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EFFECT OF SEED PRIMING TREATMENTS ON SEED QUALITY CHARACTERISTICS IN INDIAN MUSTARD (*BRASSICA JUNCEA L.* CZERN AND COSS)

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ABSTRACT

The present investigation was conducted during the Rabi season of 2023 at the Department of Seed Science & Technology, RPCAU, Pusa, "To study the effect of seed priming treatments on seed quality characteristics in Indian Mustard (*Brassica juncea* L. Czern & Coss)." The experiment was laid out in a randomized block design (RBD) with ten different seed priming treatments, which included a control (T1) and nine priming treatments: T2 (H_2O_2), T3 (H_2O_2), T4 (KH_2PO_4 1%), T5 (KH_2PO_4 2%), T6 (KNO_3 1%), T7 (KCl 1%), T8 ($ZnSO_4$ @100 ppm), T9 ($MnSO_4$ @100 ppm), and T10 (NAA @20 ppm). The results revealed significant improvements in seed quality parameters, particularly with KH_2PO_4 priming (1% and 2%). KH_2PO_4-treated seeds exhibited the highest germination percentage (94.01%), the shortest radicle emergence time (42.00 hours), longer shoot (6.47 cm) and root lengths (9.91 cm), and superior vigor indices. Enhanced biochemical parameters, including increased enzyme activities (amylase, dehydrogenase, peroxidase, and catalase), were observed in 1% KH_2PO_4. Overall, KH_2PO_4 at 1% and 2% emerged as the most effective treatment, significantly enhancing seed vigor, seedling growth, and stress tolerance, thereby promoting better crop establishment and productivity.

Keywords **:** Priming, KH_2PO_4, Vigor, Germination, Enzyme

Introduction

Indian mustard (*Brassica juncea* L. Czern and Coss) is belonging to the family Brassicaceae, essentially used for edible oil purpose and protein content, characterized by a substantial nutritive value. It is known by different names such as rai, laha, and sarson. Indian mustard is an amphidiploid resulting from the hybridization of *B. campestris* (AA, 2n=20) and *B. nigra* (BB,2n=16), *B. carinata* (BBCC, 2n=4×=34) possessing a genome size of 470Mb. The flowers display a yellow tint, arranged in an indeterminate raceme cluster. Mustard pod having septum divides wall within the mustard pod (siliqua), contributing to the organization and arrangement of seeds. The seeds lack endosperm and have cotyledons folded inward, positioned in different segments. This family's primary center of diversity is the Central Asia-Himalayas region, from where it spread to China, India, and the Caucasus. According to Song *et al.* (1988), two proposed centers of origin are the Middle East and China, based on Restriction Fragment Length Polymorphism (RFLP) analysis.

Mustard cultivation in India can be traced back to the Indus Valley Civilization, where archaeological evidence suggests that mustard was one of the earliest oilseed crops grown in the region. The crop was widely cultivated across northern India, and its oil was used for cooking, lighting lamps, and various other purposes.

In the modern era, Indian mustard has become a major commercial crop, with significant acreage and

production in states like Rajasthan, Uttar Pradesh, Madhya Pradesh, and West Bengal. Breeding initiatives have resulted in enhanced cultivars that exhibit increased productivity, superior oil quality, and resilience against biological and environmental stresses.

Mustard, primarily grown in temperate regions, is cultivated in tropical and subtropical areas as a cold-season crop. Indian mustard thrives in annual precipitation ranging from 500-4200 mm, temperatures of 6-27°C, and pH levels between 4.3-8.3. Utilizing the C_3 pathway for carbon assimilation, it shows optimal photosynthetic activity at temperatures of 15-20°C, reaching peak CO_2 exchange capacity before declining. Mustard prefers well-drained sandy loam soil and thrives with minimal water requirements (240–400 mm), making it suitable for rainfed cropping systems.

Indian mustard prefers cool seasons and extended daylight periods, exhibiting moderate resilience to acidic soils while thriving in cold and arid conditions. The oil proportion of the seed ranges from 36 to 46%, with protein content falling between 38-42%. It includes a substantial amount of Erucic acid (40-50%) and glucosinolates (180-200 micromoles). The oil extracted from the seeds is extensively utilized for culinary purposes in cooking throughout northern India. Furthermore, the foliage of juvenile plants acts as a reservoir of leafy greens, supplying crucial sulfur and minerals in the dietary intake.

Indian mustard is an important economic oil crop in India and is becoming very popular all over the world. Reduced yields of mustard due to various reasons such as environmental (pH, light, soil moisture, and temperature) and others are seed vigor, seed germination, and ineffective emergence and establishment which leads to reduced yields. To overcome these unfavourable climatic conditions, seed priming by using various chemicals and plant growth regulators offers protection against a range of environmental stresses.

Seed priming involves the controlled hydration of seeds to a degree that allows pre-germinative metabolic processes to occur while preventing the actual emergence of the radicle. Priming enhances the germination of seeds, early development of seedlings, and overall seedling vigor which contributes to the growth and development of plants. Improved uniformity in the emergence of seedlings enhances the consistent establishment of crops, consequently boosting overall yield. Varier *et al.* (2010) claimed that the benefits of seed priming are protein synthesis by conferring protection to the cellular protein. This technique enhances both the rate and uniformity of seed germination, leading to improved seed quality. By promoting uniformity among seedlings and accelerating the germination process, seed priming plays a crucial role in overall growth and ultimately increases yield.

Materials and Methods

The experiment was conducted during the Rabi season of 2023-24 at the research farm of the Department of Seed Science and Technology, RPCAU, Pusa Farm, Samastipur. The farm, located at an elevation of 74.74 meters above sea level, lies at approximately 25°97' N latitude and 85°67' E longitude. It features a flat topography with efficient drainage. The soil is primarily alluvial with evenly distributed calcium carbonate deposits, exhibiting typical calcareous properties found along the Budhi Gandak riverbanks. Rajendra Suflam variety of Indian mustard (*Brassica juncea* L.) was used in the experiment whose seeds were obtained from the Directorate of Seed, TCA, Dholi, Muzaffarpur, under RPCAU. A Randomized Block Design (RBD) was employed to study the effects of seed priming treatments on seed quality characteristics in Indian mustard, encompassing ten treatments, including a control, with three replications across 30 plots. The experiment consisted of ten treatments, including an untreated control (T1) and nine seed priming treatments which were T2 (distilled water for 4 hours), T3 (distilled water for 8 hours), T4 (1% KH_2PO_4 for 4 hours), T5 (2% KH_2PO_4 for 4 hours), T6 (1% KNO_3 for 4 hours), T7 (1% KCl for 4 hours), T8 (100 ppm $ZnSO_4$ for 4 hours), T9 (100 ppm $MnSO_4$ for 4 hours), and T10 (20 ppm NAA for 4 hours). After priming, all seeds were dried under shade conditions.

All the data collected from laboratory observations were analyzed statistically utilizing a Randomized Block Design (RBD), following the methodologies given by Panse and Sukhatme (1967) and Sundararajan *et al.* (1972). Critical differences (CD) were computed at the 5% significance level.

Result and Discussion

Seed germination (%)

The results in Table 1, demonstrate that seed priming with 1% KH_2PO_4 (T4) achieved the highest germination percentage (94.01%), followed by 2% KH_2PO_4 (T5) at 92.50%, while the control (T1) had the lowest (82.49%). T4 and T5 treatments showed significant improvements over the control by 13.96% and 11.54%, respectively. This enhancement is

attributed to KH_2PO_4's role in promoting metabolic activities, nutrient absorption, and water retention, aligning with findings by Ray *et al.* (2022) in tomato and (Saeidi *et al*., 2008) in canola cultivars.

Moisture content (%)

The study demonstrates that seed priming significantly influences moisture content, as shown in Table 1, Treatment T4 (1% KH_2PO_4) achieved the lowest moisture content (7.83%), while T1 (control) recorded the highest (9.12%). These findings suggest that KH_2PO_4 priming, especially at 1%, optimizes seed desiccation, enhancing longevity and viability, consistent with Arjunan *et al.* (1989) groundnut.

Accelerated ageing test

The accelerated aging test outcomes, influenced by seed priming treatments, are summarized in Table 1, Priming with 1% KH_2PO_4 (T4) achieved the highest value (20.00), followed by 2% KH_2PO_4 (T5) (19.99), indicating improved seed vigor. Untreated seeds (T1) showed the lowest value (14.99). The enhanced results from KH_2PO_4 priming suggest improved physiological and biochemical properties, such as better energy transfer and membrane stability, critical for seed longevity. These findings align with Krainart *et al.* (2015) in hybrid cucumber and Abdolahi *et al.* (2012) in rapeseed.

Shoot length (cm)

Seed priming treatments significantly influenced shoot length, as shown in Table 1, The highest shoot length of 6.47 cm was achieved with 1% KH_2PO_4 (T4), followed by 6.02 cm with 2% KH_2PO_4 (T5), compared to 5.16 cm in the control (T1). The improvement with phosphorus priming suggests enhanced nutrient uptake and growth, with similar results reported in maize studies by Narayanan *et al.* (2019) in maize and Sathish *et al.* (2011) in maize hybrid.

Root length (cm)

Seed priming treatments significantly influenced root length, as shown in Table 1, Priming with 1% KH_2PO_4 (T4) yielded the longest root length (9.91 cm), followed by 2% KH_2PO_4 (T5, 9.56 cm), while the control (T1) had the shortest (8.17 cm). Potassium and phosphorus, crucial for early growth, enhanced root elongation, with 1% KH_2PO_4 being optimal. Excess concentrations may induce stress, aligning with findings by Narayanan *et al.* (2019) in maize and Sathish *et al.* (2011) in maize hybrid.

Time taken for radicle emergence (hrs)

The findings in Table 1, demonstrate that seed priming significantly accelerated radicle emergence, with the fastest times (42.00 hours) recorded for seeds treated with 1% and 2% KH_2PO_4 (T4 and T5). In contrast, the control (T1) required 48.00 hours. Potassium dihydrogen phosphate treatments effectively enhanced germination speed and uniformity, likely by stimulating metabolic activity and enzyme function. These results align with Saeidi *et al.* (2008) in canola cultivars.

Electrical conductivity of seed leachate (dS/m)

The electrical conductivity (EC) of seed leachate was significantly influenced by priming treatments. The lowest EC was observed for 1% KH_2PO_4 (226.84 dS/m), followed by 2% KH_2PO_4 (252.76 dS/m), while the control had the highest EC (324.76 dS/m). These results indicate that KH_2PO_4 priming improved seed membrane integrity, reducing ion leakage, which is a positive indicator of seed quality and vigor. Similar findings were observed by Sathish *et al.* (2010) in maize hybrid.

Vigour index-I & II

Seed priming, especially with 1% KH_2PO_4, significantly enhanced seedling vigor indices compared to the control. The highest vigor indices were observed in the 1% KH_2PO_4 treatment (1539.93 for index I and 3.76 for index II), followed by 2% KH_2PO_4. This improvement is attributed to enhanced metabolic activity, nutrient absorption, and early root development, as KH_2PO_4 supplies potassium and phosphorus, which promote seedling growth. Similar findings were observed by Didar *et al.* (2017) in muskmelon, Narayanan *et al.* (2019) in maize and Sathish *et al.* (2010) in maize hybrid.

Seedlings dry weight (g)

Seed priming significantly affected seedling dry weight, with the highest recorded for 1% KH_2PO_4 (0.0400 g), followed by 2% KH_2PO_4 (0.0390 g). The control group showed the lowest dry weight (0.0340 g). Phosphorus availability through priming enhanced seedling growth, likely by promoting root development and nutrient uptake, supporting findings by Narayanan *et al.* (2019) in maize.

Amylase

Seed priming treatments significantly increased amylase activity compared to the control. The highest amylase activity was recorded in T4 (1% KH_2PO_4), producing 6.17 grams of maltose per gram per minute, followed by T5 (2% KH_2PO_4) with 5.89 grams. The control (T1) had the lowest activity (3.45 grams). These results indicate that KH_2PO_4, particularly at 1%, enhances starch breakdown, providing greater energy during seed germination, as observed in similar studies by Sathish *et al.* (2010) in maize hybrid.

Dehydrogenase

Seed priming significantly enhanced dehydrogenase activity compared to control, with the highest activity observed in T4 (1% KH_2PO_4, 1.52 OD/g). This suggests that 1% KH_2PO_4 optimally enhances enzymatic activity, promoting seed vigor and metabolic processes during germination. Similar findings were observed by Sathish *et al.* (2010) in maize hybrid and Narayanan *et al.* (2019) in maize.

Peroxidase

Seed priming with KH_2PO_4 significantly enhanced peroxidase activity compared to the control. The highest activity was recorded in T4 (1% KH_2PO_4) at 4342.34 µmol catechol oxidized/g/min, followed by T5 (2% KH_2PO_4). This suggests KH_2PO_4 primes seeds to boost enzymatic activity, improving stress tolerance and oxidative stress management. Similar findings were observed by Kibaraza *et al.* 2021 in maize hybrid.

Catalase

Seed priming with potassium dihydrogen phosphate (KH_2PO_4) significantly improved catalase activity, with the highest recorded in T4 (1% KH_2PO_4) at 13750.00 µmol H_2O_2 decomposed/g/min, followed by T5 (2% KH_2PO_4) at 11500.00 µmol H_2O_2 decomposed/g/min. The control (T1) showed the lowest activity at 3750.00 µmol H_2O_2 decomposed/g/min. These results suggest that KH_2PO_4 priming enhances antioxidant defense, with 1% KH_2PO_4 providing the optimal balance for enzyme activation and stress mitigation, similar to findings by Kibaraza *et al.,* 2021 in maize hybrid.

Table 1: Effect of seed priming treatments on germination (%), Moisture content (%), Accelerated ageing test, Shoot and root length (cm), Time taken for radicle emergence (hrs), Electrical conductivity of seed leachate (dS/m), Vigour

Treatments	Germination (%)	Moisture content (%)	Accelerated ageing test	Shoot length (cm)	Root length (cm)	Time taken for radicle emergence (hrs)	Electrical conductivity of seed leachate (dS/m)	Vigour index-I	Vigour index-II	Seedlings dry weight (g)
T_1	82.49(65.48)	9.12	14.99	5.16	8.17	48.00	324.76	1101.37	2.81	0.0340
T_2	89.54(71.30)	8.25	19.00	5.53	8.63	42.00	258.70	1268.62	3.23	0.0360
T_3	86.46(68.64)	8.41	18.99	5.36	8.50	48.00	268.46	1200.11	3.41	0.0393
T_4	94.01(75.95)	7.83	20.00	6.47	9.91	42.00	226.84	1539.93	3.76	0.0400
T_5	92.50(74.64)	8.11	19.99	6.02	9.56	42.00	252.76	1442.76	3.61	0.0390
T_6	92.40(74.44)	8.16	18.00	5.98	8.89	48.00	239.55	1375.66	3.58	0.0387
T_7	91.67(73.71)	8.22	17.99	5.87	8.81	42.00	266.65	1346.34	3.61	0.0393
T_8	85.36(67.56)	8.42	16.00	5.26	8.53	48.00	298.59	1177.13	3.22	0.0377
T_9	85.32(67.48)	8.83	15.99	5.52	8.31	42.00	302.75	1180.07	3.13	0.0367
T_{10}	86.75(68.68)	8.64	17.00	5.30	8.37	48.00	280.38	1185.98	3.18	0.0367
Mean	**88.65(70.79)**	**8.40**	**17.80**	**5.65**	**8.77**	**45.00**	**271.94**	**1281.80**	**3.35**	**0.0377**
S.E.(m)	**(2.26)**	**0.17**	**0.40**	**0.11**	**0.15**	**1.29**	**5.42**	**51.40**	**0.16**	**0.000921**
CD @ 5%	**(6.73)**	**0.50**	**1.19**	**0.32**	**0.45**	**3.82**	**16.09**	**152.72**	**0.48**	**0.002737**

indices I & II, Seedlings dry weight (g).

*Figures in parenthesis indicate arcsine transformed values

Table 2 : Effect of seed priming treatments on amylase, dehydrogenase, peroxidase and catalase

Treatments	Amylase gram maltose produced/ g of the sample / min	Dehydrogenase OD / g of the sample	Peroxidase Micro mol of catechol oxidised / g / min	Catalase Micro mol of H_2O_2 decomposed / g / min
T_1	3.45	0.76	857.14	3750.00
T_2	4.82	1.28	1393.58	9750.00
T_3	4.12	1.22	1064.60	6500.00
T_4	6.17	1.52	4342.34	13750.00
T_5	5.89	1.41	3488.38	11500.00
T_6	5.86	0.96	2056.03	10500.00
T_7	5.03	1.08	1389.64	8500.00
T_8	5.62	0.87	1621.59	8000.00
T_9	4.70	1.14	2957.32	7250.00
T_{10}	4.91	0.91	2303.98	8750.00
Mean	**5.06**	**1.11**	**2147.46**	**8825.00**
S.E.(m)	**0.12**	**0.031**	**55.10**	**239.46**
CD @ 5%	**0.37**	**0.093**	**163.71**	**711.47**

Conclusion

- Seeds treated with 1% KH_2PO_4 (T_4) for 4 hours, followed by 2% KH_2PO_4 (T_5) for 4 hours, enhanced several parameters. These improvements included the germination rate, time to radicle emergence, lengths of both shoot and root, electrical conductivity of seed leachate, moisture levels, dry weight of seedlings, vigor index I and II, and accelerated aging test.
- The activity levels of antioxidant enzymes (peroxidase and catalase) and germination-related enzymes (amylase and dehydrogenase) were significantly highest with the 1% KH_2PO_4 (T_4) seed priming treatment, followed by the 2% KH_2PO_4 (T_5) treatment among all the treatments.

The study concluded that priming Indian mustard seeds with 1% KH_2PO_4 (T4) led to improved seed quality characteristics. This treatment is recommended for seed priming in Indian mustard. Also 2% KH_2PO_4 (T4) treatment also showed promising results.

The above-mentioned conclusions are based on the results of one season experiment and need further experiments to confirm and accurate benefits due to seed priming.

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