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Germination and field emergence in osmotic and solid matrix priming in onion (*Allium cepa*)

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Rapid and uniform seedling emergence is a pre-requisite to better stand establishment and subsequent plant growth and yield in vegetable crops. The most promising technique of improving the rate and uniformity of the seedling establishment is seed priming (Taylor *et al*. 1998). Seed priming can improve germination and seedling emergence in a number of vegetable crops by reducing the time required for the seeds to emerge and produce seedlings. Seed priming allows seed to imbibe moisture using certain protocols, followed by re-drying to permit routine handling (Heydecker 1973). This is a process of controls hydration of seed to a level that allows pre germination activity but does not permit primary root protrusion. Various pre-sowing treatments have been used to increase the rate and uniformity of emergence in many vegetable and flower species (Parera and Cantliffe 1994). Osmotic priming has shown to promote increases in the rate and uniformity of germination in several crops (Cantliffe 2003, Pandita and Nagarajan 2000, Pandita *et al*. 2007). Solid matrix priming (SMP) developed by Eastin (1990) used solid matrix materials, water and seed in combination that control water, oxygen and temperature effect on germination. Hydration of the seed is restricted to a level that allows 'pre-germination' activity but prevents redicle emergence. Seed water uptake is regulated by the matric potential of the seed. The characteristics of the solid matrix system, minimizes problems of aeration and facilitates the incorporation of fungicides or biological agents. The success of priming conditions depends on environmental conditions such as temperature, aeration and light, duration of treatment, osmotic potential of the solution, seed quality and drying. Since incidence of pathogens is a critical factor affecting germination of onion seeds these seed enhancements treatments need to be standardized for better germination and field performance.

Seeds harvested from onion (*Allium cepa* L. cv. Pusa Red) crop grown at the experimental field of Indian Agricultural Research Institute, Regional Station, Karnal during winter season of 2009-10 was used for priming experiment. Seed were hermetically sealed in aluminium foil packets and stored at room temperature before performing priming treatments. For solid matrix priming 100 g seed per replicate were mixed with 200 g vermiculite to which 250 ml of distilled water was added. These were then incubated for 12, 24, 36 and 48h at 15°C and 20°C temperature. After the completion of incubation period of each treatment, seeds were sieved out and dried to the original moisture content. Seeds of onion were osmotically primed on one layer of filter paper wetted with different potentials of PEG 6000 solution (-0.5MPa, -1.0MPa and -1.5MPa) in 9cm diameter petri dishes. In this treatment, 10 petri dishes for each treatment were kept under dark in an incubator at 25° C for 2, 4, and 6 day durations. After the completion of treatment duration, seeds were washed in running water to remove osmoticum and redried to their original moisture content in cold room at 15°C and 30% relative humidity. Osmotic priming was standardized using PEG6000 at 20°C. To maintain constant osmotic potential, the solution was changed every 48 hr and evaporation of solution was reduced by sealing the Petri dishes with Parafilm. Germination was performed as per ISTA (2004) procedures. One hundred seeds per replicate were used. Seeds were incubated in growth cabinets (Sanyo, Japan) maintained at 20°C. Daily germination counts were performed until no further germination occurred for three consecutive days, when percentage and speed of germination were calculated. Seedling vigour indices were calculated following formula suggested by Abdul-Baki and Anderson (1973). Seedling length was recorded by taking 10 normal seedlings at random from each replication and root and shoot length of each seedling was measured. The mean value was measured in cm. For seedling dry weight 10 normal seedlings per replication were selected at random and were dried in a hot air oven maintained at 80 ± 1°C for 24 hr. Seedling dry weight was expressed as g/10 seedling.

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Table 1 Effect of solid matrix priming duration and temperature on seed quality parameters of onion

Priming duration (h)	Temperature (°C)		Mean	Temperature (°C)		Mean
	15	20		15	20	
	Germination (%)			Speed of germination		
12	77.3	81.3	79.3a	14.08	16.36	15.22b
24	80.6	82.6	81.6a	16.56	17.34	16.95a
36	79.3	69.3	74.3b	15.68	14.94	15.31b
48	70.6	51.6	61.1	11.65	10.95	11.30c
Mean	77.0A	71.2B		14.49	14.90	
CD (P=0.05)		Duration	2.66	CD (P=0.05)	Duration	1.04
		Temperature	1.88		Temperature	N.S
		Interaction	3.77		Interaction	1.48
	Vigour index-I			*Vigour index-II*		
12	637.0	746.8	691.9c	2.49	3.04	2.77b
24	814.7	881.5	848.1a	2.90	3.40	3.15a
36	804.1	714.8	759.4b	2.90	2.63	2.77b
48	789.2	656.8	723.0bc	2.87	2.68	2.78b
Mean	761.3	750.0		2.79	2.94	
CD (P=0.05)		Duration	42.75	CD (P=0.05)	Duration	0.226
		Temperature	NS		Temperature	N.S
		Interaction	60.46		Interaction	0.320

Means followed by the same letters are not significantly different. Separation by Duncan's Multiple Range test at 5% level of significance.

Based on the observations recorded on germination, speed of germination and vigour index of primed seeds, two best treatments each in osmopriming and SMP were selected for field performance along with control. In all these six treatments were sown in the field following standard package and practices. The experiment was laid in a Randomized Complete Block Design (RCBD) with four replications. Field emergence percentage was estimated on the basis number of seedling emerged after 21 days of sowing (DAS). Field emergence index (FEI) was calculated based on the procedure used by Egli and Tekrony (1985).

Solid matrix priming for 24 hr significantly improved seed germination (81.6%) over other treatment durations. With increase in priming duration from 24 to 48 hr, there was a significant decrease in germination. The seed germination of SMP seeds for 48 hr was significantly reduced to 61.1% (Table 1). Among the different priming temperatures tested, higher seed germination of 77% was noticed at 15°C as compared to priming performed at 20°C (71.2%). The interaction effect of priming duration and temperature revealed that solid matrix priming for 24 hr at 20°C gave maximum seed germination (82.6%) over all other treatment combinations. The minimum seed germination of 51.6% was recorded at a priming duration of 48 hr and 20°C temperature. SMP improved laboratory germination at suboptimal temperatures (15°C) and reduced mean days to germination from 12.0 days (non-primed) to 8.5 days (Pandita *et al*. 2010). A priming duration of 24 hr gave maximum speed of germination (16.95) while priming duration of 48 hr gave minimum value of speed of germination (11.30). Temperature had no significant differences on speed of germination in onion. The interaction effect of priming duration and temperature revealed that solid matrix priming for 24 hr at 20°C is optimum for obtaining maximum speed of germination (17.34) over all other treatment combinations. Priming durations of 24 hr gave higher vigour index-I (848.1) as compared to 12 hr durations (691.9). Maximum vigour index I (881.5) was obtained in solid matrix primed seeds for 24 hr duration at 20°C while minimum values were recorded at 12 hr duration and 15°C treatment. Similar results were obtained for vigour index II. Lin and Sung (2001) and Pandita *et al*. (2007) reported that solid matrix primed seeds had rapid and greater final germination as compared to non-primed seeds under sub-optimal temperatures in bittergourd and hot pepper, respectively. Taylor *et al.* (1988) reported that SMP treatment reduced the time between seeding and emergence of tomato, onion and carrot seeds compared to non-primed seed.

Seed germination improved significantly with the increase in PEG potential from –0.5 MPa (67.1%) to –1.5 MPa (78%). Osmopriming for 2 days significantly improved seed germination (82.6%). With increase in priming duration from 2 days to 6 days, there was significant decrease in germination (Table 2). The interaction effect of PEG potential and priming duration revealed that osmopriming for 2 days at –1.0 MPa PEG potential gave maximum seed germination (86.6%) over all other treatment combinations. Osmotic priming has shown to promote increases in the rate and uniformity of germination in several crops (Heydecker and Coolbear 1977, Pil 1995, Pandita and Nagarajan 2000, Nagarajan 2005). Osmopriming at –1.0 MPa PEG potential significantly improved speed of germination (7.07) and was at par to –0.5MPa PEG6000 priming treatment. The speed of germination decreases

Table 2 Effect of osmopriming potential and duration on seed quality parameters of onion

Priming Potential (MPa)	Duration (days)			Mean	Duration (days)			Mean
	2	4	6		2	4	6	
	Germination (%)				Speed of germination			
–0.5	80.6	69.3	51.3	67.1b	7.66	7.80	5.37	6.94a
–1.0	86.6	66.0	50.6	67.7b	8.35	6.58	6.28	7.07a
–1.5	80.6	81.3	72.0	78.0a	7.34	5.39	5.65	6.13b
Mean	82.6A	72.2B	58.0C		7.78A	6.59B	5.77C	
CD (P=0.05)		Potential	2.57		CD (P=0.05)	Potential	0.35	
		Duration	2.57			Duration	0.35	
		Interaction	4.46			Interaction	0.61	
		Vigour index-I				*Vigour index-II*		
–0.5	851.93	833.74	803.84	829.40a	3.54	2.80	2.49	2.94a
–1.0	880.48	816.81	809.31	835.53a	3.48	3.13	2.86	3.16a
–1.5	813.20	822.22	796.26	810.56b	3.11	3.20	3.21	3.17a
Mean	848.53A	824.26B	803.13AB		3.37A	3.05B	2.85B	
CD (P=0.05)		Potential	16.83		CD (P=0.05)	Potential	NS	
		Duration	16.83			Duration	0.295	
		Interaction	29.16			Interaction	0.512	

Means followed by the same letters are not significantly different. Separation by Duncan's Multiple Range test at 5% level of significance.

significantly with the increase of priming duration from 2 days to 6 days. The interaction effect of PEG potential and priming duration revealed that osmopriming at –1.0 Mpa PEG potential for 2 days had maximum speed of germination (8.35) than other treatment combinations. Osmopriming at –1.0 MPa PEG significantly improved vigour index-I (835.53) than any other PEG potential. Lowest vigour index-I was recorded in osmopriming at PEG potential of –1.5 MPa. With increase in priming duration from 2 days to 6 days, there was significant decrease in vigour index-I. The interaction effect of PEG potential and priming duration revealed that osmopriming for 2 days at –1.0 MPa gave maximum vigour index-I (880.48) over all other treatment combinations. Osmopriming at 0.5, 1.0 and 1.5 MPa PEG potential showed vigour index-II of 2.94, 3.16 and 3.17, respectively. It has been demonstrated with muskmelon (Oluoch and Welbaum, 1996) that an optimal priming treatment is required to achieve the best criteria in seed vigour.

Seed priming has shown benefits for improving seedling emergence and speed under a wide variety of environmental conditions (Cantliffe 2003). Based on the above observations two best treatments each in osmopriming and SMP were selected for field performance along with control. Osmopriming using –1.0 MPa PEG 6000 for 2 days gave maximum germination percentage (86%) and was at par with solid matrix priming at 20°C for 24 hr (Table 3). Priming reduced the number of abnormal seedlings thereby improved the performance of poorer seeds within a lot Hydropriming onion seed significantly reduced seed germination over unprimed control. Osmopriming at –1.0 MPa for 2 days significantly improved field emergence of onion seed and was at par to solid matrix priming at 20°C for 24 hr Minimum field emergence of 48.7% was recorded

Table 3 Effect of various priming treatments on germination and emergence in onion

Treatment	Standard germination test			Field emergence (%)	Field emergence index
	Normal seedlings (%)	Abnormal seedlings (%)	Dead seed (%)		
Solid matrix priming at 15°C for 24 hr	80.7b	8.5c	10.7	54.7b	67.8b
Solid matrix priming at 20°C for 24 hr	84.7a	5.0d	10.2	60.0a	70.8ab
Osmopriming at –1.0 MPa for 2 days	86.0a	4.0d	10.0	61.7a	71.8b
Osmopriming at –1.5 MPa for 4 days	81.2b	8.5c	10.2	56.2b	69.7b
Hydropriming 24 hr	69.7d	20.2a	10.0	52.0c	74.5a
Dry control	71.7c	17.5b	10.7	48.7d	67.9b
CD(P=0.05)	1.72	2.49	NS	2.70	3.78

Means followed by the same letters are not significantly different. Separation by Duncan's Multiple Range test at 5% level of significance.

in control (dry seed). Poor field stand establishment in commercial onion production has led increased seeding rates and resulted in slower emergence of seedlings (Pill 1995). For onion growers a simple method of seed priming for maintaining seed vigour was found to be highly beneficial (Parera and Cantliffe 1994). After priming the rate, synchrony, and percentage of germination/emergence of seedlings were found to be higher for primed seeds as compared to the control. Maximum field emergence index (74.5) was recorded in osmoprimed seed at –1.5 MPa. Seed priming has been reported to increase yield of direct seeded crops like chickpea, maize, rice and wheat under semiarid conditions (Harris *et al.*1999, Musa *et al.* 2001, Harris and Mottram 2004). The beneficial effects reported in these crops were faster emergence, better drought tolerance, early flowering and higher grain yield. The results indicate that osmopriming (–1.0 MPa for 2 days) and solid matrix priming (at 20°C for 24 hr) can be successfully used to improve germination and field emergence of onion seeds.

SUMMARY

Solid matrix priming for 24 hr significantly improved seed germination (81.6%) as compared to 12 hr, 36 hr or 48 hr duration. A priming duration of 24 hr gave maximum speed of germination (16.95) while priming duration of 48 hr gave minimum value for speed of germination. No significant differences in speed of germination were found at different temperatures. The interaction effect of priming duration and temperature revealed that solid matrix priming for 24 hr at 20°C is optimum for obtaining maximum speed of germination (17.34). Maximum vigour index I (848.1) was obtained in solid matrix primed seeds for 24 hr duration at 20°C temperature. Osmopriming using PEG 6000 (–1.5MPa) significantly improved seed germination (78%). With increase in priming duration from 2 days to 6 days, there was significant decrease in germination. Osmopriming at –1.0 MPa PEG potential significantly improved speed of germination (7.78) as compared to –0.5 and –1.5MPa potential. The interaction effect of PEG potential and priming duration revealed that osmopriming for 2 days at –1.0 MPa PEG potential gave maximum speed of germination (8.35) over all other treatment combinations. Osmopriming using PEG 6000 (–1.0MPa for 2 days) improved germination by 14.3 percent and field emergence by 13 percent over control. Solid matrix priming for 24 hr at 20ºC also improved germination by 13 percent and field emergence by 11.3 percent over control. These results indicate that osmopriming and solid matrix priming can be effectively employed to prime onion seeds for improved field performance.

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