Himachal Journal of Agricultural Research 42(2): 155-161(2016)

Effect of seed priming on seed yield and yield components of wheat (*Triticum aestivum* L.) under irrigated and rainfed conditions

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Received: 22 October 2016; Accepted: 20 November 2016

Abstract

Field experiment was conducted to study the effect of different seed priming treatments on yield and yield components of wheat (Triticum aestivum L.) under irrigated and rainfed conditions with cv. HPW 236 at CSKHPKV, Palampur, India during 2014-15. The experimental design was randomized complete block design (factorial) with four replications each under irrigated and rainfed situations. The first factor was situation i.e. irrigated and rainfed situation and the second factor was priming treatments viz., unprimed seed (control), tap water, KNO_3 (2.5%), KCl (2.0%) and KH_2PO_4 (1.0%). Results showed that situation and priming treatments significantly reduced the days to 75 per cent field emergence, days to 75 per cent flowering, days to maturity, increased the plant height (cm), leaf area (cm^2), spike length, number of tillers per plant, number of spikes per plant, number of spikelets per spike, number of grains per spike, 1000-grain weight, seed recovery percentage, straw yield and seed yield. Results of the experiment showed that seed priming with KNO_3 (2.5 %) and water for 16 hours significantly increased seed germination, seed yield and yield components of wheat under both irrigated and rainfed situations.

Key words: Wheat, priming, rainfed, irrigated, seed yield, yield components.

Wheat (*Triticum aestivum* L.) is world's most widely cultivated cereal grain, belonging to family poaceae. It is the second most important staple food crop of India after rice and contributes major share to food basket of the country. Germination and seedling emergence stages are critical for crop production; rapid and uniform field emergence is essential to achieve high yield and uniform plant stands, early maturity and reduced disease attack (Ali *et al.* 2005; Cheng and Bradford 1999). Wheat plants are exposed to a number of potentially adverse environmental conditions such as water deficit, high salinity, extreme temperature and submergence etc. Water deficit pose an increasing problem worldwide, especially in arid and semi-arid zones where the water intake period for seed germination is limited. Finding ways to overcome environmental stresses, such as inadequate moisture during seed germination, is important for an economic crop production (Ashraf and Rauf 2001). Seed priming is one of the most important developments to help rapid and uniform germination, emergence of seeds and to increase seed tolerance to adverse environmental conditions (Heydecker *et al.* 1973, 1975). Seed priming is commonly used to reduce the time between seed sowing and seedling emergence and to synchronize seedling emergence. The rationale is that sowing the soaked seed decreases the time needed for germination and may allow the seedlings to escape from the deteriorating soil physical conditions. In addition to better seedling establishment, primed crops grew more vigorously, flower earlier and gave higher yield (Farooq *et al.* 2008). Seed priming also improves emergence, stand establishment, tillering, grain, straw yields, and harvest index. Rapid and uniform emergence is utmost important, because it is the foundation on which stand establishment is based and potential yield is determined. Seedling stand establishment is dependent upon rapid and uniform germination (Fischer and Turner 1978, Yordanov *et al.* 2000). Seed priming is a controlled hydration process followed by re-drying that allows seed to imbibe water and begin internal biological processes necessary for germination, but not allow the seed to germinate (Kathiresan *et al.* 1984a; Saglam *et al.* 2010). Keeping in view the desirable effect of seed priming on seed germination and further establishment under stress conditions, the experiment was planned to evaluate the effect of seed priming using tap water, KNO_3, KCl, KH_2PO_4 on field emergence, yield attributes and seed yield of wheat under irrigated and rainfed situations.

Materials and Methods

The experiment was carried out at experimental farm of Department of Seed Science and Technology, CSK

Himachal Pradesh Krishi Vishvavidyalaya Palampur during 2014-15. Seeds of wheat (*Triticum aestivum* L.) were primed with five treatments *viz*., T_1 - unprimed control, T_2 - priming with tap water, T_3 - priming with KNO3 (2.5%), T_4 - priming with KCl (2.0%) and T_5 - priming with KH_2PO_4 (1.0%). All priming media were prepared in distilled water. Seeds were fully immersed in priming media at 25 ºC for 16 h under dark conditions. Seeds were given 2 to 3 washings after priming and surface dried on filter paper. All seeds were removed from priming media at the same time and then rinsed thoroughly with distilled water and hand dried using blotting papers to original moisture content under shade at room temperature. The experiment was laid out in randomized complete block design with factorial arrangement having four replications in each factor. Data were obtained on phenological and yield parameters of wheat. Days after sowing were counted for days to emergence and maturity. Five plants were randomly selected from each plot for recording plant height, leaf area, tillers per plant, spike length, spikelets per spike, grains per spike and 1000-grains weight.

Results and Discussion

Seed priming had significant positive effect on different aspects of wheat growth and yield parameters (Table 1). Significantly lower (17.80) number of days to 75 per cent emergence was recorded under irrigated situation when compared to those under rainfed situation (18.90). The days to 75 per cent field emergence due to seed priming treatments was significantly influenced. Minimum days (16.63) to 75 per cent field emergence was recorded in seeds primed with KNO_3 (2.5%), followed by priming with tap water (17.50), while maximum days (19.88) to 75 per cent field emergence was recorded in unprimed seeds (control). The faster emergence of seeds primed with KNO_3 may be due to its stimulation effect in the formation of enzymes which are important in the early phases of germination which help for a fast radicle protrusion and hypocotyl elongation to penetrate the soil. The earliness in emergence and lower mean emergence time might be the fact that seed priming induces a range of biochemical changes such as hydrolysis, activation of enzymes, DNA replication, increase RNA and protein synthesis enhances embryo growth and reduced leakage of metabolites (McDonald 2000). This edge of primed seeds over non-primed resulted improvement in field emergence. Harris *et al*. (1999) suggested that early emergence and maturity in seed priming treatment could be due to advancement in metabolic activities.

The plant height (cm) increased significantly from 30 days after sowing (DAS) to maturity, irrespective of situation i.e. under irrigated and rainfed situation, and seed priming treatments (Table 1). Significantly higher plant height (113.61 cm) was recorded under irrigated situation compared to the lower plant height (106.16 cm) under rainfed situation. Seeds primed with KNO_3 (2.5%) recorded highest (111.66 cm) plant height, followed by seeds primed with tap water (110.88 cm) as compared to unprimed seeds (control). Increased plant height may be due to early emergence and also rapid cell division in meristematic region, number of cells and increase in cell elongation due to multiplication of various parts of the plant tissue, auxin metabolism, cell wall plasticity and permeability of cell membrane, increasing photosynthates, cell enlargement and rapid cell elongation (Sadavarthe and Gupta 1963). Similar results were recorded by Ahmadvand *et al.* (2012) in soybean, where seed priming with KNO_3 resulted in significant increase in plant height.

The leaf area per plant (cm^2) increased significantly from 30 DAS to maturity, irrespective of situations and seed priming treatments (Table 2). The leaf area showed significant difference due to seed priming treatments. Significantly higher leaf area was recorded under irrigated situation (57.56 cm2) compared to under rainfed situation (55.80 cm^2). Wheat seeds primed with KNO_3 (2.5%) recorded highest (60.51 cm^2) leaf area at maturity, followed by seeds primed with tap water (57.65 cm^2). The increased leaf area from 30 DAS to maturity may be due to early emergence and increased plant height. Ahmadvand *et al.* (2012) in soybean found that seed priming with KNO_3 caused a significant increase in leaf area. Similar results was found by Sarlach *et al.* (2013) under irrigated situations in wheat, where maximum plant height was found by seed priming with KNO_3 (1.0%).

The days to 75 per cent flowering was significantly influenced under irrigated and rainfed situation (Table 3). Significantly lesser number of days to 75 per cent flowering was recorded under irrigated situation (118.40) compared to rainfed situation (121.40). The number of days to 75 per cent flowering showed significant difference due to seed priming treatments. Significantly minimum number of days (118.13) to 75 per cent flowering was recorded in seeds primed with

KNO_3 (2.5%), followed by priming with tap water (119.50) as compared to unprimed seeds (control). Early flowering might be due to early field emergence and rapid growth of primed seeds with KNO_3. Similar results were recorded by Kumar *et al.* (2002) in finger millet, where primed seeds take minimum days for flowering. The days to maturity was significantly affected under irrigated and rainfed situation (Table 3). Significantly lesser number of days (157.90) to maturity was recorded under irrigated situation compared to rainfed situation (161.45). Seeds primed with KNO_3 (2.5%) recorded minimum number of days (157.75) to maturity, followed by seed priming with tap water (159.00) as compared to unprimed control (161.38). The early maturity of the primed seed with KNO_3 might be due to lesser days to emergence and flowering. Similar results were observed by Harris *et al.* (2001) and Amin *et al.* (2012) in wheat, Jehan *et al.* (2011) in maize and Kumar *et al.* (2002) in finger millet, where KNO_3 primed wheat seeds took lesser days to maturity.

The number of tillers per plant was significantly affected under irrigated and rainfed situation (Table 3). Significantly higher number of tillers per plant was recorded in irrigated situation (5.47) compared to rainfed situation (4.45). Wheat seeds primed with KNO_3 (2.5%) recorded highest number of tillers per plant (5.43), followed by seed priming with tap water (5.03) as compared to unprimed control (4.71). However, treatments; seed priming with tap water and seed priming with 2.5% KNO_3 were statistically at par with each other. Primed seeds produced significantly more number of tillers and panicles as compared to non-primed plants in rice (WARDA, 2002). Similarly, Farooq *et al.* (2006c, 2008a, 2009) reported increase in tillering and growth of wheat and rice due to priming. The number of spikes per plant was significantly affected under irrigated and rainfed situation (Table 3). Significantly higher number of spikes per plant was recorded in irrigated situation (5.51) compared to rainfed situation (3.99). Highest number of spikes per plant (5.14) was recorded in wheat seeds primed with KNO_3 (2.5%) as compared to other treatments.

The number of spikelets per spike was significantly affected under irrigated and rainfed situation (Table 3). Significantly highest number of spikelets per spike was recorded under irrigated situation (18.26) compared to rainfed situation (16.62). The number of spikelets per spike showed significant difference due to seed priming treatments. Highest number of spikelets per spike (17.96) was recorded in wheat seeds primed with KNO_3 (2.5%), followed by seeds primed with tap water (17.77) as compared to unprimed seeds i.e. control (16.78). However, treatments; seed priming with tap water and seed priming with 2.5% KNO_3 were statistically at par with each other. Similar results were recorded by Sarlach *et al.* (2013) in wheat, where maximum number of spikelets per ear was observed for seed priming with KNO_3 (2.5%) under irrigated situations.

Spike length was not significantly influenced under irrigated and rainfed situation and there was no significant effect of different seed priming treatment on spike length. The number of grains per spike was significantly influenced under irrigated and rainfed situation (Table 3). Significantly highest number of grains per spike was recorded under irrigated situation (56.25) compared to rainfed situation (52.40). The number of grains per spike showed significant difference due to seed priming treatments. Significantly highest number of grains per spike (56.08) was recorded in wheat seeds primed with KNO_3 (2.5%), followed by seeds primed with tap water (55.42) as compared to unprimed seeds i.e. control (51.96). Similar results were recorded by Sarlach *et al.* (2013) and Arif *et al.* (2007) in wheat, where highest number of grains per spike was recorded for the primed seeds with KNO_3 as compared to unprimed seeds. Amin *et al.* (2012) found that wheat seed primed with KNO_3 under moisture stress situation attained maximum grains per spike.

Significantly highest straw yield per hectare was recorded under irrigated situation (6.16 t/ha) compared to rainfed situation (5.51 t/ha). The straw yield per hectare showed significant difference due to seed priming treatments. Seeds primed with KNO_3 (2.5%) recorded highest straw yield (6.05 t/ha), followed by seeds primed with tap water (5.93 t/ha) as compared to unprimed seeds i.e. control (5.65 t/ha). The increased straw yield in seeds primed with KNO_3 (2.5%) might be due to higher plant density and leaf area. However, T_2 - priming with tap water and T_3 - priming with 2.5% KNO_3 treatments were statistically at par with each other. Significantly highest seed yield per hectare was recorded under irrigated situation (4.61 t/ha) compared to rainfed situation (3.82 t/ha). The seed yield per hectare showed significant difference due to seed priming treatments

Table1. Effect of seed priming treatments on days to 75% field emergence and plant height in wheat

Treatments/ situations	Days to 75% field emergence	Plant height (cm)					
		30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At maturity
Irrigated	17.80	12.66	27.50	55.16	105.60	111.97	113.61
Rainfed	18.90	11.11	26.13	50.45	99.94	104.81	106.16
SE(m±)	0.19	0.14	0.34	0.19	0.56	0.08	0.30
LSD (P=0.05)	0.84	0.61	0.91	0.83	2.51	0.37	1.35
Priming treatments (T)							
T_1	19.88	11.28	25.85	49.89	100.72	106.46	108.04
T_2	17.50	12.06	27.09	54.08	103.80	109.54	110.88
T_3	16.63	12.70	27.67	54.67	105.13	110.30	111.66
T_4	18.50	11.81	26.90	53.22	102.87	108.53	109.81
T_5	19.25	11.57	.54	52.16	101.35	107.11	109.05
SE(m±)	0.32	0.30	0.24	0.31	0.63	0.27	0.30
LSD (P=0.05)	0.93	0.87	0.70	0.91	1.83	0.78	0.88

T_1 - unprimed control; T_2 - priming with tap water; T_3 - priming with 2.5% KNO_3; T_4 - priming with 2.0% KCl; T_5 - priming with 1.0% KH_2PO_4, DAS: days after sowing

Table 2. Effect of seed priming treatments on leaf area (cm^2) in wheat

Treatments/ situations	Leaf area per plant (cm^2)					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At maturity
Irrigated	5.57	15.37	45.03	57.42	57.42	57.56
Rainfed	4.88	14.64	43.99	55.52	55.59	55.80
SE(m±)	0.12	0.12	0.07	0.07	0.09	0.09
LSD (P=0.05)	0.52	0.53	0.31	0.31	0.40	0.39
Priming treatments (T)						
T_1	4.88	13.61	42.09	53.46	53.17	53.59
T_2	5.23	15.46	45.78	57.41	57.61	57.65
T_3	5.99	15.96	47.90	60.11	60.21	60.51
T_4	5.05	15.18	43.55	56.62	56.72	56.77
T_5	4.96	14.81	43.24	54.75	54.82	54.88
SE(m±)	0.14	0.28	0.33	0.35	0.38	0.32
LSD (P=0.05)	0.40	0.82	0.95	1.02	1.10	0.93

T_1 - unprimed control; T_2 - priming with tap water; T_3 - priming with 2.5% KNO_3; T_4 - priming with 2.0% KCl; T_5 - priming with 1.0% KH_2PO_4, DAS: days after sowing

Table 3. Effect of seed priming treatments on yield and yield attributes in wheat

Treatments/ situations	Days to 75 % flowering	Days to maturity	No. of tillers per plant	Number of spikes per plant	No. of spikelets per spike	Spike length (cm)	No. of grains per spike	Seed yield (t/ha)	Straw yield (t/ha)	Seed recovery (%)	1000-grain weight (g)
Irrigated	118.40	157.90	5.47	5.51	18.26	12.23	56.25	4.61	6.16	91.99	52.55
Rainfed	121.40	161.45	4.45	3.99	16.62	11.67	52.40	3.82	5.51	89.65	50.37
SE(m±)	0.18	0.19	0.05	0.04	0.08	0.21	0.11	0.04	0.06	0.11	0.09
LSD (P=0.05)	0.82	0.84	0.25	0.19	0.38	NS	0.49	0.20	0.25	0.48	0.42
Priming treatments (T)											
T_1	121.38	161.38	4.71	4.55	16.78	11.49	51.96	4.04	5.65	89.36	49.71
T_2	119.50	159.00	5.03	4.78	17.77	12.04	55.42	4.33	5.93	91.75	52.50
T_3	118.13	157.75	5.43	5.14	17.96	12.16	56.08	4.39	6.05	93.40	53.35
T_4	120.00	159.75	4.88	4.65	17.50	12.16	54.76	4.20	5.81	90.06	51.17
T_5	120.75	160.50	4.77	4.63	17.21	11.88	53.4	4.11	5.75	89.55	50.56
SE(m±)	0.26	0.29	0.15	0.12	0.15	0.21	0.20	0.06	0.07	0.19	0.14
LSD (P=0.05)	0.75	0.84	0.44	0.36	0.45	NS	0.59	0.18	0.20	0.55	0.41

T_1 - unprimed control; T_2 - priming with tap water; T_3 - priming with 2.5% KNO_3; T_4 - priming with 2.0% KCl; T_5 - priming with 1.0% KH_2PO_4

(Table 3). Seeds primed with KNO_3 (2.5%) recorded highest seed yield (4.39 t/ha), followed by seeds primed with tap water (4.33 t/ha) as compared to unprimed seeds i.e. control (4.04 t/ha). However, treatments; seed priming with tap water and seed priming with 2.5% KNO_3 were statistically at par with each other. Increase in seed yield of wheat under irrigated situation and seed priming treatments could be attributed to higher yield attributes. Enzymes such as amylase, protease and lipase have a great role in initial growth and development of embryo and every increase in activity of these enzymes results in faster initial growth of seedling, therefore, its establishment improvement result in higher yield. Higher seed yield under irrigated situation with seed priming treatments could also be attributed to early germination, vigorous growth and consequently good crop establishment as compared to rainfed situation. Increased seed yield with seed priming in wheat has been also reported by Harris *et al.* (2001) and Rashid *et al.* (2002). Similar result was recorded by Sarlach *et al.* (2013) in wheat, where priming wheat seeds with KNO_3 (2.0%) resulted increased seed yield under irrigated conditions. Tiwari *et al.* (2014) in pigeon pea revealed that primed pigeon pea seeds with KNO_3 resulted in significantly higher seed yield. Mishra and Dwivedi (1980) found that pre-soaking seed treatment with potassium significantly increased the seed yield of wheat under rainfed conditions as compared to control. The increase in yield due to seed priming may be due to the fact that primed seed emerge faster and more uniformly and seedlings grow more vigorously, leading to a wide range of phenological and yield related benefits (Harris *et al.* 2000).

Significantly higher seed recovery (91.99%) was recorded under irrigated situation (Table 4) as compared to rainfed situation (89.65%). The seed recovery per cent showed significant difference due to seed priming treatments. Significantly higher seed recovery (93.40 %) was recorded in seeds primed with KNO_3 (2.5%), followed by seeds primed with tap water (91.75 %) as compared to unprimed seeds *i.e.* control (89.36 %). The 1000-grain weight was significantly influenced under irrigated and rainfed situation (Table 3). Significantly higher 1000-grain weight was recorded under irrigated situation (52.55 g) compared to rainfed situation (50.37 g). Wheat seeds primed with KNO_3 (2.5%) recorded significantly higher 1000-grain weight (53.35 g), followed by seeds primed with tap water (52.50 g) as compared to unprimed seeds *i.e.* control (49.71 g). Arif *et al.* (2007) revealed that wheat and chickpea seed priming enhanced 1000-grains weight. Similar results were recorded by Mehri (2015) in soybean, Musa *et al.* (1999) in chickpea and Abro *et* *al.* (2009) in wheat, where seed priming with water increased the 1000-grain weight.

Conclusions

It is concluded from the present study that treatments T_3 - priming with KNO_3 (2.5%) and T_2 - priming with tap water showed significantly superior results for most of the field parameters as compared to T_1 - unprimed control, Therefore, for enhancing the seed yield and yield parameters, the seeds of wheat can either be primed with KNO_3(2.5%) or tap water.

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