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Priming Dusty Miller Seeds: Role of Aeration, Temperature, and Relative Humidity

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Abstract. **Priming permits seeds to slowly imbibe water at regulated rates and to begin the initial stages of germination. Hypertonic polyethylene glycol (PEG) 8000 solutions of 1.0 and 1.2 MPa at 15C improved seed germination of dusty miller *(Senecio cineraria* DC.). At 0.8 MPa, germination was promoted during priming. No differences in rates, span, or total germination were found among seeds primed for 1, 2, or 3 weeks with or without aeration during priming. Germination percentages of primed and nonprimed seeds were similar at 10, 15, 20, and 25C, but 42% to 81% higher for primed seed at 30 or 35C. Priming reduced days to 50% of total germination (T_{50}) 23% to 61%, and germination spans in days 30% to 67%. Primed seeds germinated most rapidly and uniformly at 20 and 25C. No change in total germination, T_{50}, or germination span resulted when moisture contents of primed seeds were lowered to 7.8% or seeds were held at –80C for 7 days. Primed seed performance was unchanged after storage at 5C and 52% RH for 16 weeks.**

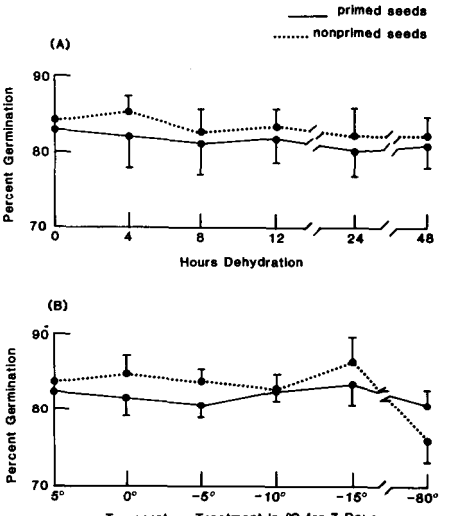

Fig. 1. Primed seed germination after **(A)** dehydration for 0 to 48 hr and **(B)** cold temperature treatment at 5 to –80C for 7 days. Data points in each study are the means of four replications of 100 seeds.

Delayed germination and seedling emergence result in nonuniform plant stands. Currah et al. (1974) found 50% to 80% of lettuce *(Lactuca sativa* L.) head weight variation resulted from time of seedling emergence. The natural germination variability occurring within bedding plant cultivars determines the uniformity of seedling emergence and plant size (Simmonds, 1980). Seed thermodormancy promotes irregular germination when medium temperatures exceed the recommended range. Priming, also termed osmotic priming or osmoconditioning, limits the water that seeds imbibe, permitting the initial stages of germination, but preventing radicle penetration of the testa. Priming promotes faster and more uniform seedling emergence, even at unfavorable temperatures (Cantliffe, 1981). Priming seeds in osmotic solutions of PEG 8000 or potassium salts, K_3PO_4 and KNO_3, promotes more rapid and uniform germination of tomato *(Lycopersicon esculentum* Mill) (Bradford and Murray, 1983), lettuce (Cantliffe, 1981), and salvia *(Salvia splendens* F. Sellow ex Roem. & Schult) (Carpenter, 1989) seeds. 'Silverdust' dusty miller is a silvery-leaved landscape foliage plant commercially produced in greenhouses as an annual bedding plant. Direct-seeding dusty miller in propagation flats causes irregular germination at recommended temperatures and seed thermodormancy above 25C. The objectives of these experiments were to develop recommendations for priming dusty miller seeds, to determine if priming overcomes seed thermodormancy, and to measure the response to priming after storage at varying relative humidity levels.

Dusty miller seeds were primed in darkness at 15C in aerated PEG 8000 solutions at 0.8, 1.0, or 1.2 MPa for 0, 1, 2, or 3 weeks. The water potential of the PEG solutions were measured at 15C with a Wescor vapor pressure osmometer (Wescor, Logan, Utah). Seeds were placed in 80-ml test tubes with 20 ml of PEG solution per 0.1 g of seed. After priming, seeds were washed with

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Table 1. Comparison of PEG 8000 concentration and period of seed priming at 15C on dusty miller germination.

Priming		Germination		
PEG (MPa)	Period (weeks)	Percent	T_{50}z (days)	Spay[y] (days)
Nonprimed	1	81	4.5	4.5
	2	83	5.0	4.0
	3	81	4.8	4.3
Significance				
Linear		NS	NS	NS
Quadratic				
0.8[x]	1	83	1.5	1.0
	2	80	1.3	1.0
	3	89	1.0	0.9
Significance				
Linear		*	NS	NS
Quadratic		**	NS	
1.0	1	84	2.0	1.8
	2	79	1.8	1.5
	3	87	1.8	1.5
Significance				
Linear		NS	NS	NS
Quadratic		*	NS	NS
1.2	1	83	2.5	2.0
	2	80	2.0	1.8
	3	76	2.3	1.5
Significance				
Linear		*	NS	NS
Quadratic		NS	NS	NS
Concentration (C)		NS	**	**
Period (P)		NS	NS	NS
C × P		*	NS	NS

[z]Mean days to 50% germination.
[y]Days from 10% to 90% germination.
[x]Data for this treatment included seeds that germinated during the priming treatment.
[NS,*,**]Nonsignificant or significant at $P = 0.05$ or 0.01, respectively. Data are means of 400 seeds.

Table 2. Dusty miller germination comparing seeds aerated and nonaerated during priming with nonprimed seeds.

Seed treatment	Germination temp (C)	Germination		
		Percent	T_{50}z (days)	Spany (days)
Nonprimed	10	80	11.6	6.8
	15	83	6.5	5.0
	20	89	5.1	4.5
	25	78	5.4	4.3
	30	35	6.3	5.8
	35	16	8.2	6.3
Significance				
Linear		**	**	NS
Quadratic		**	**	**
Primed aerated	10	80	5.5	3.8
	15	86	3.2	2.5
	20	86	2.0	1.8
	25	82	2.1	2.0
	30	65	4.4	3.3
	35	59	6.3	4.5
Significance				
Linear		**	**	**
Quadratic		**	**	**
Primed nonaerated	10	79	6.1	4.0
	15	80	2.6	2.3
	20	84	2.1	1.5
	25	80	2.3	1.8
	30	76	3.9	3.0
	35	65	5.8	4.3
Significance				
Linear		**	NS	NS
Quadratic		**	**	**
Treatment (T)		**	**	**
Temperature (TE)		**	**	**
T × TE		**	**	*

[z]Mean days to 50% germination.
[y]Days from 10% to 90% germination.
[NS,*,**]Nonsignificant or significant at $P = 0.05$ or 0.01, respectively. Data are means of 400 seeds.

100 ml of distilled water (dw), surface moisture was removed by 5 min of vacuum aspiration, and they then were stored at 5C and 45% RH 4 days before germination. Treatments contained four 100-seed replicates. Seeds were germinated at 20C in 9-cm petri dishes on two layers of Whatman No. 1 filter paper wetted With 5 ml of dw. Germination counts were made daily. Germination was defined as seeds with visible radicle protrusion through the testa. Treatment means in days to 50% of final germination (T_{50}) and span of germination (days between 10% and 90% germination) were calculated as recommended by Furutani et al. (1985). The experiment was a randomized complete block designed as a 4 × 3 factorial, with data analyzed by an analysis of variance (ANOVA) and multiple regression analysis.

A second study compared the germination of seeds primed with or without aeration of the 1.0 MPa PEG 8000 osmoticum. Seeds were primed 1 week in aerated PEG solutions in 80-ml test tubes or immersed in 25 ml of nonaerated solutions in sealed 9-cm petri dishes. Following priming, all seeds were washed, surface dried, and stored as previously described. Treatments consisting of four 100-seed replications of primed or nonprimed seeds were germinated as described above at a constant 10, 15, 20, 25, 30, or 35C. Germination counts, T_{50}, and spans of germination were calculated. The experiment was a randomized complete block designed as a 3 × 6 factorial with analyses as in the previous study.

Primed and nonprimed seed germination were determined after reducing seed moisture contents. Seeds primed 1 week at 15C in nonaerated 1.0 MPa PEG osmoticum were washed, dried, stored 5 days at 5C and 45% RH, and weighed. The four 100-seed replications comprising each treatment were placed in open 9-cm petri dishes and dehydrated for 0, 4, 8, 12, 24, or 48 hr in 35C forced draft incubators. Treatment replications were reweighed and immediately sealed in screw-capped 4-ml glass vials, 100 seeds per vial, and stored at 5C for 8 weeks. Seeds were reweighed after storage and germinated in petri dishes at 20C as previously described. Seeds with radicle emergence were counted daily. Total moisture contents of both primed and nonprimed seeds were determined by weighing before and after desiccation at 105C for 48 hr. The experimental design was a 2 × 6 factorial.

Low-temperature effects on primed seed also were evaluated. Seeds primed in nonaerated 1.0 MPa osmoticum of PEG 8000 at 15C for 1 week were weighed after washing and surface moisture was removed by 30 min of vacuum aspiration. Treatments of four 100-seed replications were placed in 15 × 2.5-cm petri dishes on wire screens supported by segments of tubing 1 cm above a chemical desiccant. A constant 11% RH was maintained in the sealed petri dishes by adding 50 ml of saturated lithium chloride to the bottom of each dish (Copeland, 1976). The incubator was held at 5C during the week of seed dehydration. Following dehydration,

Table 3. Relative humidity level during 5C storage influences primed dusty miller seed germination.

Seed storage		Germination		
Period (weeks)	RH (%)	Percent	T_{50}[z] (days)	Span[y] (days)
0		81	2.3	1.8
2	11	78	2.5	2.3
	52	80	2.3	1.8
	75	79	2.0	1.5
	95	84	2.0	1.8
Significance				
Linear		*	NS	NS
Quadratic		NS		
8	11	83	2.8	2.5
	52	78	2.0	1.5
	75	78	2.3	1.8
	95	66	2.3	1.5
Significance				
Linear			NS	
Quadratic		*		NS
16	11	78	2.8	2.8
	52	80	2.3	2.0
	75	72	2.8	3.0
	95	53	3.3	3.8
Significance				
Linear		*	NS	
Quadratic		**	*	**
Weeks(W)		**	*	**
RH		**		**
W × RH		**	*	**

[z]Mean days to 50% germination.
[y]Days from 10% to 90% germination.
[NS,*,**]Nonsignificant or significant at $P = 0.05$ or 0.01, respectively. Data are the means of 400 seeds.

seeds were weighed, immediately placed in 10-ml sealed glass vials, and immersed and held for 7 days in polyethylene glycol : water (v/v) in controlled temperature baths (Guy and Carter, 1984) maintained at 5, 0, –5, –10, –15, or –80C. Bath temperatures were lowered 3C/hr to final temperatures; after 7 days of storage, seeds were warmed at 4C/hr to 5C. Daily germination counts were made as noted earlier. The-experimental design was a 2 × 6 factorial.

The relative humidity level during storage of primed seed was evaluated. Seeds primed in nonaerated 1.0 MPa osmoticum of PEG 8000 at 15C for 1 week were prepared as previously described and stored at 11%, 52%, 75%, or 95% RH for 2, 8, or 16 weeks. Treatments consisted of four 100-seed replications placed in 15 × 2.5-cm petri dishes on wire screens supported by segments of tubing 1 cm above chemical desiccants. Differential relative humidity levels were maintained in sealed petri dishes by adding 50 ml of saturated salt solutions as desiccants of known equilibrium values to the bottom of each dish (Copeland, 1976). Incubators maintained a constant 5C during seed storage. Seeds in treatment replications were weighed before and after storage and germinated tit 20C in petri dishes as described previously. Daily counts were made of germinated seeds. The experimental design was a 3 × 4 factorial with data analyzed using ANOVA and multiple regression analyses.

Total germination was similar for primed and nonprimed seeds for all treatments (Table 1). Germination counts made after terminating priming showed 18%, 24%, and 35% of seeds primed in 0.8 MPa PEG 8000 for 1, 2, or 3 weeks, respectively, had radicle protrusion. Seeds did not germinate during priming in 1.0 or 1.2 MPa PEG. Primed seeds required significantly fewer days to T_{50} and had shorter spans in days to germination than seeds not primed (Table 1). Seeds primed in 0.8 MPa PEG 8000 required fewer days to germinate, since seeds germinated during priming were included in germination means and spans in Table 1. In subsequent studies, all seed priming was in 1.0 MPa PEG 8000 for 1 week.

Similar total germination resulted at 10, 15, 20, or 25C among nonprimed seeds and those with or without aeration during priming (Table 2). Total germination at 30 or 35C was reduced 6% to 29% for primed seed and 42% to 81% for nonprimed seed. No differences in germination were found at 30 or 35C between seeds primed with or without aeration. Khan et al. (1981) reported adequate O_2 is required during seed osmoconditioning. Come and Tissaouri (1972) found many seeds fail to germinate after priming' in solutions lacking O_2. Cantliffe (1981) reported lettuce seeds primed with or without aeration had similar germination percentages, although aeration promoted more rapid and uniform germination.

Primed seeds had T_{50} and germination span means 23% to 61% and 30% to 67% shorter, respectively, than nonprimed seeds (Table 2). No differences in T_{50} or germination spans were found between seeds primed with or without aeration. Although total germination, T_{50}, and span of days significantly varied among seed germination temperatures, treatment differences consistently were smaller for primed than nonprimed seeds. Germination percentages were similar for seeds primed with or without aeration, and no differences were found in germination rates or uniformity as reported by Simmonds (1980).

No reductions in total germination occurred when primed or nonprimed seeds were dehydrated for 0 to 48 hr (Fig. 1A). Although primed seed moisture levels declined from 18.1% to 7.8% and nonprimed seed moisture levels from 9.9% to 5.2%, total germination for all treatments only ranged from 83% to 88%. These results agree with those of Hegarty (1978) that dehydration of seeds following imbibition and before signs of visible germination have no effect on the level or rate of germination on subsequent rehydration. Seed storage for 7 days at 5C to – 80C had no effect on primed seed total germination, and nonprimed seed germination was reduced only at –80C (Fig. 1B).

The relative humidity level during 5C primed seed storage influenced total germination, T_{50}, and germination span length following storage. Total germination was reduced after 8 or 16 weeks at 95% RH seed storage, but not at 11%, 52%, or 75% RH (Table 3). The T_{50} and germination spans were lengthened following 8 weeks of seed storage at 11% RH and 16 weeks at 11%, 75%, or 95% RH. Primed seed storage was best at 52% RH, with no changes in total germination, T_{50}, or germination span during 16 weeks.

These studies show that seed priming improved dusty miller germination. The best osmoticum concentrations were 1.0 or 1.2 MPa, with 0.8 MPa permitting seed germination during priming. Osmoticum aeration was not necessary, which simplified the priming procedure. Primed seed had higher germination than nonprimed only at temperatures >25C. High temperature seed thermodormancy was reduced by priming, which could permit direct greenhouse seeding during late summer or fall. The reduced days to T_{50} and shorter germination span after seed priming could improve seedling emergence uniformity and plant stands from greenhouse-sown seeds. Primed dusty miller seed was found to tolerate –80C for 1 week or desiccation-reducing seed moisture contents from 18.1% to 7.8% without significant germination loss. Primed seeds stored 16 weeks at 52% RH and 5C had no reduction in total germination, increase in days to T_{50}, or longer germination spans after storage. Sixteen weeks storage at 11%, 75%, or 95% RH increased the days to T_{50} and germination span, and 95% RH reduced total germination.

Seed priming appears promising as a technique for hastening and increasing total germination and seedling emergence of dusty miller. Direct planting of primed seed in production flats was not evaluated in this study, although the results indicate significant benefits could be achieved. The ease of priming seeds in nonaerated PEG osmoticum should contribute to the adoption of the procedure. Primed seed tolerance of low temperatures, desiccation, and 5C storage for 4 months at

52% RH without losing the benefits of priming indicates the likelihood that primed dusty miller seeds can be used commercially.

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