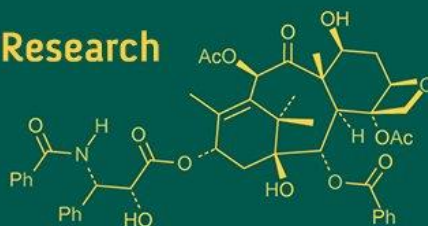


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(8): 659-661
www.biochemjournal.com
Received: 08-06-2026
Accepted: 10-07-2026

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Evaluation of seed priming treatments for improving germination and seedling vigour in onion (*Allium cepa* L.)

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8Sh.9509>

Abstract

Seed priming has emerged as a simple and effective technique to improve seed physiological quality and early seedling growth. Therefore, the present investigation was conducted during 2025-26 at the Department of Horticulture, S.K.N. College of Agriculture, Jobner, Rajasthan, to evaluate the effects of different hormonal, nutrient, organic and biological seed priming treatments on germination, seedling growth and vigour of onion under laboratory conditions. The experiment was laid out in a Completely Randomized Design with 13 treatments and three replications. Treatments comprised GA₃ (100 ppm), KNO₃ (1%), humic acid (0.05%), biochar extract (3%), *Trichoderma viride* (10 g kg⁻¹ seed) and *Pseudomonas fluorescens* (10 g kg⁻¹ seed), each applied for 6 and 12 h, along with an unprimed control. Seed priming significantly improved germination and seedling growth compared with the control. Among all treatments, GA₃ @ 100 ppm for 12 h recorded the highest germination (90.07%), root length (2.51 cm), shoot length (3.63 cm), seedling length (6.14 cm), fresh weight (0.417 g), dry weight (0.0262 g), vigour index-I (553.01) and vigour index-II (2.357). GA₃ @ 100 ppm for 6 h and KNO₃ @ 1% for 12 h exhibited statistically comparable performance for several parameters. The superior response of GA₃ priming may be attributed to enhanced reserve mobilization, improved water uptake and accelerated metabolic activity during germination. The study demonstrates that GA₃ priming at 100 ppm for 12 h is an effective, economical and practical seed enhancement strategy for improving onion seed quality, germination and seedling vigour, thereby facilitating rapid and uniform crop establishment.

Keywords: Seed priming, germination, seedling vigour, seed quality, crop establishment

Introduction

Onion (*Allium cepa* L.; 2n = 16) is one of the most important bulb vegetable crops belonging to the family Amaryllidaceae. It is cultivated extensively throughout temperate, subtropical, and tropical regions and is valued for its culinary, nutritional, medicinal, and economic importance. Onion bulbs are rich sources of carbohydrates, dietary fibre, vitamins, minerals, flavonoids, phenolic compounds, and sulphur-containing metabolites that impart their characteristic flavour, pungency, antioxidant activity, and health-promoting properties. Successful onion production largely depends on rapid and uniform seed germination and vigorous seedling establishment, both of which can be enhanced through appropriate seed enhancement techniques (Yanchenko *et al.*, 2024) [11]. Improved seed quality and early seedling vigour have also been reported to contribute to better crop establishment and productivity under field conditions (Afifa *et al.*, 2024) [2]. India is the second-largest producer of onion globally and occupies a prominent position in its cultivation and export. Despite the large cultivation area, onion productivity is often limited by poor crop establishment resulting from low seed vigour, uneven germination, and rapid deterioration of seed quality during storage. Onion seeds are naturally short-lived because of their high oil content, delicate seed coat, and susceptibility to oxidative damage, membrane deterioration, and lipid peroxidation. Consequently, seed viability and vigour decline rapidly under conventional storage conditions, leading to poor field emergence, non-uniform crop establishment, and ultimately reduced bulb yield and quality (Singh *et al.*, 2018) [9]. Several investigators have reported positive effects of seed priming on onion and other vegetable crops.

Pagano *et al.*, (2023) ^[7] reviewed recent advances in seed priming for onion and related *Allium* species and highlighted its role in improving germination, seedling establishment, and stress resilience. Naveenkumar *et al.*, (2023) ^[6] observed significant improvements in germination and seed vigour following different priming treatments in onion. Das and Prabha (2025) ^[3] reported that appropriate priming treatments effectively mitigated seed ageing effects and enhanced germination and vigour. Likewise, Vij *et al.*, (2025) ^[10] demonstrated that GA₃-mediated priming improved physiological processes associated with germination, resulting in superior seedling growth and vigour. Collectively, these studies confirm that seed priming enhances metabolic efficiency, antioxidant defence, and reserve mobilization, thereby improving seed quality and early crop establishment.

Therefore, the present investigation was undertaken to comparatively evaluate different hormonal, nutrient, organic, and biological seed priming treatments for their effects on germination, seedling growth, and vigour of onion under laboratory conditions. It was hypothesized that appropriate seed priming would enhance pre-germinative metabolic processes, leading to improved germination, vigorous seedling growth, and superior seed physiological quality compared with untreated seeds. The findings of the present study are expected to provide a scientific basis for recommending an effective and economically feasible seed priming technique for improving onion seed quality and ensuring rapid, uniform crop establishment.

Materials and Methods

Experimental site

The laboratory experiment was conducted during 2025-26 at Department of Horticulture, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University (SKNAU), Jobner, Jaipur, Rajasthan, India. The experiment was performed under controlled laboratory conditions to ensure uniformity during seed germination and seedling growth evaluation. The experiment was laid out in a Completely Randomized Design (CRD) comprising 13 treatments with 3 replications. Each replication consisted of 100 seeds.

Table 1: Treatment details with their symbols

Treatment	Description
T ₀	Unprimed control
T ₁	GA ₃ @ 100 ppm for 6 h
T ₂	GA ₃ @ 100 ppm for 12 h
T ₃	KNO ₃ @ 1% for 6 h
T ₄	KNO ₃ @ 1% for 12 h
T ₅	Humic acid @ 0.05% for 6 h
T ₆	Humic acid @ 0.05% for 12 h
T ₇	Biochar extract @ 3% for 6 h
T ₈	Biochar extract @ 3% for 12 h
T ₉	<i>Trichoderma viride</i> @ 10 g kg ⁻¹ seed for 6 h
T ₁₀	<i>Trichoderma viride</i> @ 10 g kg ⁻¹ seed for 12 h
T ₁₁	<i>Pseudomonas fluorescens</i> @ 10 g kg ⁻¹ seed for 6 h
T ₁₂	<i>Pseudomonas fluorescens</i> @ 10 g kg ⁻¹ seed for 12 h

The concentrations and soaking durations were selected based on previous studies on onion seed priming and seed enhancement (Paparella *et al.*, 2015; Farooq *et al.*, 2019; Pagano *et al.*, 2023) ^[8, 4, 7].

Germination test

The germination test was conducted using the Between Paper (BP) method following the *International Rules for*

Seed Testing (ISTA, 1993) ^[5]. One hundred seeds from each replication were placed uniformly between moistened germination papers, rolled carefully, and incubated in a seed germinator maintained at 25±1 °C under optimum moisture conditions. Normal seedlings were counted on the 15 day of the germination test, and germination percentage was calculated as:

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

Seedling growth measurements

Ten normal seedlings were selected randomly from each replication for recording seedling growth parameters. Seedling length was calculated by summing root length and shoot length.

$$\text{Seedling length (cm)} = \text{shoot length (cm)} + \text{root length (cm)}$$

Dry weight (g)

Ten normal seedlings were dried in a hot-air oven at 80±2 °C for 24 h until constant weight and weighed again to determine seedling dry weight.

Seed vigour indices

Seed vigour indices were calculated according to the method of Abdul-Baki and Anderson (1973) ^[1].

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

$$\text{Seed vigour index-II} = \text{Germination (\%)} \times \text{dry weight of seedling (g)}$$

Results and Discussion

Effect of seed priming treatments on germination, seedling growth and vigour of onion.

The present investigation revealed that seed priming significantly improved germination, seedling growth, biomass accumulation, and seed vigour of onion under laboratory conditions (Table 2). Significant differences among priming treatments indicated that both the priming agent and soaking duration played a decisive role in enhancing seed physiological quality. Among the treatments, GA₃ @ 100 ppm for 12 h (T₂) recorded the highest germination (90.07%), root length (2.51 cm), shoot length (3.63 cm), seedling length (6.14 cm), fresh weight (0.417 g), dry weight (0.0262 g), vigour index-I (553.01) and vigour index-II (2.357). These values were significantly superior to the unprimed control and most other treatments, while GA₃ @ 100 ppm for 6 h (T₁) and KNO₃ @ 1% for 12 h (T₄) also produced statistically comparable improvements for several traits.

Among the seed priming treatments, GA₃ @ 100 ppm for 12 h (T₂) proved to be the most effective in improving germination, seedling growth and seed vigour of onion. The superior performance of GA₃ may be attributed to its role in stimulating α-amylase activity, promoting reserve mobilization, enhancing water uptake, and accelerating cell division and elongation, which collectively improved seedling establishment and biomass accumulation. Similar findings were reported by Vij *et al.*, (2025) ^[10], who observed significant improvements in germination and

seedling vigour following GA₃ priming in onion. Likewise, Das and Prabha (2025) [3] reported that GA₃ priming enhanced seed physiological quality by improving metabolic activity and antioxidant defence. Likewise, Pagano *et al.*, (2023) [7] and Yanchenko *et al.*, (2024) [11] highlighted that seed priming enhances metabolic activity, antioxidant defence and early seedling growth in onion and related *Allium* crops. The statistically comparable performance of

GA₃ @ 100 ppm for 6 h (T₁) and KNO₃ @ 1% for 12 h (T₄) further suggests that both hormonal and nutrient priming effectively improve seed physiological quality by enhancing reserve mobilization and germination processes. These findings are also consistent with the observations of Naveenkumar *et al.*, (2023) [6], who reported significant improvements in onion seed germination and vigour through seed priming.

Table 1: Effect of different seed priming treatments on germination, seedling growth and vigour of onion.

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Fresh weight (g)	Dry weight (g)	Vigour index-I	Vigour index-II
T ₀	75.65	1.33	1.86	3.19	0.252	0.0171	241.51	1.291
T ₁	88.40	2.38	3.44	5.82	0.402	0.0244	514.49	2.157
T ₂	90.07	2.51	3.63	6.14	0.417	0.0262	553.01	2.357
T ₃	85.75	2.13	3.07	5.20	0.372	0.0226	445.61	1.935
T ₄	89.05	2.46	3.51	5.97	0.407	0.0251	531.33	2.235
T ₅	79.77	1.62	2.15	3.77	0.290	0.0187	300.72	1.489
T ₆	81.63	1.77	2.53	4.30	0.335	0.0201	351.02	1.644
T ₇	77.40	1.49	1.98	3.46	0.274	0.0179	273.86	1.415
T ₈	80.67	1.65	2.33	3.98	0.317	0.0196	321.32	1.578
T ₉	82.86	1.83	2.76	4.59	0.337	0.0206	380.59	1.704
T ₁₀	84.88	2.05	2.95	4.99	0.360	0.0217	423.75	1.845
T ₁₁	83.90	1.89	2.82	4.70	0.349	0.0214	394.61	1.793
T ₁₂	86.37	2.25	3.19	5.43	0.387	0.0233	469.26	2.009
S.Em.±	2.76	0.08	0.11	0.18	0.013	0.0008	15.66	0.069
CD (P = 0.05)	8.04	0.23	0.31	0.53	0.038	0.0024	45.51	0.203
CV (%)	5.73	7.03	6.69	6.70	6.62	6.64	6.78	6.70

Conclusion

Overall, the findings indicate that GA₃ priming at 100 ppm for 12 h is the most effective treatment for enhancing germination, seedling growth and seed vigour in onion under laboratory conditions. Although GA₃ @ 100 ppm for 6 h and KNO₃ @ 1% for 12 h exhibited statistically comparable performance for several parameters, GA₃ priming for 12 h consistently produced the highest overall response. These results suggest that hormonal priming with GA₃ provides a simple, economical and efficient strategy for improving seed physiological quality and ensuring rapid, uniform seedling establishment, thereby offering a practical seed enhancement technique for onion cultivation.

Acknowledgement

The author is thankful to management and the Dean S.K.N. Collage of Agriculture Jobner, Jaipur for providing laboratory facilities to carry out this study. This research would not have been possible without the inspiration and support of several wonderful individuals.

Conflict of Interest Statement

The author declares that there is no conflict of interest.

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