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Impact of seed priming on water productivity and performances of wheat (*Triticum aestivum* L) varieties

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Abstract

Followed by rice, wheat pays a major portion to the food basket of the country and it appeared as the second important cereal crop of India. Availability of quality irrigation water determines the economic yield, because wheat production depends on a secure irrigation facility. With the increase in population, the quality and the quantity of irrigation water used for cultivaton is becoming a concern. Therefore, it is the need of the hour to improve water use efficiency for wheat production. In this background, the present investigation was taken to assess the impacts of seed priming on water productivity and performances of wheat. This experiment was conducted for two consecutive years 2017-18 and 2018-19 in factorial random block design (RBD) with three replications. The treatment comprised of five varieties C-306, PBW-343, HD-2967, K-1006, and DBW-39 with three methods of seed priming namely hydro priming, gibberellic acid (GA_3) priming, and control. Results of the experiment clearly showed that seed priming with GA_3 recorded significantly higher germination count (209 and 196 m^{-2}) in the case of variety PBW-343, which helps in better crop stand and more number of spike m^{-2} (376.48 and 373.37) and grains $spike^{-1}$ (38.69 and 36.12) during 2017-18 and 2018-19 respectively. Seed priming with GA_3 also registered the highest grain yield irrespective of the variety and the year of experimentation followed by hydro-priming. Among all the experimental varieties, PBW-343 recorded a significantly highest grain yield of 3.32 and 3.21 t ha^{-1} during 2017-18 and 2018-19 which was followed by C-306, HD-2967, K-1006, and DBW-39. Seed priming with GA_3 also realized higher grain yield for every cubic meter water use.

Keywords germination, seed priming, water productivity, wheat, yield

Introduction

Wheat (*Triticum aestivum* L) ranked first in the world in terms of area (221.6 million hectares) and third in terms of production (728.9 million tonnes) out of three major cereal crops i.e. maize, rice, and wheat [1]. In India wheat is grown in 30.23 million hectares area with 93.50 million tonnes production [2]. Wheat is mainly grown in the areas having assured irrigation facilities as it requires an enormous amount of fresh water for its cultivation. With time, the amount of good quality water for irrigation is shrinking due to vagaries of monsoon, urbanization, and industrialization. The scarcity of soil moisture is one the foremost abiotic stresses which affect germination and thereby productivity of wheat. Seed germination is the principal step in the life cycle of any crop plant and the absence of sufficient soil moisture during germination severely hampers the germination traits and yield [3]. Seed priming is presently an extensively used viable practice that accelerates the

Table 1. Effect of seed priming on germination count m^{-2} and plant height (cm) of wheat varieties

Variety	Germination (m^{-2})						Plant height (cm)					
	Methods of seed priming						Methods of seed priming					
	Hydro priming		GA_3 priming		Control		Hydro priming		GA_3 priming		Control	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
C-306	185	179	194	183	167	158	108.85	106.24	112.02	110.45	106.18	102.51
PBW-343	198	192	209	196	179	167	105.18	103.01	107.76	105.20	104.36	101.44
HD-2967	172	165	180	171	158	149	106.56	104.19	109.58	106.83	103.78	99.23
K-1006	153	146	165	152	143	135	108.14	105.33	111.35	109.52	107.42	104.39
DBW 39	166	157	173	160	151	140	106.33	104.05	108.96	105.61	99.95	95.26
S Em (±)	5.64	6.42	8.09	6.13	4.81	4.47	0.52	0.84	0.76	0.92	1.25	0.95
CD (P=0.05%)	19.85	21.03	24.35	17.96	14.22	12.74	1.65	1.87	2.19	2.66	3.61	3.49

germination rate and improves seedling equality in numerous crops. Seed priming is the application of natural or synthetic compounds to seed before germination. Seed priming escalates the physiological and biochemical processes required for improving the seed germination and associated traits. Seeds are hydrated to a point so that the germination processes start but radical does not emerge out [4].

Hydro-priming is the soaking of seed in sterilized distilled water or normal water at a specific temperature for a specific duration of time. Its effects on the enhancement of germination trait has been reported by Rashid et al., [5] in Green gram, Janmohammadi et al., [6] in maize, and Caseiro et al., [7] in onion. Phytohormones play an imperative role in the germinating seeds. The germinating seed has altered levels of abscisic acid and gibberellic acid [8] in comparison to non-germinating seeds. Osmotic stress decreases the cytokinin and GA_3 levels in seeds whereas abscisic acid increases their level [9]. Hence, the external use of GA_3 and other phyto-hormones has been reported by many researchers. Therefore, it is the need of the hour to improve the water use efficiency of wheat genotypes to increase the production. Keeping the above requirements in mind, present experiment has been conceptualized to evaluate different techniques of seed priming for enhancing the yield and water use efficiency of wheat.

Methodology

The present experiment has been conducted at the research farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during the rabi season of 2017-18 and 2018-19 to find out the effect of seed priming on the water productivity and performances of wheat varieties. The farm is situated at $26^0$19'86" N latitude and $89^0$23'53" E longitude at an elevation of 43 meters above mean sea level. The crop season received 555.71 mm and 492.80 mm rainfall during 2017-18 and 2018-19, respectively. The soil is sandy loam, acidic with a pH of 5.63, low in available nitrogen (154.63 kg ha^{-1}), medium in available phosphorus (22.15 kg ha^{-1}), and available potash (88.72 kg ha^{-1}). The experiment is conducted in factorial randomized block design with three levels of seed priming (hydro-priming, GA_3 priming, and control) and five varieties (C-306, PBW-343, HD-2967, K-1006, and DBW 39). All treatments were replicated three times. Seeds were sown on 27th and 29th November in 2017 and 2018 and harvested on 2nd May and 6th May in 2018 and 2019, respectively. Row to row distance was retained 20 cm in 5 m x 4 m plots. Soon after sowing one light irrigation was given in the control plot. NPK @120:60:60 kg ha^{-1} was applied in all the plots. A full dose of phosphorus and potassium in the form of single super phosphate and muriate of potash along with half of the nitrogen in the form of urea was applied before sowing. The remaining nitrogen was applied equally in two parts at 25 and 50 days after sowing. Three irrigations were given at 21, 45, and 65 days after sowing. Standard management practices recommended for irrigated wheat were adopted. At first, the wheat seed is disinfected with a 0.1% solution of $HgCl_2$ for 5 minutes. Thereafter, seeds were pre-soaked for 24 hours at 25 ± 1 °C either with hydro-priming (pre-soaking with distilled water) or with phyto-hormonal treatment (pre-soaking with GA_3 solution made of 50 ppm). Germination count per square meter was recorded on 5th day after sowing. Plant heights were noted

Table 2. Effect of seed priming on yield attributes of wheat varieties

Variety	No. of spike m^{-2}						Spike length (cm)					
	Methods of seed priming						Level of seed priming					
	Hydro priming		GA_3 priming		Control		Hydro priming		GA_3 priming		Control	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
C-306	343.15	330.56	350.35	341.62	319.82	306.27	9.03	8.95	9.03	8.91	8.87	8.85
PBW-343	372.22	361.22	376.48	373.37	315.33	296.33	9.25	9.15	9.29	9.20	9.07	9.01
HD-2967	330.29	315.09	338.67	322.50	313.20	293.56	8.85	8.69	8.87	8.70	8.62	8.49
K-1006	345.56	325.75	362.45	339.12	329.10	312.06	8.89	8.73	8.94	8.78	8.80	8.64
DBW 39	337.17	320.45	357.82	328.43	324.25	316.41	8.96	8.82	8.99	8.83	8.68	8.52
S Em (±)	5.36	6.75	4.58	5.40	2.78	4.62	0.08	0.10	0.07	0.11	0.09	0.10
CD (P=0.05%)	16.24	22.03	14.76	19.08	8.45	14.36	0.26	0.32	0.23	0.34	0.28	0.31

Table 3. Effect of seed priming on number of grain $spike^{-1}$ and test weight (g) of wheat varieties

Variety	Number of grain $spike^{-1}$						Test weight (g)					
	Methods of seed priming						Level of seed priming					
	Hydro priming		GA_3 priming		Control		Hydro priming		GA_3 priming		Control	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
C-306	34.07	32.19	34.85	32.54	31.95	29.25	40.71	38.49	40.82	38.21	38.67	35.02
PBW-343	38.17	35.86	38.69	36.12	32.07	30.73	41.40	39.20	41.52	39.02	40.33	37.85
HD-2967	32.98	30.75	33.65	31.83	29.05	26.50	38.50	36.35	39.03	36.30	39.83	36.17
K-1006	33.15	31.63	35.50	33.65	30.12	28.46	40.41	37.73	40.55	37.94	38.74	35.29
DBW 39	33.65	31.27	35.98	32.05	29.33	27.68	39.04	37.12	39.15	36.48	38.01	35.08
S Em (±)	0.97	1.27	1.05	1.02	0.88	1.16	0.57	0.92	0.45	0.97	0.44	0.77
CD (P=0.05%)	3.02	4.03	3.18	3.88	1.82	2.91	1.64	1.88	1.36	2.01	1.25	1.89

by calculating the height of ten representative plants from each plot randomly. The number of spike m^{-2}, spike length, number of grains $spike^{-1,}$ and test weight was measured during harvesting from each treatment. A net plot of size 10 m^2 was harvested manually to obtain grain yield. Water productivity (kg m^{-3}) was calculated as the proportion of grain yield to the total water intake. The total quantity of water required by the crop was estimated by the number of irrigations multiplying the average discharge of tube well with 10 HP pump [10] plus rainfall received during the crop season. Average discharge of tube well with 10 HP was considered as per the estimation of Kaur et al., [10]. All the data were analyzed using statistical software SPSS version 20 for comparing the treatment means.

Results and Discussion

Effect on germination count

It was observed that seed priming with either normal water or gibberellic acid offered a positive effect on seed germination irrespective of the variety and the year of experimentation which helped in better crop stand, augmented drought tolerance, and finally more yield (Table 1).

Among the methods of seed priming,GA_3 priming was found to be superior in achieving higher germination followed by hydro priming and control. Higher sprouting with priming might be due to the completion of pre-germination metabolic process and thereby early germination. A significantly higher germination count (209 and 196 m^{-2}) was noticed in the case of variety PBW-343 when primed with GA_3 which was at par with the variety C-306 (194 and 183 m^{-2}) followed by HD-2967 (180 and 171 m^{-2}), DBW

39 (173 and 160 m^{-2}) and K-1006 (165 and 152 m^{-2}). In hydro-priming, the varietal performance trend in germination count was similar to that of GA_3 priming. The lowest germination count was recorded in the control plot having dry seeds or non-primed seeds. The probable reason might be the escalations of biochemical and physiological progressions in seeds and consequently augmenting the germination abilities as compared to the non-primed seeds. A similar trend of results has been reported earlier by several researchers in Green gram, maize, and onion [5-7].

Effect on plant height

Seed priming with GA_3 resulted in maximum plant height regardless of the varieties and the year of investigation, followed by the hypro-priming and no-priming (control). This might be due to early germination and better crop stand which helped in accessing more water, light, and nutrients and thereby rapid cell elongation, division and enlargement, which increases plant height. These findings are in accordance with the results reported by Mirshekari et al., [11] Meera and Poonam [12] Chaudhry and Zahur [13], and Chaudhry and Khan [14]. Among the varieties, C-306 attained maximum height (108.85 and 106.24 cm during 2017-18 and 2018-19, respectively) in hydro-priming treatment as well as in GA_3 treatment (112.02 and 110.45 cm during 2017-18 and 2018-19, respectively) followed by K-1006, though there was no statistical disparity. Variety PBW-343 recorded the shortest plant irrespective of experimentation year and the method of priming (Table 1). In control plots, wheat variety K-1006 recorded maximum height (107.42 and 104.39 cm during 2017-18 and 2018-19, respectively) and DBW-39 recorded minimum height (99.95 and 95.26 cm during 2017-18 and 2018-19, respectively).

Yield attributes and Grain yield

Yield attributes of wheat were greatly influenced by the combined effect of varieties and priming during both the years of the experiment. Among the priming methods, GA_3 priming proved to be superior with respect to the number of spike m^{-2}, spike length, the number of grains $spike^{-1,}$ and 1000 grains weight over hydro-priming regardless of years and variety. This might be due to the more pronounced effect of hormonal priming on germination, early crop stand, photosynthetic activities, tillering, and synthesis of hydrolytic enzymes. The higher seed weight, seeds per spike, harvest index, and seed yield with hormonal priming using GA_3 was also reported by Ulfat et al., [15]. The results obtained in our study were in close agreement with the findings of Shaddad et al., [16] and Liu et al., [17]. Table 2 and 3 clearly indicate that the variety PBW-343 produced significantly highest number of spike m^{-2} (376.48 and 373.37 and 372.22 and 361.22), spike length (9.29 and 9.20 cm and 9.25 and 9.15 cm), number of grains $spike^{-1}$ (38.69 and 36.12 and 38.17and 35.86), and 1000 grain weight (41.52 and 39.02g and 41.40 and 39.20) in GA_3 priming and hydro-priming followed by K-1006 and C-306 while variety HD-2967 recorded significantly lowest yield determinants which might be due to the genetic character of the variety. The non-primed (control) seeds showed substandard outcomes in achieving yield attributes than GA_3 priming and hydro-priming irrespective of the variety and the year of experimentation.

Economic yield (grain) is the ultimate aim of crop production which is the collective effect of yield attributes. The grain yield was significantly affected by varietal characteristics and the method of seed priming (Table 4). The promising results were obtained in terms of seed yield whenever seeds were primed with GA_3 as compared to hydro-priming, regardless of variety and year of study. It might be due to the effective utilization of nutrients and translocation of photo-assimilates in the recognized sink-source system [18-19]. Irrespective of the method of priming PBW-343 recorded the highest grain yield of 3.10 and 2.95 t ha^{-1} and 3.32 and 3.21 t ha^{-1} respectively in hydro-priming and GA3 priming followed by C-306, K-1006, DBW-39, and HD-2967 during both the years of experimentation. All the varieties were found superior in achieving grain yield whenever primed with either normal water or GA_3 than the conventional method (non-primed seed). On average hydro-priming and GA_3 priming gave 1.31 to 7.44% and 7.54 to 14.40 % yield advantage respectively over no-priming.

Table 4. Effect of seed priming on grain yield of wheat and water productivity

Variety	Grain yield (t ha^{-1})						Water Productivity (kg grain m^{-3} water)					
	Method of seed priming						Method of seed priming					
	Hydro priming		GA3 priming		Control		Hydro priming		GA3 priming		Control	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
C-306	2.98	2.81	3.12	3.05	2.80	2.57	1.27	1.23	1.32	1.33	1.05	0.99
PBW-343	3.10	2.95	3.32	3.21	2.89	2.70	1.32	1.29	1.41	1.40	1.09	1.04
HD-2967	2.73	2.60	3.01	2.88	2.69	2.56	1.16	1.13	1.28	1.26	1.01	0.99
K-1006	2.87	2.71	2.95	2.78	2.70	2.54	1.22	1.18	1.25	1.21	1.02	0.98
DBW 39	2.82	2.62	2.97	2.73	2.75	2.52	1.20	1.14	1.26	1.19	1.04	0.97
S Em (±)	0.04	0.06	0.05	0.11	0.03	0.04	0.03	0.04	0.03	0.04	0.06	0.05
CD (P=0.05%)	0.12	0.20	0.16	0.34	0.10	0.13	0.08	0.12	0.10	0.15	NS	NS

Water productivity

Higher values of water productivity realized during the first year of experimentation irrespective of the priming methods and varieties might be due to the high rainfall coupled with the congenial climatic condition which ultimately helped in producing more grain yield. Among the priming methods, GA_3 priming recorded higher values of water productivity during both the year of experimentation. Among the varieties, PBW-343 recorded significantly highest water productivity both in hydro-priming (1.32 and 1.29 kg m^{-3}) and GA_3 priming (1.41 and 1.40 kg m^{-3}) followed by C-306, K-1006, DBW-39, and HD-2967 during 2017-18 and 2018-19 (Table 4). Higher water productivity indicated efficient utilization of water in wheat production.

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