

Selecting *Atriplex canescens* for greater tolerance to competition

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Abstract

Success in establishing fourwing saltbush [*Atriplex canescens* (Pursh) Nutt.] is often limited by competition from associated vegetation. Fourwing saltbush is reported to have abundant natural genetic variation, hence selection for plant vigor or competitiveness may be an effective tool for cultivar improvement. We observed distinctive within-accession variation in the apparent ability of fourwing saltbush seedlings to tolerate competition from sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.] in a 1982 field planting. Superior and inferior parental saltbush phenotypes in the field planting were cloned in 1984 by rooting stem cuttings, and the cloned propagules were transplanted into plots with or without competition to test the hypothesis that the competitiveness trait was genetically controlled. Survival and canopy development of superior and inferior clones planted at the same time in competition regimens were similar, suggesting that the parental phenotypes were not genetically different in their ability to tolerate competition. Differences observed in the parental phenotypes may have been environmentally induced, or genetic differences in the clonal material may have been masked by using rooted cuttings rather than seedlings, by excessive competitive pressure in the competition regimens utilized, or both. Clones from the 2 parental phenotypes performed similarly when transplanted into competition-free regimens in November when growing conditions were favorable, but canopy development of clones from superior parental phenotypes exceeded that of those from inferior parental phenotypes when transplanted into competition-free regimens in April when growing conditions were poor.

Key Words: fourwing saltbush, seedling establishment, cultivar improvement, genotype

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Fourwing saltbush [*Atriplex canescens* (Pursh) Nutt.] is widely used for rangeland reseeding and revegetation of disturbed sites because of its broad range of adaptation to soils and climate, winter leaf retention, and its potential to produce high-quality forage for livestock and wildlife. Success in establishing productive fourwing saltbush stands has been highly variable (Springfield 1970, Nord et al. 1971, Aldon 1972, Petersen et al. 1986), and failures have often been attributed to the detrimental impact of competing vegetation on seedling establishment and growth (Giunta et al. 1975, Van Epps and McKell 1983, Geist and Edger-ton 1984, Petersen et al. 1986, Petersen et al. 1990). Because the control of competing vegetation in fourwing saltbush plantings is usually neither practical nor economically feasible, selection for greater competitive ability appears to be an alternative strategy worthy of investigation.

Variation in growth form and seedling vigor among and within fourwing saltbush accessions and ecotypes has been recognized (Blauer et al. 1976, McArthur et al. 1983, Petersen et al. 1987, Tiedemann et al. 1987). The variation among plants within an accession has been attributed to the outcrossing, principally dioecious, flowering habit (McArthur et al. 1983). The abundant natural genetic variation exhibited by this species permits significant responses to selection (Stutz and Carlson 1985), and 3 cultivars have been released by selecting superior plants adapted to large geographical areas (Carlson 1984).

The use of rooted cuttings permits superior plant materials to be increased rapidly without loss of genetic integrity (Everett et al. 1978). Procedures for rooting cuttings of fourwing saltbush have been developed (Wiesner and Johnson 1977, McArthur et al. 1984), and traits of superior parental plants are reported to be constant in their cloned propagules (McArthur et al. 1978).

We observed extreme variability in the growth rates of fourwing saltbush seedlings from a San Angelo, Texas, accession trans-

planted into a sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.] sward in 1982 (Petersen et al. 1986). "Superior" phenotypes were >75 cm tall and much-branched after 17 months, whereas "inferior" phenotypes of the same accession, subjected to the same cultural treatments, were <20 cm tall and sparsely branched. We hypothesized that these differences were due to genetic variation in the ability to tolerate competition among plants within the accession. The objective of this study was to determine if the ability of superior and inferior fourwing saltbush plants to tolerate competition was genetically controlled. Our approach was to clone superior and inferior plants and determine if the trait was constant in the vegetative propagules when transplanted into areas with or without competing vegetation.

Materials and Methods

The study was conducted on a clay loam soil (Kimbrough-Mereta-Angelo association) (Petrocalcic and Torricalcic Calciustolls) 8 km northwest of San Angelo, Texas in the southern rolling plains resource area. Elevation is about 580 m and mean annual precipitation is 47 cm.

Seeds were harvested in November 1980 from about 100 fourwing saltbush plants in a natural population growing in an undeveloped area within the city limits of San Angelo. The population was identified as being tetraploid (Jerry Barrow, USDA-Agr. Res. Service, Las Cruces, N.Mex., personal communication). We assumed that the population was a single ecotype with a relatively narrow genetic base. Attributes of the ecotype have been described by Petersen et al. (1987). Seedlings were grown from this bulk seed harvest in a greenhouse for 15 weeks, then 1,116 of the seedlings were transplanted into a stand of 'El Reno' sideoats grama in April 1982 (Petersen et al. 1986). Growth rates of 511 seedlings that survived were recorded for 38 months after transplanting. Superior individuals were identified after 17 months as those that were much-branched with canopy heights >75 cm and canopy diameters >50 cm, and inferior individuals were identified as those sparsely branched with canopy heights and diameters <20 cm.

Stem cuttings were rooted from about 25 superior and about 200 inferior plants during June and November 1984. Cuttings of leafy softwood (succulent current year's growth) were placed in an ice chest and transported to the greenhouse. Cuttings 10 to 12 cm long were stripped of basal leaves (lower 4 cm) and submersed in water. Basal ends were dipped in a commercial rooting hormone talc {0.3% indole-3-butyric acid [4-(3-indolyl)butyric acid]}, then inserted into individual plastic potting cups (5 × 5 × 5 cm) containing sand, vermiculite, and peat moss (1:1:1, v/v/v). An automatic, intermittent misting system applied a fine mist of water for 15 sec every 30 min. Greenhouse air temperatures were 16 to 30° C during June–July and 10 to 27° C during November. Cuttings were transferred to plastic tubepacks (4 × 5 × 18 cm) containing soil, vermiculite, and peat moss (1:1:1) after roots appeared through the bottoms of the potting cups (10 to 30 days). Rooted cuttings were maintained in the greenhouse about 6 weeks then moved to a lathhouse for environmental conditioning.

The field experiment was arranged as a randomized, complete block with 2 planting dates, 15 November 1984 and 23 April 1985, and 4 replications. A replication consisted of 19 rooted cuttings from superior or inferior plants transplanted on 1.5-m centers in rows 3.4 m apart within a sideoats grama sward (competition regimen) or in adjacent plots that had been initially tilled to kill existing vegetation and subsequently cultivated and hand weeded for the duration of the study (competition-free regimen). Each rooted cutting received 8 liters of water immediately after transplanting, and those transplanted in April received an additional 8 liters 23 days after transplanting.

Survival, canopy heights, and canopy diameters were deter-

mined 12 and 24 months after transplanting. Plant height was measured to the tallest stem, and plant diameter was the average of crown intercept parallel with the row and perpendicular to the row. Oven-dry standing crops of associated grasses and broadleaf weeds in the sideoats grama plots were estimated by harvesting at ground level from 15, 0.25-m² quadrats in September 1986. Floral phenotype (♀ = pistillate, ♂ = staminate, [♀♂] = monoecious, or no flowering) of each shrub was recorded in July 1988.

Clone responses within the competition and competition-free regimens were compared separately for each planting date by analyses of variance ($P \leq 0.05$) since competition was not considered a treatment. Transformation of percentage data ($\sin^{-1} \sqrt{x}$) did not change data interpretation, so actual values are presented. Chi-square analyses were used to determine if ratios of sexual phenotypes among the clonal populations were similar to the expected 55♀:35♂:10[♀♂], for tetraploid populations (McArthur 1977).

Results and Discussion

Growing conditions were more favorable for clones planted in November 1984 compared to April 1985. About 21 cm of precipitation were received during the 60-day period preceding planting and 11 cm were received during the 90-day period after planting in November 1984. Only 2 and 17 cm of precipitation were received in the 60-day period preceding planting and the 90-day period after planting in April 1985, respectively. Total precipitation received during the 12-month period after planting was 47 and 38 cm for the November and April plantings, respectively. Peak standing crop of grasses and forbs during September 1986 was $1,890 \pm 314$ ($\bar{x} \pm S.E.$) and $2,870 \pm 217$ kg/ha for competition regimens planted in November and April, respectively.

Fourwing saltbush clones in the sideoats grama swards were obviously stressed, compared to those observed in competition-free plots, as evidenced by lower survival percentages and decreased canopy development (Table 1). Clones planted in the sideoats grama in April were more seriously stressed than those planted in November because of drier conditions at time of the April planting.

Table 1. Mean survival, canopy heights, and canopy diameters of clones from superior and inferior fourwing saltbush parental phenotypes transplanted into competition or competition-free regimens in November 1984 and April 1985 on a clay loam soil near San Angelo, Texas.¹

Parental phenotype	Survival		Canopy height		Canopy diameter	
	Months after transplanting					
	12	24	12	24	12	24
	---- (%) ----					
	----- (cm) -----					
	Competition regimen					
	----- November transplanting -----					
Superior	66 (7)	62 (9)	12 (2)	30 (7)	6 (1)	22 (6)
Inferior	54 (8)	52 (8)	14 (1)	38 (8)	7 (1)	26 (7)
	----- April transplanting -----					
Superior	27 (5)	21 (8)	10 (2)	16 (5)	5 (1)	10 (4)
Inferior	30 (7)	15 (8)	8 (1)	9 (2)	4 (1)	7 (2)
	Competition-free regimen					
	----- November transplanting -----					
Superior	74 (6)	74 (6)	68 (2)	95 (2)	82 (2)	145 (1)
Inferior	80 (3)	80 (3)	64 (6)	98 (5)	77 (5)	139 (5)
	----- April transplanting -----					
Superior	81 (6)	81 (6)	55 (4)	92 (5)	57 (4)	135 (9)
Inferior	83 (4)	79 (4)	43 (1)	77 (2)	43 (2)	114 (5)

¹Values in parentheses following means are standard errors. Means separated by an * are significantly different ($P \leq 0.05$).

Also, the sideoats grama was dormant at time of planting and for several months after planting in November, whereas spring growth of the grass shortly after the April planting probably increased the demand for a limited supply of soil water. The standing crop of competing vegetation was also greater in the plots planted in April compared to November.

There was little definitive evidence that clones from superior parental plants were more vigorous or more tolerant of competition than clones from inferior parental plants (Table 1). The only significant differences observed were that canopy heights and diameters of clones from superior individuals were greater than those from inferior individuals in the April planting in competition-free regimens. Survival of cuttings from the 2 parental phenotypes was similar within each of the competition regimens, and canopy development was similar within each of the competition regimens except for planting in April into competition-free areas. The absence of differences in survival and/or canopy development among clones from superior and inferior parental plants grown in the competition regimens (Table 1) suggests that the superior and inferior parental plants were not genetically different in ability to tolerate competition. Differences observed in canopy development in the 2 parental phenotypes may have been caused by microsite soil differences or other unknown biotic or abiotic factors. Growth of the inferior phenotypes in the 1982 study may have been stunted due to feeding by rodents or lagomorphs, while the superior phenotypes may have escaped herbivory. However, genetic differences among the superior and inferior parental phenotypes may not have been expressed by their vegetative propagules if our competition pressures exceeded the maximum threshold that could be tolerated by the superior genotype. Also, differences in growth rates observed in seedlings grown from seed in the 1982 study may have been masked by the use of rooted cuttings in this study. To our knowledge there have been no studies on the comparative development of root systems of fourwing saltbush seedlings and vegetatively propagated cuttings.

None of the fourwing saltbush plants in the competition regimens were flowering in July 1988, apparently because of their small size and the stress imposed by associated vegetation. Ratios of pistillate, staminate, and monoecious phenotypes among clones from inferior parental plants planted into competition-free regimens were similar to those expected for tetraploid populations (Table 2). However, sex ratios of clones from superior parental

Table 2. Floral phenotypic ratios of fourwing saltbush clones grown in competition-free plots.¹

Date planted	Parental phenotype	Pistillate ♀	Staminate ♂	Monoecious [♀♂]	χ^2	P
Nov.	inferior	59	36	5	1.66	>0.25
Nov.	superior	74	26	0	13.26	<0.005
Apr.	inferior	51	43	6	3.02	>0.10
Apr.	superior	93	7	0	39.98	<0.005

¹ χ^2 values calculated based on expected ratio of 55 ♀ : 35 ♂ : 10 [♀♂]

phenotypes planted into competition-free regimens were heavily skewed toward the pistillate type, and there were no monoecious plants. This suggests that pistillate plants are more competitive and/or better adapted to favorable sites than staminate or monoecious plants. However, it is more likely that the unusual sexual phenotype ratios among clones from superior parent plants were associated with the small number of superior parent plants cloned (25 superior vs 200 inferior).

Development of a fourwing saltbush cultivar with improved

survivability and growth rates in the presence of competition by selection within a single, narrow-based genetic population may be difficult to achieve, but additional research toward this goal is warranted. Chances for success in achieving this goal would obviously be greater if broader genetic populations were sampled. Researchers should be aware that distinctive performance of specific plants may be a function of environment and not of genetics, even within plantings on apparently homogenous sites.

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