A Germination Study of Purple Sage

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Summary. Germination of purple sage [*Salvia dorrii* (Kellogg) Abrams] seed was evaluated under 21 temperature combinations (day temperatures from 5 to 30C and night temperatures from 5 to 30C) in two experiments: 1) cool-moist stratification; and 2) sandpaper scarification, leaching with water, or gibberellic acid (GA_3). The quadratic responses of weighted germination percentage (WGP), a combined index of germination percentage and speed of germination, were significant ($P \leq 0.05$) for all treatments. The interaction of day and night temperatures was significant ($P \leq 0.05$) only for the 2-week stratification treatments and for the Expt. 2 control. Stratification increased WGP over the control. Optimal WGP for all stratification treatments ranged from 46% to 51%. Optimal WGP was the same for both GA_3 treatments. Optimal WGP for 0.29 mmol GA_3 occurred at 16C night temperature and 22C day temperature, and for the 1.44 mmol GA_3 treatment at 18C night and at 30C day temperature.

Use of native and adapted exotic species is being emphasized to reduce landscape maintenance and to conserve water (Johnson et al., 1990; Rodiek, 1984). Purple sage is a native evergreen shrub, 2 to 5 dm tall, with opposite, silver, round-obovate to spatulate leaves. It grows on arid, sandy, rocky, and disturbed sites throughout the Great Basin of the United States at elevations ranging from 762 to 3000 m (Cronquist et al., 1984; Munz, 1968; Starr, 1985). The range of purple sage includes Washington, Oregon, California, Nevada, Idaho, Utah, and Arizona. Once established, purple sage requires little supplemental water or maintenance. Despite its ornamental potential, purple sage seldom is used because it is neither propagated nor grown in nurseries.

Little research has been conducted on purple sage germination requirements. After 4 years of storage at 4C, purple sage seed germination percentage was greatest at 15C, and room-temperature storage decreased germination after 1 year of storage (Kay et al., 1988). We conducted germination studies using purple sage to determine the effects of constant and alternating temperatures and selected seed treatments on cumulative germination percentage (CGP), and weighted germination percentage (WGP), which is a combined index of germination percentage and speed of germination (Reddy et al., 1985).

Seeds were collected daily during July 1988 from field-grown shrubs established from seeds collected in the wild. Purple sage seeds ripened basipetally over several weeks in midsummer. Seed collection was timed to avoid loss of fully mature seed to shattering and to eliminate collecting large quantities of immature seeds, which decreases the viability percentage and increases seed-cleaning difficulties. Four replications of 25 seeds each were placed on germination blotters in covered petri dishes in the dark, at 21 temperature combinations, which consisted of six constant and 15 alternating temperatures (Table 1).

Experiment 1. Because little germination research had been conducted on purple sage, and dormancy requirements were unknown, we stratified the seeds beginning 3 May 1989. Treatments included stratification on moistened blotter paper in petri dishes at 5C for 1, 2, 4, and 8 weeks. Seeds were treated before placement in the 21 temperature combinations. After considering the stratification results, we chose to continue with additional treatments based on the work of Nord et al. (1971) in a second experiment.

Experiment 2. These treatments included sandpaper-scarification (320A grade), leaching with deionized, distilled water (12 h), and gibberellic acid (GA_3) soaks at 0.29 mmol for 1 h or 1.44 mmol for 30 min. Seeds were treated before placement in the 21 temperature combinations on 30 Aug. 1989. Each treatment was represented by four replications of 25 seeds in each of 21 temperature combinations. Evans et al. (1982) showed that 25 seeds per replication were sufficient when limited seeds were available. All trials lasted for 28 days and were checked daily for moisture and germination. Germination was considered complete when the radicle length reached 2 mm.

Cumulative germination percentage and weighted germination percentage (Reddy et al., 1985) were calculated. An arcsin transformation was performed on the germination percentages (Steel and Torrie, 1980), and a two-factor quadratic response surface regression analysis was performed on the germination data using the PCSAS–RSREG Procedure. An analysis of variance (ANOVA) also was used to discriminate among treatments at optimal day and night temperatures.

Day temperature significantly ($P \leq 0.05$) affected WGP, except for the 1.44 mmol GA_3 for 30 min, and the scarification treatments in Expt. 2. Night temperatures also significantly affected WGP regardless of treatment in both experiments. The linear effects of day and night temperatures were

Table 1. *Day and night temperature combinations used in purple sage seed germination study.*

Night (16 h) temp (°C)	Day (8 h) temp (°C) 5	10	15	20	25	30
5	X	X	X	X	X	X
10		X	X	X	X	X
15			X	X	X	X
20				X	X	X
25					X	X
30						X

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significant ($P \leq 0.05$) for all treatments except the 4-week stratification treatment. The quadratic effects of day and night temperatures were significant ($P \leq 0.05$) for all treatments, whereas the cross-products were significant ($P \leq 0.05$) only for the control of the GA_3 and the 2-week stratification treatments in Expt. 1. The significant linear and quadratic effects imply that the WGP increased with the increase in day and night temperatures up to the optimum day and night temperature combination. Beyond the optimum day–night temperature combinations, the WGP decreased with the increase in both temperatures. The prediction of WGP by the response-surface model for the scarification treatment (Expt. 2) was not as successful ($R^2 < 0.30$) as the other treatments.

Experiment 1

Stratification treatments. Our

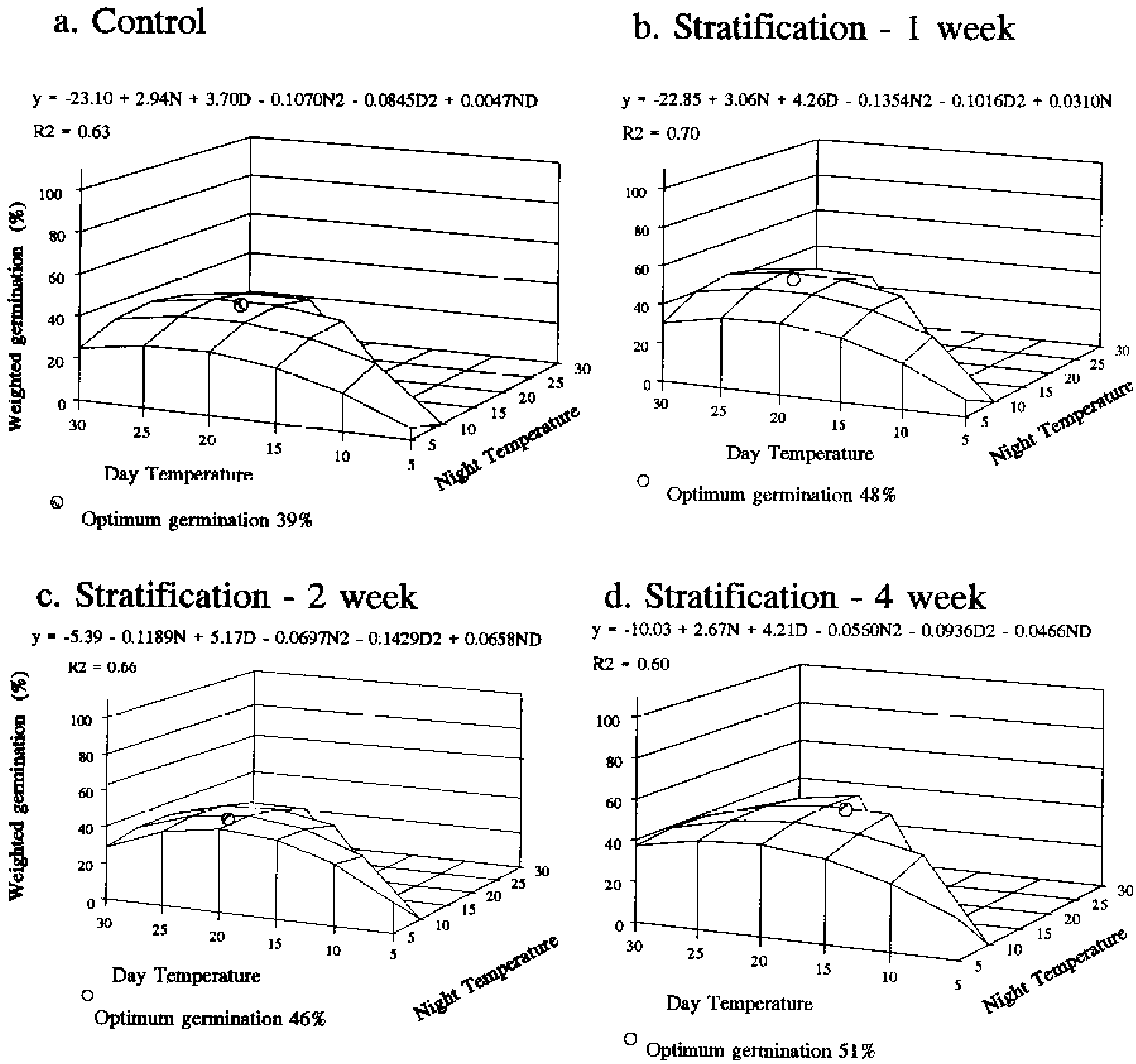

Fig. 1. *Stratification and day and night temperature effects on weighted germination percentages of purple sage seed.*

work indicated that 8 weeks of stratification resulted in the greatest overall WGP, but seed began to germinate during the 7th week of the 8-week stratification period, prior to placement in alternating temperatures (data not presented). Thus, 6 weeks of cold stratification at 5C may be sufficient to enhance germination. Stratification

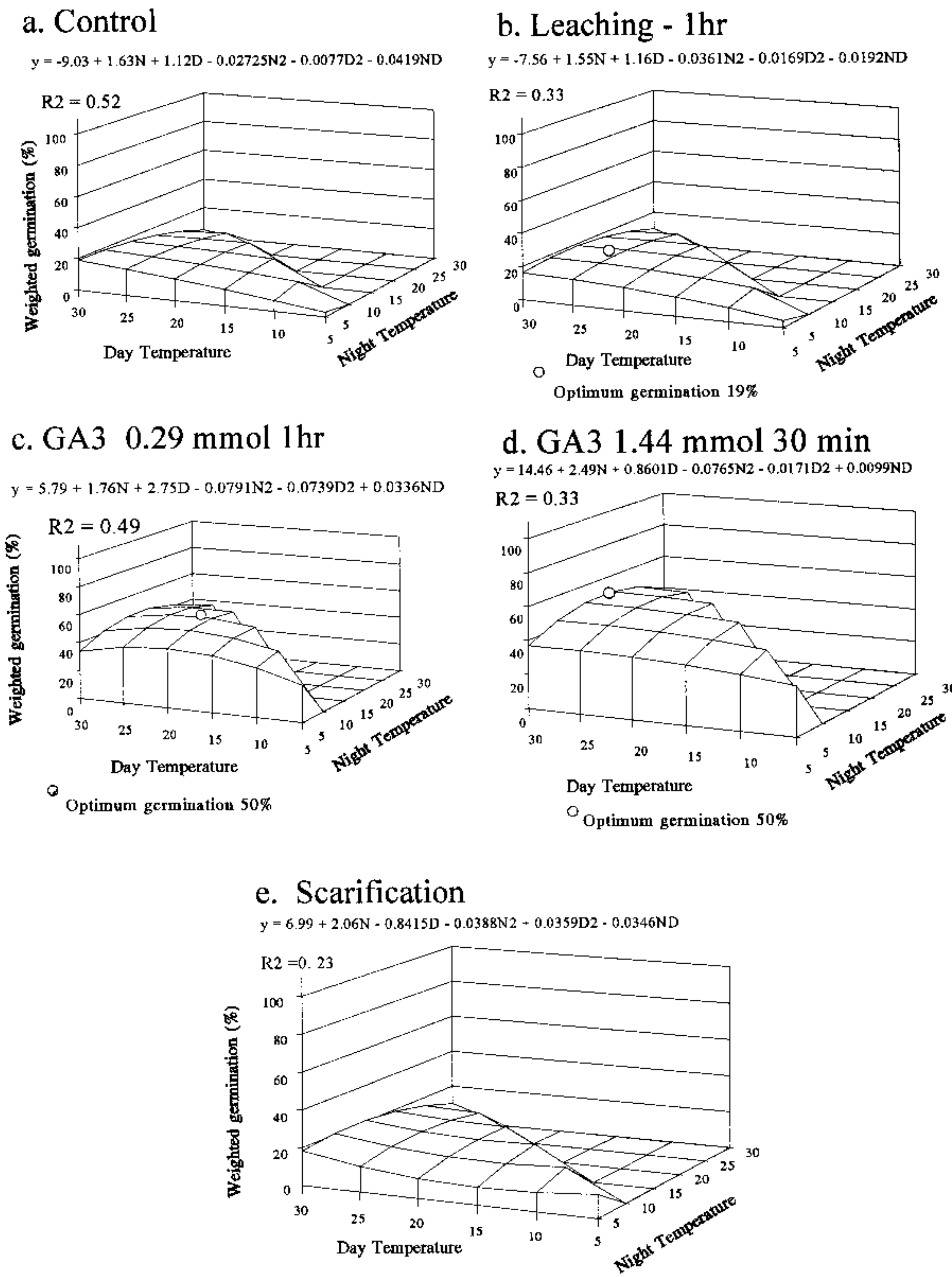

Fig. 2. *GA_3 and day and night temperature effects on weighted germination percentages of purple sage seed.*

increased WGP over that of the control (Fig. 1 a–d). Optimal WGP for all stratification treatments ranged from 46% to 51%. Although optimal WGP occurred at similar temperature combinations for the control (Fig. 1a) and after 1 week of stratification (Fig.1b), it occurred at lower day and night temperatures after 2 weeks of stratification (Fig. 1c). Stratification for 4 weeks (Fig. 1d) resulted in increased WGPs over the range of night temperatures.

Experiment 2

Gibberellic acid treatments. Both GA_3 treatments (0.29 mmol for 1 h and 1.44 mmol for 30 min) stimulated germination over a wide range of temperatures (Fig. 2 c–d). Optimal WGP was the same for the two treatments, but optimal temperature combinations were not. Optimal WGP for 0.29 mmol GA_3 occurred at 16C night temperature and at 22C day temperature, and for the 1.44 mmol GA_3 treatment at 18C night and at 30C day temperature.

Neither leaching (Fig. 2b) nor scarification (Fig. 2e) enhanced germination. The lack of a response indicates a lack of water-soluble inhibitors in the seed coat or in the seed; thus, seed coat permeability may not limit germination. The control, scarification, and leaching (Fig. 2a) showed a marked decrease in germination compared with the control for stratification (Fig. 1a) (stratification treatments were executed 3 months before the other set of treatments). Thus, germination of untreated seed may decrease after storage, supporting the observations by Kay et al. (1988).

The optimal temperatures differed with treatment. For all stratification and GA_3 treatments, optimal day temperature ranged from 18 to 30C, and optimal night temperature ranged from 9 to 18C. When seeds were treated with GA_3, germination was relatively uniform over all temperature combinations. When night temperature ranged from 16 and 18C, stratification for 2 and 4 weeks and 0.29 mmol GA_3 for 1 h had optimal germination percentages between 18 and 22C day temperature, while 1.44 mmol GA_3 for 30 min had an optimal germination percentage at 30C. Thus, 1.44 mmol GA_3 for 30 min germinated at high day temperatures.

Table 2. *Cumulative germination percentage and weighted germination treatment means after 28 days at 15C night (16 h) and 25C day (8 h) temperatures.*

Treatment	Cumulative germination (%)	Weighted germination (%)
	Experiment 1	
Control	50.5 AB[z]	40.9 BC
Stratification, 1 week	55.7 A	49.5 A
Stratification, 2 weeks	42.7 B	38.8 C
Stratification, 4 weeks	54.5 A	50.3 A
	Experiment 2	
Control	25.5 B	17.2 C
GA_3, 0.29 mmol, 1 h	52.1 A	47.5 A
GA_3, 1.44 mmol 30 min	55.7 A	50.6 A
Leach	27.6 B	23.9 B
Scarification	22.7 B	16.6 C

[z]*Means within experiments followed by the same letter are not significantly different according to Waller–Duncan's* t-*test with K-ratio = 100.*

ANOVA were performed to discriminate among treatment means in both experiments at 15C night temperature and 25C day temperature. These temperatures fell within optimal temperature ranges and more closely represented spring germination conditions. The WGPs for the stratification for 1 and 4 weeks were significantly higher than the control and stratification for 2 weeks in Expt. 1 (Table 2). Why germination decreased after 2 weeks of stratification was not determined by this experiment, but these results deserve further study. In Expt. 2, WGP for 1.44 mmol GA_3 for 30 min and 0.29 mmol GA_3 for 1 h were significantly higher compared to the remaining treatments (Table 2).

Stratifying purple sage seed for 1 or 4 weeks or treating them with 0.29 mmol GA_3 for 1 h at an optimum day temperature between 18 and 30C and a night temperature ranging between 9 to 18C are recommended for optimum germination. The rate of germination with GA_3 treatment was more rapid and produced equally successful results; therefore, we recommend it when GA_3 is available.

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