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RESEARCH ARTICLE

Enhancing okra performance through osmo-priming: Effects on germination, yield and quality

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Abstract

To assess the impact of various seed priming techniques on okra (Punjab Suhawani variety) performance. Seeds were sourced from Punjab Agricultural University; Ludhiana and the study was structured using a randomized block design (RBD) with three replications and eight treatments with plot size of 2.25×3.75m and followed spacing was 45×15 cm. The treatments included: T_0 (un-primed) control, T_1 (hydro-priming), T_2 (osmo-priming with 5 % polyethylene glycol), T_3 (osmo-priming with 3 % potassium chloride), T_4 (halo-priming with 5 % potassium nitrate), T_5 (halo-priming with 1.5 % magnesium nitrate), T_6 (hormonal priming with 50 ppm gibberellic acid) and T_7 (hormonal priming with 50 ppm naphthalene acetic acid). For each treatment, seeds were soaked in the prepared solutions for 24 hrs before sowing under the shade. The study assessed germination percentage (92.17 %), number of days to germination (5.06 days), seedling dry weight (30.10 mg), seedling length (23.66 cm), seedling Vigor index (2166.95 I and 2627.83 II), root and shoot ratio (0.69), number of pods plant^{-1} (12.28), individual pod weight (9.28 g), pod yield plot^{-1} (14.24 kg), pod yield plant^{-1} (14.29 g), pod yield tonnes hectare (12.89 t ha^{-1}), chlorophyll index (52.13) and mucilage content (5.57 %) and iodine content (mg/kg). The highest germination rate and seedling performance were recorded in T_2 (osmo-priming with 5 % PEG), followed closely by T_6 (hormonal priming with 50 ppm GA_3). In contrast, the unprimed seeds (T_0) control showed no significant improvement in any of the evaluated parameters.

Keywords: hormonal priming; okra; osmo-priming; responsible consumption and production; seed priming and quality

Introduction

Okra (*Abelmoschus esculentus*), a member of the Malvaceae family, as a popular vegetable of India. It is a staple summer vegetable of many countries (1, 2). It has a somatic chromosome number of 2n = 130. Commonly known as “lady finger,” okra is often called “a perfect villager’s vegetable” due to its widespread popularity and suitability for cultivation in rural areas (3), different species of the *Abelmoschus* genus are cultivated. Due to its significant economic value, particularly in nutrition, okra is extensively grown in Africa and America too. In India, okra cultivation spanned 526 thousand hectares in 2019-2020, yielding approximately 6,505 thousand metric tonnes (4). In Punjab, okra production stands at around 6.3 million tonnes from 0.51 million hectares. Okra seeds do not germinate at temperatures below 20 °C, with an optimal germination temperature of 29 °C. The fastest emergence rate occurs between 30°C and 35 °C; however, higher temperatures can delay flower initiation and blooming. Structurally, okra stems and leaves have pubescence, while its flowers are distinguishable by their yellow hue with a crimson-centered margin (5). The edible part of the plant is the capsule (pod), which typically measures 15-20 cm in length. Immature okra fruits are widely consumed as vegetables and used in various dishes such as salads, soups and stews, either dried or boiled (6). Additionally, with the increasing demand for fresh vegetables in local and global markets, okra has gained significant popularity. Apart from its nutritional benefits, okra is also valued for its applications in oil production, biofuel and medicinal products (7, 8). Okra leaves are useful for many medicinal purposes. Nonetheless, okra leaves are thought to be effective in treating many illnesses, including diabetes, heart disease, digestive disorders and more. Mineral enrichment of okra is necessary to maintain normal cellular homeostasis. It is often foreseen that okra fruits can help prevent diabetes and obesity (9,10). After harvesting the okra fruit, the green stems are used to extract a crude mucilaginous substance, which finds applications in both the food industry and the pharmaceutical industry (11). Longitudinal okra flesh is rich in minerals and has significant levels of these minerals i.e. 0.6 to 1 mg iron (Fe), 81 to 82 mg calcium (Ca) and 61 to 63 mg phosphorus (P) respectively. Also present in okra is pro-vitamin A (185 0g), vitamin B2 (0.08 mg) and vitamin B complex (0.08 mg) and vitamin B complex (0.04 mg) respectively (12). Okra can be recognized as an abundant source of nutrients with advantageous health benefits. Consequently, because of the magnificence of polyphenols, they could serve as an extremely fruitful antioxidant source. Additionally, studies have confirmed that the fruit extract of okra contains several

phenolic compounds, including protocatechuic acid, rutin, catechin, quercetin and quercetin-3-O-gentiobioside (13). It has been reported that seed emergence and seedling growth, seed priming plays a vital role by initiating the hydration process, which activates the α-amylase enzyme. This enzyme facilitates the breakdown of starch reserves into simpler carbohydrates, providing essential energy to the embryo for respiration and supporting vigorous seedling development. Through priming, seeds become better prepared for rapid and uniform germination, enhancing overall plant establishment (14). Hydro-priming can improve the percentage of seeds that germinate and the emergence of seedlings in both saline and non-saline environments (15, 16). This controlled imbibition enables the embryo to activate its metabolic processes without radicle protrusion, thereby maintaining seed viability while enhancing germination (17). Generally, PEG (polyethylene glycol) is used for osmo-priming, but there are many other osmotic solutions involved, including potassium dihydrogen phosphate, magnesium sulfate, potassium nitrate, calcium chloride, potassium chloride, polyethylene glycol and mannitol are involved (18). When growing okra, seed hardness is a major issue since it hinders rapid germination and uniform field stands due to diminished, delayed and irregular emergence (3). Additionally, because okra seeds can be hard seeded, they may exhibit poor seedling emergence and vigour, resulting in a generally low germination rate (19). In seed priming, seeds are initially soaked in a pre-sowing treatment that allows them to absorb the necessary amount of water, triggering pre-germinative metabolic activities. However, this process can cause the seeds to lose their desiccation tolerance if the radicle begins to protrude prematurely. In addition to this, osmo-priming uses osmotic solutions with low water potential to slow down water uptake.

Seed priming treatments will have synergistic effects on the okra seed germination and the objectives of the study were, to determine the effects of seed priming on seed germination, yield and quality attributes and evaluate and identify the best priming treatment out of various methods of osmo-priming.

Materials and Methods

The field experiment was conducted at the experimental farm of the School of Agriculture, Lovely Professional University, Phagwara, Punjab, to evaluate the effects of various seed priming treatments on the emergence, yield and quality of okra. Seed priming, which involves soaking seeds in specific solutions before sowing, has been shown to significantly enhance Germination percentage (%), shoot length (cm), root length (cm), seedling length (cm), seedling dry weight (mg), seedling vigour index (i) and seedling vigour index (ii), root and shoot ratio, number of pods plant^{-1}, individual pod weight (g), pod yield plot^{-1} (kg), yield plant^{-1} (g), pod yield tonnes hectare (t ha^{-1}), chlorophyll index (SPAD) and mucilage content (%) and iodine content (mg kg^{-1}) of okra. The research trial utilized the okra variety Punjab-Suhawani. The Priming treatments applied were as follows: T_0- Control (un-primed seeds), T_1- Hydro-priming, T_2- Osmo-priming with 5 % polyethylene glycol, T_3- Osmo-priming with 3 % KCl, T_4- Halo-priming with 5 % KNO_3, T_5- Halo-priming with 1.5 % Mg $(NO_3)_2$, T_6- Hormonal-priming with 50 ppm GA_3, T_7- Hormonal-priming with 50 ppm NAA. The site of the experimental plot falls under the subtropical category and the rainfall during the crop growing season was recorded as 486.1 mm. Seeds were fully submerged in the respective priming solutions for 24 hrs under the shade. After priming, the seeds were air-dried at room temperature for approximately 3 hrs to restore moisture content to normal levels.

Germination test

The rolled towel method was used for seeds in each priming treatment, which were tested for germination later. From each treatment, at least 25 seeds were taken and seeds were placed uniformly on the germination paper. Moreover, with the help of distilled water paper was moistened. Eventually, in the seed germinator, rolled towel papers were retained at a constant temperature of 25±1 °C and 95 % (RH).

Germination percentage

This formula was used to calculate the germination percentage (%).

$$\text{Germination percentage} = \frac{\text{Total number of germination seeds}}{\text{Total number of seeds sown}} \times 100 \qquad \text{Eq. 1}$$

Number of days to germination

The number of days from sowing until the emergence of the first leaf is recorded to determine the days to germination.

Seedling growth

To evaluate their growth response, seedlings were cultivated under standard settings. The length of the seedling (branch plus root) was measured in centimeters at 11 days after emergence (DAE). From the collar area to the cotyledon attachment site, the length of the shoot was measured. By measuring from the collar to the root tip, the length of the roots was ascertained. To assess the growth response, seedling growth was tracked.

Dry weight of seedling (mg)

The seedlings used for measuring root and shoot lengths were the same ones from the germination test. These seedlings were dried in a hot air oven at 60 °C for 24 hrs. Afterward, they were placed in desiccators for 30 min to complete the drying process. The dry weight of the seedlings was recorded in mg per ten seedlings. An electronic balance was utilized to obtain the precise weight of the dried seedlings.

Seedling length (cm)

Ten healthy seedlings were randomly selected during the first count to measure seedling length. The length was determined by measuring from the tip of the primary leaf to the tip of the primary root using a scale. The average length was then calculated and expressed in cm.

Seedling vigour index

Seedling vigour index (SVI) is commonly calculated using two formulas, known as SVI-I and SVI-II and was calculated by following the modified formula.

$$\text{Seed Vigour index } (i) = \text{Germination (\%)} \times \text{Seedling length (cm)} \qquad \text{Eq. 2}$$

Seed Vigour index (*ii*) =

Germination (%) x Seedling dry weight (mg) Eq. 3

Root-Shoot ratio

From each treatment, 10 healthy plants were selected. The roots were carefully separated from the shoots by cutting at the soil line. Each root and shoot sample were weighed individually and the data for both parts of every plant were recorded. Using this information, the root-to-shoot ratio can be calculated.

$$Root - Shoot\ ratio = Dry\ wt.of \frac{roots}{Dry} wt.of\ top\ of\ plant$$

Eq. 4

Number of pods plant^{-1}

Pods were harvested from ten randomly tagged plants and after the counting, the average number of pods plant^{-1} was calculated and then it will record the data.

Individual weight of the pods (g)

For each plot, ten healthy plants were selected and the weight of ten healthy pods from these plants was recorded. The individual weight of each pod was measured using a digital balance.

Pod yield plant^{-1} (g)

At harvest, fresh fruits from the tagged plants were collected separately in polythene bags. The total average yield plant^{-1} was then calculated for each plot.

Pod yield plot^{-1} (kg) & Pod yield (t ha^{-1})

During the harvest, fresh pods were picked from the tagged plants in all plots. The pods were collected separately in polythene bags throughout the harvesting period. Afterwards, the total average yield plant^{-1} was calculated for each plot. Fresh pods were harvested from the tagged plants across all plots. Throughout the harvesting period, the pods were collected separately in polythene bags. Finally, the total average yield in tonnes ha^{-1} was calculated for each plot.

Chlorophyll index

Chlorophyll index is computed after ten plants that are tagged are drawn randomly in each plot. The most common technique of measuring chlorophyll concentration is a SPAD meter (SPAD-502) and it was what was used to calculate the chlorophyll in the okra leaves.

Mucilage content (%)

A 25 g sample was mixed with 100 mL of distilled water and left to soak for 24 hrs. The resulting suspension was then filtered using a muslin cloth. After filtration, 50 mL of ethanol was added to the filtrate. The mixture was blended for at least 15 min using a magnetic stirrer. Next, the sample was filtered again using pre-weighed filter paper and then dried in an oven. Once dried, the filter paper with the residue was weighed again. The viscus matter is shown in the Fig. 1 (a, b, c, d). The mucilage content was calculated using the following formula (20).

$$Mucilage\ content\ (\%) = \frac{W_2 - W_1}{W}$$

Eq. 5

W_2 = Weight of filter paper along with material after drying, W_1 = Weight of pre-weighed filter paper, W = Weight of sample.

Fig. 1 (a, b, c, d). Illustrating the mucilage of okra.

Iodine content (mg)

By using the Teepol detergent, the glassware was thoroughly cleaned, followed closely by washing with distilled water. After washing with distilled water, it was soaked overnight in a 10 % hydrochloric acid solution. The glassware was rinsed with tap water as well as thoroughly rinsed again with distilled water, after the soaking. Finally, before use, the glassware was dried in a hot air oven at a temperature of at least 60 °C.

For sample preparation, by using an electric mixer-cum-grinder the dried samples were ground into a fine powder. To maintain the quality, the powdered samples were then stored in airtight polyethylene bags. One gram of the dried and finely ground sample was accurately weighed and transferred into a clean test tube for the process of analysis. The sample was added with 1 mL of a 10 time's diluted 6 M KOH solution. The sample was then placed in an oven and dried overnight at 95±1 °C for the blank. Subsequently, the test tubes were transferred to a muffle furnace preheated to 100 °C. The samples were burnt for 1 hr, when the furnace temperature was then raised to 600 °C. Air was circulated by moving the tubes every 15 min for 15 seconds to ensure proper combustion during this period. After the ashing process, the tubes were transferred to a desiccator and allowed to cool to room temperature. If ashing was incomplete, 1 mL of a 10 time's diluted zinc sulfate solution was added to all tubes and the drying and ashing process was repeated as described above.

Whenever ashing was complete, added the 0.2 mL of water to each test tube, followed by thorough stirring and vortexing. The volume was then adjusted to 5 mL with water. Finally, the tubes were centrifuged at 3500 rpm for 30 min and the supernatant was collected for the final assay. Into a test tube, the following reagents were added in sequence: 0.5 mL of double -distilled water, 0.5 mL of a H_2SO_4: HCl solution, 0.5 mL of cerate reagent (prepared by dissolving 0.316 g of ammonium ceric (IV) sulfate in 15 mL of water, to which 40 mL of concentrated nitric acid was added dropwise), 5 mL of concentrated H_2SO_4. The mixture was then made up to a final volume of 100 ml with distilled water. After that, 0.5 ml of arsenic reagent was added. (The arsenic reagent was prepared by dissolving 0.593 g of arsenic trioxide and 0.6 g of potassium hydroxide in 30 mL of water, then adding 0.1 mL of concentrated HCl and finally making the volume up to 100 mL with distilled water.)

The combined solution was thoroughly mixed and incubated at room temperature for 1 min. After incubation, 0.5 mL of blank, standard, or sample was added, mixed well and the reaction was allowed to proceed for 1 minute. The optical density (OD) was then measured at 400 nm. The slope was calculated from the standard curve using pure potassium iodide (KI) (21).

$$Dry\ matter\ content\ (\%) = \frac{Final\ dry\ wt.\ of\ the\ sample}{Initial\ fresh\ wt.\ of\ the\ sample} \times 100$$

Eq. 6

Statistical analysis

Data was organized and analyzed using one-way ANOVA through SPSS software. Treatment means were compared using the Least Significant Difference (LSD) test at a significance level of $p < 0.05$.

Results and Discussion

Effect of different seed priming with osmo-priming on Okra crop

Germination percentage and number of days to germination

The seed pre-treatment with different chemicals had a significant effect ($p<0.05$) on germination percentage (%). However, it showed no significant effect on the number of days to emergence. The pooled data indicated that PEG is a priming agent that germinates more okra seeds than un-primed seeds. The results indicated that T_2 (92.17 %) showed maximum germination percentage on the different sources of priming like T_6 (89.50 %) table 1. Conversely, T_0 (62.33 %) that contained unprimed seeds recorded low percentage of germination. Nonetheless, the overall combined data indicated that it has not been significantly influenced by various priming treatments on the number of days to germination ($p<0.05$). The time to germination was highest in treatment T_6 with 5.53 days of germination and secondly in treatment T_2 which had 5.06 days. Similar results were found with T_2 and T_6 however, on 5.06 and 5.53 days. Similarly, T_6 and T_7 recorded the same trends with 5.06 and 7.81 days respectively. Conversely, T_0 (8.22) days that involved unprimed seeds had the least number of days to germination. All pre-germination metabolic functions are believed to require a particular amount of water to activate and enter into the lag phase before germination. This optimum water availability is offered by priming treatments and facilitates the occurrence of such metabolic activities successfully. As a result, different priming agents not only stimulate pre-germination metabolism but also positively influence the emergence percentage of seeds (17).

Shoot and root length (cm)

The combined data identified a significant difference in the shoot and root lengths of different kind of priming treatment ($p<0.05$). This phenomenon of growth increase in shoot length after priming of seeds can be explained by increasing the cell division, meristem activity and the stimulation of the elongation of cells. All these physiological processes have been found to enhance seedling growth and vigour after being subjected to priming treatments (22) table 2. The finding was that regarding all the priming treatments, T_6 (15.83 cm) with GA_3 50 ppm had the longest shoot recorded as being significantly at par with T_2 which was 15.50 cm. Conversely, the bottom sample T_0 (7.55 cm) comprised of un-primed seeds that recorded the fewest shoots.

Conversely, the pooled data indicated that, the various priming treatments influenced the length of the longest root substantially ($p< 0.05$). Thus, T_2 with PEG 5 % had the maximum root length of 8.16 cm, followed by T_6 with GA_3 50 ppm having root length of 7.47 cm. Also, they were quite equal with T_2 and T_7 i.e., 8.16 cm and 7.63 cm. Likewise T_7 and T_6 are also very much at par with the T_6 being (7.47 cm) and the T_7 being (7.63 cm). Conversely, the minimum root length was observed in T_0 (3.57 cm), which is the value of the un-primed seeds table 2. High germination percent synchronized seedling emergence and better shoot and root length of primed seeds can be possibly explained by initiation of certain metabolic processes in the seed embryo (23, 17). So-called soybean and cumin have also been used to depict that osmo-priming as well as hydropriming can also enhance root and shoot growth (24).

Table 1. Effect of various priming treatments on the germination percentage (%) and number of days to germination in Okra

	Germination percentage (%)			Number of days for germination Days		
Treatment's detail	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_0 (un-primed)	62.00^{g}±1.00	62.67^{g}±1.53	62.33^{g}±1.15	8.00^{a}±0.77	8.45^{a}±0.77	8.22^{a}±1.12
T_1 (hydropriming)	77.33^{d}±2.08	76.67^{d}±1.53	77.00^{d}±1.32	6.63^{a}±0.83	6.55^{bcd}±0.83	6.59^{bcd}±0.96
T_2 (PEG 5 %)	92.33^{a}±1.53	92.00^{a}±1.00	92.17^{a}±0.29	5.00^{b}±0.87	5.13^{d}±0.87	5.06^{d}±0.81
T_3 (KCL) 3 %	72.33^{e}±1.53	71.00^{e}±1.00	71.67^{e}±0.29	7.11^{ab}±1.12	7.19^{abc}±1.12	7.15^{abc}±1.40
T_4 (KNO_3) 5 %	81.00^{c}±1.00	82.00^{c}±1.00	81.50^{c}±0.50	6.33^{ab}±1.58	6.67^{bcd}±0.57	6.50^{bcd}±0.87
T_5 ($MgNO_3$)$_2$ 1.5 %	66.67^{f}±1.53	67.33^{f}±1.53	67.00^{f}±0.50	7.77^{a}±1.02	7.84^{ab}±1.01	7.81^{ab}±0.47
T_6 (GA_3) 50ppm	90.00^{a}±1.00	89.00^{a}±1.00	89.50^{a}±1.00	5.43^{b}±0.63	5.63^{cd}±0.63	5.53^{d}±0.51
T_7 (NAA) 50ppm	85.00^{b}±1.00	86.00^{b}±1.00	85.50^{b}±0.87	6.18^{ab}±0.60	6.31^{bcd}±0.60	6.25^{cd}±0.74
CD (*p<0.05*)	2.50	1.69	1.51	1.92	1.51	1.41

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

Table 2. Effect of various priming treatments shoot length and root length (cm) in Okra

	Shoot length (cm)			Root length (cm)		
Treatment's detail	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_0 (un-primed)	7.28^{f}±1.23	7.82^{e}±0.55	7.55^{g}±0.79	3.55^{c}±0.95	3.59^{c}±0.89	3.57^{c}±0.92
T_1 (hydropriming)	10.69^{de}±1.05	11.36^{cd}±1.12	11.02^{ef}±0.58	7.46^{ab}±1.11	6.46^{a}±1.04	6.53^{b}±1.00
T_2 (PEG 5 %)	15.94^{a}±0.99	15.06^{ab}±1.42	15.50^{ab}±1.20	8.84^{a}±0.96	7.48^{a}±1.03	8.16^{a}±0.99
T_3 (KCL) 3 %	11.55^{cde}±0.94	12.74^{c}±0.95	12.15^{de}±0.56	6.32^{b}±0.90	6.34^{ab}±0.87	6.33^{b}±0.88
T_4 (KNO_3) 5 %	12.54^{cd}±1.04	13.15^{bc}±1.03	12.85^{cd}±0.87	7.41^{ab}±0.09	7.49^{a}±1.17	7.45^{ab}±0.56
T_5 ($MgNO_3$)$_2$ 1.5 %	9.66^{e}±0.89	9.99^{d}±0.93	9.83^{f}±0.70	4.11^{c}±1.02	5.21^{b}±1.01	4.66^{c}±0.52
T_6 (GA_3) 50ppm	14.74^{ab}±0.88	16.92^{a}±1.04	15.83^{a}±0.83	6.59^{b}±0.97	8.78^{a}±0.96	7.47^{ab}±1.07
T_7 (NAA) 50ppm	13.13^{bc}±1.44	14.84^{b}±0.90	13.99^{bc}±0.96	7.69^{ab}±0.76	7.56^{a}±1.28	7.63^{ab}±1.01
CD (*p<0.05*)	1.91	1.92	1.54	1.48	1.19	1.91

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

Seedling length (cm) and dry weight of seedling (mg)

The pooled data in seedling length (root length+ shoot length) as recommended that numerous priming sources affected seedling length significantly *(p<0.05)* table 3. The result showed that among various priming sources, maximum seedling length was recorded in T_2 (23.66 cm), which is PEG 5 %, followed closely by T_6 (23.52 cm), which is GA_3 50 ppm. Additionally, there were *at par* shows between T_2, T_7 and T_6 which were (23.66 cm, 23.61 cm and 21.52 cm, respectively). The minimum seedling length was observed in T_0 (13.60 cm), un-primed seeds, followed by T_5 (14.49 cm), which is Magnesium nitrate 1.5 %. On the opposite side, as shown in table no. 3, the pooled data revealed that different priming treatments had a significant impact on the dry weight of seedlings *(p<0.05).* The highest seedling dry weight was observed in T_2 at 30.10 mg, followed closely by T_7 at 28.46 mg and T_6 at 28.44 mg. Additionally, the dry weight of seedling values T_2, T_7 and T_6 are significantly at par with each other, which are 30.10 mg, 28.46 mg and 28.44 mg, respectively. In contrast, the lowest dry weight of seedlings of okra (23.59 mg) was observed in T_0, the unprimed control. Multiple studies confirm that seed priming leads to a stronger and more effective root and shoot system, as well as a reduction in physiological deterioration, due to a series of physiological and biochemical changes within the seed. Seed priming initiates early metabolic activities-such as enzyme activation, protein and nucleic acid synthesis and membrane repair before radicle emergence, which increases the physiological activity of the embryo and supports the mobilization of food reserves into developing seedlings. This could have led to DNA repair because the imbibition process creates enzymes and protein membranes (25, 26). Osmo-priming treatments increased the dry weight of seedlings in all the investigated Berseem clover species, both primed and non-primed (27). When the seeds sprout, it reduces the seed coat's adherence. Seed germination and increased vigour during osmotic priming may be due to active nutrition and the resynthesis of certain enzymes. Furthermore, the production of DNA and RNA might have started. Eliminating obstacles causes seeds to germinate more quickly and eventually grow into a sturdy shoot with a higher dry weight (28).

Seedling vigour index (I) and (II)

Seed priming treatments significantly influenced both Seedling Vigour Index I and II, highlighting the impact of various priming methods on enhancing seedling growth and development. Priming can conceivably increase the competitive ability of the plant for the available resources such as nutrients, water and sunlight and thus, can affect seedling vigour (29). The pooled data indicated that different priming treatments had a significant effect on both Seedling Vigour Index-I and Seedling Vigour Index-II *(p<0.05).* Table 4 shows that among the several priming sources, the highest seedling vigour (i) was recorded in T_2 (2166.95) followed closely by T_6 (2109.41). In contrast, the

Table 3. Effect of various priming treatments on seedling length (cm) and dry weight of seedlings (mg) in Okra

	Seedling length (cm)			Dry weight of seedlings (mg)		
Treatment's detail	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_0 (un-primed)	10.83^{d}±2.18	11.39^{e}±1.26	13.60^{e}±4.34	23.64^{d}±0.89	23.54^{d}±1.07	23.59^{d}±0.98
T_1 (hydropriming)	18.15^{bc}±0.90	17.82^{c}±0.11	17.98^{d}±0.09	26.27^{c}±1.05	27.42^{bc}±0.96	26.85^{bc}±0.83
T_2 (PEG 5 %)	24.78^{a}±0.02	22.54^{a}±1.07	23.66^{a}±1.03	29.84^{a}±0.95	30.35^{a}±1.37	30.10^{a}±1.15
T_3 (KCL) 3 %	17.87^{bc}±0.81	19.08^{c}±0.83	18.48^{cd}±0.32	26.42^{c}±0.84	26.54^{c}±1.14	26.48^{c}±0.28
T_4 (KNO_3) 5 %	19.95^{abc}±1.11	20.64^{ab}±1.01	20.30^{bcd}±0.38	27.74^{bc}±0.90	28.51^{abc}±1.52	28.13^{ab}±0.56
T_5 $(MgNO_3)_2$ 1.5 %	13.77^{d}±1.72	15.20^{d}±1.93	14.49^{e}±1.17	24.16^{d}±0.92	24.61^{d}±1.30	24.39^{de}±0.19
T_6 (GA_3) 50ppm	21.33^{a}±1.69	25.70^{a}±0.84	23.52^{ab}±0.55	28.73^{ab}±0.81	28.15^{bc}±0.95	28.44^{a}±0.88
T_7 (NAA) 50ppm	20.82^{ab}±1.86	22.40^{a}±2.16	21.61^{abc}±1.77	28.06^{abc}±1.55	28.85^{ab}±1.08	28.46^{a}±1.16
CD (*p<0.05*)	2.69	1.87	3.11	1.86	1.88	1.34

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

Table 4. Effect of various priming treatments on seedling vigour index-i (SVI) and seedling vigour index-ii (SVI) in Okra

	Seedling vigour index-i			Seedling vigour index-ii		
Treatment's detail	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_0 (un-primed)	687.96^{e}±105.49	755.04^{e}±93.96	721.50^{g}±53.38	1374.28^{e}±109.93	1342.86^{e}±88.16	1358.57^{e}±87.52
T_1 (hydropriming)	1274.26^{c}±95.08	1366.06^{c}±91.03	1320.16^{d}±43.26	2152.51^{c}±84.50	2027.99^{b}±137.75	2090.25^{c}±88.59
T_2 (PEG 5 %)	2260.81^{a}±95.75	2073.08^{a}±82.17	2166.95^{a}±56.76	2721.48^{a}±145.82	2534.18^{a}±94.28	2627.83^{a}±26.01
T_3 (KCL) 3 %	1146.42^{c}±141.03	1241.42^{c}±94.43	1193.92^{e}±72.89	1703.59^{d}±157.18	1756.96^{c}±103.35	1730.28^{d}±81.88
T_4 (KNO_3) 5 %	1655.93^{b}±83.14	1670.07^{b}±107.78	1663.00^{c}±93.55	2212.87^{bc}±89.66	2116.53^{b}±58.79	2164.70^{c}±16.01
T_5 $(MgNO_3)_2$ 1.5 %	983.15^{d}±95.98	973.79^{d}±94.86	978.47^{f}±95.00	1673.48^{d}±85.47	1573.84^{d}±117.09	1623.66^{d}±49.80
T_6 (GA_3) 50ppm	1955.36^{a}±108.58	2263.46^{a}±110.52	2109.41^{a}±94.75	2473.04^{a}±94.96	2736.82^{a}±94.32	2604.93^{a}±94.63
T_7 (NAA) 50ppm	1728.08^{b}±135.09	1770.72^{b}±115.03	1749.4^{b}±57.54	2365.17^{ab}±113.86	2365.17^{a}±108.06	2365.17^{b}±110.86
CD (*p<0.05*)	138.30	171.54	82.25	186.50	185.22	119.97

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

lowest seedling vigour index (i) was observed in T_0 (721.50), the untreated control, followed by T_5 (978.47). On the other hand, table 4, the pooled data revealed that different priming treatments had a significant impact on seedling vigour index II *(p<0.05).* Therefore, seedling vigour index (ii) was recorded in T_2 (2627.83), which is PEG 5 %, followed by T_6 (2604.93). Whereas they were significantly at par shows between $T_2$and T_6 which were 2627.83 and 2604.93. In addition, the minimum seedling vigour index (ii) was observed in T_0 (1358.57), which is un-primed seeds, followed by T_5 (1623.66), which is Magnesium nitrate 1.5 %. Consistent with this result is the finding of (30) that seed priming raised antioxidant levels in seeds, including glutathione and ascorbate. Through a reduction in lipid peroxidation activity, these enzymes speed up germination. A study was done on Osmo and halo-priming of okra showed that seed priming holds close conformity in the enhancement of seed vigour (17).

Root-shoot ratio

The pooled data indicated that various priming sources significantly affected shoot length and root length *(p<0.05).* Table 5 shows that among the various priming treatments, T_2recorded the highest root-shoot ratio of okra at 0.69, followed by T_6 with a ratio of 0.65. Moreover, the minimum (0.21) root/shoot ratio of okra was found in T_0. (31) observed physiological and biochemical alterations that enhanced the physiological activity of the embryo and facilitated the mobilization of food stores into the developing seedlings. (32) that resulted in the establishment of a more resilient and efficient root and shoot system, thereby significantly mitigating physiological degradation (33). This process may have accelerated the repair of DNA, protein membranes and enzymes during imbibition (34). The priming-induced increase in the root to shoot ratio may be attributed to increased metabolic activities and greater cell wall extensibility. These physiological changes are possibly activated by the slower imbibition rate that occurs during hydro or matrix priming.

Effect of different seed priming with osmo-priming on yield attributes characters

Number of pods plant^{-1} and individual pod weight (g)

The combination of data showed that there was a significant influence of different priming sources on the number of pods plant^{-1}and individual pod weight (*p<0.05*). Table 6 indicates that plant^{-1} had the highest number of pods number namely 12.28 which was under treatment T_2. And the second highest number of pods plant^{-1} was 10.57 which represented in treatment T_7. However, they are significantly at par between the T_2 and T_7 of 12.28 and 10.57 and T_7 and T_6 are at par with each other (10.57

Table 5. Effect of various priming treatments on root-shoot ratio in Okra

	Root-shoot ratio		
Treatment's detail	**2019**	**2020**	**Pooled**
T_0 (un-primed)	0.23^{f}±0.04	0.19^{f}±0.03	0.21^{e}±0.03
T_1 (hydropriming)	0.44^{de}±0.10	0.38^{cd}±0.04	0.41^{cd}±0.06
T_2 (PEG 5 %)	0.69^{a}±0.06	0.62^{ab}±0.05	0.65^{ab}±0.03
T_3 (KCL) 3 %	0.52^{cd}±0.04	0.31^{de}±0.04	0.42^{cd}±0.02
T_4 (KNO_3) 5 %	0.48^{d}±0.10	0.43^{c}±0.06	0.45^{c}±0.08
T_5 ($MgNO_3$)$_2$ 1.5 %	0.38^{e}±0.05	0.25^{ef}±0.04	0.32^{de}±0.01
T_6 (GA_3) 50ppm	0.72^{ab}±0.10	0.66^{a}±0.07	0.69^{a}±0.08
T_7 (NAA) 50ppm	0.59^{bc}±0.10	0.55^{b}±0.06	0.57^{b}±0.08
CD (*p<0.05*)	0.12	0.09	0.09

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

Table 6. Effect of different seed priming treatments on the number of pods plant^{-1} and individual pod weight (g) in Okra

	Number of pods plant^{-1}			Individual pod weight (g)		
Treatment's detail	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_0 (un-primed)	7.00^{e}±1.00	6.43^{c}±0.59	6.72^{c}±0.53	7.92^{d}±0.54	7.20^{d}±0.08	7.56^{d}±0.23
T_1 (hydropriming)	10.33^{cd}±0.58	9.07^{ab}±0.90	9.70^{ab}±0.72	8.42^{c}±0.06	8.40^{c}±0.08	8.41^{c}±0.06
T_2 (PEG 5 %)	12.67^{a}±0.58	11.90^{a}±0.10	12.28^{a}±0.29	9.02^{a}±0.15	9.55^{a}±0.011	9.28^{a}±0.11
T_3 (KCL) 3 %	10.00^{cd}±1.00	8.00^{b}±1.00	9.00^{b}±0.50	8.48^{bc}±0.03	8.45^{c}±0.04	8.47^{c}±0.02
T_4 (KNO_3) 5 %	12.00^{ab}±1.00	9.10^{ab}±0.95	10.55^{a}±0.53	8.54^{bc}±0.04	8.56^{b}±0.03	8.55^{bc}±0.03
T_5 ($MgNO_3$)$_2$ 1.5 %	9.00^{d}±1.00	9.33^{ab}±0.58	9.17^{b}±0.58	8.34^{cd}±0.03	8.37^{c}±0.05	8.36^{c}±0.02
T_6 (GA_3) 50ppm	11.00^{bc}±1.00	9.63^{a}±0.55	10.32^{a}±0.55	8.87^{ab}±0.20	8.75^{a}±0.03	8.81^{a}±0.09
T_7 (NAA) 50ppm	12.33^{ab}±0.58	8.80^{ab}±0.95	10.57^{a}±0.73	8.65^{abc}±0.04	8.68^{a}±0.04	8.67^{ab}±0.02
CD (*p<0.05*)	1.52	1.25	0.86	0.38	0.09	0.18

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

and 10.32). Similarly, T_6 and T_4 are in par with each other which is (10.32 and 10.55). Also, minimum (6.72) number of pods plant^{-1} was obtained on treatment of T_0. On the other hand, pooled data revealed that the sources of priming had significant effect on the individual pod weight (g) of okra (*p<0.05*) table 6 shows that treatment T_2 had the highest individual pod weight of okra which was 9.28 g.

Individual pod weight values of T_2, T_6 and T_7 (9.28g, 8.81g and 8.67g, correspondingly) were however proved to be significantly at par with one another, priming treatments. These were opposed by the lowest individual pod weight of okra (7.56 g) observed in T_0 treatment. Certainly, the increase in pods plant^{-1} can be characterized by the number of increases in leaves. According to (35), seed priming influenced seed emergence, increase seedling growth and Vigour has consequence resulted in showing an increased number of leaves and in the course of time, it will bear more pods. In addition, the number of pods plant^{-1} is the outcome of the final output, which is one of the significant factors. The number of pods will also increase in the same fashion with the leaves number. The correlation between the pods and leaves are coherent. Polyethylene glycol solution help in the enhancement of the yield of wheat which is noted by (36) and agrees with the current findings (37). As primed seed plots can possibly yield more grain since primed seeds germinate faster and more evenly and seedlings are avidly grown. All these leads to numerous phonological and yield.

Effect of different seed priming with osmo-priming on okra yield

Pod yield plant^{-1} (g) and pod yield plot^{-1} (Kg)

The pooled data showed that different priming sources had a significant impact on both pod yield plant^{-1} (g) and pod yield plot^{-1} (Kg) (*p<0.05*). Based on table 7, treatment T_2 recorded the highest pod yield plant^{-1}, with a value of 113.96 g. However, several pod yield plant^{-1} (g) values of T_2 and T_6 are significantly at par with each which are (113.96 g and 90.99 g). Similarly, T_4 and T_7 significantly at par with each other (90.25 g and 91.51g, respectively). The minimum pod yield plant^{-1} (50.90 g) was found from the T_0. On the other hand, the pooled data demonstrated that different priming sources had a significant effect on pod yield plot^{-1} (Kg) of okra (*p<0.05*). Treatment T_2 produced the highest pod yield plot^{-1} at 14.24 Kg, followed closely by T_7 at 11.73 Kg table 7. The number of pod yield plot^{-1} (Kg) values of T_2 and T_7, are significantly at par with each other, which is (14.24 Kg and 11.73 Kg. Likewise, $T_6$and T_4 significantly at par with each other (11.37 Kg and 11.28 Kg respectively). The minimum pod yield plot^{-1} (6.17 Kg) was found from T_0. Seeds primed plots have contributed to the best performance in the

Table 7. Effect of different seed priming treatments on the Pod yield plant^{-1} (g) and Pod yield plot^{-1} (Kg) in Okra

	Pod yield plant^{-1} (g)			Pod yield plot^{-1} (Kg)		
Treatment's detail	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_0 (un-primed)	55.44^{e}±9.26	46.37^{c}±4.71	50.90^{c}±3.92	6.93^{e}±1.16	5.80^{c}±0.59	6.17^{d}±0.56
T_1 (hydropriming)	86.76^{cd}±4.70	76.14^{ab}±7.26	81.45^{b}±5.79	10.87^{cd}±0.57	9.52^{ab}±0.91	10.19^{b}±0.72
T_2 (PEG 5 %)	114.30^{a}±6.86	113.61^{a}±1.90	113.96^{a}±3.97	14.29^{a}±0.86	14.20^{a}±0.24	14.24^{a}±0.50
T_3 (KCL) 3 %	84.79^{cd}±8.27	68.35^{b}±7.71	76.57^{b}±3.63	10.60^{cd}±1.03	9.21^{ab}±0.97	9.90^{b}±0.52
T_4 (KNO_3) 5 %	102.53^{ab}±8.65	77.97^{ab}±8.04	90.25^{a}±4.28	12.82^{ab}±1.08	9.74^{ab}±1.00	11.28^{a}±0.53
T_5 ($MgNO_3$)$_2$ 1.5 %	75.02^{d}±8.23	78.15^{ab}±4.82	76.59^{b}±5.01	9.38^{d}±1.03	8.46^{b}±1.09	8.92^{c}±0.55
T_6 (GA_3) 50ppm	97.72^{bc}±10.90	84.25^{a}±4.64	90.99^{a}±5.87	12.22^{bc}±1.36	10.53^{a}±0.58	11.37^{a}±0.73
T_7 (NAA) 50ppm	106.32^{ab}±4.94	76.38^{ab}±7.94	91.51^{a}±6.23	13.33^{ab}±0.62	10.13^{a}±0.58	11.73^{a}±0.60
CD (*p<0.05*)	4.84	10.45	7.00	1.76	1.33	0.87

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

field (38). Uniform and improved germination, strong seedling growth, a well-developed root system and efficient subsequent growth may be the biggest reasons to increase the final yield. improved vigor of the seedlings and improved vegetative and reproductive characteristics may have come up with higher pod production. A typical limiting variable, likely crust development, dwindling soil moisture and high salt, hinder effective emergence, has been improved because of the head start of germination considering that primed seeds are in a different developmental stage than dry seeds (39).

Pod yield (t ha^{-1})

The pooled data revealed that different priming sources had a significant impact on pod yield measured in t ha^{-1} (*p<0.05*). Based on table 8, treatment T_2 recorded the highest pod yield of okra, producing 12.89 (t ha^{-1}). The number of pod yield tonnes (t ha^{-1}) values of T_2 and T_6 are significantly at par with each other (12.89 t ha^{-1} and 12.36 t ha^{-1}). Similarly, $T_6$and were shown to be significantly at par with each other 12.36 t ha^{-1} and 12.10 t ha^{-1} respectively. The minimum (9.92 t ha^{-1}) pod yield of okra was found from T_0 treatment. The priming treatment greatly raised overall biomass and raised wheat and soybean yields (40, 41). For any crop being studied, yield is the final product and is influenced by several variables, including soil types, environmental conditions and genetic composition. Priming may boost biological yield because it improves early seedling growth and plant nutrition (42).

Chlorophyll index and Mucilage content (%)

The pooled data noticed that the source of priming etiologically influenced value of SPAD of okra was significant (*p<0.05*). Table 9 reveals that okra showed a maximum value of SPAD in treatment T_2 which was 52.13. Nonetheless, this was not statistically different with treatment T_6 that recorded a SPAD value of 50.44. In T_0, the lowest value of SPAD of okra (40.46) was obtained. Conversely, the pooled data revealed that all the sources of priming had significant effect on the content of mucilage in okra at p<0.05 table 9 reveals that T_6 priming recorded the highest value of the mucilage content in okra at 5.64, which is closely followed by treatment T_2 at 5.57. There were however shows between T_2 and T_6 that were at par which were 5.57 and 5.64 %. The lowest (3.68 %) mucilage content of okra was seen in the T_0 and T_7. The assistance of Chlorophylls, plants have the capability of capturing a large proportion of the light energy besides the fact that the performance of chlorophyll in the plants can result into photosynthesis reactions in plants hence, chlorophyll is highly important pigment. But there might be a possibility that chlorophyll is particularly sensitive to several environmental stresses, as a consequence of which, it may lead to an outstanding decline of SPAD value and biosynthesis, consequently it may be subject to the growth and yield of plants (43, 44). Moreover, osmo-priming resulted in enhancement of photosynthetic processes in cucumber seedlings, such as those involving stomatal conductance, transpiration rate and photosynthesis rate when

Table 8. Effect of different seed priming treatments on the Pod yield (t ha^{-1}) in okra

	Pod yield (t ha^{-1})		
Treatment's detail	**2019**	**2020**	**Pooled**
T_0 (un-primed)	9.88^{e}±0.17	9.95^{c}±0.23	9.92^{e}±0.03
T_1 (hydropriming)	10.86^{c}±0.27	10.28^{c}±0.18	10.57^{cd}±0.06
T_2 (PEG 5 %)	12.75^{a}±0.23	13.02^{a}±1.80	12.89^{a}±0.20
T_3 (KCL) 3 %	10.54^{cd}±0.34	10.86^{b}±0.30	10.70^{c}±0.32
T_4 (KNO_3) 5 %	11.61^{b}±0.27	11.74^{a}±0.19	11.68^{b}±0.21
T_5 ($MgNO_3$)$_2$ 1.5 %	10.13^{de}±0.14	10.36^{c}±0.23	10.24^{de}±0.16
T_6 (GA_3) 50ppm	12.51^{a}±0.24	12.21^{a}±0.21	12.36^{a}±0.18
T_7 (NAA) 50ppm	12.05^{b}±0.44	12.15^{a}±0.40	12.10^{a}±0.34
CD (*p<0.05*)	0.46	0.45	0.39

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

Table 9. Effect of different seed priming treatments on okra's chlorophyll index (SPAD) and mucilage content (%)

	Chlorophyll Index (SPAD)			Mucilage content (%)		
Treatment's detail	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_0 (un-primed)	40.06^{f}±1.78	40.85^{e}±1.52	40.46^{d}±1.15	3.66^{e}±0.11	3.70^{e}±0.06	3.68^{e}±0.08
T_1 (hydropriming)	44.81^{de}±1.18	43.58^{de}±1.47	44.19^{c}±0.96	4.42^{cd}±0.38	4.58^{cd}±0.17	4.50^{cd}±0.26
T_2 (PEG 5 %)	51.38^{a}±1.21	52.88^{a}±1.73	52.13^{a}±0.74	5.82^{a}±0.15	5.33^{a}±0.32	5.57^{a}±0.20
T_3 (KCL) 3 %	46.34^{cd}±1.96	46.01^{cd}±3.08	46.18^{c}±1.81	4.44^{cd}±0.12	4.41^{cd}±0.08	4.43^{cd}±0.10
T_4 (KNO_3) 5 %	48.27^{bc}±1.43	49.69^{ab}±0.94	48.98^{b}±1.16	4.84^{bc}±0.11	4.83^{bc}±0.10	4.84^{bc}±0.10
T_5 $(MgNO_3)_2$ 1.5 %	42.58^{ef}±1.92	44.98^{d}±1.43	43.78^{c}±0.74	4.22^{de}±0.03	4.19^{de}±0.02	4.21^{de}±0.01
T_6 (GA_3) 50ppm	50.42^{ab}±0.41	50.45^{ab}±0.98	50.44^{ab}±0.67	5.39^{ab}±0.40	5.88^{a}±0.10	5.64^{a}±0.25
T_7 (NAA) 50ppm	49.01^{ab}±2.41	49.06^{bc}±2.35	49.04^{b}±2.38	5.16^{b}±0.56	5.12^{ab}±0.60	5.14^{ab}±0.58
CD (*p<0.05*)	2.38	3.27	2.36	0.53	0.47	0.49

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

the seeds were primed (45). whereas the same finding is also comparable in the okra study in the sense that indubitably, this attribute also rises in photosynthetic activities to increased chlorophyll index as well in this okra study. However (46) depicted the same result that when the seeds were primed that has increased mucilage content it lies between 3.40 to 5.93 %. Besides that, okra mucilage has the capacity to hold more zinc, calcium and minerals which are also present in entire fruit of okra and okra mucilage on the whole are natural polysaccharides, which contain L-rhamnose and monosaccharide D-galactose, galacturonic acid combined with proteins and minerals. Polysaccharides that are available in mucilage can provide the biological significance like immunomodulators and anti-inflammatories that can be obtained by polysaccharides (47, 48).

Iodine content

The pooled data observed that several priming sources significantly affected the iodine content of okra (*p<0.05*). Table 10 shows that treatment T_2 recorded the highest iodine content in okra at 13.14 mg kg^{-1}, which was statistically at par with treatment T_6 that recorded 13.08 mg kg^{-1}. The minimum iodine content of okra (6.71 mg kg^{-1}) was found in T_0 treatment. This result is supported by (49, 50).

Conclusion

The present research advises that Osmo-priming is a viable method of improving germination in okra. Osmo-priming using 5 % polyethylene glycol (PEG) as seed priming can be utilized to increase the percentage germination (%), a number of days to germinate, shoot length (cm), root length (cm), length of seedling (cm) and dry weight of seedling (mg) vigour index (i), seedling vigour index (ii), root-shoot ratio, pods $plant^{-1}$, individual pod weight (g), pod yield $plot^{-1}$ (kg), yield $plant^{-1}$ (g), pod yield (t ha^{-1}), It was also seen that osmo-priming seeds have the best degree of tolerance to biotic and abiotic factors, probably because of the enhanced functioning of antioxidant enzymes. Hence, it is possible to recommend osmo priming to farmers to be used in the future.

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Authors' contributions

NK did field work and wrote the paper. DM carried out the analysis and AS did the corrections.

Table 10. Effect of different seed priming treatments on okra's iodine content (mg kg^{-1})

	Iodine content (mg kg^{-1})		
Treatments	**2019**	**2020**	**Pooled**
T_0 (un-primed)	6.75^{e}±0.95	6.69^{e}±1.07	6.71^{f}±1.00
T_1 (hydropriming)	9.64^{cd}±0.96	9.75^{cd}±1.12	9.69^{d}±1.04
T_2 (PEG 5 %)	13.44^{a}±1.11	12.84^{a}±0.91	13.14^{a}±0.91
T_3 (KCL) 3 %	10.31^{bc}±0.95	10.41^{bc}±0.84	10.36^{cd}±0.89
T_4 (KNO_3) 5 %	11.01^{b}±1.43	11.42^{b}±1.43	11.22^{b}±1.43
T_5 $(MgNO_3)_2$ 1.5 %	8.76^{d}±1.07	8.79^{d}±1.03	8.77^{e}±1.05
T_6 (GA_3) 50ppm	12.82^{a}±1.17	13.354^{a}±1.06	13.08^{a}±0.93
T_7 (NAA) 50ppm	10.47^{bc}±0.90	10.67^{bc}±1.16	10.57^{bc}±1.03
CD (*p<0.05*)	0.90	1.03	0.81

Each value in the treatment is a means of three replicates ± SD. Means followed by the same letter (s), in each row, are not significantly different (ANOVA, LSD test p<0.05).

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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