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Research Communication

Effect of seed priming and seed rate on the performance of wheat (*Triticum aestivum*)

AJAY KUMAR SEROHIYA[1], DHIRENDRA KUMAR ROY[2], SHIVANI RANJAN[3] AND SUMIT SOW[4]

Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur 848 125, Bihar

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ABSTRACT

A field experiment was carried out to determine the impact of different seed rates and priming strategies on germination percentage, growth attributes, and yield of wheat (*Triticum aestivum* L.). The experiment comprised twelve treatments i.e. surface seeding with no seed priming, priming for 12 hours in water, 1% KNO_3, and 1% $CaCl_2$ at 100, 125, and 150 kg/ha seed rates. The results indicated that the highest final germination percentage (84%) at 10 DAS was found with seed priming with 1% $CaCl_2$ at a 100 kg/ha seed rate. The tallest plant was observed with seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate. However, number of tiller/m^2 and dry matter accumulation was recorded maximum with seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate, which was 7.27% and 20% higher compared to number of tillers/m^2 and dry matter accumulation under dry seed surface seeding with 100 kg/ha seed rate, respectively. The highest grain yield (4662 kg/ha) and straw yield (5694 kg/ha) were found with seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate. Similarly, maximum gross (₹114851/ha) and net (₹76884/ha) returns were obtained in seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate but the highest B: C ratio (3.09) was obtained with seed priming with 1% $CaCl_2$ at 125 kg/ha seed rate. Hence, adopting seed priming strategies at different seed rates can improve the growth and yield of wheat.

***Key words*: Germination percentage, Growth attributes, Seed priming, Seed rate, Wheat, Yield**

Wheat (*Triticum aestivum* L.) is the most valuable cereal crop and the primary source of food and nutrition for the world's population. India ranked second in wheat production with a crop of 112.8 million metric tonnes an area of 32.0 million ha and productivity of 3.56 t/ha. The area, production, and productivity of wheat in Bihar are 2.20 Mha, 6.72 Million tonnes, and 2.872 t/ha, respectively (Directorate of Economics and Statistics, Ministry of Agriculture & Farmers' Welfare, Government of India, 2022-23). There are different methods of sowing for wheat crops such as broadcasting, broad bed furrow, dibbling, and surface seeding (Singh *et al.,* 2013). In surface seeding, seeds are broad-cast on the surface without any field preparation. Surface seeding is adopted in areas where excess moisture is present in the soil as there may be issues during tillage operation and land preparation (Sharma *et al*., 2024). In surface seeding, there are high chances of seeding mortality as the upper layer of the soil surface becomes dry as compared to the layers beneath the soil surface resulting in reduced moisture for the germination of seed. This problem can be mitigated by increasing the seed rate and adopting seed priming methods (Ambreen *et al*., 2021). Seed priming is a useful technique for achieving fast and uniform emergence along with high vigor, which leads to improved crop establishment and yield benefits in a variety of field crops, including cereals (Abou-Zeid *et al*., 2021; Paswan *et al*., 2023). Moreover, the seed rate of the crop is an important factor that determines the ability of plants to utilize available resources (Sheteiwy *et al*., 2017). To get a higher germination percentage and wheat yield under surface seeding, the optimum seed rate with proper seed priming strategies should be adopted and hence optimization of these parameters needs to be studied.

The field experiment was conducted at Pusa farm, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar during the *rabi* season of 2020-21. Geographically, Pusa is situated at 25°60' North latitude, 85°76' East longitude, and 51.3 meters above mean sea level. It comes under the subtropical zone and is near the Burhi Gandak River in North Bihar. The experiment was laid out in a randomized complete block design (RCBD) and replicated

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[3]**Corresponding author's Email:** ranjanshivani54@gmail.com
[1]M.Sc. Student, [2]Professor-*cum*-Chief Scientist, [3,4]Ph.D. Scholar, Department of Agronomy, Dr. RPCAU, Pusa, Samastipur 848 125, Bihar

thrice. There were twelve treatments *viz*., surface seeding of dry seed with 100, 125, and 150 kg/ha seed rate; surface seeding of soaked seed with 100, 125, and 150 kg/ha seed rate; seed priming with 1% KNO_3 at 100, 125 and 150 kg/ha seed rate; seed priming with 1% $CaCl_2$ at 100, 125 and 150 kg/ha seed rate. The variety HD 2967 was used in the experiment. The recommended dose of N: P_2O_5:K_2O was 120:60:40 kg/ha. Urea, DAP, and MOP were the sources of fertilizers used in the experimental field. As a basal dose, ½ dose of N was added along with the full dose of P_2O_5 and K_2O, while the remaining dose of N was applied in two equal split doses of ½ N was applied after the first irrigation and a second split dose of ½ N was applied after second irrigation. The soil of the experimental field was low in available N (195.8 kg/ha), low in organic carbon (0.43%), medium in available P (21.28 kg/ha), and medium in K (124.3 kg/ha). Soil pH (8.4) was alkaline in nature.

For seed priming, 1 kg wheat seeds were soaked in water, 1% KNO_3, and $CaCl_2$ solution for 12 hours. The solution of KNO_3 and $CaCl_2$ was prepared by dissolving 10 g of KNO_3 and KCl, respectively in 1 L of water. After soaking of seed for 12 hours, the priming solution was drained off. Thereafter, seeds were shade-dried until they reached the original seed moisture content (determined by the seed moisture meter) which was 12%. Sowing was done manually as surface seeding in definite rows at 20 cm row-to-row spacing. Sowing was done with dry seeds as well as overnight pre-soaking priming seeds with hydropriming, $CaCl_2$, and KNO_3 for 12 hours. Surface seeding as well as seed priming was carried out following seed rates of 100, 125, and 150 kg/ha.

The germination percentage is the ratio of germinated seed to total seed used for sowing purposes. For estimating germination percentage count, the total germinated seedling from 1m length from each experimental plot was counted. Then, the germination percentage is calculated from the ratio of germinated seed to total seed used for sowing purposes. The germination percentage was calculated following the first count, second, and third count on the fifth, seventh day, and tenth day of germination for normal seedlings respectively. Seedling length is the total sum of the length of coleoptile and coleorhiza. For calculating seedling length, five normal seedlings were chosen from the randomly selected experimental plot, and the seedlings were uprooted carefully in such a way that the root of seedlings would not be damaged. The soil is removed from the base of the seedling and the total length of the chosen seedling is measured at 5, 7, and 10 days after sowing (DAS) and weighed without drying for taking fresh biomass. The seedling vigor index indicates the robustness and hardiness of the seedling to a contingent environment and other competitive factors. The seedling vigor index was determined using the formula given below, which was suggested by Abdul-Baki and Anderson (1973).

Seedling Vigour Index (VI) = Germination (%) × Seedling length (cm)

Five randomly selected plants from each experimental plot were taken into observation to estimate plant height and number of tillers/m^2 at 30, 60, and 90 DAS and at harvest. In the case of dry matter accumulation five random plants were taken from each experiment plot and cut over the ground level with a sickle at 30, 60, 90 DAS, and at harvest. For 48 hours, these plants were sundried. After sun drying, these plants were dried in an oven at 65°C for 48–72 hours. Plants were harvested at maturity and the harvested net area of each plot was threshed and cleaned to obtain the produce (grains) from whole biomass. Thereafter, the grain yield from each plot was recorded in kg per plot and changed over to t/ha. The harvest index was calculated with the help of the following formula:

$$Harvest\ Index\ (\%) = \frac{Grain\ yield}{Biological\ (grain+straw)\ yield} \times 100$$

The data generated from the field experiment was analyzed using "Analysis of Variance" (ANOVA) in RBD as suggested by Gomez and Gomez (1984). The standard error of the mean (SEm±) and critical difference (CD) at a 5% level of significance was calculated for each character to compare the treatment difference. Statistical analysis was performed in SPSS version 16.0 (SPSS Inc., Chicago, USA).

Germination percentage is an important characteristic for any plant species because plant stand depends on germination percentage, plant genotype, and climatic factors. The maximum germination percentage *i.e*., 69%, 80%, and 84% at 5, 7, and 10 DAS, respectively was recorded highest in seed priming with 1% $CaCl_2$ at 100 kg/ha seed rate (Table 1). This might be due to the activation of reserve amylase content that acts as a catalyst for the secretion of hydrolase from the aleurone layer and helps in starch and sugar reduction. Reduction of starch and sugar helps in early germination and provides nutrition to germinated seeds. These results are in conformity with the findings of Dayal *et al*. (2023), Khaing *et al*. (2020), and Sow *et al*. (2023).

The analysis of data from various treatments revealed that the highest seedling length at 5 DAS (95 mm), 7 DAS (160 mm), and 10 DAS (216 mm) was recorded by adopting seed priming with 1% $CaCl_2$ at 100 kg/ha seed rate (Table 1). The minimum seedling length at 5 DAS (65 mm), 7 DAS (118 mm), and 10 DAS (175 mm) were found with dry seed surface seeding at 150 kg/ha seed rate. This was due to the effect of priming which activates reserve amylase content and helps in early germination as well as establishment of radicle. It leads to better crop establishment and an increase in seedling length. On the other hand,

Table 1. Effect of different seed priming methods and seed rate on seed quality parameters of wheat

Treatments	Germination percentage			Seedling length (mm)			Seedling fresh weight (mg)			Seedling vigour index		
	5 DAS	7 DAS	10 DAS	5 DAS	7 DAS	10 DAS	5 DAS	7 DAS	10 DAS	5 DAS	7 DAS	10 DAS
T_1	60	75	77	70	127	184	980	1,160	1,230	420	952	1,416
T_2	59	72	75	67	122	180	920	1,157	1,224	395	878	1,350
T_3	57	71	74	65	118	175	870	1,020	1,180	370	837	1,295
T_4	64	76	79	90	155	209	1,104	1,185	1,415	576	1,178	1,630
T_5	62	74	76	80	141	190	1,017	1178	1,354	496	1,043	1,444
T_6	61	72	73	72	133	182	875	1022	1,217	439	957	1,328
T_7	66	78	81	93	157	213	1,110	1192	1,422	613	1,291	1,725
T_8	65	75	79	85	145	196	1,020	1,180	1,359	552	1,176	1,572
T_9	62	74	76	76	135	185	882	1,025	1,220	471	1,065	1,406
T_{10}	69	80	84	95	160	216	1,115	1,205	1,430	655	1,346	1,814
T_{11}	67	77	82	88	148	208	1,035	1,184	1,365	589	1,229	1,664
T_{12}	64	76	79	77	139	189	971	1,150	1,218	492	1,488	1,474
SEm±	1.02	1.67	1.81	3.32	4.18	6.32	6.98	12.93	13.57	16	29	38
CD (P=0.05)	3.0	4.92	5.31	10.25	12.49	19.02	20.48	37.94	39.81	47	87	112

T_1, dry seed surface seeding with 100 kg/ha seed rate; T_2, dry seed surface seeding with 125 kg/ha seed rate; T_3, dry seed surface seeding with 150 kg/ha seed rate; T_4-12 hours soaked seed surface seeding with 100 kg/ha seed rate; T_5, 12 hours soaked seed surface seeding with 125 kg/ha seed rate; T_6, 12 hours soaked seed surface seeding with 150 kg/ha seed rate; T_7, seed priming with 1% KNO_3 at 100 kg/ha seed rate; T_8, seed priming with 1% KNO_3 at 125 kg/ha seed rate; T_9, seed priming with 1% KNO_3 at 150 kg/ha seed rate; T_{10}, seed priming with 1% $CaCl_2$ at 100 kg/ha seed rate; T_{11}, seed priming with 1% $CaCl_2$ at 125 kg/ha seed rate; T_{12}, seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate

with an increase in seed rate a decrease in seedling length was found in the results. This is due to a rise in amylase and hydrogenase activity, which augmented starch reduction that acts as an energy for increasing metabolic activity, and O_2 demand of seed. Therefore, with an increased seed rate, there was more competition for proper O_2 requirements and natural resources. Therefore, seedling length decreased with an increase in seed rate. These results conform with the findings of Sharma *et al*. (2022).

Among different treatments, seedling fresh weight was significantly varied with different seed rates and priming techniques. Seed priming with 1% $CaCl_2$ at 100 kg/ha (T_{10}) seed rate recorded maximum seedling fresh weight of 1115 mg, 1205 mg, and 1430 mg at 5, 7, and 10 DAS, respectively (Table 1). This was due to an increase in seed rate and priming chemicals *i.e.*, KNO_3 and $CaCl_2$ which activate reserve amylase content and help in early germination, early emergence, better crop establishment, and increased dry matter accumulation. However, with increased seed rate there was more competition among the emerging seedlings for water, nutrients, space, and other natural resources so a decrease in the fresh weight of seedlings was observed. The results corroborate the findings of Sneha *et al*. (2024).

Seed priming with 1% $CaCl_2$ at 100 kg/ha (T_{10}) seed rate recorded the highest seedling vigor index of 655, 1346, and 1814 at 5, 7, and 10 DAS, respectively (Table 1). The lowest germination percentage at 5, 7, and 10 DAS *i.e.*, 370, 837, and 1295 was found with dry seed surface seeding at 150 kg/ha seed rate. This was due to higher seedling length and germination percentage in seed priming with 1% $CaCl_2$ at 100 kg/ha seed rate (T_{10}) compared to other treatments.

Plant height was significantly varied during the experiment period (Table 2). Plant height at 30 (25.91 cm), 60 (68.01 cm), 90 (95.53 cm) DAS and harvest stage (100.53 cm) was recorded highest with the adoption of seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate (T_{12}). The minimum plant height of 20.18 cm, 60.41 cm, 92.81 cm, and 94.33 cm was found under dry seed surface seeding at 100 kg/ha seed rate. This can be due to salt priming with $CaCl_2$ and KNO_3 combined with a high seed rate. Plant height increased with increasing seed rate because there was more competition for space and sunlight in higher seed rate so plants increased their height for taking optimum sunlight. Seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate recorded a maximum number of tillers m^2 at 30 (242), 60 (306), 90 (362) DAS and at harvest (348). It can be deduced from the results that both factors *i.e.* seed rate and priming techniques lead to the production of a greater number of tillers/m^2 (Table 2). Similar findings were also reported by Farooq *et al*. (2017) and Iqbal *et al*. (2020).

Dry matter accumulation is the process of storage of photosynthates in the different plant parts. It continuously increases from germination to harvesting. Dry matter accumulates till the vegetative stage and is mainly stored in vegetative parts after that it is stored in reproductive parts

Table 2. Growth and yield attributing characters of wheat affected by different seed priming methods and seed rate

Treatment	Plant height (cm)				No. of tillers/m²				Dry-matter accumulation (g/m²)			
	30 DAS	60 DAS	90 DAS	At harvesting	30 DAS	60 DAS	90 DAS	At harvesting	30 DAS	60 DAS	90 DAS	At harvesting
T_1	20.18	60.41	89.27	94.33	227	295	348	330	59	485	690	828
T_2	20.95	62.41	91.93	95.87	234	301	354	338	65	490	698	900
T_3	23.30	65.45	93.0	97.73	237	304	357	342	69	494	704	950
T_4	21.09	63.22	92.0	97.67	230	297	353	335	61	489	694	843
T_5	21.85	64.82	93.12	98.25	238	305	359	345	71	499	708	998
T_6	24.70	66.60	94.0	99.63	242	306	362	348	74	503	712	1,004
T_7	22.33	65.88	93.40	98.12	231	300	357	339	64	492	697	958
T_8	22.09	67.02	94.12	100.13	236	309	361	348	75	503	710	1,000
T_9	25.06	67.18	95.41	100.20	240	308	365	353	78	506	716	1,009
T_{10}	22.84	66.20	93.55	98.57	233	304	359	343	69	496	707	985
T_{11}	23.12	67.66	95.42	100.47	243	310	366	352	76	514	724	1,028
T_{12}	25.91	68.01	95.53	100.53	245	313	368	354	80	520	733	1,035
SEm±	0.33	0.57	0.60	0.64	2.37	2.56	2.97	2.89	3	7	9	13
CD (P=0.05)	1.00	1.60	1.78	1.88	6.95	7.51	8.71	8.50	9	21	27	39

T_1, dry seed surface seeding with 100 kg/ha seed rate; T_2, dry seed surface seeding with 125 kg/ha seed rate; T_3, dry seed surface seeding with 150 kg/ha seed rate; T_4-12 hours soaked seed surface seeding with 100 kg/ha seed rate; T_5, 12 hours soaked seed surface seeding with 125 kg/ha seed rate; T_6, 12 hours soaked seed surface seeding with 150 kg/ha seed rate; T_7, seed priming with 1% KNO_3 at 100 kg/ha seed rate; T_8, seed priming with 1% KNO_3 at 125 kg/ha seed rate; T_9, seed priming with 1% KNO_3 at 150 kg/ha seed rate; T_{10}, seed priming with 1% $CaCl_2$ at 100 kg/ha seed rate; T_{11}, seed priming with 1% $CaCl_2$ at 125 kg/ha seed rate; T_{12}, seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate

such as grain. Adoption of seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate (T_{12}) showed highest dry matter accumulation of 80.45 g/m², 527 g/m², 733 g/m² and 1035 g/m² at 30, 60 90 DAS respectively (Table 2). Dry matter accumulation increased with increasing seed rate and with adoption of various priming techniques because of enhanced plant population, and chlorophyll content leading to more accumulation of photosynthates (Alhammad *et al.*, 2023).

The analysis of data revealed that the highest grain yield of 4.67 t/ha was reported in seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate and the lowest (3.51 t/ha) in dry seed surface seeding at 100 kg/ha seed rate (Table 3). It was due to increased mortality of seedlings in dry seed surface seeding. An increase in seed rate and priming helps in maintaining the optimum plant population as well as the number of tillers resulting in increased yield. The treatment seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate showed the high-

Table 3. Effect of different seed priming methods and seed rate on yield and economics of wheat

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
T_1	3.54	4.45	44.05	87,715	53,198	2.51
T_2	3.82	4.79	44.40	94,676	59,109	2.66
T_3	4.10	4.38	43.50	98,495	61,878	2.68
T_4	3.80	4.36	45.06	93,634	59,117	2.71
T_5	3.93	4.83	44.53	97,234	61,667	2.73
T_6	4.32	5.27	45.05	106,325	69,708	2.90
T_7	4.01	5.16	43.74	99,897	64,490	2.82
T_8	4.46	5.52	44.71	110,288	73,608	3.00
T_9	4.50	5.59	44.59	111,271	73,319	2.93
T_{10}	4.11	4.99	45.15	101,219	65,802	2.85
T_{11}	4.60	5.68	44.78	113,661	76,969	3.09
T_{12}	4.67	5.69	45.02	114,851	76,884	3.02
SEm±	0.18	0.27	2.24	4,222	4,222	0.04
CD (P=0.05)	0.52	0.80	NS	12,382	12,382	0.14

T_1, dry seed surface seeding with 100 kg/ha seed rate; T_2, dry seed surface seeding with 125 kg/ha seed rate; T_3, dry seed surface seeding with 150 kg/ha seed rate; T_4, 12 hours soaked seed surface seeding with 100 kg/ha seed rate; T_5, 12 hours soaked seed surface seeding with 125 kg/ha seed rate; T_6, 12 hours soaked seed surface seeding with 150 kg/ha seed rate; T_7, seed priming with 1% KNO_3 at 100 kg/ha seed rate; T_8, seed priming with 1% KNO_3 at 125 kg/ha seed rate; T_9, seed priming with 1% KNO_3 at 150 kg/ha seed rate; T_{10}, seed priming with 1% $CaCl_2$ at 100 kg/ha seed rate; T_{11}, seed priming with 1% $CaCl_2$ at 125 kg/ha seed rate; T_{12}, seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate est straw yield (5.69 t/ha). Higher seed rate and priming techniques resulted in more dry matter accumulation per unit area and ultimately enhanced straw yield (Kubsad and Mansur, 2020). Different seed rates and priming techniques did not affect the harvest index significantly. The highest harvest index (45.15 %) was under seed priming with 1% $CaCl_2$ at 100 kg/ha seed rate (T_{10}), which was 3.81% higher compared to the lowest harvest index (43.50 %) obtained with dry seed surface seeding at 150 kg/ha seed rate. Harvest index mainly depends on crop species and cultivars. In this experiment, the cultivar was the same so there was no significant difference among different treatments (Elhag *et al*., 2017).

Likewise, different economic parameters such as gross return, net return, and benefit-cost ratio (B: C ratio) are calculated for different treatments (different seed rates and priming techniques) for wheat growth, yield, and their attributes. Data presented in Table 3 clearly show that there was significant variation in gross return, net return, and benefit-cost ratio among different treatments. The highest gross return (₹114851/ha) and net return (₹76884/ha) were obtained under seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate (T_{12}) because the highest grain and straw yield was obtained from the same treatment. The highest benefit-cost ratio 3.09 was obtained with T_{11} as the cost of cultivation was less under T_{11} ratio was higher under T_{11}. These results conform with Farooq *et al*. (2020) and Tikait *et al*. (2023).

Thus, it can be concluded that the seed priming with 1% $CaCl_2$ at 150 kg/ha seed rate is a viable option for sustainable wheat production.

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