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Germination in Black Greasewood (Sarcobatus vermiculatus (Hook.) Torr.)

Abstract

Greasewood (*Sarcobatus vermiculatus* (Hook.) Torr.) is an indigenous spiny shrub found on moist alkali-sodic soils in southeastern Montana. Flowering is primarily in August, seed matures in October, and seed shatter begins in November. Filled seed percentages ranged from 16 to 94. Highly viable dewinged seed numbered 425 per gm. When the membranous pericarp is ruptured, germination—a simple uncoiling of the embryo—may occur in less than an hour and root hairs may appear in less than 24 hours. Rapid imbibition occurs when the pericarp is fully intact; however, germination is slow and many achenes do not germinate even after 30 days of being fully imbibed. Germination peak was in two days, and germination was 98 percent complete in ten days. Optimum germination temperatures were 4°C and 10°C without stratification, and either 30°C or alternating temperatures when preceded by stratification.

Introduction

Black greasewood or greasewood is a spiny, erect shrub 1-2 m in height (Booth and Wright, 1966). The species is distributed throughout most of the western states on heavier soils which receive either surface or subsurface moisture from higher areas. Clements (1916) described greasewood communities as being stable due to excess salts, relying on water tables, and having soil surfaces that frequently dry out during summer. This water table may be up to 6 m deep (Rollins *et al.*, 1968).

Soils on which the species grow tend to be clay-loams, silt-loams, or deep fine sandy loams; these soils are most likely alkali-sodic in the upper stratum immediately under the plant crown, and either saline or alkali-sodic between plants and in the strata below a depth of 23-30 cm (Brown, 1965; Fireman and Hayward, 1952; Richard, 1965a, 1965b; and Richard and Cline, 1965). Greasewood concentrates exchangeable sodium in the surface horizon underneath the canopy (Richard and Cline, 1965), and this concentration is directly related to canopy size. Soils supporting greasewood can have exchangeable sodium as high as 12.0 meq/100 gms (Brown, 1965) and pH as high as 9.83 (Fireman and Hayward, 1952).

The forage value of the plant varies by area and animal species. It is reported as good browse for deer and antelope, and it is occasionally browsed by cattle (Morris *et al.*, 1962); it is considered poisonous to sheep under conditions of high, rapid intake because of its oxalate production (MacLean and Davidson, 1970).

Greasewood concentrates sodium in the upper soil horizons, appears to be a stable dominant under moist-sodic conditions, and occurs widely in the Fort Union Basin of southeastern Montana. It is important to understand its ecological significance within the plant community and its response to reclamation and rehabilitation practices of large expanses of disturbed lands resulting from coal strip mines. This paper examines some of the aspects of plant establishment (particularly germination) that should aid in determining the plant's ecological requirements and response within the natural community, as well as its response to perturbations within that community. Germination studies have not previously been reported.

Methods and Materials

Seeds from greasewood were collected in 1975 and 1976 near Epsie, Montana, on an upland bench in the mixed-prairie, and in 1975 from the Tongue River bottoms south of Birney, Montana. Collection was by hand stripping in late October and November of 1975 and late September of 1976. Seeds were dried under cool conditions, the wings removed from the dried seed by a mechanical flail, hand screened, and stored in the laboratory in paper envelopes at 21°C and 20 percent relative humidity.

Seed fill determinations were made from ten samples of ten seeds each, and from analysis of ungerminated seeds in the germination trials. Five random samples of 100 seeds each were weighed to obtain seed number per unit weight and two samples of 13 cm^3 each were used to estimate weight-volume relationships.

Seeds were dusted with captan, placed directly on moist pure cellulose pads in covered petri dishes, and germinated under controlled temperature and light conditions. Four replications of 25 seeds each were examined under each treatment. Germination counts were made daily for 30 days. Seeds were considered germinated when the radicle protruded 5 mm or more. The stratification treatment, when applied, consisted of placing the seeds on moist cellulose pads within a 4°C dark cabinet for 30, 60, and 90 days.

Germination was conducted at 10, 20, and 30°C constant temperature, and at 20-5°C and 30-20°C day-night alternating temperatures. Light exposure treatments were dark, 8 hours light, and 14 hours light.

Observations were made on seed and seedling morphology, and the effect of freezing on imbibed embryos.

Phenology observations in the general area of seed collection were made in 1975 to determine seed ripe and seed shatter dates.

Results

In southeastern Montana pistillate flowers were found from late July to late August in 1975. Seed set began in mid-August, mature seeds appeared in late September, and all seeds were mature by early November, at which time seed shatter began. A few seeds produced in 1974 were found intact in July of 1975, so seed shatter appears to be a slow process.

The greasewood fruit is a circular, winged, coriaceous utricle containing an achene composed of a transparent membrane (pericarp) which surrounds a helically coiled embryo (Figs. 1 and 2). No endosperm is present. The embryo coil contains the two cotyledons innermost, successively followed by the hypocotyl and the radicle. Both the cotyledons and hypocotyl are chlorophyllous at seed maturity.

In the germination studies the percentage of filled seed became very important, inasmuch as it varied from 16 to 94 percent (Table 1). Insect damage was particularly high—58 percent—in the 1976 collection from Epsie. Using a seed blower eliminated nearly all damaged, undeveloped, and empty seeds from the trials.

Weight of dewinged seed proved to be the best measure of seed quality. Dewinged seed from Epsie and Birney collections from which empty seed had been removed by

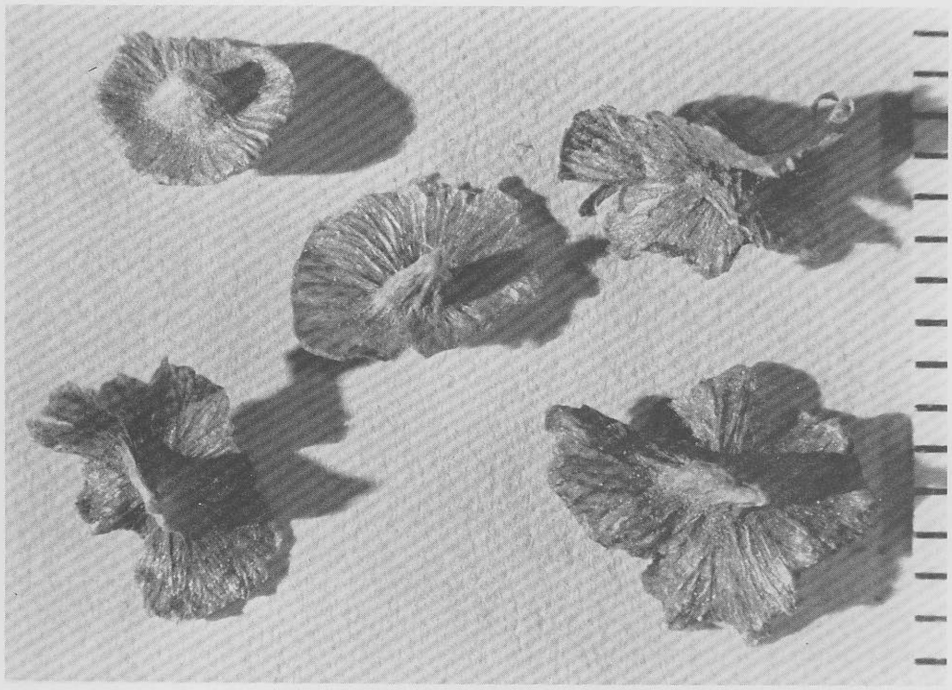

Figure 1. Winged utricle of greasewood (scale in mm).

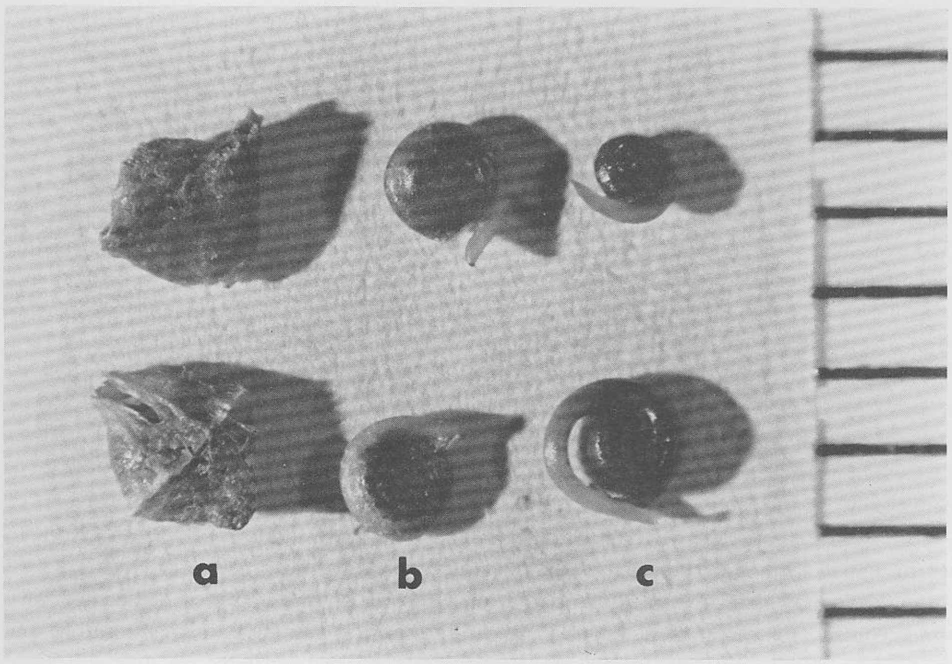

Figure 2. a) Dewinged greasewood utricle, b) pericarps intact, and c) the helically coiled embryo (scale in mm).

a seed blower yielded 425 and 435 seeds per gm, respectively (coefficient variation—CV = 2 percent and 1 percent, respectively). Random samples from dewinged seed of the Epsie-76 collection yielded 775 seeds per gm (CV = 5 percent). Filled dewinged seed from the Birney collection averaged 606 gm per liter, while dewinged seed from the total population in the Epsie-76 collection averaged 202 gm per liter.

TABLE 1. Characteristics of greasewood seed collected in 1975 at Epsie and Birney and in 1976 at Epsie (s=standard deviation).

Collection	Filled		Insect Damaged		Empty	
	%	s	%	s	%	s
Epsie-75	70	15.6	16	7.0	14	14.3
Birney-75	94	7.0	1	3.2	6	7.0
Epsie-76	16	9.7	58	14.8	26	13.5

The germination process is one of rapid imbibition by the pericarp and embryo; if the pericarp is ruptured or weak in any area, the imbibition is followed by an immediate uncoiling and extension of the radicle, hypocotyl, and finally the cotyledons (Fig 2). The radicles on many seeds from the Epsie-75 collection were protruding before they could be placed in the germinator and some seedlings were fully formed in an hour.

Root hairs appear early, on some seedlings within 24 hours. Radicle elongation precedes cotyledon elongation, and the cotyledons remain partially coiled up to an average radicle length of 25 mm. Radicle elongation depends on contact with substrate; in this study it averaged 10 mm/24 hr for the first five days at optimal temperatures.

The Birney-75 collection responded by rapid imbibition of the embryo and pericarp; nonetheless, the pericarp did not rupture, and although it maintained a positive pressure inside, the embryo did not emerge. This turgid, fully imbibed condition lasted the full 30 days on many seeds. Rupture of the membrane with a needle caused a rapid expansion of the embryo.

Germination energy was high for both the Birney-75 and the Epsie-75 and -76 collections. A majority (60 percent) of the trials reached a peak germination rate in two days. Sixty-seven percent (s=2.1) of all seed had completed germination at the end of two days. A ten-day cut-off point in germination counting is suitable since no seed germinated after this point in 41 percent of the trials, and the mean germination after 10 days for all trials was 1.8 percent (s=2.2) of the total final germination.

Optimum germination temperatures were cool (10°C) without stratification, and warm (20-30°C) with stratification (Table 2). A period of cool, moist stratification reduced germination percentage and rate when followed by temperatures below 20°C. Data show that stratification is neither required for high germination nor does it necessarily inhibit germination.

The only significant difference in light and dark germination was a reduction at warm (30°C) temperatures under dark conditions.

A period of after-ripening is apparently necessary for the embryo to mature. This time required for maturation ranges from a minimum of 30 days to a maximum of 60 days under dry conditions. Immediate germination of seed, without an after-ripening period, never exceeded 24 percent.

Germination response also changed with longer periods of after-ripening. Percent germination at low temperatures improved significantly (P=.90) as seed age increased. Following 90, 180, and 300 days of dry storage, germination at 4°C dark was 43, 57, and 93 percent, respectively.

TABLE 2. Germination percent of greasewood seed based on pure, live seed—Epsie-75 and -76 collections.

		Temperature (°C) Constant				Alternating	
	Light Hours	4	10	20	30	20-5	30-20
UNSTRATIFIED							
	Dark-0	**79**a*	**100**ab**	89ac	61ad	—	—
	8	—	**87**a	79a	86a	—	—
STRATIFIED							
30 day	14	—	63a	71bd	**96**ce	76bde	**94**cde
60 day	14	—	64a	89bd	**100**cde	**100**cde	**100**cde
90 day	14	—	60ab	79ab	84bc	96d	**100**e

*Optimum germination, numbers in bold face not significantly different (P=.90) from maximum.
**Row means not followed by the same letter are significantly different (P=.90), as determined by pair-wise sample t test.

Rate of germination reached a maximum following 60 days of storage. Two days were required to reach 50 percent of total germination with no differences existing in the 10-30°C range, or between light and dark treatments. As with total germination, the rate appears much slower for freshly collected seed, and it appears to be directly related to temperature.

Seed from the Birney collection germinated at about the same rate as that of the Epsie collections. Although the Birney seed averaged lower total germination, the difference was significant only at 30°C temperature (86 vs. 66 percent). The major difference in the two collections was the retained viability of the ungerminated seed from the Birney collection, while ungerminated seeds from the Epsie collections had all lost their viability at the end of 30 days.

Since the breakdown of the pericarp is necessary for germination, freeze-thaw action was examined for indications of response. Following the 30-day germination trial, two samples from the Birney collection containing 10 germinated seedlings and 15 fully turgid embryos still surrounded with the pericarp were placed in a freezer (-10°C), one for 24 hours and one for four days, after which they were exposed to 20°C temperature and eight hours of light. The short freeze stimulated all imbibed embryos to germinate and did not damage previously emerged seedlings. The longer freeze period killed all previously emerged seedlings, but again the imbibed embryos germinated when placed in the warmer environment.

Discussion

Black greasewood in southeastern Montana begins to form mature seeds by late September. Following an after-ripening period of 30-60 days, germination is high at either high or low temperatures, although there is an increase in the ability of seeds to germinate at very low temperatures with longer after-ripening periods.

Germination from pure, live seed should exceed 60 percent under optimal conditions. Germination and seedling growth are both very rapid from embryos not surrounded by a resistant pericarp, while germination is slowed or delayed for embryos surrounded by a resistant pericarp unless, as indicated above, freeze-thaw action breaks the membrane down. Observations made on the two populations suggest the presence of a chemical inhibitor to germination in the Birney collection which at least slows germination in 25 percent or more of the population. Although this inhibitor may be present in the Epsie population, the membranous pericarp is not continuous around the embryo, and thereby allows unrestricted embryo expansion. Seeds from both populations would be expected to germinate differently under natural conditions. Fall germination should occur in both; however, the Birney source possesses a delay mechanism for a portion of the seed. High seedling mortality would be expected on a site where freeze-thaw action occurs, for example, on southerly aspects.

Seed dispersal from the plant is a gradual process occurring throughout the late fall, winter, and spring, therefore presenting a multitude of conditions for germination. Although all indications are that greasewood should be quite competitive in reproducing itself, established seedlings were infrequent at the two collection sites. Since the species is long-lived and produces abundant seed, maintenance in the community seems assured. Regeneration, however, would be strongly reduced by insect-caused seed damage as shown in the 58 percent embryo loss of the 1976 Epsie collection and by freeze-injury to new seedlings.

Acknowledgments

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