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Effect of hydropriming and different sowing dates on growth and yield attributes of Wheat (*Triticum aestivum* L.)

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Abstract: The present investigation was conducted to study the effects of hydropriming and different sowing dates on growth and yield attributes of wheat (*Triticum aestivum L.*) during Rabi season of 2014-15.The experiment was conducted in Randomised Block Design with three replications. The highest germination percentage was recorded at T_4 [hydropriming] 22nd Nov + 16 hrs. (94.04%), plant height highest was recorded at T_4 (95.23cm), highest number of tillers at T_4 (4.40), number of spikelet per spike highest at T_4 (18.73), numbers of grains per spike highest at T_4 (53.13), root length (16.07cm), test weight (43.33g), grain yield (42.79 q/ha), harvest index (63.46%) recorded similar result in same treatment. Therefore it may be concluded that 22nd Nov with 16 hrs. of hydropriming treatment can be recommended to PBW-343 wheat grower for obtaining better growth and yield.

Keywords: Germination, Hydropriming, Sowing, Yield, Wheat

INTRODUCTION

Wheat is a cereal grass of the *Graminae* (*Poaceae*) family and of the genus *Triticum*, is the world's largest cereal crop. It has been described as the 'King of Cereals' because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. World production of wheat was 713 million tons, making it the third most-produced cereal after maize (1,016 million tons) and rice (745 million tons) (FAO, 2013).Wheat is the important food crop of the world it provides food to 36% of the global population contributing 20% of the food calories for the world people and is a national staple in many countries. Wheat plays an important role in Indian economy. Wheat is grown only in Central & south India and that too under rainfed conditions.100 grams of wheat contain about 10-14% of protein, 1-2% of total fat, 3-5% grams of carbohydrates.PBW 343 is a wheat variety suitable for timely sown and irrigated conditions. It gives an average yield of 46-50 qtls/ha. The variety normally takes early (126-134 days) to mature. On maturity the plants of the variety attains a height of 80-90 cm. The variety is resistant to stripe rust (yellow rust), leaf rust (brown rust), karnal bunt. Although care should be taken to save it from the attack of loose smut. The variety grows well in high fertility condition (Patra *et al.,* 2016). Its protein contents are 11-12 percent *(Expert system on wheat crop management)*. Priming seed improves stand establishment, growth and yield of late sown wheat in rice-wheat systems (Kant *et al.,* 2006). Poor stand establishment results in less tillers and ultimately reduced grain yield. Seed priming improves the germination rate, speed and uniformity even under less than optimum field condition *(*Lee *et al.,* 1998; Kant *et al.,* 2006) thus enabling the establishment of uniform and good crop stand establishment. Due to readily available food during germination *(*Farooq *et al.,* 2006*)*. The sowing time also the most important factor determining the yield of wheat. The nutrient content in grain and straw has been reported to be increased with delay in sowing of wheat whereas, uptake of these nutrients decreased as the sowing of wheat gets delayed (Singh and Uttam, 1999). There are many factors responsible for low yield of wheat. Sowing time is crucial factor for obtaining desirable yield and hydropriming is a very simple, economical and environment friendly seed priming. Every crop has its own definite requirements for particular environmental conditions for its proper

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growth and yield (Haq and Khan, 2002). So a need was felt to to study the effect of hydropriming and different sowing dates on growth and yield attributes of Wheat (*Triticum aestivum* L.).

MATERIALS AND METHODS

The investigation was carried out during Rabi season 2014-15 at the Forest nursery and research centre, School of Forestry & Environment, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad. It is located in the South-East part of Uttar Pradesh, India. Allahabad comes under agro-climatic zone-IV, which is named as "Middle Gangetic Plains". Soil of this region is sandy loam and slightly alkaline. The site of experiment is located at 25.57^{o} N latitude, 81.51^{0} E longitude and 90 meter above the sea level. This region has Sub-tropical climate with extreme of summer and winter. The temperature falls down to as low as $1\text{-}2^{0}$C during winter season especially in the month of December and January. The mercury rise up to $46\text{-}48^{0}$C during summer. The Allahabad receives the mean annual rainfall ranges 886 mm. More than 70 per cent rains are received during S-W monsoon season, 5 –10 per cent rains are received in winter, 10–15 per cent in pre monsoon and 5–10 percent during post monsoon season. Normal rainy days exceed 40 annually. Summer monsoon rainfall comes in down pours while winter rainfall comes in light drizzles and is easily absorbed in soils. During crop season 2014-15, the morning relative humidity ranged between 82.43 % to 94.71 %. However, the evening relative humidity varied between 42 % to 70.71 % (Maurya *et al.,* 2015). The physico chemical properties of Experiment field soil: Bulk density-1.26 g/cm 3 , O.C.-0.75 % and pH-7.37.

The present investigation was the two factor Randomized Block Design with three replications. The plot treatment comprised of three dates of sowing such as 22^{nd} Nov. (D_1), 02^{nd} Dec.(D_2), 12^{th} Dec.(D_3) and four hydropriming treatments viz, H_0(Control), H_1(8hrs. hydropriming), H_2 (12hrs. hydropriming), H_3(16hr. hydropriming) at room temperature.The wheat variety used was PBW-343. First of all, stubbles of the previous crop were removed manually. The field was ploughed once with the help of tractor and harrowed with blade harrow in both the directions. Then, layout of the experiment was carried out. A recommended dose of N: P: K fertilizers @ 100:60:60 kg/ha was applied in experimental plot and was equally distributed to each experimental unit. The graded and healthy seed of wheat crop was selected by using recommended seed rate @ 100-125 kg ha^{-1}. The seeds were then soaked in distilled water for specific time duration mentioned in four treatments above viz, for H_1; seeds should be soaked for 8hrs and as follows. The seeds were sown manually with hand in previously opened furrow in field. The sowings were done according to the treatment. Gap filling was carried out after 15 days of sowing while thinning operation was carried out to facilitate optimum plant population. Intercultural and hand weeding operations were carried out when required for soil aeration and removal of weeds. The first common irrigation was applied just after sowing for the establishment of the seedling. In case of hydropriming, the seeds soaked in distilled water germinated more rapidly than the non-treated by avoiding any kind of moisture stress. Subsequently irrigation was applied to the crop as per requirement. Other plant protections measures were taken as and when required. The seeds were sown as per the treatment combination.The crop was harvested when more than 90% of grain in the spike was fully ripened, after sun drying it was bundled separately. The observations were recorded on five randomly selected competitive plants in each treatment and replication for all the characters except for days to 50% flowering and days to maturity, which were recorded on plot basis. Five plants from each plot were randomly selected and tagged for recording a representative sample of the entire population. The data were recorded for following traits: Pre-harvest observations like emergence, germination percentage, plant height (cm) at different growing stages viz, 20,40,60,80,100 Days after sowing (DAS), number of tillers per plant at different growing stages viz, 20, 40, 60 DAS. Post harvest observations like: Length of Spike (cm), number of spike/plant, number of grains/ spike, flag leaf length (cm), root length (cm), grain yield (q/ ha), straw yield (q/ ha), test weight (g), harvest index (%) calculated. The data observed were subjected to statistical analysis as for the methods detailed by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The result obtained during the present course of investigation was carried out to visualize a significant influence of different date sowing and duration of hydropriming on wheat. It was observed that from the mean result of all parameters.There was a steady decrease in number of days taken for seed emergence from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., mean average number of days taken by H_0 (control or non treated seeds) for 50% seed emergence was 6.33 which was highest, and mean average number of days taken by H_3 (16 hrs. of hydropriming) was 4.67 days which was the lowest. Both 50% and 100% seed emergence showed significant difference. At 100% seed emergence, highest mean number of days (9.44 on average) was taken by H_0 (control or non treated seeds), while mean lowest number of days (8.22 on average) was taken by H_2 (12 hrs. of hydropriming) among treatments (Table1). Abbasdokht *et al.* (2010) reported that hydro-primed seeds could achieve earlier and more uniform germination than un-primed seeds. These positive effects are probably due to the stimulatory effects of priming on the early stages of germination process by mediation of cell division in

Table 1. Effect of different sowing dates and hydropriming treatments on seed emergence of wheat.

Date of sowing (D)	50% Seed emergence					100% Seed emergence				
	Levels of hydropriming (H)				Mean (D)	Levels of hydropriming (H)				Mean (D)
	Con-trol (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)		Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	5.67	5.00	4.00	3.67	4.58	8.67	8.00	7.67	7.33	7.92
D_2	6.33	5.67	5.33	5.33	5.67	9.33	8.67	8.33	8.67	8.75
D_3	7.00	6.00	5.67	5.00	5.92	10.33	9.00	8.67	9.00	9.25
Mean (H)	6.33	5.56	5.00	4.67		9.44	8.56	8.22	8.33	
		F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.07	0.14			S	0.07	0.14	
Hydro priming (H)		S	0.08	0.16			S	0.08	0.16	
Int. (D x H)		S	0.14	0.28			S	0.14	0.28	

Table 2. Effect of different sowing dates and hydropriming treatments on germination percentage (%) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
1st date of sowing (D_1)	90.00	91.67	92.62	94.04	92.08
2nd date of sowing (D_2)	86.43	90.24	90.71	92.62	90.00
3 rd date of sowing (D_3)	84.29	86.90	89.05	90.24	87.62
Mean (H)	86.90	89.60	90.79	92.30	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.29	0.59	
Hydro priming (H)		S	0.33	0.69	
Int. (D x H)		NS	0.57	-	

germinating seeds (Golezani *et. al.,* 2010). Priming may improve germination by accelerating imbibitions, which in turn would facilitate the emergence phase and the multiplication of radicle cells (McDonald, 1999). This process is important because it allows the subsequent development of the embryo, especially in seeds characterized by a morphological dormancy (immature embryo). In case of showing dates it was observed that there was a steady increase in number of days taken for seed emergence from D_1(22^{nd} Nov.) to D_3(12^{th} Dec.) i.e., average number of days taken by D_1(22^{nd} Nov.) for 50% seed emergence was 3.67 which was lowest and average number of days taken by D_2(02^{nd} Dec.) was 5.33 days which was highest. Both 50% and 100% seed showed significant difference. At 100% seed emergence, highest number of days (9 on average) was taken by D_3 (12^{th} Dec), while lowest number of days (7.33 on average) was taken by D_1 (22^{nd} Nov.) among the three different sowing dates. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. This may be due to seed priming improves the germination rate, speed and uniformity even under less than optimum field condition *(*Kant *et al.,* 2006) thus enabling the establishment of uniform and good crop stand establishment. Due to readily available food during germination (Farooq *et al.,* 006), primed seed are better able to complete the process of germination in a short time and cope with environmental stresses including low temperature (Kant *et al.,* 2006; Farooq *et al.,* 2007; Golezani *et al.,* 2010). For germination percentage it was observed that there was a steady increase in germination percentage from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., germination percentage for H_0 (control or non treated seeds) was 86.90% which was lowest, and germination percentage for H_3 (16 hrs. of hydropriming) was 92.30% which was highest. The effect of hydropriming on germination showed significant difference and there was a steady decrease in germination percentage from date D_1(22^{nd} Nov.) to D_3(12^{th} Dec.) i.e., germination percentage for D_1 (22^{nd} Nov.) was 92.08% which was highest and germination percentage for D_3(12^{th} Dec.) was 87.62% which was lowest (Table 2). The effect of different sowing dates on germination percentage showed significant difference, the interaction effect between different sowing dates and hydropriming treatments showed non-significant difference. Birendra and Shambhoo, (2011) recorded higher germination percentage in rice seeds those were hydro-primed. Amylases are key enzymes that play a vital role in hydrolyzing the seeds starch reserve, there by supplying sugars to the developing embryo. Increase in plant height from 20, 40, 60, 80 and 100 DAS. At 20, 40, 60, 80 and 100 DAS interval plant height showed significant difference. At 20 DAS, highest plant height (20.67 cm.) was observed in H_3 (16 hrs. of hydropriming), while lowest plant height (19.46 cm) was observed in H_0 (control or non treated seeds) among hydropriming treatments. At 40 DAS, highest plant

Table 3. Effect of different sowing dates and hydropriming treatments on plant height (cm) of wheat.

20 DAS						40 DAS				
Date of sowing (D)	**Levels of Hydropriming (H)**				**Mean (D)**	**Levels of Hydropriming (H)**				**Mean (D)**
	Control (H_0)	**8hr. Hydro priming (H_1)**	**12hr. Hydro priming (H_2)**	**16hr. Hydro priming (H_3)**		**Control (H_0)**	**8hr. Hydro priming (H_1)**	**12hr. Hydro priming (H_2)**	**16hr. Hydro priming (H_3)**	
D1	20.31	21.84	21.71	21.95	21.45	38.35	40.79	44.45	44.87	42.12
D2	19.23	19.95	20.34	20.76	20.07	40.01	42.41	41.82	42.02	41.57
D3	18.84	18.41	18.84	19.30	18.85	39.08	39.69	37.67	38.39	38.71
Mean (H)	19.46	20.07	20.30	20.67		39.15	40.96	41.31	41.76	
		F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.75	1.56			S	0.53	1.11	
Hydro priming (H)		S	0.87	1.81			S	0.62	1.28	
Int. (D x H)		NS	1.51	-			S	1.07	2.22	

60 DAS					
Date of sowing (D)	**Levels of hydropriming (H)**				**Mean (D)**
	Control (H_0)	**8hr. Hydro priming(H_1)**	**12hr. Hydro priming (H_2)**	**16hr. Hydro priming (H_3)**	
D1	57.69	58.07	62.03	63.37	60.29
D2	56.77	58.84	57.66	54.08	56.84
D3	54.63	55.37	54.51	61.04	56.39
Mean (H)	56.36	57.43	58.40	59.16	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.41	0.85	
Hydro priming (H)		S	0.48	0.99	
Int. (D x H)		S	0.82	1.71	

80 DAS						100 DAS				
Date of sowing (D)	**Levels of hydropriming (H)**				**Mean (D)**	**Levels of hydropriming (H)**				**Mean (D)**
	Con-trol (H_1)	**8hr. Hydro prim-ing (H_1)**	**12hr. Hydro priming (H_2)**	**16hr. Hydro priming (H_3)**		**Control (H_0)**	**8hr. Hydro priming (H_1)**	**12hr. Hydro priming (H_2)**	**16hr. Hydro priming (H_3)**	
D_1	73.11	76.23	78.09	78.99	76.61	90.30	91.49	93.85	95.23	92.72
D_2	75.01	72.35	74.11	71.01	73.12	88.12	89.30	87.21	92.51	89.29
D_3	70.59	70.81	69.21	76.08	71.67	88.27	87.12	91.59	87.81	88.70
Mean (H)	72.90	73.13	73.80	75.36		88.90	89.30	90.88	91.85	
		F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.40	0.82			S	0.44	0.91	
Hydro priming (H)		S	0.46	0.95			S	0.51	1.05	
Int. (D x H)		S	0.79	1.64			S	0.88	1.82	

Table 4. Effect of different sowing dates and hydropriming treatments on number of tillers of wheat.

20 DAS					
Date of sowing (D)	**Levels of hydropriming (H)**				**Mean (D)**
	Control (H_0)	**8hr. Hydro priming (H_1)**	**12hr. Hydro priming (H_2)**	**16hr. Hydro priming (H_3)**	
D_1	2.47	2.67	2.73	2.87	2.69
D_2	2.07	2.20	2.67	2.60	2.39
D_3	2.67	2.40	2.13	2.33	2.38
Mean (H)	2.40	2.42	2.51	2.60	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		NS	0.21	-	
Hydro priming (H)		NS	0.24	-	
Int. (D x H)		NS	0.42	-	

Date of sowing (D)	40 DAS					60 DAS				
	Levels of Hydropriming (H)					Levels of Hydropriming (H)				
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	Mean (D)	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	Mean (D)
D_1	3.27	3.47	3.33	3.47	3.39	4.13	4.07	4.20	4.40	4.20
D_2	2.87	2.87	3.47	3.40	3.15	4.07	3.53	3.80	4.13	3.88
D_3	3.07	3.07	2.93	2.93	3.00	3.20	3.87	4.00	4.00	3.77
Mean (H)	3.07	3.13	3.24	3.27		3.80	3.82	4.00	4.18	
		F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.06	0.12			S	0.07	0.15	
Hydro priming (H)		S	0.07	0.14			S	0.09	0.18	
Int. (D x H)		S	0.11	0.24			S	0.15	0.31	

Table 5. Effect of different sowing dates and hydropriming treatments on number of days taken for emergence of headings of wheat**.**

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	89.80	89.33	89.13	89.67	89.48
D_2	92.67	92.27	92.13	91.27	92.08
D_3	95.47	95.20	94.73	94.93	95.08
Mean (H)	92.64	92.27	92.00	91.96	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.14	0.29	
Hydro priming (H)		S	0.16	0.33	
Int. (D x H)		S	0.28	0.57	

height (41.76 cm) was observed in H_3 (16 hrs. of hydropriming), while lowest plant height (39.15 cm) was observed in H_0 (control or non treated seeds) among hydropriming treatments (Table 3). At 60 DAS, highest plant height (59.16 cm) was observed in H_3 (16 hrs. of hydropriming), while lowest plant height (56.36 cm) was observed in H_0 (control or non treated seeds) among hydropriming treatments. At 80 DAS, highest plant height (75.36 cm) was observed in H_3 (16 hrs. of hydropriming), while lowest plant height (72.90 cm) was observed in H_0 (control or non treated seeds) among hydropriming treatments. At 100 DAS, highest plant height (91.85 cm) was observed in H_3 (16 hrs. of hydropriming), while lowest plant height (88.90 cm) was observed in H_0 (control or non treated seeds) among hydropriming treatments. This may be due to respiration, radicle protrusion and cell division consistently occurred sooner in primed (radicle) seeds compared to non primed seed of Letuce (Daniel *et al.,* 2009).In case of sowing date it was observed that there was a steady increase in plant height from 20, 40, 60, 80 and 100 DAS. At 20, 40, 60, 80 and 100 DAS interval plant height showed significant difference. At 20 DAS, highest plant height (21.45 cm.) was observed in D_1 (22^{nd} Nov.), while lowest plant height (18.85 cm) was observed in D_3 (12^{th} Dec.) among different sowing dates At 40 DAS, highest plant height (42.12 cm.) was observed in D_1 (22^{nd} Nov.), while lowest plant height (38.71 cm) was observed in D_3 (12^{th} Dec.) among different sowing dates. At 60 DAS, highest plant height (60.29 cm.) was observed in D_1 (22^{nd} Nov.), while lowest plant height (56.39 cm) was observed in D_3 (12^{th} Dec.) among different sowing dates. At 80 DAS, highest plant height (76.61 cm.) was observed in D_1 (22^{nd} Nov.), while lowest plant height (71.67 cm) was observed in D_3 (12^{th} Dec.) among different sowing dates. At 100 DAS, highest plant height (92.72 cm.) was observed in D_1 (22^{nd} Nov.), while lowest plant height (88.70 cm) was observed in D_3 (12^{th} Dec.) among different sowing dates. Decrease in plant height in late sowing was due to shorter growing period. Early sown crop may have enjoyed the better environmental conditions especially the temperature and solar radiation which resulted to tallest plants. These results are in line with those reported in Shorgam (Shehzad *et al*., 2012). The interaction effect between different sowing dates and hydropriming treatments at 20 DAS there was no effect, while 40, 60, 80 and 100 DAS plant height also increases. Different sowing dates and treatments are affected the plant height (cm.) at all stages of growth. Interaction shows the results in treatment T_4 [hydropriming] (22^{nd} Nov + H_3 [16 hrs. of hydropriming]) was significantly increased of plant height at all stages as compared with all other treatments and sowing dates. The plant height was increases due to availability of the optimum temperature, sun-shine hours, and long time active evaporation per day and suitable rainfall during crop growth. This was in agreement with similar results reported by Bannayan *et al*. (2013) in wheat. There was a steady

increase in number of tillers from 20, 40 and 60 DAS. At 20 DAS number of tillers showed non-significant difference while at 40 and 60 DAS interval number of tillers showed significant difference. At 20 DAS, highest number of tillers (2.60) was observed in H_3 (16 hrs. of hydropriming), while lowest number of tillers (2.40) was observed in H_0 (control or non treated seeds) among hydropriming treatments. At 40 DAS, highest number of tillers (3.27) was observed in H_3 (16 hrs. of hydropriming), while lowest number of tillers (3.07) was observed in H_0 (control or non treated seeds) among hydropriming treatments. At 60 DAS, highest number of tillers (4.18) was observed in H_3 (16 hrs. of hydropriming), while lowest number of tillers (3.80) was observed in H_0 (control or non treated seeds) among hydropriming treatments (Table 4). It was observed that there was a steady increase in number of tillers from 20, 40 and 60 DAS. At 20 DAS number of tillers showed non-significant difference while at 40 and 60 DAS interval number of tillers showed significant difference. At 20 DAS, highest number of tillers (2.69) was observed in D_1 (22^{nd} Nov.), while lowest number of tillers (2.38) was observed in D_3 (12^{th} Dec.) among different sowing dates. At 40 DAS, highest number of tillers (3.39) was observed in D_1 (22^{nd} Nov.), while lowest number of tillers (3.00) was observed in D_3 (12^{th} Dec.) among different sowing dates. At 60 DAS, highest number of tillers (4.20) was observed in D_1 (22^{nd} Nov.), while lowest number of tillers (3.77) was observed in D_3 (12^{th} Dec.) among different sowing dates. The interaction effect between different sowing dates and hydropriming treatments at 20 DAS was non-significant, while 40 and 60 DAS number of tillers showed significant difference. However priming seed improves stand establishment, growth and yield of late sown wheat in rice-wheat systems (Kant *et al.*, 2006). Poor stand establishment results in less tillers and ultimately reduced grain yield. It was observed that there was a steady decrease in number of days taken for emergence of headings from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., number of days taken by H_0 (control or non treated seeds) was 92.64 which was highest, and number of days taken by H_3 (16 hrs. of hydropriming) was 91.96 which was lowest (Table 5). The effect of hydropriming on number of days taken for emergence of headings showed significant difference. There was a steady decrease in number of days taken for emergence of headings from D_1 (22^{nd} Nov.) to D_3 (12^{th} Dec.) i.e., number of days taken by D_1 (22^{nd} Nov.) was 89.48 which was lowest and number of days taken by D_3 (12^{th} Dec.) was 95.08 which was highest. The effect of different sowing dates on number of days taken for emergence of headings showed significant difference. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. In case of number of spikes/plant there was a steady increase in number of spikes from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., number of spikes per plant in case of H_0 (control or non treated seeds) was 3.76 which was lowest, and number of spikes in case of H_3 (16 hrs. of hydropriming) was 4.11 which was highest (Table 6). The effect of hydropriming on number spikes per plant showed

Table 6. Effect of different sowing dates and hydropriming treatments on number of spike per plant of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	3.73	3.53	4.13	4.27	3.92
D_2	3.67	3.93	4.00	4.13	3.92
D_3	3.87	3.87	3.33	3.93	3.75
Mean (H)	3.76	3.78	3.82	4.11	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		NS	0.12	-	
Hydro priming (H)		NS	0.14	-	
Int. (D x H)		S	0.24	0.49	

Table 7. Effect of different sowing dates and hydropriming treatments on length of spike (cm) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	13.43	13.87	14.74	14.49	14.13
D_2	14.15	13.89	13.43	13.29	13.69
D_3	12.03	12.75	12.69	13.52	12.75
Mean (H)	13.20	13.50	13.62	13.77	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.09	0.18	
Hydro priming (H)		S	0.10	0.21	
Int. (D x H)		S	0.18	0.36	

Table 8. Effect of different sowing dates and hydropriming treatments on flag leaf length (cm) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	Mean (D)
D_1	18.76	22.40	20.92	21.85	20.98
D_2	21.43	19.40	20.47	21.93	20.81
D_3	19.57	18.43	19.16	22.22	19.85
Mean (H)	19.92	20.08	20.18	22.00	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		NS	0.54	-	
Hydro priming (H)		S	0.63	1.29	
Int. (D x H)		S	1.08	2.26	

Table 9. Effect of different sowing dates and hydropriming treatments on number of spikelets per spike of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	17.27	17.47	18.07	18.73	17.88
D_2	16.13	17.80	15.87	16.27	16.52
D_3	14.60	15.33	16.93	16.27	15.78
Mean (H)	16.00	16.87	16.96	17.09	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.16	0.33	
Hydro priming (H)		S	0.19	0.39	
Int. (D x H)		S	0.32	0.67	

non-significant difference. It was observed that there was a steady decrease in number of spikes from D_1 (22^{nd} Nov.) to D_3(12^{th} Dec.) i.e., number of spikes in case of D_1 (22^{nd} Nov.) and D_2(02^{nd} Dec.) were 3.92 which was highest and number of spikes in case of D_3 (12^{th} Dec.) was 3.75 which was lowest. The effect of different sowing dates on number of spikes per plant showed non-significant difference. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. In case of length of spike it was observed that there was a steady increase in length of spike from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., length of spike in case of H_0 (control or non treated seeds) was 13.20 cm which was lowest, and length of spike in case of H_3 (16 hrs. of hydropriming) was 13.77 cm. which was highest. The effect of hydropriming on length of spike showed significant difference. It was observed that there was a steady decrease in length of spike from D_1 (22^{nd} Nov.) to D_3 (12^{th} Dec.) i.e., length of spike in case of D_1 (22^{nd} Nov.) was 14.13cm.which was highest and length of spike in case of D_3 (12^{th} Dec.) was 12.75 cm which was lowest (Table 7). The effect of different sowing dates on length of spike showed significant difference. The effect of hydropriming on flag leaf length showed significant difference (Table 8). It was observed that there was a steady decrease in flag leaf length from D_1 (22^{nd} Nov.) to D_3 (12^{th} Dec.) i.e., flag leaf length in case of D_1 (22^{nd} Nov.) was 20.98 cm which was highest and flag leaf length during D_3 (12^{th} Dec.) was 19.85 which was lowest. The effect of different sowing dates on flag leaf length showed non-significant difference. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. In case of spikelets per spike it was observed that there was a steady decrease in number of spikelets per spike from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., number of spikelets per spike in case of H_0 (control or non treated seeds) was 16 which was lowest, and number of spikelets per spike in case of H_3 (16 hrs. of hydropriming) was 17.09 which was highest (Table 9). The effect of hydropriming on number of spikelets per spike showed significant difference. It was observed that there was a steady decrease in number of spikelets per spike from D_1 (22^{nd} Nov.) to D_3(12^{th} Dec.) i.e., number of spikelets per spike in case of D_1 (22^{nd} Nov.) was 17.88 which was highest and number of spikelets per spike during D_3 (12^{th} Dec.) was 15.78 which was lowest. The effect of different sowing dates on number of spikelets per spike showed significant difference. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. In case of number of grains/spike, it was observed that there was a steady increase in number of grains per spike from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., number of grains per spike in case of H_0 (control or non treated seeds) was 48.40 which was lowest, and number of grains per spike in case of H_3 (16 hrs. of hydropriming) was 50.40 which was highest (Table 10). The effect of hydropriming on number of grains per spike showed significant difference. It was observed that there was a steady decrease in number of grains per spike from D_1 (22^{nd} Nov.) to D_3 (12^{th} Dec.) i.e., number of grains per spike in case of D_1 (22^{nd} Nov.) was 52.58 which was highest and number of grains per spike in case of D_3(12^{th} Dec.) was 48.17 which was lowest. The effect of different sowing dates on number of grains per spike showed

Table 10. Effect of different sowing dates and hydropriming treatments on number of grains per spike of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	51.60	52.47	52.93	53.13	52.58
D_2	46.67	46.47	50.00	51.00	48.54
D_3	46.93	51.20	47.47	47.07	48.17
Mean (H)	48.40	50.04	50.13	50.40	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.27	0.56	
Hydro priming (H)		S	0.31	0.64	
Int. (D x H)		S	0.54	1.12	

Table 11. Effect of different sowing dates and hydropriming treatments on root length (cm) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	14.44	14.31	15.23	16.07	15.01
D_2	12.61	13.46	13.69	13.07	13.21
D_3	11.54	11.91	12.53	10.44	11.60
Mean (H)	12.86	13.23	13.82	13.19	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.64	1.320	
Hydro priming (H)		NS	0.74	-	
Int. (D x H)		NS	1.27	-	

significant difference. Lower grain yield in late sowing was mainly due to lower germination count, less number of tillers, less number of grains per spike and lower 1000-grain weight. These results are in accordance with those of Spink *et al.* (2000) and Aslam *et al.* (2003). They also reported that late sowing results in less grain yield per hectare. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. In case of root length it was observed that there was a steady increase in root length from H_0(control or non treated seeds) to H_2(12 hrs. of hydropriming) then decreases in case of H_3(16 hrs. of hydropriming) i.e. root length in case of H_0 (control or non treated seeds) was 12.86 cm. which was lowest, and root length in case of H_2(12 hrs. of hydropriming) was 13.82 cm which was highest (Table 11). The effect of hydropriming on root length showed non-significant difference. It was observed that there was a steady decrease in root length from D_1 (22nd Nov.) to D_3(12th Dec.) i.e., root length in case of D_1 (22nd Nov.) was 15.01 cm which was highest and root length in case of D_3 (12th Dec.) was 11.60 cm. which was lowest. The effect of different sowing dates on root length showed significant difference. The interaction effect between different sowing dates and hydropriming treatments showed non-significant difference. In case of test weight it was observed that there was a steady increase in test weight from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., test weight of H_0 (control or non treated seeds) was 39.11 g which was lowest and test weight of H_3(16 hrs. of hydropriming) was 41.56 g which was highest (Table 12).The effect of hydropriming on test weight showed non-significant difference. It was observed that there was a steady decrease in test weight from D_1 (22nd Nov.) to D_3 (12th Dec.) i.e., test weight in case of D_1 (22nd Nov.) was 41.50 g which was highest and test weight in case of D_3 (12th Dec.) was 39.67 g which was lowest. The effect of different sowing dates on test weight showed non-significant difference. The interaction effect between different sowing dates and hydropriming treatments showed non-significant difference. For grain yield it was observed that there was a steady increase in grain yield from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming) i.e., grain yield in case of H_0 (control or non treated seeds) was 38.66 q/ha which was lowest, and grain yield by H_3 (16 hrs. of hydropriming) was 42.33 q/ha which was highest. The effect of hydropriming on grain yield showed significant difference. It was observed that there was a steady decrease in grain yield from D_1 (22nd Nov.) to D_3 (12th Dec.) i.e. grain yield in case of D_1 (22nd Nov.) was 41.34 q/ha which was highest and grain yield by D_3 (12th Dec.) was 38.35 q/ha which was lowest (Table 13). The effect of different sowing dates on grain yield showed significant difference. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. Straw yield from H_0(control or non treated seeds) to H_3(16 hrs. of hydropriming) i.e., straw yield in case of H_0 (control or non treated seeds) was 24.63 q/ha which was lowest, and straw yield in case of H_3(16 hrs. of hydropriming) was 26.10 q/ha which was highest. The effect of hydropriming on straw yield showed significant difference. It was observed that there was a steady decrease in straw yield from D_1 (22nd Nov.) to D_3(12th Dec.) i.e., straw yield in case of D_1(22nd Nov.) was 26.42 q/ha which was highest and straw yield in case of D_3 (12th

Table 12. Effect of different sowing dates and hydropriming treatments on test weight (g) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	40.67	42	40	43.33	41.50
D_2	39.33	40	42.67	41.33	40.83
D_3	37.33	40.67	40.67	40	39.67
Mean (H)	39.11	40.89	41.11	41.56	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		NS	1.14	-	
Hydro priming (H)		NS	1.31	-	
Int. (D x H)		NS	2.27	-	

Table 13. Effect of different sowing dates and hydropriming treatments on grain yield (q/ha) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_2)	12hr. Hydro priming (H_3)	16hr. Hydro priming (H_4)	
D_1	38.41	41.64	42.50	42.79	41.34
D_2	41.07	36.52	39.76	42.21	39.89
D_3	35.62	39.55	36.24	41.98	38.35
Mean (H)	38.66	39.24	39.50	42.33	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.35	0.73	
Hydro priming (H)		S	0.41	0.85	
Int. (D x H)		S	0.71	1.48	

Table 14. Effect of different sowing dates and hydropriming treatments on straw yield (q/ha) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	27.02	24.32	27.24	27.08	26.42
D_2	22.99	25.08	24.46	26.12	24.66
D_3	23.88	21.17	20.88	25.10	22.76
Mean (H)	24.63	23.52	24.19	26.10	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.19	0.39	
Hydro priming (H)		S	0.22	0.45	
Int. (D x H)		S	0.38	0.78	

Table 15. Effect of different sowing dates and hydropriming treatments on harvest index (%) of wheat.

Date of sowing (D)	Levels of hydropriming (H)				Mean (D)
	Control (H_0)	8hr. Hydro priming (H_1)	12hr. Hydro priming (H_2)	16hr. Hydro priming (H_3)	
D_1	62.50	62.56	63.16	63.46	62.92
D_2	61.56	62.07	61.83	61.92	61.85
D_3	60.64	61.15	61.00	61.16	60.99
Mean (H)	61.57	61.93	62.00	62.18	
		F-test	S. Em. (±)	C.D. at 5%	
Date (D)		S	0.06	0.13	
Hydro priming (H)		S	0.07	0.15	
Int. (D x H)		S	0.12	0.25	

Dec.) was 22.76 q/ha which was lowest (Table 14). The effect of different sowing dates on straw yield showed significant difference. The interaction effect between different sowing dates and hydropriming treatments showed significant difference. In case of harvest index it was observed that there was a steady increase in harvest index from H_0 (control or non treated seeds) to H_3 (16 hrs. of hydropriming). i.e., harvest index of H_0 (control or non treated seeds) was 61.57% which was lowest, and harvest index of H_3 (16 hrs. of hydropriming) was 62.18% which was highest. The effect of hydropriming on harvest index showed significant difference. There was a steady decrease in harvest index from D_1 (22^{nd} Nov.) to D_3 (12^{th} Dec.). i.e., harvest index of D_1 (22^{nd} Nov.) was 62.92% which was highest and harvest index of D_3 (12^{th} Dec.) was 60.99% which was lowest (Table 15). The effect of different sowing dates on harvest index showed significant difference. The interaction effect between different sowing dates and hydropriming treatments showed significant difference.

Conclusion

The results of this study show earlier sowing increased germination percentage in treatment T_4 [hydropriming] (94.04%), plant height, number of tillers, number of spike, numbers of grains per spike, test weight (43.33g), grain yield (42.79 q/ha), harvest index (63.46%) among the different treatments. Therefore, it is recommended that for good yield of PBW-343 wheat 22nd November was found to be optimum date for sowing for with 16 hrs. of hydropriming.

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