Solanum* spp.; on the nonsaline control the major species were Johnsongrass (*Sorghum halepense* (L.) Pers.), carelessweed, common sunflower (*Helianthus annus* L.), hooded windmillgrass, common Bermudagrass, and cowpen daisy (*Verbesina encelioides* (Cav.) Gray).

Chemical Composition of Herbage

We compared chemical composition and crude protein of forage grown in nonsaline soil with that grown in saline soil for two seasons, July 1964 and July 1966 (Table 2). Magnesium, Ca, and K concentrations were higher in 1964 samples, as compared with 1966 samples, in both saline and nonsaline soils for both seeded grass treatments. The decrease in concentration of Mg, Ca, and K in 1966 seems to be related to lower rainfall amounts received in June and July 1964 than in the same period in 1966. During periods of low rainfall and high evaporation, cations and anions are probably more concentrated in the root zone. The magnitude of decrease for both grass treatments was in the order of Mg > Ca > K and was the same for saline and nonsaline soils. The magnitude of decrease for the unseeded treatment was Mg > K > Ca for both saline and nonsaline soils. The different order of decrease for the unseeded treatment can possibly be attributed to the different plant species composition and phenology stages at harvest.

The percent of Na in Rhodesgrass for 1964 and 1966 was very high on both saline and nonsaline soils as compared with that of Bermudagrass (Table 2). From 1964 to 1966, Na in Bermudagrass increased .01% on nonsaline soil and decreased .15% on

Table 2. Chemical composition (%)[1] of two seeded grass species and vegetation from the control treatment grown on nonsaline and saline soil. Data were collected from forage harvested in July of each year.

Treatment and constituent	Nonsaline		Saline	
	1964	1966	1964	1966
Rhodesgrass				
Mg	0.56	0.15	0.43	0.15
Ca	1.02	0.52	1.12	0.62
K	1.75	1.07	1.56	1.01
Na	0.63	1.61	1.25	1.35
Crude protein	10.1	10.8	10.7	10.6
Coastal Bermudagrass				
Mg	0.54	0.11	0.78	0.13
Ca	0.98	0.56	0.92	0.40
K	2.17	1.29	2.10	1.13
Na	0.08	0.09	0.20	0.05
Crude protein	8.3	8.4	9.5	9.8
Control (unseeded)				
Mg	1.29	0.48	0.45	0.15
Ca	1.55	0.74	1.36	0.52
K	4.60	1.99	3.14	1.05
Na	0.11	0.18	0.36	1.76
Crude protein	13.2	12.9	11.1	10.6

[1] Oven dried basis.

saline soil. The Na percent of grasses and weeds of the unseeded treatment increased .07 and 1.4% on nonsaline and saline soils, respectively.

Soil salinity did not significantly affect crude protein percent (Table 2). Bermudagrass had a slightly lower crude protein content than did Rhodesgrass on both soils. The unseeded treatment (grasses and forbs) was higher in crude protein than either of the seeded grass species. Forage moisture percent at time of harvest for analysis was 47%, 64%, and 67% for Bermudagrass, Rhodesgrass, and the voluntary species, respectively. Soil salinity did not affect moisture percent in forage. We observed that higher crude protein percentage is associated with higher forage moisture percentage.

Soil Salinity

Table 3 shows soil salinity changes in the 0- to 60- and 0- to 80-cm depth over a 4-year period for each of three treatments in nonsaline and saline soil. In 1963, at the beginning of the study, salt content at the 0- to 60- and 0- to 80-cm depths within treatments in both soils varied little. The average EC_e's for saline and nonsaline soils at 0- to 60-cm depth were 14.6 and 3.4 mmhos/cm, respectively. By February 1964, all treatments on saline plots were lower than in 1963 at both depths and were the lowest recorded for the study period. The EC_e values for treatments on saline soil (0- to 60-cm depth) in 1964 for Rhodesgrass, coastal Bermudagrass, and voluntary species were 3.9, 1.2, and 2.6 mmhos/cm, respectively. This was due to the 70 cm of rainfall recorded between January 22, 1963, to February 10, 1964.

Table 3. The effect of different treatments on the EC_e (mmhos/cm) in nonsaline and saline soils for four years after treatment.

Soils and treatment	Jan. 22, 1963		Feb. 10, 1964		Sept. 20, 1965		Dec. 12, 1966	
	0–60	0–180	0–60	0–180	0–60	0–180	0–60	0–180
Saline								
Rhodesgrass	14.9	13.7	3.9	9.3	8.9	13.9	9.1	12.5
Coastal Bermudagrass	13.1	11.5	1.2	10.7	5.7	12.5	5.8	12.5
Control (unseeded)	15.9	13.5	2.6	9.1	10.0	13.6	4.7	10.9
Nonsaline								
Rhodesgrass	2.8	4.1	1.3	4.2	1.9	4.8	1.8	5.9
Coastal Bermudagrass	4.5	4.8	1.7	4.3	2.1	3.9	2.7	5.9
Control (unseeded)	3.1	4.3	1.0	3.7	3.1	6.1	2.7	5.8

Between 1963 and 1966, salt at the 0- to 60-cm depth decreased in both saline and nonsaline soils for saline Rhodesgrass, coastal Bermudagrass, and control treatment from 14.9 to 9.1, 13.1 to 5.8, and 15.9 to 4.7 mmhos/cm, respectively. Salt content fluctuated seasonally at the 0- to 60-cm depth; however, it was greater for the control treatment than for either the coastal Bermudagrass or Rhodesgrass treatments.

Discussion

Rhodesgrass and Bermudagrass produced a substantial amount (>12 MT/ha) of forage on both nonsaline and saline soils under dryland conditions. This is about half of these species potential forage production under irrigated conditions in south Texas (Trew and Hoveland, undated). Thus, our data indicated that both Rhodesgrass and coastal Bermudagrass were well adapted to saline soils. Coastal Bermudagrass produced significantly higher forage yields on saline as compared with nonsaline soil, while Rhodesgrass was more productive on nonsaline soil. Thus, higher yields by coastal Bermudagrass on saline soils indicated that it could tolerate greater soil salinity than could Rhodesgrass. Similar responses have been reported by Bernstein (1958).

After periods of high rainfall (September 1964, with almost 23 cm of rainfall) the October water table rose from 250- to 140-cm depth. Grasses and forbs, like grain sorghum (Lyles and Fanning 1965) utilize moisture from the capillary fringe of a high water table, so plant growth and production were usually increased. This condition probably explains the higher yields in 1964.

Yearly variations in the chemical composition of grasses, grown on nonsaline and saline soils, were probably due to rainfall variation and their phenological stage and conditions at harvest. The amount of change always followed the same trend on grasses, regardless of soil salinity. In general, our data indicated that different soil salinity did not affect Ca, Mg, and K content of Bermudagrass and Rhodesgrass, which is contrary to data reported by Stewart (1967), who found that plants grown in soil having a high salinity accumulated mineral salts in their tissues. However, Na content seems to be higher for Bermudagrass and Rhodesgrass in 1964, and much higher in volunteer species in both 1964 and 1966. The higher Na content is in agreement with data reported by Stewart (1967). The difference is probably attributed to species, since data reported by Stewart is based on chamiza (*Atriplex canescens*).

Crude protein content was not significantly affected by soil salinity. Protein content of plants under all treatments equalled or exceeded requirements for beef cattle (National Research Council 1970).

Salinity content of soil profile (0- to 60-cm depth) for all treatments decreased between 1963 and 1966. However, the decrease was greater for the unseeded treatment. Under grass treatments, evapotranspiration probably left little excess water for leaching. Short periods of leaching after heavy rains were more effective under grass treatments than under the control. However, this decrease in salinity was temporary. Since both grass treatments had a higher density of plants, which extracted moisture from the underlying saline water table, this caused salt to accumulate in the root zone. Also with evaporation, the salt was transported to and deposited on the soil surface. Similar results have been reported by Fanning and Carter (1963), Sandoval and Bentz (1966), and Heilman et al. (1968).

It appears from this study that production on saline soils can be promoted by proper selection of salt-tolerant species that can best utilize rainfall moisture under saline conditions. Even though saline soils cannot be reclaimed by growing grasses, a large component of major rangeland types in the southwestern United States can be important forage producers if seeded with adapted grass species. In areas with adequate soil moisture as well as optimum temperatures, production from well-managed saline land seeded to selected species could be equal to that of nonsaline land.

Literature Cited

Allen, R. R., L. R. Ussery, and B. M. Taylor. 1966. Water table depth and ground water salinity in the nonirrigated area of the Lower Rio Grande Valley of Texas. U.S. Dep. Agr., Agr. Res. Serv., Beltsville, Maryland. 41-115.

Beck, M. W., and B. H. Hendrickson. 1928. Soil survey of Cameron County, Texas. U.S. Dep. Agr., Bureau of Chemistry and Soils: Series 1923 #17. p. 36-38.

Bernstein, L. 1958. Salt tolerance of grasses and forage legumes. U.S. Dep. Agr., Agr. Inform. Bull. 194.

Fanning, C. D., and D. L. Carter. 1963. The effectiveness of a cotton bur mulch and a ridge-furrow system in reclaiming saline soils by rainfall. Soil Sci. Soc. Amer., Proc. 27:703-706.

Fanning, C. D., C. M. Thompson, and D. Isaacs. 1965. Properties of saline range soils of the Rio Grande Plains. J. Range Manage. 18:190-194.

Hawker, H. W., M. W. Beck, and R. E. Devereux. 1929. Soil survey of Hidalgo County, Texas. U.S. Dep. Agr., Bureau of Chemistry and Soils: Series 1925 #13. p 50-58.

Hawker, H. W., and C. S. Simmons. 1926. Soil survey of Willacy County, Texas. U.S. Dep. Agr., Bureau of Chemistry and Soil: Series 1926 #3. p. 51-55.

Heilman, M. D., C. L. Wiegand, and C. L. Gonzalez. 1968. Sand and cotton bur mulches, Bermudagrass sod, and bare soil effects on: II salt leaching. Soil Sci. Soc. Amer. Proc. 32:280-283.

Lyles, L., and C. D. Fanning. 1965. Effect of soil salinity. fertilization, water table depth and runoff control on production of nonirrigated grain sorghum in the Lower Rio Grande Valley. Texas A&M Univ. Agr. Exp. Sta. MP 757.

N. R. C. 1970. Nutrient requirements of domestic animals, No. 4, nutrient requirements of beef cattle. Nat. Res. Counc., Washington, D.C.

Peech, M. L., A. Dean, and J. F. Reed. 1947. Methods of soil and analysis for fertility investigations. U.S. Dep. Agr. Circ. 754. 25 p.

Sandoval, F. M., and L. C. Benz. 1966. Effect of bare fallow, barley, and grass on salinity of a soil over a saline water table. Soil Sci. Soc. Amer. Proc. 30:392-396.

Stewart, A. E. 1967. Establishing vegetative cover with saline water. New Mexico State Univ. Agr. Exp. Sta. Bull. 513.

Trew, E. M., and C. S. Hoveland. Undated. Irrigated pastures for South Texas. Texas Agr. Exp. Sta. Bull. 819.

U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. U.S. Dep. Agr. Agr. Handbook 60.

Growth of Selected Species Under Trans-Pecos Conditions, by Gary Stephen Kemph, MS, Range Science. 1975.

Crested wheatgrass, Russian wildrye, wintergreen hardinggrass (cv. "TAM"), and burnet were compared to sideoats grama (cv. "Premier") under growth chamber conditions simulating environmental conditions of a representative Trans-Pecos location. Plant survival, the importance of grass subcoleoptile internode elongation to survival, and growth parameters were evaluated under three precipitation regimes for a year as a step toward selecting a species to help alleviate the critical cool-season range forage shortage in the Trans-Pecos.

Crested wheatgrass and Russian wildrye had higher survival percentages than Premier sideoats grama at the end of the first year of growth. Survival of Russian wildrye and Premier sideoats grama was highest under the driest precipitation regime. Physiological hardening probably played an important part in survival of these species in this study. Crested wheatgrass year-end survival was highest under the wettest precipitation regime, and was associated with high fall root and shoot weights and numbers of adventitious roots. No TAM wintergreen hardinggrass and only 4% of the burnet survived the first year of growth. This high mortality was attributed to low winter and spring precipitation and low nitrogen fertility of the soil. Crested wheatgrass and Russian wildrye are probably adapted to certain areas of the Trans-Pecos, but Russian wildrye would probably have better stand establishment than crested wheatgrass in years with low fall precipitation. Neither TAM wintergreen hardinggrass nor burnet appear adapted to Trans-Pecos range seedings.

Grasses with elongated subcoleoptile internodes (ESI) had lower year-end survival percentages than the grasses without the elongation. However, Premier sideoats grama, and ESI grass, had as high a survival under the driest precipitation regime as either of the non-ESI grasses, crested wheatgrass and Russian wildrye. Therefore, other plant characteristics in addition to presence or absence of subcoleoptile internode elongation were important in grass survival in this study.