Seed Quality Enhancement through different Priming Treatments in Onion (*Allium cepa* L.)

ABSTRACT

In a meticulously executed experiment at the Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, during the *Rabi* season of 2022-23, In the experiment, treatments were arranged in a Factorial Randomized Block Design (FRBD) with two factors concepts. The first factor was mobilized with twelve distinct seed priming treatments *i.e.*; KNO_3 (2%), TiO_2 (500ppm), PEG (1MPa), Salicylic acid (50ppm), *Pseudomonas* (1%), along with water as a control treatment. The second factor assigned to onion varieties ***i.e.,*** Phule Samarth and B780) Among the findings, the combination of B2A1 (TiO_2@ 500 ppm + Phule Samarth) significantly influenced radicle emergence time, while B2A2 (TiO_2 @500 ppm + B780) exhibited a noteworthy impact on initial germination counts and final germination counts. Moreover (TiO_2 @ 500ppm + B780) recorded distinct effects on plumule length and radicle length. In terms of vigour, variety A2 (B780) demonstrated the highest vigour I with TiO_2 @ 500ppm. The results highlighted TiO_2 @ 500ppm as the most effective priming agent, with PEG -1Mpa showing less efficacy in promoting seed Vigour II. Additionally, KNO_3 @ 2% emerged as a promising agent, and the Phule Samarth variety exhibited a slightly higher mean dry weight compared to B780. Notably, the combination B6A1 (Water + Phule Samarth) resulted in the highest mortality %, while B1A1 (KNO_3 @ 2% + Phule Samarth) was particularly associated with intensified pyruvic acid synthesis. Furthermore, the maximum TSS content was observed for B1A1 (KNO_3 @ 2% + Phule Samarth), underscoring the intricate interplay between priming and genetic factors.

Key words: Seed Quality Enhancement, Priming Treatments in Onion, onion production

INTRODUCTION

Onion (*Allium cepa* L.) is an important vegetable crop grown and consumed widely across the world. India is the second largest producer of onion in the world next to China and ranks third in export of fresh onions. It is an indispensable vegetable in every kitchen and has gained the importance of a cash crop in recent years because of its very high export potential. Indian onions are famous for their pungency due to the presence of a volatile oil ‘Allyl propyl disulphide’ and are available round the year. It is used both in raw and mature bulb stage as vegetable and spices. It is valued for its characteristics flavour, pungent taste and medicinal importance (Padmini et al., 2007and Tyagi and Yadav., 2007) [14,22]. Seed priming is one of the best methods which show rapid and uniform germination, synchrony in growth, development and increased yield. Seedling establishment is an important factor in bulb production of onion and largely depends on the seed germination and vigour. Seed quality enhancement is possible through various seed priming techniques including hydro priming, halo priming, osmo priming, thermo priming, solid matrix priming, and bio priming (Ashraf and Foolad 2005; Venkatasubramanian and Umarani, 2007) [4,23]. seed priming permits the preliminary process of germination but not the final phase of radicle emergence (Heydecker and Coolbear, 1977; Heydecker and Gibbins, 1978) [7,8]. Many researchers have studied the effects of seed priming on enhancement of germination, morphological characters, yield, etc. (Thejeshwini et al., 2019; Muruli et al., 2016; Saranya, 2017; Patil and Manjare, 2013; Arin et al., 2011; Selvarani and Umarani, 2011; Nego et al., 2015) [21,12,18,16,3,19,13]. Onion seeds show poor germination with slow growth of seedling and it has a short storage life. Hence, considering the above facts, the present study was undertaken to enhance the onion seed quality by priming treatments.

MATERIALS AND METHODS

During the Rabi season of 2022-2023, a meticulous experiment was conducted on Onion crop (*Allium cepa* L.) at the Vegetable Research Centre, Maharajpur, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Jabalpur, Madhya Pradesh. Employing a factorial experiment in a Randomized Complete Block Design (RCBD) including three replications and twelve distinct treatments. The crop, with a row spacing of 20 cm and a plant spacing of 15 cm, underwent a comprehensive assessment to discern the nuanced impact of various factors. Factor A, representing two onion varieties; Phule Samarth and B 780, each contributing unique characteristics, played a pivotal role. Factor (B) was mobilized with seed-priming treatments denoted by unique notations i.e., KNO_3 @ 2%, TiO_2 @ 500 ppm, PEG - 1Mpa, Salicylic acid 50ppm, *Pseudomonas* @ 1%, along with water as (a control treatment). Treatment details from T1 – T12 resulting from the combination of the factors under study were as follows: B1A1: Phule Samarth + KNO_3 @ 2%, B2A1: Phule Samarth + TiO_2 @ 500 ppm, B3A1: Phule Samarth + PEG - 1Mpa, B4A1: Phule Samarth + Salicylic acid 50ppm, B5A1: Phule Samarth + *Pseudomonas* @ 1%, B6A1: Phule Samarth + Control, B1A2: B 780 + KNO_3 @ 2%, B2A2: B 780 + TiO_2 @ 500 ppm, B3A2: B 780 + PEG - 1Mpa, B4A2: B 780 + Salicylic acid 50ppm, B5A2: B 780 +

Pseudomonas @ 1%, B6A2: B 780 + Control. This structured experiment aims to study the effects of the seed priming technique on germinability, seedling Vigor, and field establishment on two promising varieties of onion. Paper towel method was utilized to evaluate the germination and seed vigour parameters. The germinated seeds were counted daily by unrolling the paper sheet carefully till 12 days which is the final count of onion seed.

Methodology for seed priming treatments

The seeds were collected from seed lots. Eight gram seeds of B780 and six gram seeds of Phule Samarth were subjected to each priming agents *viz;* KNO_3 @ 2%, TiO_2 @ 500ppm, Salicylic acid @ 50ppm, PEG @ -1Mpa and *Pseudomonas* @1%. The solution was prepared by mixing of 2g of KNO_3, 50mg of TiO_2, 5mg of Salicylic acid, 27.3g of PEG and 1g of *Pseudomonas* in 100ml of distilled water separately in beaker. The seeds were soaked in solutions for 24 h for each treatment. After completion of soaking seeds were washed thoroughly with distilled water followed by drying of seeds in shade for 24h to bring the seeds to original moisture content. Detail of seed priming process was given in plate number 1.

Germination percentage (G%)

Germination percentage (G%) was measured at the end of test period according to international seed testing association (ISTA, 1999) [9];

$$G\ \% = \frac{\text{Total number of germinated seeds}}{\text{Total number of evaluated seeds}} \times 100$$

The seedling vigour index (SVI-I & II) were calculated according to Abdul-Baki and Anderson (1970) and Abdul-Baki and Anderson (1973) [1,2] by the following formula;

Seedling vigor index (SVI-I)

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

Seedling vigor index (SVI-II)

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

The seedling dry weight was determined by placing ten normal seedlings, used for root and shoot length measurements, in a hot air oven at 50 ± 1°C for 24 hours until a constant weight was achieved. The recorded dry weight of the seedlings was expressed in grams.

Mortality%

The percentage of seeds that fails to germinate or established into viable seedling.

$$\text{Mortality (\%)} = \frac{\text{Number of non germinated seeds}}{\text{Total number of seed sown}} \times 100$$

TSS estimation

Utilizing a refractometer, total soluble solids or TSS are measured. This instrument is used to determine the amount of dissolved solids, which are frequently sugars, in a liquid sample.

Pyruvic acid estimation

To quantify pyruvic acid concentration, 0.5 ml of onion extract was combined with 1.5 ml of 5% TCA and 18 ml of distilled water. Subsequently, 1 ml of this mixture was incubated at 37ºC for 10 minutes after the addition of 1 ml each of 2,4-DNPH and distilled water. Following incubation, 5 ml of 0.6 N NaOH was added, and the absorbance was measured at 420 nanometres using a Spectrophotometer to establish a standard curve.

Statistical analysis

To determine the effect of different treatments, the data collected in the course of investigation under lab) and at field condition were analysed by (FRBD) applying the Analysis of Variance (ANOVA) techniques laid down by Panse and Sukhtame (1978) [15]. The significance of various treatments was judged and suggested by Fisher applying "F" test. The significance of difference was judged at 5% level of significance by F test.

RESULTS AND DISCUSSION

The analysis of Table 1 and Figure 1 reveals a subtle difference in radicle emergence times between onion varieties A1 (Phule Samarth) and A2 (B780). Phule Samarth exhibited a slightly quicker mean emergence time of 48.23 hours compared to B780 at 48.58 hours, emphasizing its faster germination. TiO_2 at 500 ppm demonstrated the fastest radicle emergence time at 46.84 hours. Water priming showed the longest emergence time at 49.59 hours (Table 1 and Figure 1). The interaction effect between Factors A and B was significant, with B2A1 (TiO_2 at 500 ppm + Phule Samarth) influencing radicle emergence time most prominently at 46.80 hours. KNO_3 at 2% priming treatment promotes faster radicle emergence, while PEG at -1MPa and water treatments exhibit longer times. The marginal difference between Phule Samarth and B780 suggests genetic or physiological disparities. The study aligns with Levent et al. (2011) [11].

In the comparison of onion varieties, Phule Samarth (A1) recorded a mean germination percentage of 63.28%, slightly lower than B780 (A2) at 68.78%, indicating B780's enhanced early germination ability. TiO_2 at 500 ppm exhibited the highest mean germination percentage at 71.5%, emphasizing its potential for facilitating favourable germination pathways. The control treatment with water showed the least effectiveness at 61.85% (Table 1 and Figure 1). Other priming agents, including KNO_3 at 2%, PEG - 1MPa, Salicylic acid at 50ppm, and *Pseudomonas* at 1%, exhibited intermediate results. The significant interaction effect between seed priming agents and onion varieties, particularly with B2A2 (TiO_2 at 500 ppm + B780), influences initial germination counts. This study aligns with Haghighi et al. (2014) [6].

The comparative analysis of onion varieties indicates that B780 (A2) has a slightly higher mean germination percentage of 84.85% compared to Phule Samarth (A1) at 82.95%, suggesting inherent advantages for improved germination. Among seed priming agents, TiO_2 at 500 ppm proved most effective with a mean germination percentage of 86.84%, while the control treatment with water resulted in the lowest at 81.17%. Other priming agents showed varying efficacy. The interaction effect between seed priming agents and onion varieties was notably significant, with B2A2 (TiO_2 at 500 ppm + B780) having the most distinct impact on germination final count at 91.67% (Table 1 and Figure 1). This study emphasizes the influence of priming agents on final germination count, with TiO_2 at 500 ppm being particularly effective. The interaction between variety and priming agent underscores the complex interplay between external treatments and genetic attributes. B2A2 (TiO_2 at 500 ppm + B780) demonstrated a distinctive effect on germination final count, aligning with findings by Haghighi et al. (2014) [6].

In comparing plumule length between onion varieties A1 (Phule Samarth) and A2 (B780), A2 showed a slightly longer mean length at 8.26 cm compared to A1 at 8.11 cm. Seed priming with TiO_2 at 500ppm proved most effective, resulting in a mean plumule length of 8.9 cm. The interaction effect showed B2A2 (TiO_2 at 500ppm + B780) had a distinct impact at 9.89 cm, emphasizing the genetic influence (Table 1 and Figure 1). This study underscores the varied effects of seed priming agents on plumule length, with TiO_2 notably enhancing growth. B780 outperforms Phule Samarth, and the interaction between seed variety and priming agent reveals the intricate interplay of genetics and the environment, with B2A2 having a distinct effect on plumule length. These findings align with Paul et al. (2020) [17].

Analysing Table1 and Figure1 data reveals significant influences on radicle length by onion variety (Factor A) and seed priming agents (Factor B). A2 (B780) surpasses A1 (Phule Samarth), with radicle lengths of 6.90 cm and 5.52 cm, respectively. Among priming agents, TiO_2 at 500 ppm exhibits the most promising results at 7.15 cm, Water, the least effective agent, yields 5.17 cm. The interaction effect ($A \times B$) emphasizes the agent's efficacy depends on the variety. B2A2 (TiO_2 at 500 ppm + B780) shows the maximum radicle length (7.93 cm), followed by B5A2 (*Pseudomonas* + B780) at 7.61 cm, while B6A1 (Water + Phule Samarth) records the minimum at 4.35 cm. Tailored strategies considering both seed variety and priming agent are crucial for optimal results. The combination B2A2 (TiO_2 at 500 ppm + B780) is particularly effective, as observed by Paul et al. (2020) [17].

Analysing onion variety influence (Factor A), A2 (B780) exhibited superior seed vigour I, with a mean vigour index I of 1310.63, surpassing A1 (Phule Samarth) at 1149.41. Regarding seed priming agents (Factor B), TiO_2 at 500 ppm recorded the highest vigour index I (1349.45), followed by KNO_3 at 2% (1339.34), while the control (Water) had the lowest (1051.15). The interaction (A × B) emphasized variety-specific responses, with B780 reaching its highest vigour with TiO_2 at 500 ppm (1529.53) and the lowest for B6A1 (Water + Phule Samarth) at 1035.03 (Table 2 and Figure 2). The Critical Difference (C.D.) at the 1% level (115.00) highlights significant variations in the vigour index I due to priming and variety interactions. Seed priming treatments, especially TiO_2 at 500 ppm, enhance seed physiological and metabolic activities, contributing to improved germination and vigour. The diverse roles of priming agents suggest specific metabolic pathways, with variety-specific responses emphasizing the need for tailored agronomic approaches. Shah et al. (2021) [20] corroborate these findings.

Assessing onion variety impact (Factor A), Phule Samarth (A1) slightly outperforms B780 (A2) with a mean vigour index II of 1.33 compared to 1.28. However, the difference is minor, emphasizing their overall similarity in vigour index II without considering priming treatments. Exploring seed priming agents (Factor B) reveals significant variation, with TiO_2 at 500 ppm achieving the highest mean vigour index II of 1.53 and water the lowest at 1.13 (Table 2 and Figure 2). Other treatments, including PEG -1MPa, salicylic acid, and *Pseudomonas*, show moderate efficacy. The interaction between Factors A and B is not statistically significant at the 5% level, suggesting their combined impact on vigour index II is not substantial. TiO_2 at 500 ppm's efficacy aligns with previous research on nanoparticles' role in enhancing seed vigour, while PEG's lower vigour may be attributed to concentration or osmotic stress. Variability between onion varieties implies genetic factors in treatment response, emphasizing the need for tailored seed enhancement strategies. Overall, both seed variety and priming agents have individual effects, but their combined impact on vigour index II remains relatively consistent. Shah et al. (2021) [20] support these findings.

In assessing onion variety impact (Factor A) on seedling dry weight, Phule Samarth (A1) slightly outperforms B780 (A2), with mean weights of 0.016g and 0.015g, indicating Phule Samarth's responsiveness to priming. Examining seed priming agents (Factor B) shows subtle differences, with KNO_3 at 2% (B1) having the highest mean weight at 0.018g (Table 2 and Figure 2). The interaction effect (Factor A × B) is not significant at the 1% level, indicating that combined effects on seedling dry weight are not substantial. This study highlights KNO_3 at 2% as an effective priming agent, potentially enhancing seedling biomass through improved nutrient uptake and metabolic pathways. Conversely, PEG -1MPa and Salicylic acid treatments show lower seedling dry weight, possibly due to osmotic or hormonal effects. The slightly better performance of Phule Samarth suggests genetic or physiological advantages in responding to priming-induced growth. However, the interaction between variety and priming agents does not significantly influence seedling dry weight. Brar et al. (2019) and Jima et al. (2015) [5,10] support these findings.

In assessing onion variety impact (Factor A) on seed mortality, Phule Samarth (A1) exhibited 17.05%, and B780 (A2) showed 15.15%, reflecting genetic factors' influence. For seed priming agents (Factor B), TiO_2 @ 500ppm had the lowest mortality at 13.17%, while water had the highest at 18.84%. Interaction effects (Factor A × B) revealed B2A2 (TiO_2 @ 500ppm + B780) with the lowest mortality at 8.33% (Table 2 and Figure 2). Different priming agents have varying efficacy, with TiO_2 @ 500ppm notably enhancing seed viability. Water priming resulted in the highest mortality, emphasizing the need for priming agents offering more than hydration. The distinct response of Phule Samarth and B780 highlights genetic and physiological differences. These findings resonate with the broader consensus, with the combination B6A1 (Water + Phule Samarth) demonstrating the highest mortality percentage. Haghighi et al. (2014) [6] support these results.

Table 1. Effect of seed priming agents, Varieties and their interactions on time taken for radicle emergence, Initial germination count, final germination count and seedling length of onion

S. No.	Priming	Time taken for maximum radicle emergence			Germination Initial Count			Germination Final count (%)			Plumule length (cm)			Radicle length (cm)		
		A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B
1	B1 (KNO_3 @ 2%)	47.23	48.33	47.78	65.00	65.00	65.00	84.67	83.33	84.00	8.66	8.75	8.71	5.37	6.81	6.09
2	B2 (TiO_2 @ 500ppm)	46.80	46.88	46.84	66.70	76.30	71.50	82.00	91.67	86.84	7.91	9.89	8.90	6.36	7.93	7.15
3	B3 (PEG - 1MPa)	48.94	49.27	49.11	62.30	66.00	64.15	81.67	83.43	82.55	8.40	7.77	8.09	4.68	6.87	5.78
4	B4 (Salicylic acid @ 50ppm)	47.96	48.91	48.43	63.00	69.70	66.35	83.67	87.33	85.50	8.55	7.58	8.07	6.21	6.18	6.20
5	B5 (*Psuedomonas* @1%)	48.44	48.91	48.68	62.00	72.70	67.35	85.67	81.00	83.34	7.41	8.22	7.82	6.15	7.61	6.88
6	B6 (Water)	50.00	49.19	49.59	60.70	63.00	61.85	80.00	82.33	81.17	7.73	7.36	7.55	4.35	5.99	5.17
	Mean A	48.23	48.58		63.28	68.78		82.95	84.85		8.11	8.26		5.52		
	C.D. @ 1% level	0.30	0.52	0.74	1.95	3.38	4.79	1.49	2.58	3.65	NA	0.49	0.69	0.25	0.44	0.62
	S.E.(m)	0.10	0.17	0.25	0.66	1.14	1.62	0.5	0.87	1.23	0.09	0.16	0.23	0.08	0.15	0.21

Table 2. Effect of seed priming agents, Varieties and their interactions on Vigour Index, Seedling dry weight and Mortality % of onion

S. No.	Priming	Vigour index I			Vigour Index II			Seedling dry weight (g)			Mortality (%)		
		A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B
1	B1 (KNO_3 @ 2%)	1202.77	1475.90	1339.34	1.31	1.42	1.37	0.02	0.02	0.02	15.33	16.67	16.00
2	B2 (TiO_2 @ 500ppm)	1169.37	1529.53	1349.45	1.51	1.54	1.53	0.02	0.02	0.02	18.00	8.33	13.17
3	B3 (PEG - 1MPa)	1059.10	1206.07	1132.59	1.18	1.18	1.18	0.02	0.01	0.01	18.33	16.57	17.45
4	B4 (Salicylic acid @ 50ppm)	1295.47	1155.13	1225.30	1.50	1.12	1.31	0.02	0.01	0.01	16.33	12.67	14.50
5	B5 (*Psuedomonas* @1%)	1134.73	1429.87	1282.30	1.24	1.38	1.31	0.02	0.02	0.02	14.33	19.00	16.67
6	B6 (Water)	1035.03	1067.27	1051.15	1.25	1.01	1.13	0.02	0.01	0.02	20.00	17.67	18.84
	Mean A	1149.41	1310.63		1.33	1.28		0.02	0.02		17.05	15.15	
	C.D. @ 1% level	46.96	81.25	115	NA	0.23	NA	NA	NA	NA	1.49	2.58	3.65
	S.E.(m)	15.90	87.50	38.97	0.04	0.07	0.11	0.001	0.001	0.001	0.5	0.87	1.23

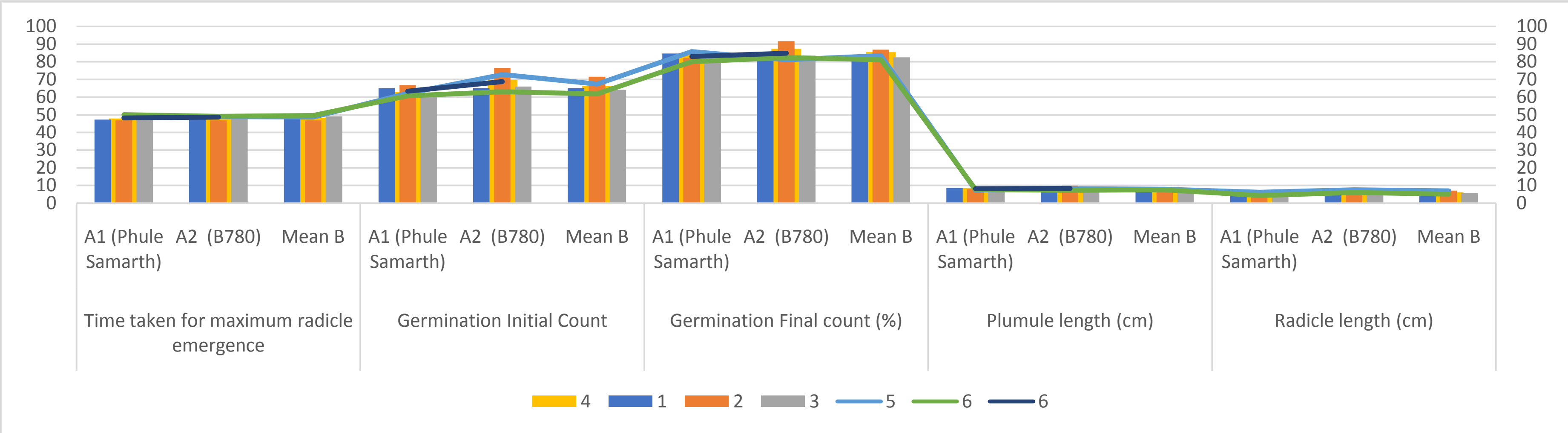

Figure 1. Influences of Seed Priming on Germination Parameters

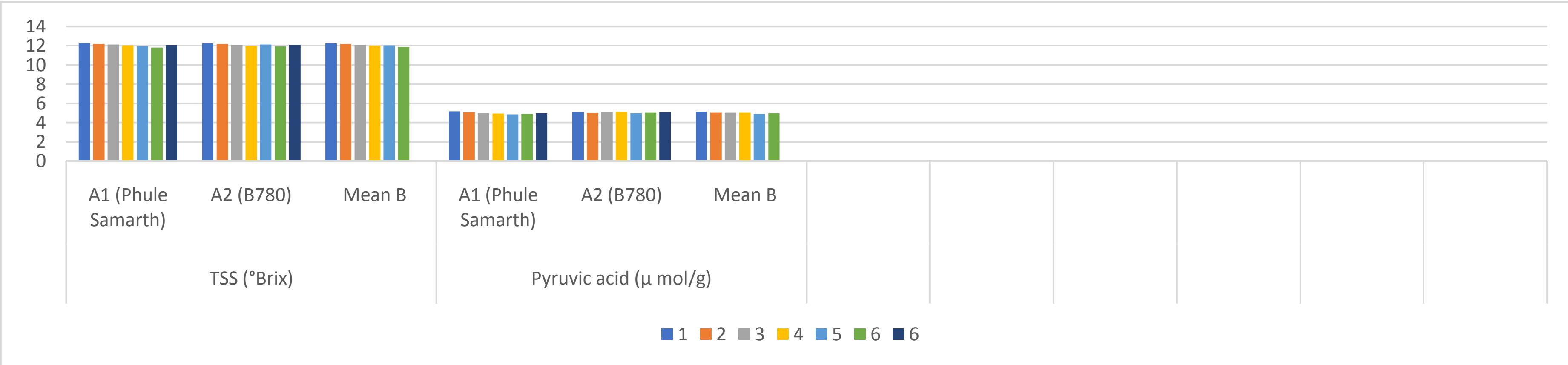

Figure 2. Impacts of Seed Priming on Germination Parameters

Quality parameters

TSS

The genetic makeup of onion varieties played a role in determining TSS (°Brix) values. A1 (Phule Samarth) and A2 (B780) exhibited minimal differences, with mean TSS values of 12.06 and 12.09 °Brix, respectively, suggesting similar potential. KNO_3 at 2% resulted in the highest TSS value of 12.25 °Brix, while water yielded the lowest at 11.88 °Brix (Table 3 and Figure 3). The interaction effect highlighted B1A1 (KNO_3 @ 2% + Phule Samarth) with the highest TSS at 12.26 °Brix. Seed priming agents subtly affect onion quality, and genetic differences influence TSS. The study aligns with Wakchaure et al. (2018) [24].

Pyruvic acid (µ mol/g)

The genetic aspect reveals that A2 (B780) exhibited a slightly higher mean pyruvic acid concentration of 5.05 µmol/g compared to A1 (Phule Samarth) at 4.98 µmol/g, indicating A2's predisposition to slightly more pronounced pungency. Among seed priming agents, KNO_3 at 2% resulted in the highest pyruvic acid content (5.15 µmol/g), while *Pseudomonas* at 1% had the lowest (4.91 µmol/g) (Table 3 and Figure 3). Seed priming distinctly influences onion pungency, with KNO_3 elevating pyruvic acid concentration. Interaction analysis highlighted B1A1 (KNO_3 at 2% + Phule Samarth) with the highest (5.18 µmol/g) and B5A1 (*Pseudomonas* + Phule Samarth) with the lowest (4.85 µmol/g) pyruvic acid concentration. A2 (B780) exhibits slightly higher pungency than A1 (Phule Samarth) due to genetic differences, emphasizing the intricate dynamics of priming agents and varietal genetics. The study aligns with Wakchaure et al. (2018) [24].

Table 3. Effect of seed priming agents, Varieties and their interactions on Quality parameters of onion

S. No.	Priming	TSS (°Brix)			Pyruvic acid (µ mol/g)		
		A1 (Phule Samarth)	A2 (B780)	Mean B	A1 (Phule Samarth)	A2 (B780)	Mean B
1	B1 (KNO_3 @ 2%)	12.26	12.23	12.25	5.18	5.12	5.15
2	B2 (TiO_2 @ 500ppm)	12.19	12.17	12.18	5.05	4.99	5.02
3	B3 (PEG - 1MPa)	12.12	12.09	12.11	4.98	5.09	5.04
4	B4 (Salicylic acid @ 50ppm)	12.03	11.97	12.00	4.94	5.11	5.03

5	B5 (*Psuedomonas @1%*)	11.96	12.12	12.04	4.85	4.97	4.91
6	B6 (Water)	11.82	11.93	11.88	4.90	5.02	4.96
	Mean A	12.06	12.09		4.98	5.05	
	C.D. @ 1% level	0.014	0.024	0.034	0.014	0.023	0.033
	S.E.(m)	0.005	0.008	0.012	0.005	0.008	0.011

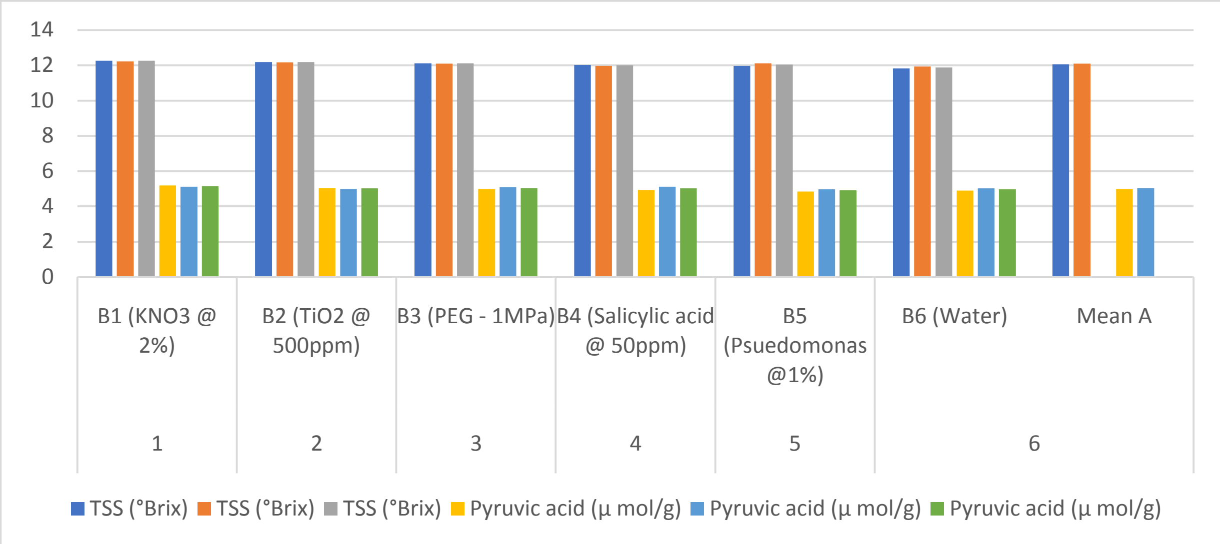

Figure 3. Influences of Seed Priming on Quality Parameters in Onion Cultivation

CONCLUSION

In this comprehensive study of priming effects on onion traits, several advantages were evident across various priming agents. TiO_2 @500ppm priming consistently outperformed in various aspects, including time for maximum radicle emergence, germination rates (both initial and final counts), plumule and radicle lengths, vigour index I and II, and mortality percentage. KNO_3 @2% priming, on the other hand, demonstrated its effectiveness in promoting seedling dry weight, TSS and pyruvic acid levels. These findings highlight the potential of tailored seed priming strategies to drive targeted enhancements in onion cultivation and yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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