ChenopodiaceaeCGoosefoot family

Kochia Roth

kochia

Stanley G. Kitchen and Stephen B. Monsen

Mr. Kitchen and Mr. Monsen are botanists at the USDA Forest Service=s Rocky Mountain Research Station, Shrub Sciences Laboratory, Provo, Utah.

Growth habit, occurrence, and use. Two woody-based non-rhizomatous sub-shrub species of kochias are found in the western United States. The widely distributed native, gray molly, and its introduced and closely related counterpart (Blackwell and others 1978), forage kochia, are found in salt-desert, sagebrush, pinyonBjuniper, and dry mountain brush communities (table 1). Erect to steeply ascending annual stems growing from a woody base and long-lived prostrate branches attain heights of 5 to 50 cm for gray molly (Welch and others 1987) and 10 to 100 cm for forage kochia (Baylan 1972).

Each species provides nutritious winter forage for livestock (Baylan 1972; Blauer and others 1976). Variability in preference by livestock (Shishkin 1936) and mule deer (*Odocoileus hemionis*) (Davis and Welch 1985) has been observed among ecotypes of forage kochia.

Both species have potential for use in revegetation of saline and alkaline soils on arid and semi-arid sites (Blauer and others 1976; Clarke and West 1969; Francois 1976; Romo and Haferkamp 1987) and forage kochia has been used successfully in stabilizing mine spoils (Frischknecht and Ferguson 1984). Perhaps the greatest potential use of forage kochia is in providing cover and forage on degraded western cold-deserts (McArthur and others 1974; Monsen and Turnipseed 1990; Pendleton and others 1992). Where established, it effectively competes with weeds such as halogeton (*Halogeton glomeratus* (Bieb.) C. A. Mey.) and cheatgrass (*Bromus tectorum* L.) (Blauer and others 1993; McArthur and others 1990). Natural spread of forage kochia from seed can be rapid where perennial cover is lacking. The high water content of stems and leaves during summer months and crown sprouting capacity make this species especially desirable for desert landscapes prone to high fire frequencies (Kitchen and Monsen 1999).

Geographic races and hybrids. Blackwell and others (1978) concluded that the random variation in pubescence in gray molly did not justify dissection of this species to subspecies level. Conversely, forage kochia is a complex species represented by 3 known ploidy levels (2X, 4X, and 6X) (Pope and McArthur 1977) and extensive phenotypic variation in plant stature, stem color and diameter, leaf size and pubescence, growing season, and adaptability to soils (Baylan 1972). Numerous regional ecotypes have been grouped into as many as 4 species; however, a single species with 2 subspeciesC*virescens* (Frenzl) Prat. (green-stem) and *grisea* Prat. (gray-stem and highly variable)Cis the most commonly accepted (Baylan 1972).

About 40 accessions of forage kochia have been introduced to the United States, primarily for evaluation as candidates for revegetation of disturbed arid and semi-arid regions in the western United States (Kitchen and Monsen 1999). To date, a single cultivar, ›Immigrant= (2X, ssp. *virescens*), has resulted from this research (Stevens and others 1995). ›Immigrant= has been planted on several thousand acres in Utah, Idaho, and surrounding states. Small plantings of other accessions (ssp. *grisea*) also exist (Blauer and others 1993; McArthur and others 1990; Monsen and Kitchen 1995;

Monsen and Turnipseed 1990).

Flowering and fruiting. Kochia flowering structures are described as one to several, mostly perfect, inconspicuous, sessile flowers occuring in axils of foliose bracts (Welsh and others 1987). Stems are potentially floriferous throughout (Blackwell and others 1978). Flowering is indeterminate from May to August for gray molly and from July to September for forage kochia (Shishkin 1936). The fruit is a 1-seeded utricle that is enclosed in a thin, fragile perianth (figure 1). The perianth is horizontally winged at maturity. Perianth pubescence for forage kochia is highly variable (Baylan 1972). Seeds are oval to orbicular in shape and 1 to 2 mm in diameter. The embryo is bent into roughly the shape of a horseshoe, a common configuration for this family (figure 2).

Fruit collection and cleaning. Fruits of forage kochia ripen from September to November (Baylan 1972) whereas those of gray molly are generally ripe by mid-October. Fruits are easily dislodged when fully ripened and dry. They are hand-harvested by stripping individual stems or by beating seeds into a hand-held hopper with a badminton racket or similar device. Mechanical harvest techniques for forage kochia seeds include mowing stems just before fruits are ready to shatter, drying, and combining. Vehicle-mounted mechanical sweepers are also used to harvest fully ripened fruits from solid stands (Stevenson 1995). Although harvesting the fruits before the seeds are fully ripened can reduce losses to shattering, it also results in lower seed viability percentages (Waller and others 1983).

The cleaning process removes empty fruits and fragments of fruits, leaves, and small stems using a barley debearder and multi-screened fanning mill (air-screen cleaner). Attainable purities for ›Immigrant‹ forage kochia depend upon harvest method and experience (Stevenson 1995). Hand-picked lots can usually be cleaned to at least 90% purity. Purities for lots harvested with mechanical harvesters are slightly lower (80 to 85%), whereas the combine method seldom produces purities greater than 70%. High-purity lots contain from 500,000 to 1,000,000 seeds/kg (225,000 to 450,000/lb) (Kitchen and Monsen 1999).

Storage. Kochia seeds are orthodox in storage behavior, but they are short-lived when storage temperatures are above 5 °C and seed moisture content is not controlled (Jorgensen and Davis 1984). Significant losses in forage kochia seed viability have been reported as early as 2 months after harvest (Baylan 1972); however, losses usually do not occur during the first 6 months of storage. Young and others (1981) reported viabilities of 18 to 34% for lots representing 13 accessions after 4 years of warehouse storage. Seed moisture contents above 7 to 8% and warm storage temperatures accelerate seed mortality. Baylan (1972) attributed this to loss of limited seed reserves through accelerated respiration rates. Storage life can be extended by drying seeds to between 4 and 8% water content and storing them in sealed containers at cool (< 5 °C) temperatures (Kitchen and Monsen 1999).

Seed germination and testing. Initial dormancy (0 to 75%) and rate of after-ripening of forage kochia seeds varies among ecotypes and years of harvest (Kitchen and Monsen 1999). After-ripening requires from 0 to 12 months at room temperature and longer in cold storage (Baylan 1972; Kitchen and Monsen 1999). Germination of recently harvested seeds is enhanced by fluorescent light and moist chilling. Germination of after-ripened or chilled seeds occurs across a wide range of temperatures and osmotic potentials (Young and others 1981; Romo and Haferkamp 1987). Germination rate at near freezing temperatures (2 °C) for recently harvested seeds is asynchronous within accessions and highly variable among ecotypes. Mean germination time shortens as seeds after-ripen (table 2). Field studies have demonstrated that when after-ripened seeds (with a rapid, synchronized germination rate) are sown in late fall/early winter, premature germination results in poor stand establishment (Kitchen and Monsen 1999). Haferkamp and others (1990) attributed poor

establishment from 1-year-old forage kochia seeds to loss of seed viability and/or vigor. Their data show that in germination tests of laboratory-stored seeds, germination rate had greatly increased for 1-year-old seed when compared to the same lots tested fresh. This suggests that the poor establishment that they observed for 1-year-old seeds may have been related, at least in part, to change in germination rate, as has been observed by Kitchen and Monsen (1999; Stewart and others 1999). Kitchen and Monsen (1995) also observed that seeds stored for more than 2 years at refrigerated and frozen temperatures retain full viability and are able to delay germination sufficiently for successful stand establishment.

Germinating gray molly seeds tolerate higher salinity levels than do seeds of many halophytic forage plants (Clarke and West 1969). In limited germination trials conducted on a single lot of fresh gray molly seeds, the level of initial dormancy was 26% and the cold temperature germination rate was comparable to that of fresh lots of forage kochia seeds (Monsen and Kitchen 1999).

Seed viability can be difficult to determine from tetrazolium chloride (TZ) staining due to interference of embryonic chlorophyll. Independent laboratory tests for the same seed lot often produce variable results. Laboratory germination tests are also sometimes inconsistent due to difficulty with seedling normality classification. Dormant healthy seeds germinate normally and rapidly after the seed coat is pierced.

Nursery and field practice. Forage kochia transplants are easily grown as bareroot and container stock from non-dormant seeds. For best results, seeds should be sown in growth medium 4 to 6 mm (c to 3 in) deep. Germinants are susceptible to fungal root pathogens, dictating clean greenhouse culture techniques. Transplant survival from early spring planting is commonly 90% or higher using standard practices (Monsen and Kitchen 1995).

Seeding should be conducted in the fall or early winter for best establishment from direct seeding on non-irrigated untreated sites (Haferkamp and others 1990). Proper seeding rate varies from 0.5 to 4.5 kg/ha (0.5 to 4.0 lb/acre) (pure live seeds) depending on species mix, site conditions, and seeding method. Successful spring plantings have been reported using after-ripened seeds (Monsen and Turnipseed 1990). Irrigated fields can be sown during summer months. Seed placement at or near the soil surface is critical for successful establishment (Baylan 1972; Stevens and Van Epps 1984). Satisfactory stands have been achieved from broadcasting seeds on the soil surface or on snow with little or no seed-bed preparation (Kitchen and Monsen 1999).

Literature Cited

Baylan GA. 1972. Prostrate summer cypress and its culture in Kirghizia. Isdatel=stvo, Frunze, Kirghizistan [translated from Russian, 1979, USDA and National Science Foundation, Washington, DC].

Blackwell WH, Baechle MD, Williamson G. 1978. Synopsis of *Kochia* (Chenopodiaceae) in North America. SIDA 7: 248B254.

Blauer AC, McArthur ED, Stevens R, Nelson, SD. 1993. Evaluation of roadside stabilization and beautification plantings in south-central Utah. Res. Pap. INT-462. Ogden, UT: USDA Forest Service, Intermountain Research Station. 65 p.

Blauer AC, Plummer AP, McArthur ED, Stevens R, Giunta BC. 1976. Characteristics and hybridization of important Intermountain shrubs: 2. Chenopod family. Res. Pap. INT-177. Ogden, UT: USDA Forest Service, Intermountain Research Station. 42 p.

Clarke LD, West NE. 1969. Germination of *Kochia americana* in relation to salinity. Journal of Range Management 22: 286B287.

Davis JN, Welch BL. 1985. Winter preference, nutritive value and other range use characteristics of *Kochia prostrata* (L.) Schrad. Great Basin Naturalist 45: 778B783.

Francois, LE. 1976. Salt tolerance of prostrate summer cypress (*Kochia prostrata*). Agronomy Journal 68: 455B456.

Frischknecht NC, Ferguson RB. 1984. Performance of Chenopodiaceae species on processed oil shale. In: Tiedemann AR, McArthur ED, Stutz HC, Stevens R, Johnson KL, comp. Proceedings, Symposium on the Biology of *Atriplex* and Related Chenopods; 1983 May 2B6; Provo, UT. Gen Tech. Rep. INT-172. Ogden, UT: USDA Forest Service, Intermountain Research Station: 293B297.

Haferkamp MR, Ganskopp DC, Marietta KL, Knapp BW. 1990. Environmental influences on germination of utricles and seedling establishment of ›Immigrant= forage kochia. Journal of Range Management 43: 518B522.

Jorgensen KR, Davis JN. 1984. A technique for retaining seed viability in *Kochia prostrata*. In: Tiedemann AR, McArthur ED, Stutz HC, Stevens R, Johnson KL, comps. Proceedings, Symposium on the Biology of *Atriplex* and Related Chenopods; 1983 May 2B6; Provo, UT. Gen Tech. Rep. INT-172. Ogden, UT: USDA Forest Service, Intermountain Research Station: 166B167.

Kitchen SG, Monsen SB. 1999. Unpublished data. Provo, UT: USDA Forest Service, Rocky Mountain Research Station.

McArthur ED, Blauer AC, Stevens R. 1990. Forage kochia competition with cheatgrass in central Utah. In: McArthur ED, Romney EM, Smith SD, Tueller PT, comps. Proceedings, Symposium on Cheatgrass Invasion, Shrub Dieoff, and Other Aspects of Shrub Biology and Management; 1989 April 5B7; Las Vegas, NV. Gen. Tech. Rep. INT-276. Ogden, UT: USDA Forest Service, Intermountain Research Station: 56B65.

McArthur ED, Guinta BC, Plummer AP. 1974. Shrubs for restoration of depleted ranges and disturbed areas. Utah Science 34: 28B33.

Monsen SB, Turnipseed D. 1990. Seeding forage kochia into cheatgrass infested ranges. In: McArthur ED, Romney EM, Smith SD, Tueller PT, comps. Proceedings, Symposium on Cheatgrass Invasion, Shrub Dieoff, and Other Aspects of Shrub Biology and Management; 1989 April 5B7. Las Vegas, NV. Gen. Tech. Rep. INT-276. Ogden, UT: USDA Forest Service, Intermountain Research Station: 66B71.

Pendleton RL, Frischknecht NC, McArthur ED. 1992. Long-term survival of 20 selected plant accessions in a Rush Valley, Utah, planting. Res. Note INT-403. Ogden, UT: USDA Forest Service, Intermountain Research Station: 7 p.

Pope CL, McArthur ED. 1977. IOBP chromosome number reports: 55. Chenopodiaceae. Taxon 26: 109.

Romo JT, Haferkamp MR. 1987. Forage kochia germination response to temperature, water stress, and specific ions. Agronomy Journal 79: 27B30.

Shishkin BK, ed. 1936. Flora of the U.S.S.R. Volume 6, Centrospermae. Moscow: Isdatel=stvo Akademii Nauk SSSR [translated from Russian, 1970, Smithsonian Institution and National Science Foundation, Washington, DC]. 731 p.

Stevens R, Van Epps GA. 1984. Seeding techniques to improve establishment of forage kochia [*Kochia prostrata* (L.) Schrad.] and fourwing saltbush [*Atriplex canescens* (Pursh) Nutt.]. In: Tiedemann AR, McArthur ED, Stutz HC, Stevens R, Johnson KL. comps. Proceedings, Symposium on the Biology of *Atriplex* and Related Chenopods; 1983 May 2B6; Provo, UT. Gen. Tech. Rep. INT-172. Ogden, UT: USDA Forest Service, Intermountain Research

Station: 269B272.
Stevens R, Jorgensen KR, McArthur ED, Davis JN. 1985. ›Immigrant= forage kochia. Rangelands 7: 22B23.
Stevenson R. 1995. Personal communication. Ephraim, UT: Stevenson Intermountain Seed.
Stewart A, Anderson VJ, Kitchen SG, 1999. ›Immigrant= forage kochia (*Kochia prostrata*) seed germination as affected by storage conditions. In: McArthur ED, Ostler WK, Wambolt CL, comps. Proceedings, Shrubland Ecotones; 1998 August 12B14; Ephraim, UT. Proc. RMRS-P11. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 274B279.
Waller SS, Britton CM, Schmidt DK, Stubbendieck J, Sneva FA. 1983. Germination characteristics of two varieties of *Kochia prostrata* (L.) Schrad. Journal Range Management 36: 242B245.
Welsh SL, Atwood ND, Higgins LC, Goodrich S. 1987. A Utah flora. Great Basin Naturalist Memoirs 9: 1B894.
Young JA, Evans RA, Stevens R, Everett RL. 1981. Germination of *Kochia prostrata* seed. Agronomy Journal 73: 957B961.

Figure 1C*Kochia prostrata*, forage kochia: fruit in perianth, × ??.

Figure 2C*Kochia prostrata*, forage kochia: longitudinal section through a utricle, × ??.

Table 1C *Kochia,* kochia: nomenclature and occurrence

Scientific name & synonym(s)	Common name	Occurrence
***K. americana* S. Wats.** *K. vestita* (S. Wats.) Rydb. *K. americana* var. *vestita* S. Wats.	**gray molly,** green molly	Oregon to Montana S to California, Arizona, & New Mexico
***K. prostrata* (L.) Schrad.** *K. suffruticulosa* Lessing *Salsola prostrata* L.	**forage kochia,** prostrate kochia, summer cypress, prostrate summer cypress	Deserts, steppes, & mtns of Central Asia, W to the Mediterranean Basin, & E to Manchuria; naturalized in W North America

Sources: Shishkin (1936), Welsh and others (1987).

Table 2C *Kochia prostrata,* forage kochia: mean germination times as affected by temperature of dry storage

Accession*	Mean germination times (days to 50% germination) Fresh	20 ° C	2 ° C	- 15 ° C
314929H	72 a	11 b	60 a	67 a
343101	51 a	12 b	46 a	55 a
356818	53 a	14 b	51 a	58 a
356826	108 a	11 c	86 b	90 b
358941	81 a	12 c	63 b	76 a
mean	71 a	12 b	61 a	69 a

Source: Kitchen and Monsen (1999).

Note: Within an accession, means followed by the same letter are not significantly different at the P <0.05 level. Five accessions of forage kochia were germinated at 2° C as affected by 24 months of dry storage at 20, 2, and - 5 ° C

* Accession numbers are plant introduction (PI) numbers assigned by the USDA Natural Resource Conservation Service=s Plant Materials Center in Pullman, Washington.

H ›Immigrant=.