Effects of Temperature and Presowing Treatments on Showy Menodora Seed Germination

TIMOTHY E. FULBRIGHT AND KAY S. FLENNIKEN

Abstract

Low seed germination is a problem in establishment of showy menodora (*Menodora longiflora* Gray). Objectives of this study were to determine the effects of temperature, light, and presowing treatments on showy menodora germination. Scarified and untreated seeds were germinated at 5/15, 10/20, 15/25, 20/30, 25/35, and 30/40° C (12 hour/12 hour) with 12 hours of light at the warmer temperature or complete darkness. Seeds were subjected to: (1) chemical scarification with concentrated (18.0 mol liter^{-1}) H_2SO_4, 2.9 mol liter^{-1} H_2O_2, or 0.7 mol liter^{-1} NaOCl, (2) a hot (80° C) water soak, and (3) nicking with a razor blade. Percent germination and germination rate were highest at 20/30° C. The highest percentage of abnormal seedlings occurred for mechanically scarified seeds at 5/15° C. Light did not affect germination at 15/25, 20/30, and 30/40° C, but enhanced germination at 5/15, 10/20, and 25/35° C. Scarification enhanced percent germination and germination rate at all temperatures. At 20/30° C, nicking seeds with a razor and a 3-minute soak in 0.7 mol liter^{-1} NaOCL resulted in 81 and 78% germination, respectively, of 1-year-old seeds, compared to 53% for untreated seeds. These results indicate that showy menodora seeds should be scarified by mechanical means or with 0.7 mol liter^{-1} NaOCL and planted when average daily minimum/maximum soil temperatures are about 20/30° C for maximum germination.

Palatable shrubs and forbs can be valuable additions to range seeding mixtures (Thornburg 1982, Whisenant and Ueckert 1982, Cook 1983, Kissock and Haferkamp 1983). Mixtures of grasses, forbs and shrubs may better meet the nutritional needs of grazing animals and may provide higher quality wildlife habitat than stands of perennial grasses alone.

Showy menodora (*Menodora longiflora* Gray) is a native half shrub of the Oleaceae (Vines 1960) currently under evaluation by the USDA Soil Conservation Service Plant Materials Center at Knox City, Texas, for use in range seeding (Richard Heizer, State Plant Materials Specialist, USDA-Soil Conservation Service, personal communication). It is adapted to rocky slopes and ledges, and ranges from southern and western Texas to southeastern New Mexico and south to Coahuila, Mexico (Vines 1960). Showy menodora is readily browsed by domestic livestock and deer (*Odocoileus* sp.) and has disappeared from parts of its former range because of heavy use (Warnock 1970, Rechenthin 1972).

Low seed germination has been a problem in establishment of showy menodora on sites where it has been planted (Richard Heizer, State Plant Materials Specialist, USDA-Soil Conservation Service, personal communication). Objectives of this study were to determine: (1) the effect of temperature on germination of showy menodora, (2) if light is required for germination, and (3) the efficacy of different methods of enhancing germination.

Methods

General Methods

Seeds of accession 477968 showy menodora were obtained from the USDA Soil Conservation Service Plant Materials Center at Knox City, Texas. Seeds used in temperature and light experiments were 3 years old while those used in presowing treatment experiments were 1 year old. Seeds were stored in cloth bags at 15° C and 40% relative humidity during the study.

Seeds in all experiments were germinated on blotter paper underlain by a layer of creped cellulose placed in plastic boxes measuring 13.0 by 13.5 by 3.5 cm with tightly fitting lids (Fulbright et al. 1983). Each plastic box contained 100 seeds. The substrata were moistened with 100 ml of tap water (electrical conductivity 1.6 dS m^{-1}, pH 7.9). Seeds were treated with thiram [bis (dimethylthiocarbamoyl) disulfide] to minimize fungal growth.

Showy menodora seeds were considered to have germinated when at least 1 cotyledon was exposed and radicles were 5 mm or greater in length (Kissock and Haferkamp 1983). Seedlings without at least 1 exposed cotyledon and with radicles less than 5 mm in

Authors are faculty researcher and research fellow, Caesar Kleberg Wildlife Research Institute, Campus Box 218, Texas A&I University, Kingsville 78363.

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length were considered abnormal. Counts were made daily for a period of 28 days in the temperature experiments and 14 days in the presowing treatment experiments. Rate of germination was calculated by the equation of Maguire (1962) for germination rate (GR):

$$GR = \frac{\text{number of seeds germinated}}{\text{days to first count}} + \ldots + \frac{\text{number of seeds germinated}}{\text{days to final germination count}}$$

where GR is the sum of the quotients of the number of seeds germinated divided by the number of days for germination.

Influence of Temperature, Light, and Scarification on Germination

Effects of temperature, light, and scarification on germination of showy menodora were examined by germinating scarified and untreated seeds under dark and light conditions in controlled environment chambers at alternating temperatures of 5/15, 10/20, 15/25, 20/30, 25/35, and 30/40° C (12 hour/12 hour). Seeds were scarified by carefully nicking the distal end with a razor blade. Dark conditions were maintained by wrapping plastic boxes with 3 layers of aluminum foil. A green safety light was used during counting. The light treatments consisted of exposure to cool-white fluorescent lights for 12 hours daily at the higher temperature. Photosynthetic photon flux density averaged 26 μmol $m^{-2}s^{-1}$.

Four plastic boxes arranged in a randomized complete-block design were used as experimental units for each treatment and the experiment was repeated twice. Response curve analysis was used to determine the relationship between temperature and germination (Snedecor and Cochran 1967). Analysis of variance was used to determine if significant differences existed between light means and scarification treatment means within each temperature. An arcsine $\sqrt{0.01 \times \%}$ transformation was used on percent germination data from the temperature, light, and scarification experiment and presowing treatment experiments for analyses. Untransformed data are reported in the text.

Presowing Treatment Effects

Showy menodora seeds were subjected to the following presowing treatments: (1) a 1, 2, 3, and 4-minute soak in concentrated (18.0 mol liter^{-1}) sulfuric acid (H_2SO_4) following by a 5-minute rinse with large volumes of tap water (Young et al. 1981); (2) a 2, 6, 8, and 10-minute soak in 2.9 mol liter^{-1} hydrogen peroxide (H_2O_2) followed by a 5-minute rinse with large volumes of tap water (Young et al. 1981); (3) a 2, 6, 8, and 10-minute soak in 0.7 mol liter^{-1} sodium hypochlorite (NaOCl) followed by a 5-minute rinse in large volumes of tap water (Stidham et al. 1980); (4) a 2, 6, 8, and 10-minute soak in hot (80° C) water (Kissock and Haferkamp 1983, Haferkamp et al. 1984); and (5) cutting seeds with a razor blade (mechanical scarification) (Kissock and Haferkamp 1983, Haferkamp et al. 1984). Seeds were germinated at 20/30° C (12 hours with light/12 hours with darkness daily). Four plastic boxes containing 100 seeds each were used as experimental units for each treatment.

Response curve analysis was used to predict the optimum level of each presowing treatment. The optimum level of each treatment was then compared in a final experiment to determine the presowing treatment most effective in enhancing germination.

In the final experiment, 4 plastic boxes arranged in a randomized complete-block design were used as experimental units for each treatment and the experiment was repeated twice. Data were analyzed by analysis of variance (Snedecor and Cochran 1967). Tukey's test was used at the 0.05 level of probability to identify significantly different means when significant *F* values were found (Kleinbaum and Kupper 1978). Differences discussed in the following section were significant at the 0.05 level of probability unless otherwise indicated.

Results

Influence of Temperature, Light, and Scarification on Germination

Percent germination and germination rate of showy menodora exhibited a quadratic response to temperature (Figs. 1 and 2).

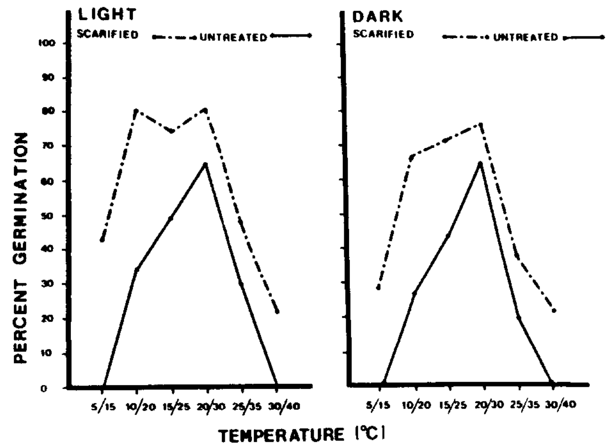

Fig. 1. *Effects of temperature on percent germination of showy menodora seeds. Equations for the relationship between percent germination and temperature were $Y=-120.55+15.67x-0.30x^2$ ($R^2=0.82$) for scarified seeds in the light, $Y=-222.21+20.21x-0.37x^2$ ($R^2=0.92$) for untreated seeds in the light, $Y=-141.29+16.28x-0.31x^2$ ($R^2=0.75$) for scarified seeds in the dark, and $Y=-208.15+18.82x-0.34x^2$ ($R^2=0.83$) for untreated seeds in the dark. The warmer temperature in each temperature combination was used as the value of x in the analysis.*

Highest germination of untreated and scarified seeds occurred at 20/30° C in both light and dark treatments. Germination rate increased with temperature from 5/15 to 20/30° C and rapidly declined at temperatures warmer than 20/30° C. Both scarified and untreated seeds exhibited peak germination rates at 20/30° C in the light and in the dark.

The percent of abnormal seedlings exhibited a quadratic response to temperature (Fig. 3). For scarified seeds, the percentage of abnormal seedlings decreased with increasing temperature from 5/15 to 20/30° C and then increased at temperatures above 20/30° C. This probably resulted because seedling vigor was lower at temperatures above and below the optimum for germination. Cotyledons of seedlings extruded through the nicked portion of seeds at 5/15 and 30/40° C, but radicles failed to reach 5 mm in length.

For untreated seeds, the percentage of abnormal seedlings

Table 1. Effect of light (12 hours daily) on mean percent germination, germination rate, and percent abnormal seedlings of showy menodora under 6 alternating (12 hour/12 hour) temperature (° C) regimes. Values are averages across scarification treatments.

Temperature	Percent germination		Germination rate		Percent abnormal seedlings	
	Light	Dark	Light	Dark	Light	Dark
5/15	22	15**	1.0	0.7*	13	20*
10/20	57	47**	5.0	3.9**	8	11^{NS}
15/25	63	58^{NS}	6.3	5.7^{NS}	8	13**
20/30	73	71^{NS}	11.3	10.4^{NS}	3	5^{NS}
25/35	39	29*	4.7	2.9*	9	14*
30/40	12	11^{NS}	1.6	1.4^{NS}	5	6^{NS}

*,**,^{NS}Means within a row for each trait significantly different at the 0.05 level, significantly different at the 0.01 level, or not significantly different (P>0.05), respectively.

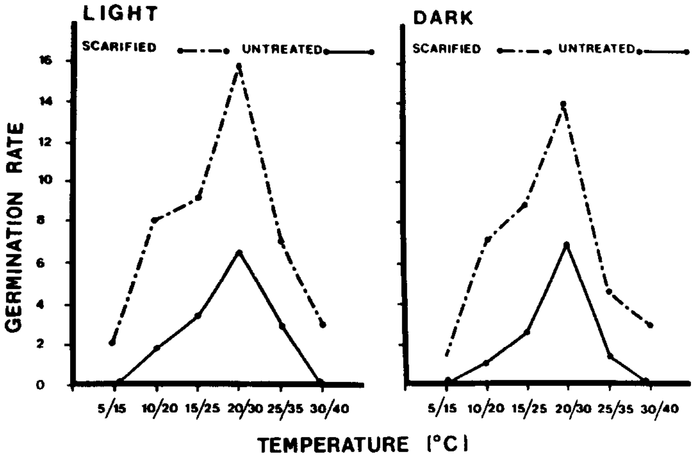

Fig. 2. *Effects of temperature on germination rate of showy menodora seeds. Equations for the relationship between germination rate and temperature were $Y=-37.80+3.59x-0.06x^2$ ($R^2=0.64$) for scarified seeds in the light, $Y=-20.07+1.77x-0.03x^2$ ($R^2=0.76$) for untreated seeds in the light, $Y=-34.15+3.22x-0.06x^2$ ($R^2=0.62$) for scarified seeds in the dark, and $Y=-18.83+1.64x-0.03x^2$ ($R^2=0.52$) for untreated seeds in the dark. The warmer temperature in each temperature combination was used as the value of x in the analysis.*

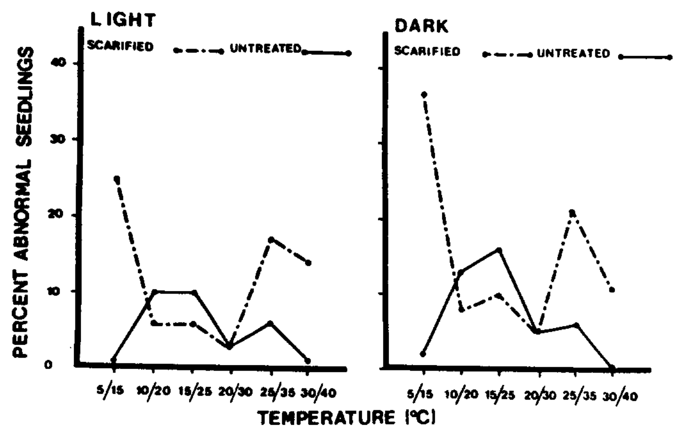

Fig. 3. *Effects of temperature on abnormal germination of showy menodora seeds. Equations for the relationship between abnormal seedlings and temperature were $Y=78.93-5.07x+0.08x^2$ ($R^2=0.64$) for scarified seeds in the light, $Y=-18.98+2.09x-0.04x^2$ ($R^2=0.49$) for untreated seeds in the light, $Y=103.42-6.40x+0.11x^2$ ($R^2=0.49$) for scarified seeds in the dark, and $Y=-31.48+3.34x-0.06x^2$ ($R^2=0.55$) for untreated seeds in the dark. The warmer temperature in each temperature combination was used as the value of x in the analysis.*

increased with temperature from 5/15 to 15/25° C and declined with increasing temperatures above 15/25° C (Fig. 3). Abnormal germination was lower at 20/30° C than at 10/20 and 15/25° C because seedlings were more vigorous at 20/30° C and were better able to completely emerge from the seed coat. Few abnormals developed at 5/15 and 30/40° C because seedling vigor was too low for seedlings to emerge from the seed coat.

Light affected germination only at temperatures above or below the optimum for germination (Table 1). Percent germination was higher in the light than in the dark at 5/15, 10/20, and 25/35° C. No significant difference ($P>0.05$) in percent germination existed between light and dark conditions at 20/30 and 15/25° C, the 2 temperatures most favorable for germination, and at 30/40° C. Germination rate was also higher in the light than in the dark at 5/15, 10/20, and 25/35° C. No significant difference ($P>0.05$) in germination rate existed between light and dark at 15/25 and 20/30° C. The percent of abnormal seedlings that developed tended to be higher in the dark than in the light. At 5/15, 15/25, and 25/35° C, more abnormal seedlings developed in the dark than in the light.

Mechanical scarification increased percent germination and germination rate at all temperatures (Table 2). The effect of scarification on percent germination was more pronounced at temperatures that were above or below the optimum for germination. Mechanical scarification increased percent germination at 20/30° C by only 14% over that of untreated seeds. In contrast, mechancial scarification increased germination from 31% for untreated seeds to 74% at 10/20° C and from 25% for untreated seeds to 43% at 25/35° C. More abnormal seedlings developed from untreated seeds than from scarified seeds at 10/20 and 15/25° C. This possibly resulted because seedlings with inherently lower vigor encountered less resistance to embryo expansion in scarified seeds than in untreated seeds. Scarification resulted in the development of a greater number of abnormal seedlings than from untreated seeds at 5/15, 25/35, and 30/40° C. Differences in abnormal seedlings between scarified and untreated seeds were not evident at the optimum temperature for germination (20/30° C).

Presowing Treatment Effects

Showy menodora germination was inhibited by concentrated H_2SO_4 and hot water treatments in pilot experiments (data not shown). Percent germination was enhanced by soaking seeds in 2.9 mol liter^{-1} H_2O_2 and 0.7 mol liter^{-1} NAOCl. A 0, 2, 6, 8, and 10 minute soak in 2.9 mol liter^{-1} H_2O_2 resulted in 54, 61, 65, 63, and 57% germination ($Y=53.9+4.0x-0.4x^2$, $R^2=0.37$), respectively. Soaking seeds for 0, 2, 6, 8, and 10 minutes in 0.7 mol liter^{-1} NaOCl resulted in 51, 67, 66, 46, and 62% germination ($Y=49.7+17.2x-41x^2+0.2x^3$, $R^2=0.51$), respectively. Predicted optimum duration of treatment was 5 minutes for 2.9 mol liter^{-1} H_2O_2 and 3 minutes for 0.7 mol liter^{-1} NaOCl.

Germination of seeds subjected to 5-minute 2.9 mol liter^{-1} H_2O_2 and 3-minute 0.7 mol liter^{-1} NaOCl treatments was compared to that of untreated seeds and mechanically scarified seeds in a final experiment (Table 3). Percent germination and germination rate of mechanically scarified seeds and seeds scarified with 0.7 mol liter^{-1} NaOCl was higher than that of untreated seeds and seeds scarified with 2.9 mol liter^{-1} H_2O_2. Mechanical scarification and chemical

Table 2. Effect of mechanical scarification on mean percent germination, germination rate, and percent abnormal seedlings of showy menodora under 6 alternating (12 hour/12 hour) temperature (° C) regimes. Values are averages across light treatments.

Temperature	Percent germination		Germination rate		Percent abnormal seedlings	
	Scarified	Intact	Scarified	Intact	Scarified	Intact
5/15	36	0**	1.7	0.0**	31	2**
10/20	74	31**	7.4	1.6**	7	12**
15/25	74	47**	9.1	3.0**	8	13**
20/30	79	65**	14.9	6.8**	4	4^{NS}
25/35	43	25**	5.5	2.1**	17	6**
30/40	22	1**	0.1	3.0**	10	1**

**,^{NS}Means within a row for each trait significantly different at the 0.01 level of probability and not significantly different ($P>0.05$), respectively.

Table 3. Effects of 4 presowing treatments on mean percent germination, germination rate, and percent abnormal seedlings of showy menodora at 20/30° C (12 hours with darkness/12 hours with light daily).

	Percent germination	Germination rate	Percent abnormal seedlings
Control	53a[1]	6.9a	4a
2.9 mol liter^{-1} H_2O_2	67b	8.7b	4a
0.7 mol liter^{-1} NaOCl	78c	13.5c	2a
Mechanical scarification	81c	14.9d	4a

[1]Means within a column followed by the same letter were not significantly different at the 0.05 level of probability according to Tukey's test.

scarification with 0.7 mol liter^{-1} NaOCl increased germination from 53% for untreated seeds to 81 and 78%, respectively. No significant difference ($P>0.05$) in percent germination existed between mechanically scarified seeds and seeds treated with 0.7 mol liter^{-1} NaOCl. Germination rate of mechanically scarified seeds was higher than that of seeds treated with 0.7 mol liter^{-1} NaOCl. No significant difference ($P>0.05$) in the number of abnormal seedlings existed between seeds subjected to presowing treatments and untreated seeds.

Discussion

Maximum percent germination and germination rate of showy menodora seeds apparently occur over a relatively narrow temperature range. Planting dates should be selected that coincide with periods of the year when temperature regimes optimal for germination are most likely to occur. Over much of the range of showy menodora, 20/30° C temperature regimes occur in the spring and fall. One of the primary areas of Texas to which showy menodora is adapted is the Edward's Plateau. Peak rainfall months in the Edward's Plateau region are May, June, and September (Gould 1975). Planting immediately prior to May or September rains would probably enhance chances of stand establishment.

Planting scarified showy menodora seeds when soil temperatures are low or when temperatures are above the optimum for germination may result in considerable abnormal germination. Planting under conditions that result in abnormal germination should be avoided because when conditions become favorable for germination the quantity of viable seed will have decreased.

Light is apparently not required for germination of showy menodora seeds. However, germination is enhanced by light at temperatures above or below the optimum for germination. Further research on the light response of showy menodora seeds is needed.

Germination of showy menodora seeds is apparently restricted by the seed coat. Additional research is needed to determine if the seed coat impedes germination through mechanical, water and/or oxygen permeability restrictions.

Scarification is required for maximum germination of showy menodora seeds; however, scarification in a mechanical seed scarifier often results in damage to a portion of the treated seeds (Young et al. 1984). Scarification with 0.7 mol liter^{-1} NaOCL could be done relatively cheaply (0.7 mol liter^{-1} NaOCl costs ca. 30¢ liter^{-1}) and would possibly damage fewer seeds than treatment in a mechanical scarifier. Scarification of seeds with NaOCl sometimes retards seedling emergence of guayule (*Parthenium argentatum* Gray) (Federer 1946). Effects of scarifying showy menodora seeds with NaOCl on seedling emergence were not determined in this study. Additional research is needed to determine the effects of scarification treatments on showy menodora establishment.

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