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Research Article

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Effect of Different Seed Priming Treatments on Seed Germination and Seedling Vigor of Okra (*Abelmoschus esculentus* L. var. Punjab Suhawani)

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Abstract

A field trial was carried out at Horticulture Research Farm, Lovely Professional University, Phagwara, Punjab during the period from February-May 2021 and 2022 to examine the effects of different seed priming treatments on number of days to germination, germination percentage (%), seedlings root length (cm), seedlings shoot length (cm), seedling length (cm), dry weight of seedling (mg), seed vigor index I (SVI-I) and seed vigor index II (SVI-II) of okra by using variety Punjab Suhawani. The study was conducted using three replications and a randomized complete block design. The treatment comprises T_0: control (no priming), T_1: hydro-priming, T_2: priming with 5% polyethylene glycol (PEG) solution, T_3: priming with 3% PEG solution, T_4: priming with 5% KCl (potassium chloride) solution, T_5: priming with 3% KCl solution, T_6: priming with 5% $MgSO_4$(magnesium sulfate), T_7: priming with 3% $MgSO_4$, T_8: priming with 5% NaCl (sodium chloride), T_9: priming with 3% NaCl. Data on different growth, yield and quality characters were recorded to estimate the appropriate level of okra seed priming agents. Analysis of the data revealed that treatment T_1 (priming with 5% PEG solution) at par with the treatment T_7 (priming with 3% $MgSO_4$ solution) shows maximum germination percentage (84.33%), seedlings root length (8.52 cm), seedlings shoot length (16.41 cm), seedling length (24.94 cm), dry weight of seedling (25.43 mg), chlorophyll content (51.27), width of pod (1.53 cm), length of pod (12.11 cm), yield t/ha (17.38), SVI-I (2102.42), SVI-II (2144.98) and minimum number of germination days (7.83) as compared to other treatments. The present investigation revealed that osmo-priming (5% PEG) optimized the okra growth, yield and quality parameters in okra followed by halo-priming (3% $MgSO_4$).

Keywords

Okra, Seed priming, Osmo-priming, Seed germination, Seedling vigor index

Introduction

One of the most well-known and commonly used species of the Malvaceae family of dicotyledonous plants is okra (*Abelmoschus esculentus* L. Moench) [1]. The crop is commonly known as bhindi, lady's finger, gumbo in different countries [2]. The crop is originated from tropical Africa and was cultivated in the Mediterranean region [3]. It is also referred to as "a perfect villager's vegetable" because of its hardiness, balance of lysine and tryptophan amino acids, and unique seed protein [4]. A vegetable crop grown primarily in tropical and subtropical regions of Asia and Africa; okra is an annual crop. It performs best during the hot and humid climate. On an area of 526 thousand hectares, India is thought to be the world leader in okra production, producing 6,505 thousand metric tons [5]. Uttar Pradesh, Andhra Pradesh, West Bengal, Bihar, Maharashtra, and Karnataka are the states in India that produces the largest amount of okra. In India, the crop is primarily grown during the summer and rainy seasons [6]. The crop is primarily grown for its tender pods, which can be eaten raw, steamed, boiled, or fried. The USDA nutrient database states that every 100 g of okra, there are 7.03 g of carbohydrates, 1.20 g of sugars, 3.2 g of dietary fiber, 0.10 g of fat, 2 g of protein, 90.17 g of water, and 129 kilojoules of energy. Although it is nutrient-rich, okra might not possess good seedling emergence or vigor.

Seed-priming has been demonstrated for increasing seedling emergence velocity and uniformity, as well as seed tolerance to adverse conditions [1]. It involves submerging seeds in water under carefully monitored conditions until radicals emerge, after which the seeds are dried to their initial moisture content [6]. Okra seeds are viable, but they emerge unevenly and very slowly. Due to its detrimental effects on uniform field stand and rapid germination, seed hardness is a major factor in reduced, delayed, and erratic emergence in okra cultivation. The hard seed coat obstructs seed germination by preventing water absorption and uniform embryonic growth and development. Seed priming is a solution to the okra plant's hard seed coat-related low germination issue. While germination is not happening, priming enables some of the metabolic processes required for germination to take place. Seed priming enables synchronized germination, enhances seed vigor, seedling growth, quality, and yield under stressful circumstances. To improve okra germination, yield and quality various seed priming techniques have been employed, including solid-matrix priming, hydro-priming, osmo-priming, hormonal priming, halo-priming, and bio-priming.

Methodology

Experimental design and treatments

The Horticulture Research Farm at Lovely Professional University in Phagwara, Punjab, which is situated at 245 meters above mean sea level and at latitude 31°15' N and longitude 75°41' E, was the site of a field experiment. As research material, the Punjab suhawani variety of okra (*A. esculentus* L. moench) seeds were utilized. The field experiment mainly possesses 10 treatments viz., T_0: control (no priming), T_1: hydro-priming, T_2: priming with 5% PEG solution, T_3: priming with 3% PEG solution, T_4: priming with 5% KCl solution, T_5: priming with 3% KCl solution, T_6: priming with 5% $MgSO_4$, T_7: priming with 3% $MgSO_4$, T_8: priming with 5% NaCl, T_9: priming with 3% NaCl. Three replications of the experiment were set up using a randomized complete block design. Seeds were primed with their respective treatments for 12 hours, then shade dried for 6 hours, and finally sown in a germination tray after the treatment solution was prepared. The area of the plot is 142.5 m^2. Data were recorded on following parameters.

Data collection

Number of days to germination

After okra seed is sown in the main field and the seedlings begin to germinate, the number of days to germination is determined.

Seed germination (%)

Seed germination (%) tests were conducted using seeds from okra, which were placed on top layers of germination towel papers and then these seeds were covered with another layer of germination towel paper. Following that, these were placed in the germination chamber and left to incubate at 25 °C and 90-95 percent relative humidity. After counting the number of normal seedlings on the eleventh day, the formula below was used to determine the percentage of seeds that had germinated.

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

Length of shoot (cm)

The seedlings were uprooted after growing for fifteen days, and the foreign sand particles were cleaned off with distilled water. Five randomly selected seedlings from each replicate had their shoot length measured in centimetres (cm) using a meter rod, from the base of the hypocotyls to the tip of the shoot. A calculation was made of the average for every replication.

Length of root (cm)

Once the seedlings had grown for fifteen days, the foreign sand particles were removed by uprooting and water washing them. Five seedlings were selected at random from each replicate, and their root lengths were measured using the meter scale. The measurements were taken in centimetres (cm) from the base of the hypocotyls to the tip of the longest root. A calculation was made of the average for each replication.

Seedling length (cm)

To determine the seedling length, five typical seedlings that were chosen at random during the first count were used. With the aid of a scale, the total length of the seedlings from the tip of the primary leaf to the tip of the primary root was measured, and the mean value was expressed in centimetres (cm).

Dry weight of seedling (mg)

Five seedlings selected for measuring seedling length were used to calculate the dry weight of the seedlings. Seedlings were heated up in an oven at 60 °C for 48 hours before being weighed and the mean value stated in milli-grams.

SVI-I

According to the formula the SVI-I was computed.

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

SVI-II

According to the formula, the SVI-II was computed.

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

Pod length (cm)

Five marketable fruits were chosen from each plot, and the length of the green pod was measured using a scale from the fruit's neck to its bottom. The average of these measurements was then calculated and expressed in centimetres.

Width of the pods (cm)

Using a digital vernier calliper, the diameter of the green pod was measured in the centre of five selected marketable fruit from each plot. The average of these measurements was then calculated and expressed in centimetres.

Pod yield (t/ha)

During the harvesting period, fresh pods were picked from each plot independently in separate polythene bags. The total average yield tons per hectare was then computed for each treatment.

Chlorophyll content (mg)

A soil plant analysis development (SPAD 502) chlorophyll meter will be used to estimate the amount of chlorophyll present.

Statistical analysis

OP-STAT software was used to analyse the obtained data, and Duncan's multiple range tests were used to compare the mean and HAU at the 0.05 level of significance.

Results and Discussion

Number of days to germination (days)

Table 1 presents the observation on the number of days to first germination of okra for the years 2021, 2022, as well as in the pooled analysis. It was evident that the number of days it took for okra to germinate varied significantly depending on the seed priming treatments used. Based on pooled analysis, the T_2 treatment's minimum number of days to germination (7.83) was found to be comparable to that of treatment T_7 (8.50). The T_0 (control) treatment produced the highest number of days to germination (13.00), which was followed by the T_1 (hydro-priming) treatment (12.00). Ali et al. [7] state that hydrolytic enzymes such as lipases, amylases, and proteases are synthesized and activated because of priming, releasing the seed's storage components [7]. Rehydration causes quick emergence because all pre-germinated processes have already taken place.

Germination percentage (%)

Table 1 presents the observations made regarding the okra germination percentage for the years 2021 and 2022 as well as in the pooled analysis. The percentage of okra that germinated differently depending on the seed priming treatments. Pertaining to the T_7 (priming with 3% $MgSO_4$ solution) and T_2 (priming with 5% PEG solution) treatments, respectively, the T_2 treatment demonstrated the highest germination percentage (84.33% and 82.67%), which was statistically superior to the other priming treatments. The T_0 (control) treatment yielded the lowest germination percentage of 62%, which was comparable to the T_1 (hydro-priming) treatment's 65.67%. Enhanced germination with priming may be due to various processes, including protein synthesis, leaching of growth inhibitors, repair of deteriorating DNA in seeds, and activation of antioxidant enzymes that reduce peroxidation in seeds [8].

Effect on shoot length of seedlings (cm)

Table 1 illustrates the observations made regarding the shoot length of okra seedlings for the years 2021 and 2022 as well as in the pooled analysis. T_2 (priming with 5% PEG solution) produced the longest shoot (16.41 cm), followed by T_7 (priming with 3% $MgSO_4$ solution) (15.48 cm), and T_0 (control) produced the shortest shoot (9.80 cm). A potential reason for the observed rise in shoot length in the primed seeds is either meristematic growth, cell division, or its function in cell elongation [9].

Effect on root length of seedlings (cm)

Table 1 demonstrates the observations made regard-

Table 1: Effect of different priming treatments on number of days to germination, germination percentage, length of the shoot and length of the root of okra.

	Number of days to germination (days)			Germination percentage (%)			Length of shoot (cm)			Length of root (cm)		
Treatments	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_0 (un-primed)	12.67	13.33	13.00	63.00	61.00	62.00	8.90	10.70	9.80	5.22	4.45	4.83
T_1 (Hydropriming)	13.00	11.00	12.00	64.57	66.77	65.67	10.59	12.48	11.53	6.10	6.13	6.12
T_2 (PEG 5%)	8.33	7.33	7.83	85.66	83.00	84.33	15.41	17.42	16.41	8.50	8.54	8.52
T_3 (PEG 3%)	8.67	9.67	9.17	69.33	68.00	68.67	11.92	14.14	13.03	7.14	6.34	6.74
T_4 (KCl) 5%	10.33	9.33	9.83	72.00	70.00	71.00	13.65	15.19	14.42	7.85	7.77	7.81
T_5 (KCl) 3%	11.67	10.33	10.67	75.33	78.00	76.67	12.59	15.71	14.15	7.75	7.74	7.75
T_6 ($MgSO_4$) 5%	11.33	12.33	11.83	76.33	78.33	77.33	11.22	13.30	12.26	6.89	5.25	6.07
T_7 ($MgSO_4$) 3%	9.67	7.33	8.50	84.00	81.33	82.67	14.24	16.71	15.48	8.20	7.65	7.93
T_8 (NaCl) 5%	12.67	10.67	11.67	78.00	80.00	79.00	10.88	12.20	11.54	6.50	5.88	6.19
T_9 (NaCl) 3%	9.33	11.67	10.50	76.00	74.00	75.00	10.69	13.76	12.22	6.70	6.16	6.43
CD (p=0.05)	1.12	1.11	0.83	3.57	4.78	3.45	1.173	0.73	0.70	0.59	0.42	0.38
SEm (±)	0.37	0.37	0.28	1.19	1.60	1.15	0.39	0.24	0.23	0.20	0.14	0.13
CV (percent)	6.01	6.23	4.54	2.78	3.73	2.69	5.65	2.96	3.08	4.82	3.65	3.23

ing the root length of okra seedlings for the years 2021 and 2022 as well as in the pooled analysis. The root length of okra seedlings was significantly impacted by various priming treatments. The T_2 treatment (priming with 5% PEG solution) yielded the longest root (8.52 cm), which was followed by the T_7 treatment (7.93 cm), the T_4 treatment (7.81 cm), and the T_5 treatment (7.75 cm) (priming with 3% KCl solution). In contrast, the T_0 treatment (control) yielded the shortest root (4.83 cm). Compared to unprimed seeds, primed seeds displayed more rapid and elongated coleoptiles as well as vigorous root growth. The untreated control seedlings in this study had significantly shorter root lengths. One possible explanation for the observed rise in root length in the primed seeds is either meristematic growth, cell division, or its function in cell elongation [10].

Dry weight of seedling (mg)

Table 2 shows the observations made regarding the dry weight of okra seedlings for the years 2021 and 2022 as well as in the pooled analysis. The dry weight of the okra seedlings varied significantly depending on the seed priming treatments. The maximum dry weight of an okra seedling (25.43 mg) was observed in the T_2 (priming with 5% PEG solution) treatment, which was statistically higher than the other priming treatments. Okra seedlings with a minimum dry weight of 17.99 mg were found to be in the T_0 (control) treatment. When the seeds sprout, it reduces the adherence of the seed coat. Seed germination and increased vigor during osmotic priming may be due to active food transportation and the resynthesis of specific enzymes. Furthermore, DNA and RNA synthesis might have started. Seeds germinate more quickly when barriers are removed, and eventually they form a strong shoot with an increase in dry weight [8].

Seedling length (cm)

Table 2 unveils the observations made on the length of okra seedlings for the years 2021 and 2022 as well as in the pooled analysis. The length of the okra seedlings varied significantly depending on the seed priming treatments. The maximum okra seedling length (24.94 cm) was observed in the T_2 (priming with 5% PEG solution) treatment, which was statistically greater than the other priming treatments. Okra seedlings with a minimum length of 14.64 cm were discovered in the T_0 (control) treatment. The physiological and biochemical changes that took place, along with the increased physiological activity of the embryo and the mobilization of food reserves into the growing seedlings, are responsible for the development of a stronger and more effective root and shoot system as well as the effective reduction of physiological deterioration [10]. This may have led to DNA repair; the process of imbibition generates protein membranes and enzymes.

SVI-I

Table 2 shows the observations made on the okra SVI-I for the years 2021 and 2022 as well as in the pooled analysis. The okra SVI-I was significantly affected by seed priming treatments. The maximum SVI-I of okra (2101.94) was observed under the T_2 (priming with 5% PEG solution) treatment, which was statistically higher than the other priming treatments. Okra's lowest SVI-I (906.59) was discovered in the T_0 (control) treatment. Higher SVI may be caused by increased stand establishment in wheat [11] and controlled but adequate hydration of seeds to a degree that permits pregerminated metabolic activity to proceed but inhibits actual bell pepper radicle emergence.

SVI-II

Table 2 unveils the observations made on the okra SVI-II for the years 2021 and 2022 as well as in the pooled analysis. The okra SVI-II showed a significant difference between seed priming treatments. The maximum SVI-II of okra (2144.18) was observed under the T_2 (priming with 5% PEG solution) treatment, which was statistically higher than the other priming treatments. Okra's lowest SVI-II, 1115.83, was discovered in the T_0 (control) treatment. Increased stand establishment in wheat [11] and the maintenance of controlled but sufficient seed hydration—which allows pregerminated metabolic activity to proceed but stops actual bell pepper radicle emergence-may lead to higher SVI.

Table 2: Effect of different priming treatments on dry weight of the seedling, seedling length of okra, SVI-I and SVI-II of okra.

	Dry weight of seedling (mg)			Seedling length (cm)			SVI-I			SVI-II		
Treatments	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0 (un-primed)	17.77	18.21	17.99	14.12	15.15	14.64	890.97	922.20	906.59	1121.05	1110.61	1115.83
T_1 (Hydropriming)	19.11	19.30	19.21	16.69	18.61	17.65	1077.51	1242.69	1160.10	1234.20	1288.63	1261.42
T_2 (PEG 5%)	24.93	25.93	25.43	23.91	25.96	24.94	2048.37	2155.51	2101.94	2135.50	2152.86	2144.18
T_3 (PEG 3%)	21.60	20.85	21.22	19.06	20.48	19.77	1322.45	1391.99	1357.22	1497.29	1418.00	1457.65
T_4 (KCl) 5%	20.86	23.03	21.94	21.50	22.96	22.23	1547.97	1607.68	1577.82	1501.65	1611.77	1556.71
T_5 (KCl) 3%	22.05	22.05	22.05	20.34	23.46	21.90	1532.33	1828.73	1680.53	1660.73	1721.05	1690.89
T_6 ($MgSO_4$) 5%	20.66	20.73	20.69	18.11	18.55	18.33	1382.50	1452.99	1417.75	1576.42	1624.10	1600.26
T_7 ($MgSO_4$) 3%	22.67	23.75	23.21	22.44	24.36	23.40	1884.60	1981.12	1932.86	1904.14	1931.61	1917.87
T_8 (NaCl) 5%	19.13	21.07	20.10	17.38	18.08	17.73	1355.56	1446.55	1401.05	1492.25	1683.57	1587.91
T_9 (NaCl) 3%	19.37	20.26	19.82	17.38	19.92	18.65	1321.37	1475.17	1398.27	1473.04	1500.76	1486.90
CD (p=0.05)	0.74	1.68	0.90	1.08	0.63	0.72	125.37	107.60	69.82	96.32	170.48	99.93
SEm (±)	0.25	0.56	0.30	0.36	0.21	0.24	41.87	35.94	23.32	32.17	56.94	33.38
CV (percent)	2.05	4.51	2.46	3.32	1.81	2.08	5.05	4.01	2.71	3.57	6.15	3.65

Length of pods (cm)

Seed priming treatments: a significant difference in okra pod length has been observed because of various priming techniques (Table 3). On the other hand, the shortest pod (7.56 cm) was found from T_0 (control) treatment, followed by T_1 (hydro-priming) treatment (8.79 cm), and T_9 (priming with 3% NaCl solution) treatment (8.93). The longest pod length (12.11 cm) was recorded from T_7 (priming with 3% $MgSO_4$ solution), at par with the T_2 (priming with 5% PEG solution) treatment (11.23 cm), followed by T_4 (priming with 5% KCl solution) treatment (10.70 cm). According to Chikkanna et al. [12] seed priming increased yield, which was in line with the experiment's conclusions.

Width of pods (cm)

On the width of the okra pod, seed priming treatments significantly differed (Table 3). The maximum width of the okra pod (1.53 cm) was observed with treatment T_2, which involved priming with a 5% PEG solution which was followed by treatment T_7, which involved priming with a 3% $MgSO_4$ solution (1.31 cm). The T_0 treatment (control) yielded the smallest pod width of okra (0.64 cm). Consistent with this result Kaur et al. [9] primed okra seeds using 5% and 10% PEG instead of hydro-priming, resulting in fruits that were wider and longer.

Pod yield tons/hectare (t/ha)

The okra pod yield in tons/hectare varied significantly depending on the seed priming treatments (Table 3). The maximum pod yield tons/hectare of okra (17.38 t ha^{-1}) was recorded by treatment T_2 (priming with 5% PEG solution), which was statistically at par with treatment T_7 (priming with 3% $MgSO_4$ solution) (16.21 t ha^{-1}). From the T_0 (control) treatment, the lowest pod yield tons/hectare of okra (10.59 t ha^{-1}) was found. The higher pod yield could have been caused by the seedlings' enhanced vegetative and reproductive traits as well as their increased vigor. Furthermore, because primed seeds are in a different developmental stage than dry seeds, they have a "head start of germination" [13]. Thus, seedlings from primed seeds have more developed roots before common limiting factors like declining soil moisture, crust formation, and/or high salinity prevent successful emergence.

Chlorophyll content (mg)

Seed priming treatments had significant difference on chlorophyll content of okra (Table 3). The treatment T_2 (priming with 5% PEG solution) showed the maximum chlorophyll content (51.27) at par with the T_7 (priming with 3% $MgSO_4$ solution) treatment (50.54) followed by T_8 (priming with 5% NaCl solution) treatment (49.94). The minimum chlorophyll content (41.15) was found from T_0 (control) treatment at par with the T_1 (Hydro-priming) treatment (42.03). Since it's important for plants to carry out photosynthesis reactions, chlorophylls are necessary pigments that absorb a large amount of light energy. Plant growth and yield are impacted when chlorophyll contents and biosynthesis are significantly reduced because of chlorophyll's extreme sensitivity to various environmental stresses [14]. In the current study, seed priming significantly raised the chlorophyll contents of okra.

Conclusion

The most effective treatment for okra seeds that are experiencing delayed germination due to seed hardness may be to prime the seeds. Priming okra seeds helps the seeds germinate more easily and can also improve the crop's growth, development, and yield.

$MgSO_4$ 3% can be used as an alternative to PEG 5%, which was found to be the most effective priming agent when okra seed priming was conducted with various treatments on seed germination and seedling vigor. Thus, seed priming is a valuable method for boosting okra's growth and yield parameters. To understand the effect of seed priming on the morphological traits and yield of okra, more investigation is essential.

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Table 3: Effect of different priming treatments on length of pods, width of pods, pod yield and chlorophyll content.

	Length of pods (cm)			Width of pods (cm)			Pod yield (tons/hectare)			Chlorophyll content (mg)		
Treatments	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_0 (un-primed)	7.54	7.58	7.56	0.65	0.64	0.64	10.58	10.60	10.59	41.15	41.14	41.15
T_1 (Hydropriming)	8.83	8.76	8.79	0.83	0.66	0.74	11.10	11.11	11.11	42.02	42.03	42.03
T_2 (PEG 5%)	11.85	10.61	11.23	1.38	1.67	1.53	17.41	17.38	17.40	51.26	51.27	51.27
T_3 (PEG 3%)	10.20	9.66	9.93	0.85	0.86	0.86	14.25	14.24	14.24	46.61	46.62	46.62
T_4 (KCl) 5%	10.29	11.11	10.70	1.06	1.08	1.07	15.14	15.19	15.16	48.70	48.71	48.71
T_5 (KCl) 3%	9.52	10.37	9.94	0.91	0.94	0.93	14.92	14.95	14.93	47.98	47.99	47.99
T_6 ($MgSO_4$) 5%	9.36	9.91	9.64	0.73	0.74	0.74	12.86	12.88	12.87	45.18	45.19	45.19
T_7 ($MgSO_4$) 3%	12.58	11.64	12.11	1.22	1.39	1.31	16.20	16.21	16.20	50.53	50.54	50.54
T_8 (NaCl) 5%	9.85	9.69	9.77	1.07	1.09	1.08	13.56	13.58	13.57	49.93	49.94	49.94
T_9 (NaCl) 3%	9.35	8.50	8.93	0.90	0.97	0.93	14.15	14.16	14.16	47.88	47.89	47.89
CD (p=0.05)	1.75	1.45	1.16	0.21	0.22	0.14	1.69	1.82	1.83	1.173	0.73	0.70
SEm (±)	0.58	0.49	0.39	0.07	0.08	0.05	0.56	0.61	0.61	0.39	0.24	0.23
CV (percent)	10.18	8.59	6.78	12.34	12.87	8.24	6.97	7.51	7.55	5.65	2.96	3.08

Conflict of Interest

There is no conflict of interest among the authors.

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