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Long-term Survival of 20 Selected Plant Accessions in a Rush Valley, Utah, Planting

Rosemary L. Pendleton
Neil C. Frischknecht
E. Durant McArthur

Abstract—Fifty-two plants each of 20 plant accessions were transplanted onto a salt-desert shrub site in Rush Valley, UT. Nine of the 20 kinds of plants; five accessions (four species) of *Atriplex*, two varieties of *Kochia prostrata*, *Sarcobatus vermiculatus*, and one species of *Yucca*, showed generally good survival (>60 percent) through the first 6 years following planting. Only *K. prostrata* and *S. vermiculatus* showed good survival for the full 12-year period. Large grasshopper populations, a high water table, and other factors likely contributed to shrub mortality during the 1984-89 period. By 1989, seedlings of both varieties of *K. prostrata* had spread throughout the enclosure, up to 5 meters from the original planting area. No plants were observed beyond the disked fire line surrounding the enclosure.

Keywords: *Kochia prostrata*, revegetation, ecological adaptation, salt desert

Salt desert shrub communities occupy 15-17 million ha in the Intermountain West (Branson and others 1967, West 1983). In recent years, an increase in wildfire frequency and subsequent conversion to fire-climax annuals, coupled with historic abuse and increased human disturbance have made revegetation efforts on salt desert shrub sites increasingly important (McArthur and others 1979; Whisenant 1990). In the 1970's, a series of outplantings were established as part of a mine-land reclamation research project for arid and semiarid lands (Frischknecht and Ferguson 1979). One such planting, made in Rush Valley, UT, was designed to determine adaptability of transplanted shrub species to a site where the mean annual precipitation is less than 25 cm and to compare growth

and survival of the transplants at different shrub densities. This note documents the performance of the shrub transplants over a 12-year period.

METHODS

The study plots were located in the northeastern corner of an existing livestock-proof enclosure in Rush Valley, about 80 km west of Provo, UT. Native vegetation at the site consists of a mosaic of *Ceratoides lanata* and *Atriplex falcata*. The ecological site is identified as Desert Silt Flat by the Soil Conservation Service. Soils consist of a slightly saline surface layer underlain by fine sandy loam or silt loam soils of the Tooele fine sandy loam series. On-site precipitation measured by a standard precipitation gauge averaged 23.4 cm for the 10-year period 1960-69 (table 1).

In the late fall of 1976, an area 33 by 15 m was cleared of vegetation to make room for 80 plots, each 1.5 by 3.0 m. Seed of 20 selected accessions representing 17 species (table 2) were grown in containers in the greenhouse during the winter of 1976-77 and transplanted to the field in early May 1977. Taxonomic treatment of the plants mainly follows Welsh and others (1987) except the treatment for *Atriplex* is supplemented by Hanson (1962) and Stutz and others (1979); the treatment for *Ceratoides* follows Grubov (1976); that for *Camphorosma* follows Shishkin (1936); and that for *Kochia* follows Balyan (1972). The study was established in a randomized block, split-plot design. Species were assigned to plots at random (fig. 1). In two of the four blocks, plants were spaced 76 cm apart in each direction, making a total of eight plants per plot. In the other two blocks, plants were spaced 51 cm apart in each direction, making a total of 18 plants per plot. Plants were given a small amount of water at planting.

Rosemary L. Pendleton is ecologist; Neil C. Frischknecht was supervisory range scientist and team leader (now deceased); E. Durant McArthur is chief research geneticist and project leader, all at the Intermountain Research Station, located at the Shrub Sciences Laboratory, Provo, UT.

Table 1—Precipitation data (inches) for the Rush Valley exclosures 1960-69. A correlation estimate of U.S. Weather Bureau data was used for Rush Valley for 1960. Thereafter data were taken from a standard precipitation gauge located at the study site

Year	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Total
1960	2.91	1.14	1.14	2.28	7.47
1961	1.46	.87	3.82	3.07	9.22
1962	2.13	3.23	1.14	.38	6.89
1963	2.17	3.35	1.73	2.13	9.38
1964	1.85	4.57	.59	2.72	9.73
1965	1.26	3.35	5.12	1.50	11.23
1966	1.38	1.02	1.93	2.01	6.34
1967	1.77	5.79	1.65	.63	9.84
1968	2.72	2.87	3.46	2.40	11.45
1969	2.24	2.91	3.19	2.48	10.82
Mean	1.99	2.91	2.38	1.96	9.24

Table 2—Species list and seed sources for the Rush Valley planting

Code	Species	Source
ARNO	<i>Artemisia nova</i> A. Nels.	unknown
ARPY	<i>Artemisia pygmaea</i> Gray	Uinta Basin, UT
ARTR	<i>Artemisia tridentata</i> Nutt.	Uinta Basin, UT
ATBO	<i>Atriplex bonnevillensis</i> C. A. Hanson	Millard Co., UT
ATCA	<i>Atriplex canescens</i> (Pursh) Nutt.	unknown
ATOB ¹	<i>Atriplex obovata</i> Moq.	San Juan Co., UT
ATTR1	<i>Atriplex tridentata</i> (Kuntze) H. & C.	Tooele Co., UT
ATTR2 ¹	<i>Atriplex tridentata</i> (Kuntze) H. & C.	Uinta Basin, UT
CAMO	<i>Camphorosma monspeliensis</i> L. ²	USSR
CELA	<i>Ceratoides lanata</i> (Pursh) Howell	Uinta Basin, UT
CEPA	<i>Ceratoides papposa</i> (Pers.) Butsch. & Ikonn. ³	USSR
CHNA	<i>Chrysothamnus nauseosus</i> (Pallas) Britt.	unknown
EPNE	<i>Ephedra nevadensis</i> Wats.	Millard Co., UT
GRSP	<i>Grayia spinosa</i> (Hook.) Moq.	Uinta Basin, UT
KOPRGR	<i>Kochia prostrata</i> ssp. <i>grisea</i> Prat. ²	USSR
KOPRVI	<i>Kochia prostrata</i> L. ssp. <i>virescens</i> (Frenzl) Prat. ²	USSR
SAVE	<i>Sarcobatus vermiculatus</i> (Hook.) Torr.	unknown
SPCO	<i>Sphaeralcea coccinea</i> (Nutt.) Rydb.	unknown
SPSA	<i>Sphaerophysa salsula</i> (Palas) DC. ³	unknown
YUSP	<i>Yucca</i> spp.	Washington Co., UT

¹Planted August 1977.

²Nonnative.

³Nonnative but adventive.

Data on survival and growth were obtained at the end of the first growing season and yearly thereafter, up to and including 1983, for a total of 7 years. The plots were revisited in 1989 and 1990, and height and crown diameter measurements of the surviving plants were recorded. Cover data (Daubenmire 1959), using 1-m² quadrats, were taken on volunteer kochia plants and invading

annuals for two randomly chosen plots in each vertical row (fig. 1), making a total of 20 quadrats. Precipitation data for the years 1981-89 were obtained from rain gauges located a few miles north of the study exclosure at the Tooele Army Depot, South Area. Survival data were analyzed by ANOVA using SAS for the personal computer (SAS Institute Inc. 1988).

SAVE	ATBO	ATTR1	CHNA	SPCO	ARNO	SPSA	CHNA	ATTR1	SPCO
ARNO	ATCA	EPNE	YUSP	GRSP	KOPRGR	GRSP	CELA	CAMO	ARTR
KOPRGR	CELA	ARPY	CEPA	CAMO	ATCA	ATTR2	EPNE	YUSP	ATBO
SPSA	KOPRVI	ARTR	ATTR2	ATOB	SAVE	ARPY	KOPRVI	CEPA	ATOB
ARTR	ATOB	SAVE	ARNO	ATCA	SPCO	ARTR	GRSP	CELA	ARNO
CAMO	KOPRVI	SPCO	CELA	ATTR2	CHNA	ATTR1	SPSA	KOPRGR	CAMO
ATBO	EPNE	GRSP	ATTR1	KOPRGR	CEPA	SAVE	EPNE	ATCA	ATTR2
YUSP	SPSA	CHNA	ARPY	CEPA	ATBO	KOPRVI	YUSP	ARPY	ATOB

Plant spacing columns 1-5

Plant spacing columns 6-10

Figure 1—Plot map of the Rush Valley planting. Plants on the west half are spaced 20 inches apart; those on the east half are 30 inches apart.

RESULTS AND DISCUSSION

Significant differences in survival were observed among accessions ($p = 0.0001$). Planting density had no effect on survival ($p > 0.50$). Heaviest early mortality was observed in *Artemisia pygmaea*, *Chrysothamnus nauseosus*, and *Sphaerophysa salsula* (table 3). Other species showing heavy mortality were *Sphaeralcea coccinea*, *Ephedra nevadensis*, *Grayia spinosa*, *Artemisia tridentata*, and *A. nova*. Nine of the 20 kinds of plants showed generally good survival (>60 percent) on this site through the first 6 years following planting, including both varieties of *Kochia prostrata* (92-96 percent), *Sarcobatus vermiculatus* (90 percent), *Atriplex bonnevillensis* (79 percent), *A. canescens* (63 percent), two accessions of *A. tridentata* (62-88 percent), and *A. obovata* (77 percent). Eight of the nine adaptive accessions were chenopods.

Between 1983 and 1989, substantial mortality occurred in all species (table 3). The years 1983-85 correspond to a period of heavy shrub mortality throughout the Great Basin region (Nelson and others 1989; Wallace and Nelson 1990). Many of the native *Atriplex* stands in Rush Valley experienced high levels of die-off (Dobrowolski and Ewing 1990). Unlike previous events, this die-off was coincident

with record high precipitation (Wallace and Nelson 1990) (fig. 2). The symptoms, which include high rootlet mortality and wilt symptoms of aboveground parts, were linked to a raised water table and subsequent buildup of pathogenic fungi (D. L. Nelson and others 1990; Wallace and Nelson 1990; Weber and others 1990).

Insect predation may also have contributed to plant stress during this period (Nelson and others 1989; Haws and others 1990; C. R. Nelson and others 1990). A large-scale grasshopper epidemic occurred in parts of Utah during 1984 and 1985 (Hills and Davidson 1984; Nelson and others 1989). We observed a high density of these insects on our plots during both years. Numbers of *Atriplex* plants in this study and in adjacent plots were completely stripped of leaves for 2 years in a row.

Precipitation in the years from 1987 to 1990 was well below normal (fig. 2). The extended drought, grasshopper plague, and years of anaerobic and saline soil conditions coupled with increased levels of pathogenic fungi combined to create a rigorous test of survivability of the transplanted species. Plants managing to survive and reproduce during this period should be capable of long-term persistence on the site.

Table 3—Numbers of surviving plants by year and plant accession

Accession	1977	1978	1979	1980	1981	1982	1983	1989
ARNO	52	50	43	34	14	7	7	0
ARPY	30	30	13	4	0	0	0	0
ARTR	49	49	47	34	7	1	0	0
ATBO	52	51	51	51	51	48	41	0
ATCA	52	52	52	51	49	41	33	0
ATOB	52	51	51	47	46	44	40	14
ATTR1	52	51	51	51	49	47	46	6
ATTR2	52	51	50	45	39	36	32	6
CAMO	52	52	51	50	39	24	24	9
CELA	52	52	51	50	38	28	28	1
CEPA	52	51	50	46	45	23	15	0
CHNA	51	49	15	0	0	0	0	0
EPNE	47	43	34	26	16	9	5	0
GRSP	52	52	51	35	26	19	19	0
KOPRGR	52	52	52	52	52	51	50	31
KOPRVI	52	52	52	52	52	50	48	33
SAVE	52	52	52	51	51	49	47	39
SPCO	51	49	34	14	7	0	0	0
SPSA	52	45	0	0	0	0	0	0
YUSP	52	51	51	51	46	46	45	0

Figure 2—Precipitation data for years 1981-89 taken from a weather station located at the Tooele Army Depot, South Area. A horizontal line denotes the precipitation mean.

A limited number of *Atriplex* plants survived through 1989: 12 percent of both *A. tridentata* accessions and 27 percent of *A. obovata*. Seventeen percent of *Camphorosma* plants and one *Ceratoides lanata* plant also survived. The *Camphorosma* plants produced seed in the first growing season, and young seedlings were observed nearby in subsequent years. However, the plants looked very poor in 1989 and 1990 and may succumb to drought. Only *Sarcobatus* and the two varieties of *Kochia* showed greater than 50 percent survival through the 12-year period.

Sarcobatus performed extremely well on this site, growing to a mean height of 73 cm and a crown diameter of over 82 cm (table 4). No reproduction of this species was observed. In contrast, both forms of *Kochia prostrata* not only survived, but spread throughout the enclosure and up to 5 m from the transplant plots. The density of volunteer *Kochia* plants made identification of the original transplants somewhat difficult. As many as 20 to 24 plants of *Kochia* were observed in a 15- by 30-m plot in 1989. In 1990, the gray form, ssp. *grisea*, was present on 18 of 20 sampled 1-m² plots with a mean cover estimate of 18.9 percent. The red-stemmed, green-leafed form, ssp. *virescens*, was present on 16 of 20 sampled plots with a mean cover of 33.7 percent.

Although present in great numbers in other parts of the enclosure and on surrounding disturbed land, cheatgrass (*Bromus tectorum*) and other introduced annuals tended to be absent in *Kochia*-dominated areas. The mean cover estimate on our plots was less than 1.1 percent for *Bromus* and less than 0.1 percent for *Salsola iberica*. A few isolated plants of *Ceratoides lanata*, *Lactuca serriola*, and *Halogeton glomeratus* were also found within the enclosure, though not in immediate proximity to *Kochia*.

McArthur and others (1990) document the invasion of *Kochia* into dense stands of cheatgrass on

an abandoned farm near Price, UT. Monsen and Turnipseed (1990) have successfully established stands of *Kochia* on sites dominated by annual weeds, with minimal site preparation. It has established and spread in the presence of several disturbance-adapted species on roadside plantings in Utah's Sanpete and Sevier Counties (McArthur and others 1990), and shows great promise in the control of cheatgrass wildfires through "green-stripping" (Pellant 1990).

Originally introduced to restore depleted and disturbed rangeland, *Kochia prostrata* is drought tolerant (Balyan 1972; Moghaddam 1978) and relatively salt tolerant (Francois 1976). *Kochia* is reportedly used as feed for a variety of livestock in its native south-central Eurasia (Balyan 1972; Keller and Bleak 1974; Moghaddam 1978). Protein levels of new spring growth range from 12.1 percent to 21.8 percent, and at least some accessions are highly palatable to mule deer (Davis and Welch 1985). Recently, concern has been voiced about introducing another exotic onto already depleted rangelands. However, the ability of *Kochia* to establish and spread on disturbed or degraded sites suggests this species will persist as part of our western flora for years to come. There have been no reports to date of consequential spread into healthy native plant communities. In our study, no plants were observed outside of the disked strip surrounding the enclosure.

In summary, biotic factors such as insect predation and extreme weather conditions, both wet and dry, created a severe test of adaptability of the transplanted species. Some *Atriplex*, *Camphorosma*, and *Sarcobatus* plants survived, but long-term persistence of these species is doubtful because of poor reproduction. In contrast, *Kochia prostrata* showed a capacity for long-term survival, spreading throughout open and disturbed areas of the enclosure. Although capable of invading disturbed areas dominated by exotic annuals, there is no evidence as yet that *Kochia* will spread aggressively into healthy, native plant stands.

Table 4—Mean height and crown diameter measures for plants surviving to 1990

Accession	n	Mean vegetative height	Mean crown diameter
----- cm -----			
ATTR1	6	29.8	52.2
ATTR2	6	28.2	39.8
ATOB	14	17.3	33.3
CAMO	7	12.4	20.4
KOPRGR	31	21.2	31.6
KOPRVI	33	22.1	40.2
SAVE	39	73.1	82.3

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