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Seed Priming Increases Germination and Seedling Quality in *Antirrhinum, Dahlia, Impatiens, Salvia* and *Zinnia* Seeds

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Abstract

This study was carried out to investigate the effect of hydropriming on seed germination and seedling growth of five different flower seed species (*Antirrhinum, Dahlia, Impatiens, Salvia* and *Zinnia*). Hydropriming (20^{o}C, 24 h), surface dried or dried back afterwards, was found to increase germination percentage, seedling emergence and fresh and dry weight. In all species, the maximum advantage in germination and emergence was obtained in those that were surface dried. The maximum benefit was observed in *Antirrhinum* and *Dahlia*. In these two species, surface dried seeds were 18% and 17% superior in terms of germination, and 20% and 13% superior in terms of seedling emergence compared to the control, respectively. For the other three species, although there was a positive effect, it was less pronounced. It was concluded that hydropriming can be used to enhance seedling quality in flower seeds.

Keywords: Emergence time, Flower seeds, Seedling fresh weight, Seed pre-treatment Transplant production.

INTRODUCTION

Germination and seedling growth are critical stages for successful stand establishment and transplant production. Low water potential seed hydration, i.e. priming, has been widely used to reduce the germination period, synchronize emergence and increase stand establishment in small seed flowers (Heydecker *et al.*, 1975).

Among the various priming strategies, hydration is shown to be an efficient, low cost, easy and effective method to enhance seed germination and seedling growth (Thornton and Powell, 1992). Moreover, hydration is advantageous when used by low-income transplant producers and farmers (Harris *et al.*, 1999). In certain cases, it can be difficult to obtain fast and uniform emergence in flowers due to their small seed size and slow germination, particularly when the seeds are sown deep. Suboptimal temperatures may also cause low and erratic germination in modules due to the low seed quality. Slow and erratic emergence causes size difference in plants and reduces the overall value of transplant quality (Cantliffe, 1998; Watkins, 1998; Guloksuz and Demir, 2012). Seed loss due to ungerminated seeds in production medium is important in flower seeds in which the use of high value hybrid seeds is common. Priming is a technique that can improve pansy (Carpenter and Boucher, 1991), salvia (Carpenter, 1989; Demir *et al.*, 2012) and impatiens (Frett and Pill, 1989) seed germination and transplant quality. The objective of this study was to determine whether hydration (priming) would improve germination and seedling emergence percentages of *Antirrhinum, Dahlia, Impatiens, Salvia* and *Zinnia* seeds.

MATERIALS AND METHODS

Plant materials

Samples of *Antirrhinum* spp., *Dahlia* spp., *Impatiens walleriana* spp., *Salvia splendens* and *Zinnia* spp. were obtained from commercial seed companies. Laboratory germination tests were conducted with four replicates of 25 seeds each. Seeds of each replicate were placed on filter paper (Filtrak, Germany) in a Petri dish (9 cm diameter) with 4 ml of distilled water. The dishes were placed in polyethylene bags and placed in an incubator at 20°C in the dark. Percentage of daily radicle emergence (2 mm long radicle) and normal seedling percentages were evaluated after 21 days.

For hydration treatment, 150 seeds (six replicates of 25 seeds) were placed in 90 mm Petri dishes on two layers of filter paper (Whatman No. 5) moistened with 6 ml of distilled water. Petri dishes were wrapped with cling film and aluminium foil and placed at 20°C in the dark for 24 h. At the end of the treatment, seeds were either surface dried using filter papers, where surface water was taken by the paper, or dried back to the original weight at 25 ± 2^{o}C and 40-45% RH.

Three replicates of 25 seeds, for each of the hydro-primed and surface dried, hydrated and dried back and control (untreated) seeds, were germinated as described earlier, or sown in plastic containers containing peat moss (Klasman, Germany) (2 kg peat moss per container, 21 x 14 x 10 cm) at sowing depth of 2 cm for each species. Peat moss with seeds sown was irrigated with tap water to about 27-30% of the weight (field capacity). Modules were kept in a growth chamber at 22^{o}C with light density of 72 µmol m^{-2} s^{-1} and relative humidity of 70±5%. During the first four days, the containers were covered with plastic bags to maintain constant field capacity by avoiding evaporation. This also prevents surface drying of the medium and allows the seeds to imbibe well. Modules were irrigated over a period of 21 days.

Total seedling emergence (the appearance of hypocotyls at the surface) was monitored by daily counts. After day 21, normal seedling percentages (healthy and well-developed plants) were determined. Seedlings with missing cotyledons, curly hypocotyl and underdeveloped shoots were considered to be abnormal. Aerial parts (surface of the soil) of the fresh and dry mass of 10 seedlings in each replicate and treatment (3 replicates x 3 treatments x 5 species= 45 x 10 seedlings = 450 seedlings) were measured. Drying was performed at 80°C for 24 h.

The mean germination / emergence time (MGT / MET) was calculated using the following formula:

$$MGT / MET = \sum n.\, t / \sum n$$

where n = number of seeds newly germinated / emerged at time t;

t = days from planting;

$\sum n$ = final germination / emergence.

Statistical analysis

Statistical analysis was performed by using analysis of variance with the Statistical Package for Social Sciences (SPSS). Mean separation was made at the 5% level using the Duncan multiple range test.

RESULTS

Compared with the control, seed hydration increased germination and seedling emergence percentages in all species, irrespective of whether they were surface dried or dried back after the treatment. In all species, seeds that were hydrated and surface dried had higher total and normal germination percentages than hydrated and dried back and control seeds (Tables 1 and 2).

Hydration also increased seedling emergence percentages in modules. It was more prominent in *Antirrhinum, Dahlia* and *Impatiens*, but less so in *Salvia* and *Zinnia*. The greatest difference in germination and emergence between surface dried and control seeds was observed in *Antirrhinum* as 18 and 20% followed by *Dahila* seeds as 17 and 13%, respectively (Table 2). For the *Impatiens* and *Salvia* seeds, the differences between treated and control were relatively low.

Among the species, *Dahlia* and *Zinnia* were found to be the fastest germinating and emerging seeds, while *Antirrhinum, Impatiens* and *Salvia* germinated and emerged more slowly. *Dahlia* and *Zinnia* took approximately two days to germinate and five days to emerge, while for the other

Table 1. The effect of hydration on seed germination and seedling emergence of five different flower species. Seeds were treated as either surface dried (PSD) or dried back (PDB) afterwards.

Species	Germination percentage			Seedling emergence		
	PSD	PDB	C	PSD	PDB	C
Antirrhinum	93a	76b	75b	72a	64b	52c
Salvia	92b	96a	88c	89a	87b	84c
Impatiens	85a	81b	80b	89a	79b	76c
Zinnia	83a	82a	78b	89a	81b	79c
Dahlia	75a	61b	58c	89a	88a	76b

Untreated seeds were considered as control.
Means with different letters in the same line, species and criterion were significantly different at 0.05.

Table 2. The effect of hydration on seed germination and seedling emergence of five flower species seeds. Values were calculated by subtracting control values than treated and surface dried (SD) or dried back (DB) ones.

Species	Germination (%)		Emergence (%)		Mean (%)
	SD	DB	SD	DB	
Anthirrinum	18	1	20	12	12.7
Dahlia	17	3	13	12	11.3
Impatiens	5	1	13	3	5.5
Salvia	4	8	5	3	4.0
Zinnia	5	4	10	2	5.2
Mean	9.8	3.4	12.2	6.4	

Table 3. The effect of hydration on mean germination time and mean emergence time of five different flower species. Seeds were treated as either surface dried (PSD) or dried back (PDB) afterwards. Untreated seeds were considered as control.

Species	Mean germination time (d)			Mean emergence time (d)		
	PSD	PDB	C	PSD	PDB	C
Antirrhinum	1.7a	2.0b	2.2c	4.4a	5.0b	5.6c
Salvia	1.9a	2.2b	2.7c	5.2a	5.6b	6.7c
Impatiens	3.9a	4.3b	4.4b	10.2a	10.3ab	10.4b
Zinnia	4.2a	4.4b	4.4b	10.1a	10.3b	10.8c
Dahlia	4.3a	4.4ab	4.6b	9.3a	10.5b	10.3b

Means with different letters in the same line, species and criterion were significantly different at 0.05.

Table 4. The effect of hydration on seedling fresh and dry weight of five different flower species. Seeds were treated as either surface dried (PSD) or dried back (PDB) afterwards. Untreated seeds were considered as control.

Species	Seedling fresh weight (mg/plant)			Seedling dry weight (mg/plant)		
	PSD	PDB	C	PSD	PDB	C
Antirrhinum	1.7a	2.0b	2.2c	4.4a	5.0b	5.6c
Salvia	1.9a	2.2b	2.7c	5.2a	5.6b	6.7c
Impatiens	3.9a	4.3b	4.4b	10.2a	10.3ab	10.4b
Zinnia	4.2a	4.4b	4.4b	10.1a	10.3b	10.8c
Dahlia	4.3a	4.4ab	4.6b	9.3a	10.5b	10.3b

Means with different letters in the same line, species and criterion were significantly different at 0.05.

three species, the mean germination time was more than four days and the mean emergence time was about 10 days (Table 3). The seeds that hydrated and surface dried were the fastest germinated and emerged in *Dahlia* and *Zinnia*. In most of the species, drying back slowed down germination and emergence compared to the surface dried ones.

Hydration enhanced fresh and dry weights in all species (Table 4). Surface dried seeds had a heavier seedling fresh and dry weight than those of the dried back and control ones. The difference was significant ($P<0.05$) in *Dahlia, Impatiens* and *Zinnia*, but not in *Antirrhinum* and *Salvia.*

DISCUSSION

In this study, seed hydration was demonstrated to be a successful and effective strategy for improving germination, seedling emergence, germination and emergence times and fresh and dry weights in five different flower seeds. The germination of flower seeds can be low and highly erratic (Frett and Pill, 1989; Carpenter and Boucher, 1991) resulting in low quality seedling size and non-uniform transplant. There are various procedures that would improve seed germination and uniformity of stand in these species. Seed hydration is considered a cheap and easily applicable priming method, and one that is being practised in various seeds (Harris *et al.,* 1999).

Seeds in the dry state show little metabolic activity, which causes sub-cellular repair mechanisms remain inactive (Roberts, 1981). Several possibilities, such as germination advancement, leaching of toxic metabolites and antifungal effect have been suggested as beneficial effects of hydration treatments (Basu, 1976). These beneficial effects may be due to the involvement of cellular repair mechanism during hydration that counteract the age lesions accumulated in the seeds prior to hydration treatment (Villiers and Edgcumbe, 1975).

The positive effects of hydration are related to its stimulatory effects in the early stages of germination. There is a rapid initial water uptake in the first stage, more physiological activities related to germination such as protein synthesis, translation of RNA and mitochondria synthesis in the second stage, and further rapid water uptake and completion of the germination process in the third stage (Woodstock, 1988). Enhancement in germination and emergence in hydrated seeds can be due to the completion of pre-germinated processes, such as repair and synthesis of nucleic acids, protein and membranes repair (McDonald, 1999). Treated seeds germinate faster, since they complete the first two stages of germination and the radicle protrudes as soon as they are given water. These metabolic changes are retained in the seed upon drying, reducing the lag phase of germination when resupplied with water (Savino *et al.,* 1979). We have not investigated any physiological events behind the hydration; however, treated seeds germinated and emerged at higher percentages and faster rates than the control in all species.

The treatment resulted in a higher (vigour) seedling fresh and dry weight. Emergence in some species were even higher than germination percentages (Table 1). Germination test was conducted in the dark but emergence test under light. Therefore, this can be due to the stimulating effect of light supplied during emergence test (Baskin and Baskin, 2004). Seedling parameters are important characteristics for obtaining successful transplants. Fast emerging seedlings improve the overall quality values for transplant production in modules (Wartidiningsih and Geneve, 1994). However, the stimulating effect of hydration varies across the species. The treatment was more effective in *Antirrhinum* and *Dahlia* seeds compared to the other three species. Different factors such as species, initial seed quality and hydration period could influence the advantage of the priming treatment. For example, Nath *et al*. (1991) determined that 2 h of soaking provides protection against deterioration, whereas long soaking (such as 24 h) increases the rate of deterioration in storage.

The positive effect of hydration was influenced by the drying methods used following hydration. In all species, surface drying after treatment was superior to drying back seeds. Surface dried seeds did not lose moisture down to the initial level, so seeds do not need to pass the initial water uptake stages of germination. Consequently, radicle protrusion occurred faster than dried back seeds. Similar conclusions have previously been reported (Burgass and Powell, 1984). Although surface dried seeds germinate more rapidly than dried back ones, they are required to be sown immediately after the treatment, as they cannot be stored due to the high seed moisture content which may trigger physiological ageing and seed quality loss during storage; however, it is possible to store treated and dried back ones for a few months depending on the storage conditions (McDonald, 1999).

The hydration treatments that we used in this study are quick and easy to apply. Harris *et al.* (1999) described that easy and cheap alternative treatments are economically feasible for poor farmers in less developed parts of the world. As a conclusion, our results also showed that flower transplant producers can also use hydration treatment to get a faster and well developed transplant production.

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