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Natural asexual reproduction in fourwing saltbush *Atriplex canescens* (Pursh) Nutt.

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Native populations of fourwing saltbush, *Atriplex canescens* (Pursh) Nutt., are generally naturally seeded. Two populations were found in New Mexico that are asexually propagated by underground stems. The ratios of female to male plants in asexually produced populations differed from naturally seeded populations. This trait appears to be under genetic control and would be valuable in improving fourwing saltbush for revegetation of rangelands.

Keywords: remediation; restoration; revegetation; reclamation; sex expression

Introduction

Fourwing saltbush, *Atriplex canescens* (Pursh) Nutt., is a dioecious, native shrub adapted to the arid portions of the western United States, extending from northern Mexico to western Canada. It is valuable as a forage, for wildlife habitat and natural landscaping (McKell, 1989, pp. 311–314). It is competitive with other native shrubs and grasses, making it a useful shrub for revegetation projects. *Atriplex* populations in the southwest U.S. are mostly tetraploid, yet diploid and hexaploid populations are common. Sex expression is under genetic control and stable female biased ratios are a characteristic of native, tetraploid, dioecious, fourwing saltbush populations (McArthur, 1977; McArthur & Freeman, 1982; Barrow, 1987). Fourwing saltbush is regenerated from seed and in most years produces copious quantities of seed. However, seed germination and plant establishment is generally low on native sites (Aldon, 1972). When soil or plants are disturbed by fire, machinery or floods and when environmental conditions are favorable, mass establishment of seedlings can occur, but these conditions are not widespread or routine (Barrow, unpublished).

Specific references of asexual reproduction in native plants *per se* in the literature are rare. McArthur (1989) reported that some shrubs species mix both sexual and asexual reproduction to insure successful establishment. Jones & Raynal (1987) studied plant regeneration with root-sprouts in American beech *Fagus grandifolia* Ehrh. Johnsen *et al.* (1969) encountered root-sprouting and re-establishment of Gambel oak, *Quercus gambelii* Nutt., after chemical control. Oak trees form dense root-sprouted thickets following cutting or burning. Two other south-western shrubs that commonly

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asexually propagate are tarbush, *Flourensia cernua* DC., and Apache plume, *Fallugia paradoxa* (D. Don) Endl. Stutz (1989) reported that saltsage, *Atriplex tridentata* Kuntze, spreads asexually by underground root-sprouting, but did not observe it in fourwing saltbush. Root-sprouting may be induced in some native plants when roots are injured or are exposed to the aerial environment by wind or water erosion.

I had observed that in two naturally occurring populations of fourwing saltbush near Alma and Corona, NM, that many plants originated from underground stems rather than seed. This trait would be valuable for re-establishment of fourwing saltbush on native lands. The objective of this study was to quantify the occurrence and characteristics of asexual reproducing native populations of fourwing saltbush in the south-western U.S.

Materials and methods

Thirteen native tetrapoloid populations of fourwing saltbush, each consisting of more than a thousand plants, were selected for study. Four populations were primarily asexual. Two of these populations were located north of Alma, NM, along U.S. highway 180, one located at mile marker (MM) 43 and the other at MM 45. Another was located 17 miles south-west of Corona, NM, and the fourth about 10 miles south-east or 2 miles east of Ancho, NM. The other nine populations were considered to be seed originated. Asexually produced plants were determined by excavating the soil from the base of each plant to a depth of about 15 cm. The first 50 young plants (less than 50 cm in height) encountered, walking randomly through these populations, were selected. Plants with a tap root were scored as sexual (originating from seed) and those originating from underground stems were scored as asexual. Seven naturally seeded populations were selected in New Mexico, one in west Texas, and one in eastern Arizona. Mature flowering plants were scored female or male as they were encountered walking randomly through each population. The numbers of plants scored in each population ranged from 72 to 250. The mean frequency of female and male plants was calculated from the nine naturally seeded populations to establish an expected frequency for seeded populations. Chi-square values were then calculated for all populations to determine goodness of fit.

Results and discussion

Asexual populations differed from normal seeded populations in their below-ground morphology in that numerous underground stems grew radially several metres from the parent plant just under the soil surface. Adventitious shoot buds developed along the stems giving rise to numerous rooted shoots. Cases were noted where the interconnected stems were severed, leaving separate plants. Most plants were asexually propagated with a few seeded plants. Seeded plants consisted of a single tap root and small lateral feeder roots occupying the upper 20 cm near the soil surface under the canopy.

A female biased ratio of 0·54 females to 0·46 males was calculated in the nine seeded populations. The calculated pooled $\chi^2 = 0{\cdot}16$, $p > 0{\cdot}75$ and the homogeneity $\chi^2 = 8{\cdot}60$, $p > 0{\cdot}95$, excluding the asexual populations indicated that the female to male ratios were homogenous in the seeded populations (Table 1). Sex expression ratios deviated in asexual populations, with all of them being strongly male-biased. This would be expected if cloned male genotypes dominated in the asexual populations. If sex expression is genetically controlled, its expression would be expected to be different in seeded populations than in asexual or cloned populations. Their relative proximity suggests that the asexual characteristic is genetically

Table 1. *Native populations of seeded and asexual fourwing saltbush,* Atriplex canescens, *illustrating the numbers of seeded and asexual plants and ratios of female to male plants*

Location	Number of plants		Female:Male[a]	χ^2	p
	Sexual	Asexual			
U.S. Highway 180, mile post marker 45, Catron County	0	66	48:125	48·60	<0·01**
U.S. Highway 180, mile post marker 43, Catron County	0	57	22:50	15·93	<0·01**
El Paso, TX, El Paso County	50	0	129:106	0·08	>0·075
Jornada Road, Dona Ana County	50	0	135:115	0·00	>0·99
Jornada Exclosure, Dona Ana County	50	0	131:113	0·01	>0·90
Jornada Headquarters, Dona Ana County	50	0	106:94	0·08	>0·75
Jornada Taylor Well, Dona Ana County	50	0	130:96	1·13	>0·25
Three River, Otero County	46	4	103:87	0·003	>0·95
Corona, Lincoln County	7	43	35:105	47·40	<0·01**
Ancho, Lincoln County	2	69	70:123	24·43	<0·01**
Cimarron, Colfax County	50	0	79:87	2·79	>0·05
Quemado, Catron County	46	4	95:80	0·01	>0·90
Springerville, AZ, Apache County	50	0	67:37	4·55	>0·025

Total $\chi^2 = 153{\cdot}25$; pooled $\chi^2 = 6{\cdot}27$, $p = < 0{\cdot}01$; homogeneity $\chi^2 = 146{\cdot}99$, $p = < 0{\cdot}01$.

[a]χ^2 calculated using proposed ratio of 0·54 females: 0·46 males., calculated mean frequency of the nine naturally seeded populations.

**The probability of a larger χ^2 is <0·01.

controlled. The asexual populations near Alma were aggressive in a relatively dry blue grama, pinyon-juniper habitat. Those near Corona were also aggressive and competitive in a more moist blue grama, pinyon-juniper habitat. Both were thriving under what was observed to be moderate to heavy utilization of forage species by domestic livestock. Four plants each in seeded populations at Three Rivers and at Quemado (Table 1) also originated from roots of nearby plants rather than from seed. However, most plants were seeded at these two sites. Since this study was completed, several other asexual populations have been observed. It is likely that root-sprouting is a more common trait in fourwing saltbush than previously assumed.

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