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Effect of seed priming and seed rate on LAI and uptake of nutrients in wheat (*Triticum aestivum* L.)

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Abstract

To reach in good plant stand, the life cycle of plants is faced with different critical stages such as uneven seed germination, poor and early seedling growth which ultimately results in low crop yield. It is well known that seed priming enhances germination, reduces seedling emergence time, and improves yield and yield contributing characters of plants. A field experiment was conducted during Rabi, season of 2019-20 at the Research farm of Bihar Agricultural University, Sabour, Bhagalpur to study the effect of seed priming and seed rate on the performance of wheat. The experiment was laid out in factorial randomized block design with three replications. The treatments consisted of four different priming methods and three different seed rates of wheat (HD2967) viz, P_1-no seed priming (dry seed), P_2- seed priming with water, P_3- seed priming with 1% KNO_3, P_4- seed priming with 1% $CaCl_2$ and three different seed rate *viz.* S_1- 100 kg ha^{-1}, S_2- 125 kg $ha^{-1}$and S_3-150 kg ha^{-1}. The result revealed that leaf area index at all the progressive growth stages (25, 50, 75 and 100 DAS) was found higher under seed priming with 1% $CaCl_2$ as compared to un-primed and seed priming with 1% KNO_3 and water. In case of total phosphorus and potassium uptake, seed priming at 1% $CaCl_2$ showed higher phosphorus (26.29 kg ha^{-1}) and potassium uptake (102.15 kg ha^{-1}) over seed priming with 1% KNO_3, water and un-primed seed, while total nitrogen uptake (114.66 kg ha^{-1}) was observed higher under seed priming with 1% KNO_3 over seed priming with 1% $CaCl_2$, water and un-primed seed. Total nitrogen (116.77 kg ha^{-1}) and potassium (99.96 kg ha^{-1}) uptake was observed higher under seed rate of 150 kg ha^{-1} while total phosphorus uptake (25.30 kg ha^{-1}) was found higher under seed rate of 125 kg ha^{-1}. In conclusion, seed treated with 1% $CaCl_2$ and 1% KNO_3 was better able to uptake nutrients.

Keywords: seed priming, seed rate, wheat, nutrient uptake

Introduction

Wheat (*Triticum aestivum* L.) is the most important rabi season cereal grown in India and Bihar. It is an annual, hexaploid (2n = 6X= 42) crop, belongs to the family Poaceae. It is the most cultivated cereal crop of the world which ranks first (30 % of all cereals) followed by rice (27 %) and maize (25 %). Wheat production of our country is 99.87 million tons from 29.65-million-hectare area with productivity of 3.37 t ha^{-1} (Directorate of economics and statistics of India, 2018-19). Globally, India is the second largest producer of wheat contributing 12% in area and 11.9% in production (USDA, 2010). In India, U.P ranks first in area and production while Punjab ranks first in productivity. In Bihar, area under wheat cultivation is 2.15 m ha with production 5.58 m ton having average yield of 2595 kg ha^{-1} (USDA 2019-20). Poor crop establishment in wheat is one of the major problems; limiting crop productivity under both normal as well as late sown conditions due to problems like moisture stress, heat stress or poor-quality seed material. Late sowing of wheat experiences terminal heat stress which affects the grain development process and the harvested grains are of poor quality if used as seed for next crop. Optimum sowing time ensures adequate plant population and produces good quality seed. Late sowing of wheat is the major reason of low yield. In late planted wheat, low temperature prevailing during crop establishment substantially affects the germination and seedling emergence. Late planted wheat plants have to complete all growth and developmental stages in lesser time (Khan *et al.*, 2010) [17] that results in great loss of yield due to high temperature during grain filling period (Riaz-ud-Din *et al.*, 2010) [20].

Pre-sowing seed treatments or seed priming offer potential solution to poor seedling establishment and improve vigour by overcoming the germination constraints under normal as well as adverse conditions. But effectiveness of seed priming is more pronounced in adverse conditions like prevailing low temperature in wheat (Farooq *et al.*, 2008) [11]. Seed priming technique improves the germination, seedling emergence, growth and yield attributes of crop. Seed priming with KCl or $CaCl_2$ improved the seedling growth, stand establishment as well yield performance in direct seeded rice (Farooq *et al.*, 2006) [12]. Likely, vigorous seedling growth, emergence and yield performance by $CaCl_2$ priming has also been reported in wheat under late sown conditions (Farooq *et al.*, 2008) [11]. Priming of normal or low vigour seeds improved the vigour of seedling in term of radicle length, plumule length and their root, shoot ratio and fresh weight (Kausar *et al.*, 2009) [16]. Moosavi *et al.*, (2009) [18] reported that primed seeds significantly improved the germination percentage, speed of germination, root length and seed vigour. When low vigour seeds were primed showed improved germination performance (Bray, 1995) [6]. Seed priming with various salts of calcium, potassium and/or priming with growth regulators or hydro priming proved best to enhance vigour of seed and also improved stand establishment (Basra *et al.*, 2003) [5]. Number of productive tillers per unit area, biological yield, grain yield and harvest index were maximum in osmoprimed wheat under late condition (Sattar *et al.*, 2010) [21]. It is evident from previous studies that primed crops showed rapid and uniform emergence, good stand establishment and better performance even under stressful environment as compared to non-primed crops. Thus, the current study was undertaken to access the impact of seed priming and seed rate in relation to enhance nutrient uptake, growth and performance of wheat.

Materials and Methods

The experiment was carried out at research farm of Bihar agricultural University, Sabour during 2019-20 *rabi* season, to evaluate the effect of seed priming and seed rate on LAI and uptake of nutrients in wheat (var. HD-2967) crop. The experimental plot had uniform topography. The climatic condition of this place is tropical to subtropical and somewhat semi-arid in nature and is characterized by very dry summer, moderate rainfall and very cold winter. The field experiment was laid out in factorial randomized block design replicated thrice. Altogether, there were 12 treatment combinations consisting of four seed priming; P_1-no seed priming (dry seed), P_2- seed priming with water, P_3- seed priming with 1% KNO_3, P_4- seed priming with 1% $CaCl_2$ and three seed rates S_1- seed rate @100 kg ha^{-1}, S_2- seed rate @ 125 kg ha^{-1} and S_3- seed rate @ 150 kg ha^{-1}. Seed of wheat was primed with 1% KNO_3 and 1% $CaCl_2$ solutions and also in water for hours. Non-primed seed was included as a control treatment.

LAI was measured non-destructively with the help of LP-80 Ceptometer at 25, 50, 75 and 100 days after sowing (DAS). For plant nutrient analysis plant samples were collected at harvest stage from each treatment and dried in oven for 48 hours at 60 ± 5̊ C temperature. After drying, these samples were ground in Willey mill and sieved through 30 mesh sieve. The plant samples were ready to use for analysis of nitrogen (N), phosphorus (P) and potassium (K) after sieving.

The nitrogen content in grain and straw was estimated by modified Kjeldhal's method (Jackson, 1967). Nitrogen uptake was calculated by multiplying grain yield and straw yields with their respective nitrogen contents. Total nitrogen uptake per ha by the crop was calculated by adding the nitrogen uptake of grain and straw.

The tri-acid digested plant samples were analysed for phosphorus content by vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973). The intensity of yellow colour developed was measured using spectronic-20 D. The uptake of phosphorus was calculated by similar way as mentioned in nitrogen uptake i.e., by multiplying phosphorus content with the respective yields. It is also expressed in kg ha^{-1}. Potassium content of the extractant of tri-acid digested material was determined using flame photometer and uptake of potassium was similarly estimated by multiplying the potassium content with the respective yields, grin & straw and presented in kg ha^{-1}. Based on the nutrient content in entire plant analysis, the uptake of N, P and K by wheat crop under different treatments was worked out using the following formula. The uptake of N, P and K were expressed in kg ha^{-1}.

Nutrient uptake = % of nutrient concentration × Yield (kg ha^{-1})/100

To interpret the effect of different treatments, the data collected in course of experiment were analyzed statistically by applying the analysis of variance techniques laid down by Cochran and Cox (1967) [8], Panse and Sukhatme (1978) [19] and Gomez and Gomze (1984) [15]. Relevant data were statistically analyzed separately to interpret the results and the mean data for each parameter has been presented. For comparison of 'F' values and for determination of critical difference at 5% level of significance, Fischer and Yates Table (1963) were consulted.

Result and Discussion

Effect of seed priming and seed rate on leaf area index of wheat:

Leaf area index at the successive growth stages of crop was influenced by seed priming. It is quite evident from the data that leaf area index increased successively till 75 DAS under different seed priming. Among all the seed priming methods, seed priming with 1% $CaCl_2$ recorded significantly higher leaf area index at all the successive growth stages as compared to un-primed and seed priming with water but was significantly at par to seed priming with 1% KNO_3. Due to seed priming LAI increases to more number of green leaves, size of leaves, etc., led to higher leaf area and leaf area index. The lowest LAI was recorded under un-primed seeds.

Table 1: Effect of seed priming and seed rate on leaf area index of wheat

Treatments		Leaf Area Index			
		25 DAS	50 DAS	75 DAS	100 DAS
P_1	Un-primed	0.82	1.92	3.73	3.55
P_2	Seed priming with water	0.84	1.95	3.76	3.57
P_3	Seed priming with 1% KNO_3	0.93	2.04	3.84	3.66
P_4	Seed priming with 1% $CaCl_2$	0.95	2.17	3.98	3.68
SEm±		0.01	0.05	0.06	0.03
CD (P = 0.05)		0.05	0.16	0.18	0.10
Treatments					
S_1	Seed rate@100 kg ha^{-1}	0.79	1.89	3.70	3.52
S_2	Seed rate@125 kg ha^{-1}	0.89	2.08	3.80	3.62
S_3	Seed rate@150 kg ha^{-1}	0.98	2.09	3.98	3.71
SEm±		0.01	0.04	0.05	0.03
CD (P=0.05)		0.04	0.14	0.15	0.09
P X V		NS	NS	NS	NS

Leaf area index was influenced by seed priming at the successive growth stages of crop. It is quite evident from the data that leaf area index increased successively till 75 DAS under different seed primings. Among all the seed priming methods, seed priming with 1% $CaCl_2$ recorded significantly higher leaf area index at all the successive growth stages as compared to un-primed, control and seed priming with water. However, it was significantly at par with seed priming with 1% KNO_3. This might be due to the fact that the seed priming lead to higher leaf area and leaf area index owing to more number of green leaves and size of leaves. The lowest LAI was recorded under un-primed.

Effect of seed priming and seed rate on nutrient (NPK) uptake by grain and straw of wheat

Nitrogen uptake (kg/ha)

Uptake of nitrogen was observed significantly highest to the total N uptake (118.91 kg ha^{-1}) under P_3 i.e., seed priming with 1% KNO_3 followed by (114.66 kg ha^{-1}) P_4 i.e., seed priming with 1% $CaCl_2$. However, lowest nitrogen uptake was recorded with treatment P_1 i.e., un-primed. Among different seed rate, seed rate @150 kg ha^{-1}recorded maximum (116.77 kg ha^{-1}) nitrogen uptake which was statistically at par with seed rate @125 kg ha^{-1} (111.15 kg ha^{-1}).

Table 2: Effect of seed priming and seed rate on nutrient (NPK) uptake by grain and straw of wheat

Treatments		Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})
P_1	Un-primed	98.13	20.48	85.60
P_2	Seed priming with water	106.22	24.14	94.62
P_3	Seed priming with 1% KNO_3	118.91	25.13	101.15
P_4	Seed priming with 1% $CaCl_2$	114.66	26.29	102.15
SEm±		2.84	0.61	1.99
CD (P = 0.05)		8.34	1.81	5.83
Treatments				
S_1	Seed rate @100 kg ha^{-1}	100.53	22.93	89.78
S_2	Seed rate @125 kg ha^{-1}	111.15	25.30	97.91
S_3	Seed rate @150 kg ha^{-1}	116.77	23.80	99.96
SEm±		2.46	0.53	1.72
CD (P=0.05)		7.23	1.57	5.05
P X V		NS	NS	NS

Phosphorus uptake (kg/ha)

The data show that effect of seed priming and seed rate significantly influenced the phosphorus uptake. Uptake of Phosphorus was significantly observed highest (26.29 kg ha^{-1}) under P_4 i.e., seed priming with 1% $CaCl_2$ which was statistically at par with (25.13 kg ha^{-1}) P_3 i.e., seed priming with 1% KNO_3. However, lowest phosphorus uptake was recorded with treatment (20.48 kg ha^{-1}) P_1 i.e., un-primed. Among different seed rate, seed rate @125 kg ha^{-1} was recorded maximum (25.30 kg ha^{-1}) phosphorus uptake which was statistically at par with seed rate @150 kg ha^{-1} (23.80 kg ha^{-1}). The lowest phosphorus uptake was recorded from seed rate @100 kg ha^{-1} (22.93 kg ha^{-1}).

Potassium uptake (Kg/ha)

The data revealed that effect of seed priming and seed rate significantly influenced the potassium uptake. Uptake of potassium was significantly observed highest K uptake (102.15 kg ha^{-1}) under P_4 i.e., seed priming with 1% $CaCl_2$ which was statistically at par with (101.15 kg ha^{-1}) P_3 i.e., seed priming with 1% KNO_3. However, lowest K uptake was recorded with treatment (85.60 kg/ha) P_1 i.e., un-primed. Among different seed rate, seed rate @150 kg $ha^{-1}$was recorded maximum (99.96 kg ha^{-1}) potassium uptake which was statistically at par with seed rate @125 kg ha^{-1} (97.91 kg ha^{-1}).

Available N, P and K in the soil after harvest decreased with successive levels of seed priming. This might be due to better utilization of available soil nutrients for producing more grain yield under the seed priming. Khan *et al.*, (2010) [17] also reported that increase in moisture levels favours phosphorus transformation into different phosphorus fractions, particularly which of aluminium phosphate and iron phosphate and at some time improves the available P status of soil.

Conclusions

Maximum total N, P and K uptake were registered under seed priming with 1% $CaCl_2$ which was statistically at par with seed priming with 1% KNO_3. This result has achieved due to better utilization of available soil nutrients for producing more grain yield under the seed priming Seed rate with 150 kg ha^{-1} gave highest values of total N, P and K uptake followed by 125 kg ha^{-1}, due to the fact that the higher primed seed leads to higher leaf area and leaf area index owing to more number of green leaves and size of leaves.

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