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Effect of seed priming on the field performance of wheat and barley

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ABSTRACT

Hydro-priming of wheat and barley seeds were conducted to evaluate on their field performance. The hydro-priming treatments used for the experiment in wheat and barley were: 0 hr priming, 6 hrs priming, 12 hrs priming, 18 hrs priming, 24 hrs priming and 36 hrs priming. For wheat, 24 hrs priming showed the highest, seedling emergence of 21.67%, 51.67% and 84.67% at 5 days after sowing (DAS), 6 DAS and 7 DAS, respectively. On the other hand 0 hr priming showed lowest performance of 4.67%, 13.00%, 40.33% and 74.33% at 4, 5, 6 and 7 DAS, respectively. From the experiment it was observed that 24 hrs priming showed the highest emergence rate of 8.00%, 20.33% and 48% at 4, 5 and 6 DAS, respectively and lowest emergence percent were found for 0 hr priming at different time in barley. The highest number of tillers hill^{-1} (4.77) and number of fertile tillers hill^{-1} (4.05) were found for 18 hrs priming. From the result it was observed that 6 hrs priming had highest (3.97) number of spikelets spike^{-1} while the highest grain yield (2.27 t ha^{-1}), straw yield (6.53 t ha^{-1}) and biological yield (8.8 t ha^{-1}) were observed from 24 hrs priming. The lowest grain yield (1.77 t ha^{-1}), straw yield (5.43 t ha^{-1}) and biological yield (7.2 t ha^{-1}) were found from the treatment 0 hr priming. The highest harvest index (25.87) was found for 12 hrs priming and lowest (24.53) for 0 hr priming. In barley the highest number of tillers hill^{-1} (5.93) and number of fertile tillers hill^{-1} (5.05) were found from 18 hr priming. The highest grains spike^{-1} (69.83) was found from 36 hr priming. The result showed that the highest grain yield (1.53 t ha^{-1}) and biological yield (5.46 t ha^{-1}) were found for 24 hrs priming. The lowest grain yield (1.23 t ha^{-1}) and biological yield (4.9 t ha^{-1}) were observed from 0 hr priming. The highest harvest index (28.03) was found for 24 hrs priming and lowest (25.17) for 0 hr priming. Therefore, seed priming played an important role in the field performance of wheat and barley. Greater influence of seed priming was observed in wheat than barley. Both wheat and barley 18-24 hrs priming showed better field performance.

INTRODUCTION

Rice is the major source of cereal food for Bangladesh but its present output is not sufficient to provide the total food requirement of the people. Therefore, transfer of pressure from single crop that is from rice to supplementary crops, such as wheat, barley, sorghum etc. assumes a great importance. Wheat *(Triticum aestivum)* is the most important cereal crop all over the world. It ranks first in area (21306 million hectares) and third in production (570.3 million metric tons) among the grain crops in the world (FAO, 2000). In Bangladesh, wheat ranks next to rice in respect of total area of 0.56 million hectares (BBS, 2006). However the average yield of wheat in Bangladesh is very low compared to that of other wheat growing countries of the world. On the other hand, barley *(Hordeum vulgare)* is the world's fourth important cereal after wheat, maize and rice. It is cultivated successfully in a much wider of climate than any other cereals. Barley as one of the supplementary cereal crops is not altogether a new crop in Bangladesh. It has ever been cultivated in smaller areas scattered over the different parts of the country. Barley is a grain crop which resembles wheat in many respects including its nutritional values.

Out of many constraints regarding low production of wheat and barley, seed germination, growth and development, yield and crop quality are of prime importance. By providing some special pre-sowing treatments, seeds can be invigorated. There are many seed invigoration techniques such pre-sowing hydration (priming), coating technologies and seed conditioning (Taylor et al. 1998). Good stand establishment of the crop is considered to be essential for the efficient use of resources like water and light. This is true in temperate regions or under irrigation or in the humid tropics where, within broad limits, yields are often proportional to plant population density. In the rainfed semi-arid tropics, however, the balance between water supply and demand is critical and more conservative population densities are often required. Nevertheless, uniform stand establishment is still a pre-requisite for cropping success because, under adverse conditions, crowding should be avoided in order to allow each plant to have maximum access to limited soil water and nutrients. Good germination and emergence are the keys to controlling stand establishment. Similarly, vigorous early growth is often associated with better yields (Okonwo and Vanderlip, 1985; Austin, 1989; Carter et al. 1992).

In marginal lands and rain fed areas, patchy plant stands often result from the failure of seed to emerge quickly and uniformly. Seed germination is a serious problem in field crop. The yield of most of crops is reduced because enough seeds could not germinate and plants that eventually emerge often grow very slowly that are susceptible to drought, pests and disease infection. Wheat is the most important cereal crop grown in rotation with chickpea in rain fed areas and with cotton or rice in irrigated areas. The rate of water absorption in initial 24 hours of imbibitions could improve the seedling vigor of crops.

In this case, seed priming leads to faster, more complete establishment of crops, a lower risk of crop failure and the need to re-plant, more vigorous growth, earlier flowering and maturity and higher yields. Seed priming is

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a technique to reduce emergence time, accomplish uniform emergence time, better algometric (changes in growth of plant parts over time) attributes and provide requisite stand in many horticultural and field crops. Various pre-hydration or priming treatments have been employed to increase the speed and synchrony of seed germination (Bradford, 1986). Common priming techniques include osmo-priming (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions) and hydropriming (soaking seeds in water). Osmopriming contributes to significant improvement in seed germination and seedling growth in different plant species. Similar to other priming techniques, hydropriming generally enhances seed germination and seedling emergence, although there are exceptions. Harris et al. (1999) demonstrated that on-farm seed priming (soaking seeds overnight in water) markedly can improve establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields.

Strategies for improving the growth and development of crop species have been investigated for many years. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Bradford, 1986; Taylor and Harman, 1990). During priming, seeds are partially hydrated so that pre-germinative metabolic activities proceed, while radicle protrusion is prevented, then are dried back to the original moisture level (McDonald, 2000). Seed priming is a generic technology and that it addresses a fundamental requirement for crop production the need to have a field full of vigorous plants. Thus, it can be incorporated with almost any other technology or process that can be used to improve crop performance.

A good number of works have been done on seed priming of wheat and barley aboard but under Bangladesh condition such works are scanty. The seed priming technology can enhance seedling emergence and ensure good plant stand which in turn can maximize yield and improve quality of the crop. Since the effect of seed priming on field emergence of wheat and barley is poorly documented, the present study was undertaken to investigate the effects of priming and on seed germination and field performance of wheat and barley.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Agronomy Field Laboratory of the Department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh, during the period from November 2009 to April 2010 under irrigated condition. The experiment was carried out in medium high land belonging to the Old Brahmaputra floodplain, Agro-Ecological Zone (AEZ)-9 having non calcareous dark gray soil (UNDP and FAO, 1998). The soil was sandy loam with pH value 6.5. The climate of the experimental site is characterized by relatively low rainfall and low temperature from December to March.

Plant materials

The materials used in the study were wheat and barley seeds which were collected from the Agronomy Field Laboratory of the Department of Agronomy, BAU, Mymensingh. The initial seed moisture content was in between 10-12%. The seeds were fresh, clean, and disease and insect free.

Seed priming

Hydropriming applied to wheat and barley seeds viz., 0, 6, 12, 18, 24 and 36 hrs. For, pre-sowing seed priming 180 g seeds of wheat and barley were soaked in distilled water for 0, 6, 12, 18, 24 and 36 hrs separately at room temperature. After completing the priming seeds were sown for seedling emergence.

Cultivation procedure

The experimental plot was thoroughly prepared by ploughing with power tiller followed by harrowing and laddering. After laddering, the weeds and the stubble of previous crops were removed from the land. Recommended doses of fertilizers and manures were applied at 200, 150, 80, 50 and 10000 kg of urea, triple super phosphate, muriate of potash, gypsum and cowdung, respectively. Half amount of urea, entire amount of other fertilizers and cowdung were applied to the soil at the time of final land preparation. The rest of the urea was top dressed in two equal splits at tillering stage and at booting stage of wheat and barley plant. The experiment was set up in a randomized complete block design with three replications. The plot size was 1 m $\times$ 1 m. The distance between two plots was 25 cm. Pre-sowing hydro-primed seeds of wheat and barley were sown in the field on 22 November 2009. Intercultural practices were done uniformly for all plots. Thinning was done 25 days after sowing. Weeding was done as and when necessary. The crop was irrigated two times, one at the crown root initiation stage and the other at peak tillering stage.

Data collection

Wheat and barley crops matured at different times. So harvesting of wheat and barley was done on 30 March and 04 April, 2010, respectively. Five plants from each plot were randomly selected to collect data on plant parameters and these were harvested by uprooting. The whole plots were harvested to assess grain and straw yields. Data on seedling emergence, plant height, number of tillers hill^{-1}, number of fertile tillers hill^{-1}, number of non fertile tillers hill^{-1}, panicle length, number of spikelets spike^{-1}, number of fertile spikelets spike^{-1}, grain spike^{-1}, 1000-grain weight, straw yield, grain yield, biological yield and harvest index were collected from experimental plots and selected plants.

Statistical analysis

The collected data were compiled and tabulated. Statistical analysis was done on various plant characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of computer package programme MSTAT-C (software) (Russel and Freed, 1986) and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) as laid out by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of seed priming on seedling emergence of wheat

There was a significant influence of seed priming on seedling emergence of wheat (Table 1). At 4 DAS, the highest seedling emergence percent (8.33) was recorded for 18 hrs priming and that was followed by 24 hr priming. 0 hr priming showed the lowest emergence percent (4.67). It indicated that the highest emergence percent (21.69) was recorded for 24 hrs priming and the lowest emergence percent (13.00) recorded from 0 hr priming at 5 DAS. Seedling emergence 21.00% was showed in 18 hrs priming (Table 1). At 6 DAS, the highest and the lowest seedling emergence percent were at 24 hrs (51.67) and 0 hrs (40.33) priming, respectively while, 18 hrs priming given moderate performance (47.33%). On the 7 DAS, the highest seedling emergence percent (84.67) was recorded for 24 hrs priming followed by 12 hrs priming (82.00%) while 0 hr priming showed lowest percent (74.33). It is evident that at 4 DAS to 7 DAS, seedling emergence percent was significantly influenced by different priming treatments but the priming of seed had no significant effect on seedling emergence percent at 8 DAS in wheat. These findings are in conformity with that of Giri and Schillinger (2003) who conducted a 2 years study involving laboratory, greenhouse, and field components to determine seed priming effects on winter wheat germination and emergence. It also found that hydro-priming enhances seed germination, seedling emergence and resulting in faster development, earlier flowering and maturity and higher yields in wheat (Harris et al. 2001; Rajpar et al. 2006).

Table 1. Effect of seed priming on seedling emergence of wheat.

Hydro-priming (hrs)	% Emergence of seedlings				
	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS
0	4.67 c	13.00 dc	40.33 d	74.33 c	89.33
6	6.67 b	16.67 c	45.33 bc	75.67 c	89.67
12	7.33 ab	19.33 b	47.33 b	82.00 ab	90.33
18	8.33 a	21.00 a	45.00 bc	80.33 b	90.67
24	8.00 a	21.67 a	51.67 a	84.67 a	89.00
36	5.33 bc	14.67 c	43.33 c	75.67 c	90.00
Level of significance	**	**	**	**	NS

NS = non significant, and *, ** = significant at 5% and 1% level of probability; Values in the column with same letter(s) do not differ significantly as per DMRT at 5% level of probability.

Effect of seed priming on seedling emergence of barley

The influence of priming on seedling emergence of barley was found significant (Table 2). The highest emergence percent (8.0) was recorded for 24 hrs priming. 18 hrs (7.0%) and 12 hrs (6.67%) priming also showed better seedling emergence in barley while 0 hr priming showed lowest seedling emergence percent (3.67). On the 5 DAS, the highest percentage of seedling emergence (20.33) was recorded for 24 hrs priming and lowest emergence (12.00%) was recorded from 0 hr priming. 18 hrs priming (19.67) also response better to seedling emergence behavior.

Priming treatments were significantly influence on seedling emergence percent at 6 DAS. 24 hrs priming (48.00%) was showed highest seedling emergence followed by 12 hrs priming (47.00%). The lowest emergence percent showed at 0 hrs priming (39.00%). The priming treatments had no significant effect on seedling emergence behavior in barley at 7 and 8 DAS. These results were supported by some other previous study. The improved germination of primed seeds may, therefore, be attributed to counteraction of free radicals and re-synthesis of membrane bound enzymes as in unprimed seeds (Srinivasan and Saxena, 2001). Recent studies showed that seed priming resulted in faster development, earlier flowering and maturity and higher yields in barley (Abdulrahmani et al. 2007)**.**

Table 2. Effect of seed priming on seedling emergence of barley.

Hydro-priming (hrs)	% Emergence of seedlings				
	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS
0	3.67 c	12.00 d	39.00 c	77.00	87.33
6	6.00 b	15.67 c	43.67 b	76.33	87.67
12	6.67 ab	17.67 b	47.00 a	76.67	88.67
18	7.00 ab	19.67 a	44.67 ab	78.33	87.00
24	8.00 a	20.33 a	48.00 a	78.00	88.33
36	5.33 bc	15.00 c	43.33 b	77.67	89.00
Level of significance	**	**	**	NS	NS

NS = non significant, and *, ** = significant at 5% and 1% level of probability; Values in the column with same letter(s) do not differ significantly as per DMRT at 5% level of probability.

Effect of priming on yield and yield contributing characters of wheat

Seed priming of wheat seed showed significant influence on several yield and yield contributing characters (Table 3). Plant height, number of non-fertile tiller hill^{-1}, panicle length, number of spiklets spike^{-1}, grain spike^{-1} and 1000-grain weight of wheat did not affected by seed priming for different duration. Number of tillers hill^{-1} was significantly influenced by seed priming treatment. The highest number of tillers hill^{-1} (4.77) was found for 18 hrs priming. 0, 6, 12, and 36 hrs priming also showed similar result. The lowest number of tillers hill^{-1} (3.73) was observed for 36 hrs priming (Table 3). Significant variations were observed for number of fertile tillers hill^{-1} due to different priming treatments. It is also showed that the highest number of fertile tillers hill^{-1} (4.05) was found for 18 hrs priming. Moderate number of fertile tillers hill^{-1} was observed for 6 hrs priming (3-20), 12 hrs priming (3.37), 0 hr priming (3.06) and 24 hrs priming (3.01). The lowest number of fertile tillers hill^{-1} (2.99) was observed for 36 hrs priming. Different seed treatment significantly influenced number of fertile spikelets spike^{-1}. It is observed that the highest number of fertile spikelets spike^{-1} (3.97) was found for 6 hrs priming followed by 24 hrs priming (3.70) and 12 hrs priming (3.67). The lowest number of fertile spikelets spike^{-1} (3.10) was observed for 0 hr priming.

Seed priming had significant effect on straw weight of wheat (Table 3). The highest straw yield (6.53 t ha^{-1}) was found for 24 hrs priming. 12 hrs priming also showed better performance. The lowest straw yield (5.43 t ha^{-1}) was observed for 0 hr priming. In earlier study it was reported that, seed priming of wheat with hormones enhances germination in seed, growth and development in leaves and straw, reduces the early senescence in leaf (Mass et al. 1996, Ashraf and Rauf, 2001; Ashraf and Irani, 2002). Grain yield was significantly influenced by different seed priming of wheat. It is showed that the highest grain yield (2.27 t ha^{-1}) was found for 24 hrs priming followed by 12 hrs priming (2.23 t ha^{-1}) and 18 hrs priming (2.17 t ha^{-1}). The lowest grain yield (1.77 t ha^{-1}) was observed for 0 hr priming. These result were supported by Rashid et al. (2002) primed wheat seeds overnight in two RED trials in Nowshera district in Pakistan and significantly increased grain yield by 22.5% and 24.3%, respectively. Different seed priming significantly influenced biological yield of wheat. It is observed that the highest biological yield (8.8 t ha^{-1}) was found for 24 hrs priming followed by 12 hrs priming (8.63 t ha^{-1}) and 18 hrs priming (8.47 t ha^{-1}). The lowest biological yield (7.2 t ha^{-1}) was observed for 0 hr priming. The priming treatments of seed had significant effect on harvest index of wheat and the highest harvest index (25.87) was found at 12 hrs priming and lowest (24.53) at 0 hr priming.

Table 3. Effect of seed priming on yield and yield contributing characters of wheat.

Hydro-priming (hrs)	Plant height (cm)	Number of tillers $hill^{-1}$	Number of fertile tillers $hill^{-1}$	Number of non fertile tillers $hill^{-1}$	Panicle length (cm)	Number of spikelets $spike^{-1}$	Number of fertile spiklets $spike^{-1}$	Grains $spike^{-1}$	1000-grain weight (g)	straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Biological, yield (t ha^{-1})	Harvest index (%)
0	82.67	4.40 a	3.06 bc	1.34	10.63	17.13	3.10 b	45.53	47.00	5.43 c	1.77 c	7.20 d	24.53 c
6	86.27	4.60 a	3.20 abc	1.40	10.43	17.47	3.97 a	44.17	47.07	5.93 b	2.00 b	7.93 c	25.20 b
12	90.43	4.00 ab	3.37 ab	0.63	10.63	16.30	3.67 ab	44.70	46.88	6.40 a	2.23 a	8.63 a	25.87 a
18	84.47	4.77 a	4.05 a	0.72	10.77	16.47	3.37 ab	40.53	47.27	6.30 ab	2.17 ab	8.47 ab	25.57 ab
24	82.90	4.07 ab	3.01 bc	1.06	11.60	17.67	3.70 a	48.83	47.71	6.53 a	2.27 a	8.80 a	25.77 a
36	86.50	3.73 b	2.99 bc	0.74	11.50	17.53	3.13ab	42.87	47.31	6.03 b	2.03 b	8.06 bc	25.22 b
Significance level	NS	*	*	NS	NS	NS	*	NS	NS	**	**	**	**

NS = non significant, and *, ** = significant at 5% and 1% level of probability
Values in the column with same letter(s) do not differ significantly as per DMRT at 5% level of probability.

Table 4. Effect of seed priming on yield and yield contributing characters of barley.

Hydro-priming (hrs)	Plant height (cm)	Number of tillers $hill^{-1}$	Number of fertile tillers $hill^{-1}$	Number of non fertile tillers $hill^{-1}$	Panicle length (cm)	Number of spikelets $spike^{-1}$	Number of fertile spiklets $spike^{-1}$	Grain $spike^{-1}$	1000-grain weight (g)	straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Biologic al Yield (t ha^{-1})	Harvest index (%)
0	96.87	4.56 bc	4.02 abc	0.54	10.90	19.17	3.63	60.63 b	40.81	3.67	1.23 c	4.90 c	25.17 c
6	95.23	4.30 bc	4.04 abc	0.26	11.40	18.00	3.40	53.30 b	40.77	3.77	1.36 b	5.13 c	26.63 bc
12	97.73	5.16 b	4.64 ab	0.52	10.43	18.33	3.47	58.17 b	40.81	3.93	1.43 ab	5.36 b	26.70 b
18	99.27	5.93 a	5.05 a	0.88	11.37	18.93	3.43	55.70 b	40.87	3.96	1.47 ab	5.43 ab	27.00 ab
24	96.67	4.80 bc	3.60 bc	1.20	11.53	18.90	3.20	59.90 b	41.03	3.93	1.53 a	5.46 ab	28.03 a
36	101.57	5.53 b	4.20 abc	1.33	11.07	20.63	3.53	69.83 a	40.67	3.87	1.33 bc	5.20 bc	25.63 c
Sig. level	NS	**	*	NS	NS	NS	NS	*	NS	NS	**	*	*

NS = non significant, and *, ** = significant at 5% and 1% level of probability
Values in the column with same letter(s) do not differ significantly as per DMRT at 5% level of probability.

Effect of priming on yield and yield contributing characters of barley

Effect of seed priming on barley influenced the yield and yield contributing characters studied except plant height, number of non-fertile tillers $hill^{-1}$, panicle length, number of spikelets $spike^{-1}$, number of fertlie spikelets $spike^{-1}$, 1000-grain weight, and straw yield (Table 4). Number of tillers $hill^{-1}$ was significantly influenced by seed priming treatment and the highest number of tillers $hill^{-1}$ (5.9) was found for 18 hrs priming followed by 36 hrs priming (5.53) and 12 hrs priming (5.16). The lowest number of tillers $plant^{-1}$ (4.3) was observed for 6 hrs priming (Table 4). Significant variations were observed for number of fertile tillers $hill^{-1}$ due to different priming treatments. It is evident that the highest number of fertile tillers $plant^{-1}$ (5.05) was found for 18 hrs priming. Medium number of fertile tillers $plant^{-1}$ was observed for 12 hrs priming (4.64), 36 hrs priming (4.20), 6 hrs priming (4.04) and 0 hrs priming (4.02). The lowest number of fertile tillers $plant^{-1}$ (3.60) was observed for 24 hrs priming.

Significant variations were observed for grains $spike^{-1}$ of barley due to different priming and it is showed that the highest grains $spike^{-1}$ (69.83) was found for 36 hrs priming. 60.63, 59.59, 58.17 and 55.70 grains $spike^{-1}$ were observed for 0, 24, 12, and 18 hrs priming, respectively. The lowest number of grains $spike^{-1}$ (53.30) was observed for 6 hrs priming. Grain yield was significantly influenced by different seed treatments of barley (Table 4). It is indicated that that the highest grain yield (1.53 t ha^{-1}) was found for 24 hrs priming. 18 hrs priming (1.47 t ha^{-1}) and 12 hrs priming (1.43 t ha^{-1}) also showed better performance. The lowest grain yield (1.23 t ha^{-1}) was observed for 0 hr priming. Different seed treatment significantly influenced biological yield of barley. It was observed that the highest biological yield (5.46 t ha^{-1}) was found for 24 hrs priming which is statistically similar to 18 hrs priming (5.43 t ha^{-1}), 12 hrs priming (5.36 t ha^{-1}). The lowest biological yield (4.9 t ha^{-1}) was observed for 0 hr priming. Significant variations were observed for harvest index due to different priming treatments and the results showed that the highest harvest index (28.03) was produced at 24 hrs priming and the lowest (25.17) at 0 hr priming.

CONCLUSION

From the study it may be conclude that priming of seeds has positive effects on the germination, emergence and field performance of the tested crops wheat and barley. By practicing seed priming techniques farmers will be successfully overcome the poor crop establishment is a one of the widespread constraint for wheat and barley cultivation for both wet and dry soils.

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