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Research Article

Effect of different seed priming methods on seed germination and vigor of okra

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ABSTRACT

Okra (*Abelmoschus esculentus* L.) faces problems of poor germination because of its hard seed coat that restricts water uptake. Seed priming provides a pre-sowing, effective and low-cost technique to enhance germination and seedling vigor. The purpose of this study was to evaluate the effect of different seed priming methods on the germination and vigor of okra variety 'Arka Anamika' under laboratory conditions. This study was conducted in a simple Completely Randomized Design (CRD) with three replications and seven treatments (distilled water hydro-priming, 5% cow urine, 200 ppm GA_3, 10% *Trichoderma viride*, 10% *Pseudomonas fluorescens*, 5% NaCl, and an untreated control) from 30 May to 14 June 2024. The parameters measured were germination percentage, germination rate, mean germination time, germination speed index, germination energy, seedling vigor index, root & shoot length and allometric coefficient. Treatments differed significantly from one another. GA_3 priming maintained the maximum germination speed index (61.25), germination energy (74.16%), seedling vigor index (1326.33), and shoot length (24.27 cm) while the highest germination percentage (88.66%) and comparable vigor performance were recorded by *Trichoderma viride* priming. Cow urine was found to be least effective, although hydro-priming yielded a moderate improvement. The findings of this study suggest that the okra seed primed with 200 ppm GA_3 or 10% *Trichoderma viride* show better performance in terms of seedling vigor and germination under laboratory conditions.

Keywords: GA_3, Seed priming, Seed germination, Seed vigor index

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INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench), is a widely cultivated vegetable crop species of the family Malvaceae (Lamichhane *et al.*, 2021). Due to nutritional and economic importance, the crop is extensively grown across tropical, subtropical, and warm temperate regions including South and Southeast Asia of the world (Chan *et al.*, 2018). Okra is valued for its high contents of dietary fibers, minerals, and vitamins. Besides that it has a significant role in enhancing food security in rural livelihoods in developing countries like in Nepal. However, successful okra production largely depends on a rapid and uniform seed

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germination along with early seedling vigor which are often limited by environmental and physiological constraints.

The significant obstacle to okra cultivation is its hard seed coat which acts as a physical barrier to water intake and delays and reduces germination (Bereded Sheferie, 2023). Despite being viable, okra seeds often exhibit slow, erratic, and non-uniform germination, which results in uneven growth, poor crop establishment, reduced fertilizer efficiency, and eventually low production (Ali *et al.*, 2016; Purquerio *et al.*, 2010). These difficulties are especially noticeable during early spring planting when soil temperature and moisture are not ideal (Ara *et al.*, 2011). Therefore, increasing germination and vigor is essential for achieving better crop stand establishment and yield potential (Olowolaju *et al.*, 2023).

Seed priming is an effective and eco-friendly pre-sowing technique that helps to address the existing challenges in seed germination of okra. It enhances germination rate, seedling vigour, and uniformity of germination by initiating controlled metabolic processes before sowing (Devika *et al.*, 2021). Various priming techniques such as hydro-priming (soaking in water), osmo-priming (soaking in osmotic solutions), hormonal priming (using plant growth regulators like GA_3 or NAA), bio-priming (using beneficial microorganisms such as *Trichoderma* and *Pseudomonas*), and solid matrix priming have been reported by Lamichhane *et al.* (2021) and Mehata *et al.* (2023) to improve germination and early growth across various crops. Okra farmers in Nepal have major problems of poor and uneven germination after sowing. In order to identify suitable and practical priming methods that can help farmers to enhance seed performance and support sustainable okra production, this present study was carried out. The main aim of this research was to evaluate the effect of different seed priming methods on germination and seedling vigor of okra variety 'Arka Anamika' under laboratory conditions.

MATERIALS AND METHODS

Experimental Location and Materials

The experiment was conducted at the Agriculture Development Office, Bharatpur, Chitwan, under homogeneous laboratory conditions during May to June 2024. The site is situated at 27.68123° N latitude, 84.43318° E longitude, and 251 meters above sea level. Certified okra seeds of variety Arka Anamika were used as the experimental material.

Experimental Design and Treatments

The experiment was laid out in a Completely Randomized Design (CRD) with seven treatments and three replications. The treatments were as follows:

Table 1: Details of treatments

Treatments	Details
T1	Hydro-priming (distilled water)
T2	5% Cow urine
T3	200 ppm GA_3
T4	10% *Trichoderma viride*
T5	10% *Pseudomonas fluorescens*
T6	5% NaCl
T7	Control (no priming)

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Seed priming was carried out at 25 ± 2 °C for the specified duration for each treatment, after which the seeds were shade-dried for six hours to restore their initial moisture content. Each replication consisted of 40 seeds, which were sown in germination trays containing peat moss as the growing medium. The trays were maintained under controlled laboratory conditions, and daily observations were recorded for 15 days after sowing. Regular inspection ensured uniform moisture and temperature conditions. For root and shoot length measurement, eight seedlings were randomly selected from each replication at the end of the experiment.

Data Collection and Observations

Seed Germination Percentage (GP)

The number of germinated seeds was recorded daily up to 15 days after sowing. Germination percentage was calculated as:

GP = (Number of germinated seeds / Total number of seed sown) × 100% ……Eq.1

Seed Germination Rate (SGR)

The germination rate was calculated following Khanal *et al.* (2022):

$$SGR = \sum_{i=1}^{n} \frac{Ni}{Di} \quad \text{…….. Eq.2}$$

Where N= Number of germinated seeds and D = Number of day after germination

Mean Germination Time (MGT)

Mean germination time, which indicates the average time taken for germination, was calculated as:

$$MGT = \sum \frac{(n * D)}{n} \quad \text{…… Eq.3}$$

where n = number of seeds germinated each day and D = day of counting.

Germination Speed Index (GSI)

The GSI was calculated following Chan *et al.* (2018):

GSI= (No.of germinated seeds at first count/ days of first count)+(No.of germinated seeds at final count/ days of final count) …….. Eq.4

Germination Energy (GE)

Following Mehata *et al.* (2023), germination energy was determined as:

GE = (No.of seeds germinated on 4 days/ Total number of seeds tested) × 100% ……...Eq.5

Seedling Vigor Index (SVI)

Seedling vigor index was calculated using the formula:

SVI = Germination percentage×(Mean root length+Mean shoot length) ……. Eq.6

Root and Shoot Length (RL and SL)

Eight seedlings per replication were randomly sampled for measurement. Root length was measured from the hypocotyl base to the tip of the longest root, while shoot length was measured from the hypocotyl base to the apex of the shoot using a precision ruler.

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Allometric Coefficient (AC)

The allometric coefficient, expressing the growth ratio between root and shoot, was calculated following Lamichhane *et al.* (2021).

AC = Root length/Shoot length…… Eq7

Statistical Analysis

All recorded data were tabulated using Microsoft Excel 2021 and analyzed using R Studio software (Version 4.4.1). Treatment means were compared using the Least Significant Difference (LSD) test at a 5% level of significance (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Germination Percentage (GP %)

Seed priming treatments significantly influenced germination percentage as shown in Table 2. Due to stress tolerance ability, phytohormone secretion, and improved nutrient uptake *Trichoderma viride* (88.66%) and GA_3 (83.66%) priming recorded the highest germination percentages, which were statistically superior to other treatments (Mukhtar, 2008; Rai *et al.*, 2019). In contrast, Lamichhane *et al.* (2021) reported maximum germination with GA_3 alone. The present result is in agreement with findings of Bereded Sheferie (2023).

Seed Germination Rate (SGR)

The highest seed germination rate (SGR) was observed with GA_3 priming (4.78 seeds/day), followed by hydro-priming (4.26) and *Trichoderma viride* (4.17), all of which were significantly higher than the control (2.01). According to Lamichhane *et al.* (2021), the stimulatory effects of GA_3 contribute to higher seed germination rates by promoting early and uniform germination

Mean Germination Time (MGT)

GA_3 priming methods again showed better results in terms of mean germination time (6.62 days), followed by hydro-priming (7.51 days), whereas the control took the longest time to germinate (9.61 days).

Table 2: Effect of different priming treatments on germination parameters

Treatments	Germination (%)	Seed germination rate (seeds/days)	Mean germination time (days)
Hydropriming	75.00^{b}	4.26^{ab}	7.51^{cd}
5% Cow Urine	50.00^{cd}	3.22^{bc}	8.93^{ab}
200 ppm GA_3	83.66^{a}	4.78^{a}	6.62^{d}
10% *Trichoderma viride*	88.66^{a}	4.17^{ab}	8.00^{bc}
10% *Pseudomonas fluorescens*	71.00^{b}	3.67^{ab}	9.03^{ab}
5% NaCl	45.00^{d}	3.11^{bc}	9.06^{ab}
Control (No Priming)	55.00^{c}	2.01^{c}	9.61^{a}
F-probability	45.44***	3.38*	8.50***
SEM(±)	21.67	0.74	0.39
LSD(0.05)	8.15	1.51	1.09
CV%	2.59	23.97	7.47
Grand Mean	66.90	3.60	8.39

****& * indicate significant at $p < 0.001$ and $p<0.05$, respectively. Means within a column followed by the same letter are not significantly different at the 5% level according to LSD. CV = Coefficient of Variation; SEM(±) = Standard Error of Mean; LSD = Least Significant Difference.*

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The shortest germination time observed with GA_3 may be due to its ability to facilitate quicker and more uniform germination as compared to other treatments. The present finding aligns with Lamichhane *et al.* (2021).

Germination Speed Index (GSI) and Germination Energy (GE)

GA_3 recorded the highest germination speed index (GSI) i.e. 61.25 and germination energy (GE) i.e.74.16%, statistically at par with *Trichoderma viride* (GSI 50.26 and GE 68.33%). Hydro-priming ranked next, whereas cow urine and NaCl were found to be least effective. These results indicate the positive role of hormonal and microbial priming in enhancing metabolic activation during germination.

Seedling Vigor Index (SVI)

Seedling vigor index (SVI) varied significantly among treatments as shown by the Table 3. GA_3 (1326.33) and *Trichoderma viride* (1304.04) recorded the highest vigor indices, followed by hydro-priming (946.89). The lowest seedling vigor index was observed in cow urine (518.87). Here, GA_3 enhanced seedling vigor through increased enzymatic activity and faster seed metabolism.These findings are in line with findings of Bereded Sheferie (2023) and Lamichhane *et al.*(2021).

Table 3: Effect of different priming treatments on germination speed index (GSI), germination energy(GE) and seedling vigor index (SVI)

Treatments	Germination speed index	Germination energy (%)	Seedling vigor index
Hydropriming	47.14^{b}	60.00^{ab}	946.89^{b}
5% Cow Urine	27.78^{d}	35.00^{c}	518.87^{c}
200 ppm GA_3	61.25^{a}	74.16^{a}	1326.33^{a}
10% *Trichoderma viride*	50.26^{ab}	68.33^{a}	1304.04^{a}
10% *Pseudomonas fluorescens*	42.46^{bc}	40.00^{bc}	897.06^{b}
5% NaCl	32.92^{cd}	42.50^{bc}	560.83^{c}
Control (No Priming)	39.70^{bcd}	33.33^{c}	601.66^{c}
F-probability	7.94***	3.19**	45.94***
SEM(±)	47.06	155.36	75.48
LSD(0.05)	12.01	21.82	152.14
CV%	15.92	24.69	9.87
Grand Mean	43.07	50.47	879.38

***, and ** indicate significant at $p < 0.001$, and $p < 0.01$ respectively. Means within a column followed by the same letter are not significantly different at the 5% level according to LSD. CV = Coefficient of Variation; SEM(±) = Standard Error of Mean; LSD = Least Significant Difference.

Root Length (RL) and Shoot Length (SL)

Although root length did not vary significantly among treatments, GA_3 primed seedlings produced the longest shoots (24.21 cm), followed by *Trichoderma viride* (20.43 cm) and hydro-priming (18.52 cm). The control exhibited the shortest shoots (14.07 cm). The longest shoots observed under GA_3 treatment is because of rapid cell division and elongation (Al-Chalabi, 2020). In the case of *Trichoderma viride,* increased protein synthesis and improved disease resistance may have contributed to shoot growth the comparable to that of GA_3 (Rai *et al.*, 2019). Similar findings were also reported by Balchhaudi (2023) regarding shoot and root length in okra seed germination.

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Allometric Coefficient

Due to more vigorous shoot development relative to root growth, the highest allometric coefficient (0.83) was recorded with GA_3 priming, followed by *Trichoderma viride* (0.72) and hydro-priming (0.66). In contrast, restricted shoot growth under NaCl treatment and in the control resulted in lower allometric coefficients. This finding is in line with Lamichhane *et al.* (2021).

Table 4: Effect of different priming treatments on root length (RL), shoot length (SL) and allometric coefficient

Treatments	Root length (cm)	Shoot length (cm)	Allometric coefficient
Hydropriming	6.68	18.52^{b}	0.66^{c}
5% Cow Urine	6.76	14.10^{c}	0.60^{d}
200 ppm GA_3	7.53	24.21^{a}	0.83^{a}
10% *Trichoderma viride*	8.01	20.43^{b}	0.72^{b}
10% *Pseudomonas fluorescens*	7.94	17.28^{bc}	0.55^{e}
5% NaCl	7.69	17.25^{bc}	0.50^{f}
Control (No Priming)	7.09	14.07^{c}	0.45^{g}
F-probability	0.82^{NS}	9.56***	184.91***
SEM(±)	1.07	3.75	0.02
LSD(0.05)	1.81	3.39	0.02
CV%	14.06	10.72	2.73
Grand Mean	7.38	18.07	0.61

***, indicates significant at $p < 0.001$. NS= Not significant. Means within a column followed by the same letter are not significantly different at the 5% level according to LSD. CV = Coefficient of Variation; SEM(±) = Standard Error of Mean; LSD = Least Significant Difference,

Correlation between Seed Germination Rate (SGR) and Mean Germination Time (MGT)

A moderate negative correlation (r = - 0.64) was observed between seed germination rate (SGR) and mean germination time (MGT). This indicates that higher germination rates were associated with shorter germination periods. According to Gupta and Mukherjee (1982) GA_3 helped in reducing dormancy by enhancing enzymatic activity and amino acid synthesis.

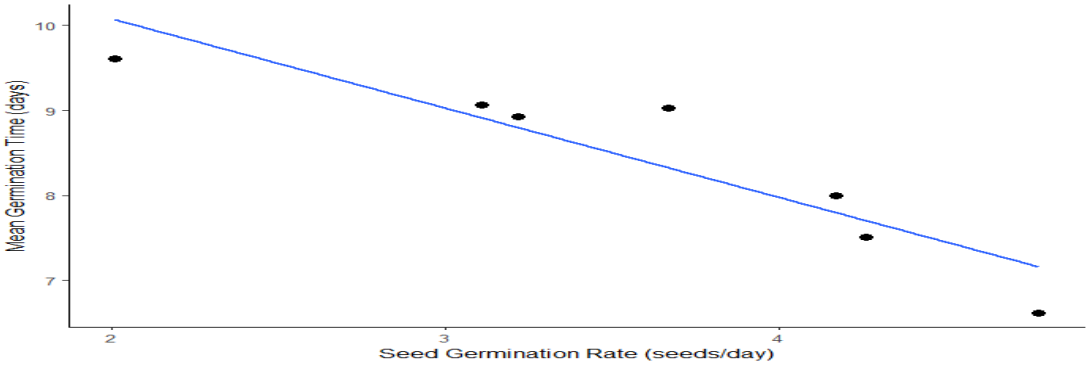

Figure 1: Association between SGR and MGT

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CONCLUSION

In general, the experiment showed significant differences among different seed priming methods on seed germination and vigor of okra (*Abelmoschus esculentus* var. Arka Anamika). Okra seed treated with 200 ppm GA_3 and 10% *Trichoderma viride* showed superior performance in terms of germination percentage, seedling vigor, shoot and root length compared to other priming methods. Hydro-priming also performed well, whereas cow urine priming was the least effective. Based on these findings, this study recommends okra farmers to use 200 ppm GA_3 or 10% *Trichoderma viride* for commercial okra cultivation.

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Authors' Contribution

Rashmishree Singh: Experimentation, data processing and data analysis.
Khumananda Kandel: Data analysis and preparing manuscripts of the article.

Conflict of Interest

The authors declare no conflicts of interest regarding publication of the manuscript.

Ethics Approval Statement

This field-based study did not involve humans or animals. Experimental activities were carried out with prior approval from relevant authorities and in accordance with environmental and biosafety guidelines.

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