# Effect of seed priming and storability on okra (*Abelmoschus esculentus* L) seed

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## ABSTRACT

The study consisted of two separate experiments conducted under laboratory conditions. Firstly, hydropriming duration was standardized for okra seed and then the effect of hydropriming and osmopriming on its storability was assessed. The experiment for standardization of hydropriming duration (16, 24,32,40 and 48 h) laid out in CRD revealed that amongst all seed hydropriming treatments, hydropriming of okra seed for 24 h at room temperature was found to be the best as it resulted in maximum germination and vigour. The seeds of okra cv P-8 were primed with 12 treatments comprising osmopriming with two concentrations of PEG-6000 (–0.5 and –1.0 M Pa) for five different durations (16, 24, 32, 40 and 48 h), hydropriming for 24 h and control (no priming). The seed storage studies were carried out in the laboratory and the stored seeds were tested in CRD with four replications. The primed seeds were stored for three, six, nine and twelve months before testing for germination and vigour at 25°C in the germinator using paper towel. It was found that seeds primed with PEG 6000 (–0.5M Pa) for 24 h exhibited best results in terms of characters like speed of germination, germination percentage, seedling length and dry weight and vigour index-I and II when these were stored up to 12 months. However after 12 months of storage, there was a sharp decline in germination and vigour of the primed seeds.

**Keywords:** Hydropriming; osmopriming; polyethylene glycol; germination; seedlings

## INTRODUCTION

Okra (*Abelmoschus esculentus* L) is an important member of family Malvaceae. It has its origin in tropical Africa. The crop being highly nutritious is considered a good source of valuable nutrients. It is also called a perfect 'villager's vegetable' due to its robust nature, dietary fibres and distinct seed protein balanced both in lysine and tryptophan amino acids (Kumar et al 2010). It is medicinally used as plasma replacement or blood volume expander. The green tender fruits are quite rich in calcium and iron and edible vitamins A, B and C. The genus *Abelmoschus* (2n= 130) includes about thirty species in the old world, four in the new world and four in Australia. *A tuberculatus* with n= 29 is the progenitor of *A esculentus*. Almost all parts of the okra plant are economical. It is an annual vegetable crop cultivated in tropical and subtropical regions of Africa and Asia. It thrives well in the hot humid season. It is mainly grown as a summer and rainy season crop in India (Baloch 1994). Uttar Pradesh, Andhra Pradesh, West Bengal, Bihar, Maharashtra and Karnataka are the major okra growing states in India. In India, the crop is cultivated in an area of 513 thousand hectares with production of 6,170 thousand metric tonnes (Anon 2019). In Himachal Pradesh, the crop is grown during summer and rainy seasons in low and mid hills occupying an area of 3.39 thousand hectares with annual production of 45.98 thousand metric tonnes (Anon 2018). The presence of hard seed coat in okra is a major physiological problem to rapid water imbibition and uniform stand establishment in the field. The most recent studies have reported an interrelationship between seed moisture content and hard seededness. Several reports indicate that the percentage of hard seeds showed a progressive decline with increasing moisture content. Seed producers often leave the seeds in pods until they dry completely to moisture less than 10 per cent that results in higher proportion of hard seeds in a lot.

Environmental factors such as inadequate or excessive soil moisture, low soil temperature and soil crusting also contribute to erratic seed germination in okra. Since most of the environmental factors are often beyond human control, modification of the seed by either biological, chemical or physiological techniques needs to be evaluated to improve seedling vigour and stand uniformity under field conditions. The problem of seed germination in okra can be overcome by many techniques and seed priming is one of them. Seed priming is a pre-sowing seed treatment wherein seeds are allowed to imbibe water to start pre-germinative metabolic processes but insufficient for radical protrusion. The activity of many enzymes involved in mobilization of food reserves is triggered through seed priming (Srinivasan et al 2009). After priming, seeds are dried back to original moisture content to enable normal handling, storage and planting (Varier et al 2010). But before priming any crop seed, the knowledge of safe limits of priming duration is very important to get maximum beneficial effect. Priming not only improves the seed germination under sub-optimal temperature conditions but also helps to soften the hard seed coat. Hydropriming can be achieved by continuous or successive addition of a limited amount of water to the seeds. Hydropriming is a very important technique which results in rapid germination and uniform stand establishment in various crops (Adebisi et al 2013). Seed germination and seedling growth have been reported to be improved through the process of hydropriming. It is a very simple, economical and environment friendly technique because simple water is used in it. Osmopriming has been reported to give good crop stand even under sub-optimal conditions of temperature and moisture (Bradford 1986). The effect of hydropriming and osmopriming was assessed as a method of seed priming.

## MATERIAL and METHODS

The present investigations were carried out in the Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the year 2017-18 under two different experiments.

The first experiment consisted of five hydropriming durations (16, 24, 32, 40 and 48 h) to determine maximum water absorption capacity of the seeds and tri-phasic graph for seed germination. For hydropriming treatment, seeds were completely immersed in water in the ratio of 1:4 (one part of seeds and 4 parts of water). Two thousand seeds were taken for each treatment of hydropriming. After hydropriming, the seeds were shade-dried to reduce the moisture content to 8 per cent. The okra seeds (2,000 seeds for each treatment) were hydroprimed for 8 hours interval up to 48 h.

The second experiment involved osmopriming with –0.5 and –1.0 M Pa polyethylene glycol (PEG-6000) for five durations (16, 24, 32, 40 and 48 h), hydropriming for 24 h and control (no priming) at room temperature (26°C). First of all 2,000 seeds per treatment were counted, weighed and put into sterilized plastic Petri plates and seed priming was done as per the treatment. The osmotic potentials of –0.5 and –1.0 M Pa were prepared by dissolving 202.13 and 295.713 g of PEG-6000 in one litre of water respectively (Bujaski and Nienow 1991).

After priming for different durations, the seeds were taken out and washed with tap water 3-4 times. The primed seeds were then dried in shade to their original moisture content of 8 per cent before storage at room temperature. The treated seeds were tested for different quality parameters at 7 days, 3 months, 6 months, 9 month and 12 months after priming. The following observations were recorded under both the experiments:

**Seed weight immediately after hydropriming:** The wet seeds after hydropriming were weighed in an analytical balance and allowed to dry back to their original moisture content. The per cent increase in seed weight was calculated as:

$$\text{Seed weight increase (\%)} = \frac{\text{Final weight of seed (g)} - \text{Initial weight of seed (g)}}{\text{Initial weight of seed (g)}} \times 100$$

**Speed of germination:** High speed of germination is an indication of vigorous seed lot. Number of germinated seeds was counted every day from the first day and the cumulative index was worked out using formula given by Maguire (1962):

$$\text{Speed of germination} = \Sigma (n/t)$$

where n= Number of newly germinating seeds, t= Days after sowing

**Germination percentage:** Four hundred seeds from each treatment were taken and the test was carried out in four replications having 100 seeds each. The seeds were allowed to germinate using between paper method at 25°C. The germination count was taken on 4th day of the test. Germination percentage was worked out by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings germinated}}{\text{Total number of seeds kept for germination}} \times 100$$

**Seedling length:** Ten normal seedlings selected at random at first count were used to work out the seedling length. Seedling length was worked out by taking the total length of seedlings from the tip of the primary leaf to the tip of primary root with the help of a scale.

**Seedling dry weight:** Ten normal seedlings selected for measuring seedling length were used to calculate seedling dry weight. Seedlings were put in butter paper pocket and kept in oven at 60°C for 48 h and seedling dry weight was recorded.

**Seed vigour index-I:** Seed vigour index-I was calculated as per the formula given by Abdul-Baki and Anderson (1973):

$$\text{Seed vigour index-I} = \text{Germination (\%)} \times \text{Seedling length (cm)}$$

**Seed vigour index-II:** Seed vigour index-II was also calculated as per the formula given by Abdul-Baki and Anderson (1973):

$$\text{Seed vigour index-II} = \text{Germination (\%)} \times \text{Seedling dry weight (mg)}$$

## RESULTS and DISCUSSION

### Standardization of hydropriming duration of okra seeds

**Seed weight immediately after hydropriming:** The data on wet weight of seed as influenced by different hydropriming durations and subsequently per cent increase in seed weight were worked out and are presented in Table 1. The weight of seeds increased sharply up to 24 hours and thereafter a small increase in weight was observed till 48 hours. After 48 hours, seeds started to germinate and again weight started to increase. Seed weight increase from 19.69 to 42.92 per cent was considered as Phase I of germination stage where rapid water absorption occurred followed by lag phase (Phase II) with little changes in weight increase from 42.92 to 44.08 per cent. A subsequent increase in weight increase ranged from 44.27 to 46.41 per cent which was considered as Phase III. Thus the range from 19.69 to 46.41 per cent weight increase was taken as a seed hydropriming regime.

As seeds also maintained their desiccation tolerance in Phases I and II of germination, it is important to note that seed hydropriming in okra should be done for 24 hours only to maintain desiccation tolerance and also to get maximum benefits of hydropriming.

**Seed quality parameters:** The highest values for seed germination (83.40%), speed of germination (24.52), seedling length (10.90 cm), seedling dry weight (21.42

mg), seed vigour index-I (909.00) and seed vigour index-II (1,786.10) were recorded when hydropriming was done for 24 hours (Table 1). The possible reason for enhanced values of germination, speed of germination, seedling length, seedling dry weight, seed vigour index-I and seed vigour index-II with the hydropriming of seeds for 24 hours might be ascribed to the fact that during seed priming there is a rapid initial uptake of water leading to ignition of metabolic processes making conditions favorable for early and fast germination (Arif 2005).

Furthermore there is sufficient increase in intercellular space in the hydroprimed seeds that facilitates sharp uptake of water resulting in the acceleration of germination speed (Argerich and Bradford 1989). So much so, some other physiological and biochemical processes might have increased the requisite physiological activities of the embryo and mobilized the food reserves into the growing seedlings (Doijode and Raturi 1987). Ultimately above cited reasons might have contributed for increasing the seedling length and seedling dry weight as well as seed vigour index-I and II. On the other hand, minimum values obtained for the said parameters at higher priming durations may be due to adverse effect of prolonged soaking because of decrease in the repairing activities of DNA (van Pijlen et al 1996).

**Effect of hydropriming and osmopriming on storability of okra seeds**

**Speed of germination:** A perusal of the data in Table 2 indicates that maximum speed of germination (39.66) was observed when the seeds were primed with PEG-6000 (–0.5 M Pa) for 24 hours and statistically minimum value (19.99) was recorded in the non-primed seeds.

In case of storage durations, the highest speed of germination (31.00) was observed when primed seeds were stored for 7 days which was found to be statistically superior over other durations. Minimum speed of germination (27.69) was recorded at 12 MAP. Among the interactions, maximum speed of germination (39.95) was recorded in the seeds primed with PEG-6000 (–0.5M Pa) for 24 hours and stored for 7 days.

The speed of germination (18.25) was observed to be lowest in the non-primed seeds stored for 12 months. The possible reason for fastest speed of germination of the seeds primed with PEG 6000 (–0.5 M Pa) for 24 hours for 7 days of storage may be as a consequence of rapid imbibition of priming solution as well as reviving the various metabolic activities resulting in higher and faster germination rate including reduction in the inherent physiological heterogeneity during the processes of germination. Rowse (1996) also made similar observations.

**Germination percentage:** The data (Table 3) show that maximum germination (94.81%) occurred in seeds primed with PEG-6000 (–0.5 M Pa) for 24 hours while minimum (76.27%) was recorded in non-primed seeds. Significantly highest percentage of germination (88.11) was observed when primed seeds were stored for 7 days whereas significantly lowest germination (83.36%) was recorded in control. The interactive effects of priming treatments and storage durations of primed seeds revealed maximum germination (95.35%) in the PEG-6000 (–0.5 M Pa for 24 h) primed seeds stored for 7 days. The germination percentage (71.75) was observed to be minimum in non-primed seeds stored for 12 months.

It is a well established fact that enhancement of seed germination after priming is mainly as a result of stimulation of hydrolytic enzymes which are responsible for breakdown of food reserves into sugars thus promoting germination through cell division. On the contrary, non-primed seeds exhibited poor germination which might be due to lesser water uptake by the seeds leading to improper activation of warranted enzymes (Ashraf et al 2002, Guerrier 1988).

With the increase in storage period of primed seeds, there was corresponding reduction in germination percentage and this may be due to loss of vigour owing to ageing of seeds. The ageing process might have lead to higher deterioration of particularly catalase and peroxidase activities resulting into less germination.

**Seedling length:** The data presented in Table 4 indicate that tallest seedlings (16.90 cm) were in seeds primed with PEG-6000 (–0.5 M Pa) for 24 hours and minimum (9.13 cm) in control. Amongst the durations of storage, significantly longest seedlings (13.79 cm) were produced when primed seeds were stored for 7 days and the shortest (11.82 cm) in non-primed seeds. The interactions, priming treatments and storage durations exhibited tallest seedlings (17.00 cm) when seeds were primed with PEG-6000 (–0.5 M Pa) for 24 hours and stored for 7 days which was found to be

Table 1. Standardization of hydropriming duration for okra seed

| Treatment (h) | Seed weight immediately after hydropriming (g) | Germination (%) | Speed of germination | Seedling length (cm) | Seedling dry weight (mg) | SVI-1 | SVI-II |
|---|---|---|---|---|---|---|---|
| $T_1$ (16) | 66.82 | 82.18 (9.12) | 23.27 | 10.300 | 20.90 | 846.37 | 1,717.04 |
| $T_2$ (24) | 72.48 | 83.40 (9.18) | 24.52 | 10.900 | 21.42 | 909.00 | 1,786.10 |
| $T_3$ (32) | 72.93 | 81.00 (9.05) | 22.47 | 10.125 | 19.60 | 819.90 | 1,587.45 |
| $T_4$ (40) | 73.92 | 79.50 (8.91) | 21.00 | 9.300 | 18.92 | 739.15 | 1,504.15 |
| $T_5$ (48) | 76.35 | 77.50 (8.86) | 20.12 | 8.550 | 18.42 | 662.95 | 1,427.75 |
| $CD_{0.05}$ | - | (0.09) | 1.20 | 0.880 | 1.25 | 67.41 | 82.51 |

Table 2. Effect of seed priming treatments and storage period on germination speed of okra seed

| Treatment | Germination speed after | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAP | 3 MAP | 6 MAP | 9 MAP | 12 MAP | Mean |
| $T_1$: Priming with PEG-6000 (-0.5 M Pa) for 16 h | 36.93 | 36.38 | 35.70 | 34.68 | 34.45 | 35.63 |
| $T_2$: Priming with PEG-6000 (-0.5 M Pa) for 24 h | 39.95 | 39.60 | 39.70 | 39.58 | 39.45 | 39.66 |
| $T_3$: Priming with PEG-6000 (-0.5 M Pa) for 32 h | 36.18 | 35.48 | 34.73 | 33.43 | 32.93 | 34.55 |
| $T_4$: Priming with PEG-6000 (-0.5 M Pa) for 40 h | 32.30 | 31.20 | 30.43 | 30.03 | 29.40 | 30.67 |
| $T_5$: Priming with PEG-6000 (-0.5 M Pa) for 48 h | 29.13 | 28.58 | 27.75 | 27.20 | 26.63 | 27.86 |
| $T_6$: Priming with PEG-6000 (-1.0 M Pa) for 16 h | 24.60 | 23.78 | 23.18 | 22.60 | 21.15 | 23.06 |
| $T_7$: Priming with PEG-6000 (-1.0 M Pa) for 24 h | 37.00 | 36.00 | 34.75 | 34.63 | 35.55 | 35.59 |
| $T_8$: Priming with PEG-6000 (-1.0 M Pa) for 32 h | 34.70 | 33.50 | 31.50 | 30.25 | 29.25 | 31.84 |
| $T_9$: Priming with PEG-6000 (-1.0 M Pa) for 40 h | 28.00 | 26.35 | 25.38 | 24.53 | 23.88 | 25.63 |
| $T_{10}$: Priming with PEG-6000 (-1.0 M Pa) for 48 h | 25.38 | 24.93 | 23.95 | 22.90 | 22.55 | 23.94 |
| $T_{11}$: Hydropriming for 24 h | 24.53 | 21.88 | 21.00 | 19.88 | 18.80 | 21.22 |
| $T_{12}$: No priming | 23.28 | 20.48 | 19.38 | 18.58 | 18.25 | 19.99 |
| Mean | 31.00 | 29.84 | 28.95 | 28.19 | 27.69 | |

DAP= Days after priming, MAP= Months after priming
$CD_{0.05}$: Priming= 0.65, Storage= 0.42, Priming x storage= 1.46

statistically at par with the storage durations of 3 months (16.98 cm), 6 months (16.88 cm), 9 months (16.85 cm) and 12 months (16.78 cm) as well. The seedling length (8.08) was observed to be minimum when non-primed seeds were stored for 12 months.

Saxena (1980) was of the opinion that primed seeds, regardless of priming conditions (temperature, storage period and duration of treatment), germinate more rapidly and produce taller seedlings with better growth in comparison to non-primed seeds. It may be due to enhanced enzymatic activities of catalase, peroxidase, amylase and invertase in the seeds treated with PEG 6000 (-0.5 M Pa) for 24 hours. Further, there may be an increase in protein, sugar and RNA content which might have resulted in quicker germination and better growth resulting into more seedling length. Singh (1984) had also got almost identical results in the PEG primed seeds. However Heydecker et al (1974) on the other hand advocated that priming accelerated all the processes warranted for germination mainly because of high osmotic potential but prevented emergence of radical. The seedling length in general decreased as the storage period progressed. This may be due to rapid deterioration when primed seeds are stored for a longer period.

Bradford (1986) had also obtained similar effects of priming. Similar findings in tomato by Alvarado and Bradford (1988), Argerich et al (1989) and Owen and Pill (1994) as well as in wheat by Nath et al (1991) have been reported. Minimum seedling length observed in the untreated seeds may be because of the fact that non-primed seeds failed to catalyze the enzymatic, physiological and biochemical activities leading to lesser growth of seedlings which justifies the application of priming agents (Bittencourt et al 2005). Besides extensive accumulation of nucleic acids

Table 3. Effect of seed priming treatments and storage period on germination of okra seed

| Treatment | Germination (%) after | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAP | 3 MAP | 6 MAP | 9 MAP | 12 MAP | Mean |
| $T_1$: Priming with PEG-6000 (-0.5 M Pa) for 16 h | 92.50 (9.67) | 92.43 (9.67) | 92.28 (9.66) | 92.05 (9.65) | 91.98 (9.64) | 92.25 (9.66) |
| $T_2$: Priming with PEG-6000 (-0.5 M Pa) for 24 h | 95.35 (9.82) | 95.08 (9.80) | 94.63 (9.78) | 94.75 (9.79) | 94.25 (9.76) | 94.81 (9.79) |
| $T_3$: Priming with PEG-6000 (-0.5 M Pa) for 32 h | 90.83 (9.58) | 89.78 (9.53) | 88.05 (9.44) | 87.03 (9.38) | 86.25 (9.34) | 88.39 (9.45) |
| $T_4$: Priming with PEG-6000 (-0.5 M Pa) for 40 h | 90.22 (9.55) | 89.23 (9.50) | 88.00 (9.43) | 86.45 (9.35) | 84.45 (9.24) | 87.67 (942) |
| $T_5$: Priming with PEG-6000 (-0.5 M Pa) for 48 h | 86.72 (9.37) | 85.10 (9.28) | 84.28 (9.23) | 83.05 (9.17) | 81.85 (9.10) | 84.20 (9.23) |
| $T_6$: Priming with PEG-6000 (-1.0 M Pa) for 16 h | 83.45 (9.13) | 82.73 (9.15) | 82.68 (9.15) | 82.93 (9.16) | 83.05 (9.17) | 82.97 (9.16) |
| $T_7$: Priming with PEG-6000 (-1.0 M Pa) for 24 h | 90.38 (9.56) | 90.28 (9.55) | 89.93 (9.54) | 89.25 (9.50) | 89.45 (9.51) | 89.86 (9.53) |
| $T_8$: Priming with PEG-6000 (-1.0 M Pa) for 32 h | 89.38 (9.51) | 87.35 (9.40) | 85.90 (9.32) | 84.85 (9.27) | 85.05 (9.28) | 86.51 (9.35) |
| $T_9$: Priming with PEG-6000 (-1.0 M Pa) for 40 h | 88.16 (9.44) | 86.84 (9.37) | 84.95 (9.27) | 83.68 (9.20) | 82.98 (9.16) | 85.32 (9.29) |
| $T_{10}$: Priming with PEG-6000 (-1.0 M Pa) for 48 h | 86.01 (9.33) | 84.23 (9.23) | 82.55 (9.14) | 79.23 (8.96) | 76.45 (8.88) | 81.69 (9.09) |
| $T_{11}$: Hydropriming for 24 h | 83.41 (9.19) | 81.73 (9.10) | 79.75 (8.99) | 74.68 (8.70) | 72.80 (8.59) | 78.47 (8.91) |
| $T_{12}$: No priming | 80.87 (9.05) | 79.63 (8.98) | 75.60 (8.75) | 73.50 (8.63) | 71.75 (8.53) | 76.27 (8.79) |
| Mean | 88.11 (9.44) | 87.03 (9.38) | 85.72 (9.31) | 84.29 (9.23) | 83.36 (9.18) | |

Figures in parentheses are square root transformed values; DAP= Days after priming, MAP= Months after priming
$CD_{0.05}$: Priming= 0.05, Storage= 0.03, Priming x storage= 0.11

Table 4. Effect of seed priming treatments and storage period on seedling length (cm) on of okra

| Treatment | Length (cm) after | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAP | 3 MAP | 6 MAP | 9 MAP | 12 MAP | Mean |
| $T_1$: Priming with PEG-6000 (-0.5 M Pa) for 16 h | 16.15 | 15.98 | 15.88 | 15.93 | 15.95 | 15.98 |
| $T_2$: Priming with PEG-6000 (-0.5 M Pa) for 24 h | 17.00 | 16.98 | 16.88 | 16.85 | 16.78 | 16.90 |
| $T_3$: Priming with PEG-6000 (-0.5 M Pa) for 32 h | 16.20 | 15.43 | 14.83 | 14.20 | 13.58 | 14.85 |
| $T_4$: Priming with PEG-6000 (-0.5 M Pa) for 40 h | 15.35 | 14.33 | 13.53 | 13.13 | 12.35 | 13.74 |
| $T_5$: Priming with PEG-6000 (-0.5 M Pa) for 48 h | 14.18 | 13.35 | 12.65 | 11.80 | 10.00 | 12.40 |
| $T_6$: Priming with PEG-6000 (-1.0 M Pa) for 16 h | 13.73 | 12.90 | 12.38 | 11.65 | 10.25 | 12.18 |
| $T_7$: Priming with PEG-6000 (-1.0 M Pa) for 24 h | 16.08 | 16.00 | 15.98 | 15.95 | 15.58 | 15.92 |
| $T_8$: Priming with PEG-6000 (-1.0 M Pa) for 32 h | 12.63 | 11.88 | 11.28 | 10.90 | 10.45 | 11.43 |
| $T_9$: Priming with PEG-6000 (-1.0 M Pa) for 40 h | 11.88 | 11.08 | 10.60 | 10.05 | 9.53 | 10.63 |
| $T_{10}$: Priming with PEG-6000 (-1.0 M Pa) for 48 h | 11.23 | 11.10 | 10.35 | 9.90 | 9.80 | 10.48 |
| $T_{11}$: Hydropriming for 24 h | 10.90 | 10.58 | 10.15 | 9.88 | 9.55 | 10.21 |
| $T_{12}$: No priming | 10.20 | 9.63 | 9.15 | 8.60 | 8.08 | 9.13 |
| Mean | 13.79 | 13.27 | 12.80 | 12.40 | 11.82 | |

DAP= Days after priming, MAP= Months after priming
$CD_{0.05}$: Priming= 0.32, Storage= 0.21, Priming x storage= 0.71

Table 5. Effect of seed priming treatments and storage period on seedling dry weight of okra

| Treatment | Dry weight (g) after | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAP | 3 MAP | 6 MAP | 9 MAP | 12 MAP | Mean |
| $T_1$: Priming with PEG-6000 (-0.5 M Pa) for 16 h | 28.66 | 27.95 | 26.80 | 25.78 | 24.08 | 26.65 |
| $T_2$: Priming with PEG-6000 (-0.5 M Pa) for 24 h | 32.13 | 30.95 | 29.53 | 28.15 | 27.05 | 29.56 |
| $T_3$: Priming with PEG-6000 (-0.5 M Pa) for 32 h | 28.04 | 26.80 | 25.68 | 25.20 | 23.33 | 25.81 |
| $T_4$: Priming with PEG-6000 (-0.5 M Pa) for 40 h | 27.20 | 25.93 | 24.75 | 23.90 | 22.13 | 24.78 |
| $T_5$: Priming with PEG-6000 (-0.5 M Pa) for 48 h | 26.38 | 24.93 | 23.68 | 22.33 | 21.15 | 23.69 |
| $T_6$: Priming with PEG-6000 (-1.0 M Pa) for 16 h | 25.15 | 24.20 | 23.33 | 22.50 | 21.50 | 23.34 |
| $T_7$: Priming with PEG-6000 (-1.0 M Pa) for 24 h | 30.38 | 29.13 | 27.93 | 27.00 | 26.00 | 28.09 |
| $T_8$: Priming with PEG-6000 (-1.0 M Pa) for 32 h | 24.08 | 22.80 | 21.75 | 20.95 | 20.35 | 21.99 |
| $T_9$: Priming with PEG-6000 (-1.0 M Pa) for 40 h | 23.00 | 22.00 | 21.05 | 20.13 | 19.43 | 21.12 |
| $T_{10}$: Priming with PEG-6000 (-1.0 M Pa) for 48 h | 22.23 | 21.53 | 20.80 | 20.05 | 19.28 | 20.78 |
| $T_{11}$: Hydropriming for 24 h | 21.43 | 20.23 | 19.50 | 19.25 | 18.88 | 19.86 |
| $T_{12}$: No priming | 20.40 | 19.75 | 19.58 | 18.50 | 17.48 | 19.14 |
| Mean | 25.75 | 24.68 | 23.70 | 22.81 | 21.72 | |

DAP= Days after priming, MAP= Months after priming
$CD_{0.05}$: Priming= 0.71, Storage= 0.46, Priming x storage= 1.58

Table 6. Effect of seed priming treatments and storage period on seed vigour index-I of okra seed

| Treatment | Seed vigour index-I after | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAP | 3 MAP | 6 MAP | 9 MAP | 12 MAP | Mean |
| $T_1$: Priming with PEG-6000 (-0.5 M Pa) for 16 h | 1,493.80 | 1,476.50 | 1,464.85 | 1,465.90 | 1,467.00 | 1,473.61 |
| $T_2$: Priming with PEG-6000 (-0.5 M Pa) for 24 h | 1620.95 | 1,613.90 | 1,596.80 | 1,596.58 | 1,581.00 | 1,601.84 |
| $T_3$: Priming with PEG-6000 (-0.5 M Pa) for 32 h | 1,471.77 | 1,385.30 | 1,305.41 | 1,235.97 | 1,170.99 | 1,313.89 |
| $T_4$: Priming with PEG-6000 (-0.5 M Pa) for 40 h | 1,385.51 | 1,279.20 | 1,191.22 | 1,135.76 | 1,044.08 | 1,207.15 |
| $T_5$: Priming with PEG-6000 (-0.5 M Pa) for 48 h | 1,229.30 | 1,136.06 | 1,066.49 | 980.10 | 818.50 | 1,046.09 |
| $T_6$: Priming with PEG-6000 (-1.0 M Pa) for 16 h | 1,145.33 | 1,067.04 | 1,023.13 | 966.05 | 851.25 | 1,010.56 |
| $T_7$: Priming with PEG-6000 (-1.0 M Pa) for 24 h | 1,452.78 | 1,444.40 | 1,436.55 | 1,423.65 | 1,393.03 | 1,430.08 |
| $T_8$: Priming with PEG-6000 (-1.0 M Pa) for 32 h | 1,128.32 | 1,037.32 | 968.12 | 924.54 | 888.91 | 989.44 |
| $T_9$: Priming with PEG-6000 (-1.0 M Pa) for 40 h | 1,046.75 | 962.00 | 900.28 | 840.27 | 790.81 | 908.02 |
| $T_{10}$: Priming with PEG-6000 (-1.0 M Pa) for 48 h | 965.41 | 934.70 | 854.47 | 783.50 | 749.75 | 857.57 |
| $T_{11}$: Hydropriming for 24 h | 909.01 | 864.12 | 809.55 | 737.27 | 694.50 | 802.89 |
| $T_{12}$: No priming | 824.97 | 766.38 | 691.68 | 632.15 | 579.00 | 698.83 |
| Mean | 1,222.82 | 1,163.91 | 1,109.04 | 1,060.14 | 1,002.40 | |

DAP= Days after priming, MAP= Months after priming
$CD_{0.05}$: Priming= 30.45, Storage= 19.65, Priming x storage= NS

has also been found responsible for the acceleration of speed of germination (Saxena 1980, Singh 1984). On the contrary, poor seedling length in non-primed seeds might be because of the reduced water uptake by the seeds resulting in improper activation of the enzymatic activities (Ashraf et al 2002, Guerrier 1988).

**Seedling dry weight:** An introspection of the data (Table 5) reveal that significantly maximum seedling dry weight (29.56 mg) was in seeds primed with PEG-6000 (–0.5 M Pa) for 24 hours whereas minimum (19.14 mg) was recorded in control. With regards to storage durations, significantly highest seedling dry weight (25.75 mg) was observed in seeds primed with PEG-6000 (–0.5 M Pa) stored for 7 days. However minimum seedling dry weight (21.72 mg) was recorded at 12 MAP. Amongst the interactions, significantly higher seedling dry weight (32.13 mg) observed in seeds primed with PEG-6000 (-0.5 M Pa) and stored for 7 days was found to be at par with 3 months (30.95 mg),

6 months (29.53 mg), 9 months (28.15 mg) and 12 months (27.05 mg). Non-primed seeds stored for 12 months exhibited minimum (17.48 mg) seedling dry weight.

Osmopriming with PEG-6000 resulted in increased seedling dry weight as compared to non-primed seeds and hydroprimed seeds. The increased dry weight due to osmopriming might be because of the beneficial effects of osmopriming on seed structure, enzymatic activities as well as organic substances in germinating seeds as reported by several workers. The present findings are also in line with those of Khalil et al (1997) who observed higher dry weight in plants produced from seeds primed in PEG-8000 in comparison to those obtained from untreated seeds. According to Saxena (1980), along with improved hydration, different enzymatic activities also get increased in PEG treated seeds besides increase in the levels of protein, sugar and RNA content.

Table 7. Effect of seed priming treatments and storage period on seed vigour index-II of okra seed

| Treatment | Seed vigour index-II after | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAP | 3 MAP | 6 MAP | 9 MAP | 12 MAP | Mean |
| $T_1$: Priming with PEG-6000 (-0.5 M Pa) for 16 h | 2,509.11 | 2,523.21 | 2,502.96 | 2,503.76 | 2,483.33 | 2,504.47 |
| $T_2$: Priming with PEG-6000 (-0.5 M Pa) for 24 h | 3,063.10 | 3,051.92 | 3,051.66 | 2,780.54 | 3,016.00 | 2,992.64 |
| $T_3$: Priming with PEG-6000 (-0.5 M Pa) for 32 h | 2,377.42 | 2,331.58 | 2,298.07 | 2,256.18 | 2,012.99 | 2,255.25 |
| $T_4$: Priming with PEG-6000 (-0.5 M Pa) for 40 h | 2,453.76 | 2,312.85 | 2,177.55 | 2,066.55 | 1,869.49 | 2,176.04 |
| $T_5$: Priming with PEG-6000 (-0.5 M Pa) for 48 h | 2,288.02 | 2,122.10 | 1,995.61 | 1,854.31 | 1,731.10 | 1,998.23 |
| $T_6$: Priming with PEG-6000 (-1.0 M Pa) for 16 h | 2,098.99 | 2,001.90 | 1,928.33 | 1,865.74 | 1,785.63 | 1,936.12 |
| $T_7$: Priming with PEG-6000 (-1.0 M Pa) for 24 h | 2,672.76 | 2,618.00 | 2,592.08 | 2,572.73 | 2,578.15 | 2,606.74 |
| $T_8$: Priming with PEG-6000 (-1.0 M Pa) for 32 h | 2,151.49 | 1,991.00 | 1,867.23 | 1,776.81 | 1,730.42 | 1,903.39 |
| $T_9$: Priming with PEG-6000 (-1.0 M Pa) for 40 h | 2,026.08 | 1,908.15 | 1,786.93 | 1,682.56 | 1,610.56 | 1,802.86 |
| $T_{10}$: Priming with PEG-6000 (-1.0 M Pa) for 48 h | 1,910.96 | 1,811.67 | 1,715.88 | 1,585.96 | 1,473.10 | 1,699.51 |
| $T_{11}$: Hydropriming for 24 h | 1,786.10 | 1,652.49 | 1,555.24 | 1,437.07 | 1,373.49 | 1,560.88 |
| $T_{12}$: No priming | 1,649.62 | 1,572.50 | 1,479.43 | 1,358.80 | 1,254.08 | 1,462.89 |
| Mean | 2,248.95 | 2,158.11 | 2,079.25 | 1,978.42 | 1,909.86 | |

DAP= Days after priming, MAP= Months after priming
$CD_{0.05}$: Priming= 59.27, Storage= 38.26, Priming x storage= 132.53

**Seed vigour index-I:** The data (Table 6) indicate that seeds primed with PEG-6000 (–0.5 M Pa) for 24 hours exhibited significantly maximum seed vigour index-I (1,601.84) and minimum value (698.83) was recorded in untreated seeds.

As far as the effect of storage durations is concerned, maximum seed vigour index-I (1,222.82) observed in seeds stored for 7 days had statistical superiority over other durations of storage whereas minimum (1,002.40) was observed 12 MAP. The interaction effect was non-significant on seed vigour index-I.

Higher seed vigour index-I may be explained on the ground that osmopriming helps in maintenance of controlled but sufficient hydration of seed that allows the pre-germinative metabolic activities to proceed without radicle emergence as observed by Thakur et al (1997) in bell pepper. Seed priming increases the level of soluble proteins which results in reconfiguration of membrane and resynthesis of enzymes associated with it (Jeng and Sung 1994).

The values of vigour index-I in general decreased as storage period progressed but after the completion of one year there was more vigour in the control seeds which were not at all primed. Reduction in seed vigour index-I with an increase in the storage time can be attributed to enhanced activity of hydrolytic enzymes.

**Seed vigour index-II:** The data (Table 7) depict that treatment involving seed priming with PEG-6000 (–0.5 M Pa) for 24 hours resulted in significantly highest seed vigour index-II (2,992.64) while the minimum (1,462.89) was recorded in non-primed seeds. Amongst the storage durations, significantly maximum seed vigour index-II (2,248.95) was registered in primed seeds stored for 7 days and the minimum value

(1,909.86) for this trait was obtained at 12 MAP. The interaction between the two factors recorded maximum seed vigour index-II (3,063.10) in seeds primed with PEG-6000 (–0.5 M Pa) for 24 hours and stored for 7 days being statistically at par with 3 months (3,051.92), 6 months (3,051.66), 9 months (2,780.54) and 12 months (3,016.00) of storage. The minimum value (1,254.08) for this parameter was observed in non-primed seeds stored for 12 months. Higher seed vigour index-II may be attributed to the fact that various priming agents help in controlled hydration of the seeds which allows the pre-germinative metabolic activities to proceed much rapidly without radicle emergence. Thakur et al (1997) made similar observations in Shimla mirch.

## REFERENCES


Abdul-Baki AA and Anderson JD 1973. Vigour determination in soybean seed by multiple criteria. Crop Science **13(6):** 630-633.

Adebisi MA, Kehinde TO, Abdul-Rafiu MA, Esuruoso OA, Oni OD and Ativie O 2013. Seed physiological quality of three *Capsicum* species as affected by seed density and hydropriming treatment durations. Journal of Agronomy **12(1):** 38-45.

Alvarado AD and Bradford KJ 1988. Priming and storage of tomato (*Lycopersicon lycopersicum*) seeds. I. Effects of storage temperature on germination rate and viability. Seed Science and Technology **16(3):** 601-612.

Anonymous 2018. Horticultural statistics at a glance 2018. Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare, Government of India.

Anonymous 2019. Horticulture crops for 2018-19. Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare, Government of India.

Argerich CA and Bradford KJ 1989. The effects of priming and ageing on seed vigour in tomato. Journal of Experimental Botany **40(214):** 599-607.

Argerich CA, Bradford KJ and Tarquis AM 1989. The effects of priming and ageing on resistance to deterioration of tomato seeds. Journal of Experimental Botany **40(214):** 593-598.

Arif M 2005. Seed priming improves emergence, yield and storability of soybean. PhD (Agronomy) Thesis, NWFP Agricultural University, Peshawar, Pakistan, 93p.

Ashraf M, Iram A and Foolad MR 2002. Optimization and influence of seed priming with salts of potassium and calcium in two spring wheat cultivars differing in salt tolerance at the initial growth stages (*Triticum aestivum* L). Agrochimica **46(1-2):** 47-55.

Baloch MA 1994. Factors influencing the growth of okra. Pakistan Journal of Scientific Research **82:** 363-367.

Bittencourt MLDC, Dias DCFDS, Dias LADS and Araujo EF 2005. Germination and vigour of primed asparagus seeds. Scientia Agricola (Piracicaba, Brazil) **62(4):** 319-324.

Bradford KJ 1986. Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. HortScience **21(5):** 1105-1112.

Bujaski W and Nienow AW 1991. Large scale osmotic priming of onion seeds: a comparison of different strategies for oxygenation. Scientia Horticulturae **46(1-2):** 13-24.

Doijode SD and Raturi GB 1987. Effect of hydration-dehydration on the germination and vigour of certain vegetable seeds. Seed Research **15(2):** 156-169.

Guerrier G 1988. Comparative phosphatase activity in four species during germination in NaCl media. Journal of Plant Nutrition **11:** 535-546.

Heydecker W, Higgins J and Gulliver RL 1974. Instant germination: a method of brinkmanship. Common Grower **40:** 17-21.

Jeng TL and Sung JM 1994. Hydration effect on lipid peroxidation and peroxide scavenging enzyme activity of artificially aged peanut seed. Seed Science and Technology **22:** 531-539.

Khalil SK, Mexal JG and Ortiz M 1997. Osmotic priming hastens germination and improves seedling size of *Pinus brutia* var eldarica. Tree Planters' Notes **48(1-2):** 24-27.

Kumar S, Dagnoko S, Haougui A, Ratnadass A, Pasternak D and Kouame C 2010. Okra (*Abelmoschus* spp) in West and Central Africa: potential and progress on its improvement. African Journal of Agricultural Research **5(25):** 3590-3598.

Maguire JD 1962. Speed of germination- aid in selection and evaluation for seedling emergence and vigor. Crop Science **2:** 176-177.

Nath S, Coolbear P and Hampton JG 1991. Hydration-dehydration treatments to protect or repair stored Karamu wheat seeds. Crop Science **31(3):** 822-826.

Owen PL and Pill WG 1994. Germination of osmotically primed asparagus and tomato seeds after storage up to three months. Journal of the American Society of Horticultural Science **119(3):** 636-641.

Rowse HR1996. Drum priming- a non-osmotic method of priming seeds. Seed Science and Technology **24(2):** 281-294.

Saxena OP 1980. Biochemical studies on instant germination in carrot (*Daucus carota*). In: Proceeding of the International Symposium on Current Problems on Fruits and Vegetables (Tropical and Sub-tropical), PCARR, Philippines.

Singh G 1984. Physiological studies in some vegetable crops. PhD Thesis, Gujarat University, Ahmedabad, Gujarat, India, 217p.

Srinivasan K, Jain SK, Saxena S, Radhamani J and Uprety M 2009. Seed priming and fortification. Seed Research **37(1-2):** 1-13.

Thakur A, Thakur PS and Bhardwaj J 1997. Influence of seed osmoconditioning on germination potential and seedling performance of bell pepper. Seed Research **25(1):** 25-30.

van Pijlen JG, Groot SPC, Kraak HL, Bergervoet JHW and Bino RJ 1996. Effects of pre-storage hydration treatments on germination performance, moisture content, DNA synthesis and controlled deterioration tolerance of tomato (*Lycopersicon esculentum* Mill) seeds. Seed Science Research **6(2):** 57-63.

Varier A,Vari KA and Dadlani M 2010. The subcellular basis of seed priming. Current Science **99:** 450-456.