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Research Paper

Seed priming in moisture-stress conditions to improve growth and yield of wheat (*Triticum aestivum*)

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ABSTRACT

An experiment was conducted during the winter (*rabi*) seasons of 2010–11 to 2013–14 at Karnal, Haryana to assess the impact of seed priming on crop establishment, growth, productivity and water-use efficiency of wheat [*Triticum aestivum* (L.) *emend,* Fiori & Paol.] under different moisture regimes. The experiment was carried out in a split-plot design with 3 main-plot treatments (seeding at optimum moisture level, sub-optimal moisture level and in air dry soil followed by irrigation) and 3 sub-plot treatments (no seed priming, matriconditioning and sprouted seed). Sprouted seed (5.49 t/ha) and matriconditioning (5.30 t/ha) resulted in significantly higher grain yield compared to unprimed seeds. The difference among various seeding methods were found statistically at par. Matriconditioning and sprouted seeds germinated earlier than non-primed seeds leading to better crop establishment under optimum, sub-optimum soil moisture as well as air dry soil conditions having a moisture content 17.5, 10.9 and 6.2%, respectively, estimated by gravimetric method leading to higher tillering and grain yield. The results showed that matriconditioning and sprouted seeds improved germination indices, seedling growth and crop establishment.

***Key words* :** Germination indices, Matriconditioning, Soil moisture regime, Water productivity, Wheat yield

Wheat yield suffers in central and peninsular zones of India, where the wheat crop is grown as rainfed crop and also in the areas of the country where rice–wheat cropping system is in practice due to delayed sowing because of late harvesting of rice resulting in poor germination and insufficient crop stands, short period of winter seasons and moisture stress at various stages of crop. The availability of quality water is decreasing with time. At present, about 70–80% of agricultural production in our country depends on groundwater irrigation. The biggest challenge on this front is to improve the efficiency and productivity of water being used in existing systems. Seed germination is of primary importance for optimizing field production of any crop plant. At sub-optimal soil moisture conditions, poor seed germination and subsequently poor crop establishment is a common phenomenon (Hamdollah, 2013). In the era of precision agricultural technologies, it is a pre-requisite that every seed should be readily germinate and produce vigrous seedling to ensure better crop yield. Harris (1996) demonstrated that simply soaking seeds in water before sowing could increase the speed of germination and emergence, leading to better crop stands, and stimulated seedlings to grow much more vigorously. Priming was seen to promote to earlier tillering, maturity and higher grain yields. Seed priming with water is also one of the factors to improve the productivity of wheat. It is possible to prime seeds with small amount of phosphate to good effect in the early root growth is stimulated allowing more effective uptake of available P in the soil. Rajpar *et al.* (2006) reported that prior to sowing, seed priming with freshwater may improve wheat yield under non-saline conditions. Good crop establishment increases competitiveness against weeds, increases tolerance to dry spells, maximizes yields (Clark *et al.*, 2001). Direct benefits due to seed priming includes faster emergence, better and more uniform stands, more vigorous plants, better drought tolerance, earlier flowering and higher grain yield in many crops (Harris *et al.*, 1999; Harris and Hollington, 2001). Priming improves seed vigour and vigrous seeds show early, uniform emergence and good crop establishment (Shabir *et al.*, 2014). Wheat is the second most important staple food crop of India and contributes major share to food basket (93.9 million tonnes in 2013-14) of the coun-

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try. The present water productivity of wheat is 800–1,000 litres of water/kg wheat grain. Since 90% of wheat crop is grown in irrigated condition, it consumes huge quantity of freshwater for its production. It is, therefore, the need of hour to improve water-use efficiency for wheat production. Hence, present investigation was undertaken to study the effect of matriconditioning and sprouted seeds in crop establishment under sub-optimal soil moisture conditions.

MATERIALS AND METHODS

An experiment was conducted during the winter seasons of 2010–11 and 2013–14 at Indian Institute of Wheat and Barley Research, Karnal (29°43'N, 76°58'E and 245 m above mean sea-level). The experiment comprised 3 main-plot treatments viz. seeding at optimum moisture level (moisture content 17.5% estimated by gravimetric method), seeding at sub optimal moisture level (moisture content 10.9 %) and seeding in air dry soil followed by irrigation (moisture content 6.2%), and 3 sub-plot treatments, viz. no seed priming, matriconditioning seed priming and sprouted seed, and was laid out in a split-plot design with 3 replications. The region is characterized by sub tropical and semi arid climate with a hot dry summer (March–June), wet monsoon season (late June–mid-September) and a cool dry winter (November–February). Average annual rainfall of Karnal location is 744 mm, of which about 80% is received during the monsoon. The climate is sub-tropical with mean maximum temperature ranging in between 34 and 39° C in summer and mean minimum temperature ranging in between 6–7° C in winter. The crop season had received 129.7 mm, 36.3 mm, 203 mm and 189.2 mm rainfall during 2010–11 to 2013–14 respectively.

Soil-moisture content was estimated by gravimetric method before sowing from 0–15 cm depth of soil. The gravimetric method expressed as:

$$W=[(Ww–Wd)/Wd] \times 100$$

where, W, water content in soil; Ww, weight of wet soil; Wd, weight of dry soil.

After recording the wet weight, soil samples were dried to constant weight in oven at temperature of 105° C to record the dry weight of soil sample. Matriconditioning was carried out in gunny bags as described by (Basra *et al.,* 2003). Gunny bags were soaked overnight in tap-water and afterwards spread on a perforated floor. After leaching down the excess water from gunny bags, seeds were uniformly layered between gunny bags. The gunny bags were kept moist for the whole treatment period, i.e. 12 hours. For sprouted seeds, the required quantity of seeds were soaked in freshwater for 10 hours followed by spreading of seeds on a wet gunny bag and covered by another wet gunny bag for 14 hr. The soil was sandy clay loam with pH 7.9 (1:2.5 soil: water), having organic carbon 0.4%, available N 190 kg/ha, available P 17.8 kg/ha and available K 165 kg/ha at beginning of the experiment. Recommended dose of fertilizer (150:60:30 kg of N, P_2O_5 and K_2O/ha) was applied as part of nutrient management. Full dose of P and K and one-third dose of N through diammonium phosphate and NPK mixture (12:32:16) was applied at sowing and remaining N was applied in 2 equal splits–at first and second irrigation through urea. Variety 'DBW 17' was sown on 18, 20, 14 and 6 November in 2010 to 2013, respectively, and harvested on 28 April and 10, 5 and 1 May in 2011 to 2014. These seeds were sown 20 cm apart in rows with a seed rate of 100 kg/ha. First irrigation (60 mm) was applied uniformly to all the treatments at the crown-root-initiation stage (22 days after sowing). The subsequent irrigations were applied at all critical growth stages. Irrigation was done with the help of water pump (tube well). Other management practices were adopted as per recommendations of the crop under irrigated conditions. Number of effective tillers/m^2 from the centre of plot was measured in each plot at maturity. Plant height was recorded by measuring the height of 10 representative plants from each plot randomly. A random sample of 10 spikes was taken from each plot to determine spike length at maturity. A net plot of 9.8 m^2 (7 m × 1.4 m) was harvested manually for biomass and yield data. Grain samples were randomly selected from grain yield of each subplot and 1,000–grain weight was recorded. Water productivity and economic analysis combined for physical accounting of water with yield or economic output to assess how much value is being obtained from the use of water (Abdullaev *et al.,* 2007). For this analysis, physical water productivity (WP) was calculated as : WP = Output/Q

where, WP, Productivity of water in kg/m^3; Output, Productivity of wheat in kg/ha; Q, Water used by the crop in m^3/ha

Total amount of water used by wheat was calculated by multiplying the discharge from the tube-well with total time taken for irrigating the crop throughout the season (total irrigating hours multiplied by volume of water drawn out per hour). Based on this, the average discharge of tube well with 10 HP motor was estimated at 600 m^3/ha per irrigation (Kaur *et al.,* 2012). SAS (Statistical Analysis Software) version 10.3 was utilized to analyze the observations and differences among means were further grouped into significant classes by Duncan's New Multiple Range Test at 5% probability.

RESULTS AND DISCUSSION

Yield attributes

Yield attributes, viz. effective tillers/m^2, ear length and 1,000-grain weight were the highest in sprouted seeds followed by matriconditioning and found significantly higher than non-primed seeds (Table 1). The highest yield attributes in sprouted seeds may be ascribed to higher number of effective tillers, which lead to higher dry-matter accumulation (biomass), translocation and conversion of photosynthates into reproductive parts. Seeds can be soaked before sowing to meet the initial seed-imbibition requirement. These results indicated that seed priming and sprouted seeds caused early and vigorous germination, which led to proper crop establishment under sub-optimal soil-moisture conditions, thereby resulting in higher yield attributes. Rajpar *et al*. (2006) found similar beneficial effects of seed priming, who reported that seedlings were significantly faster in emergence, took fewer days to mature and gave significantly higher grain yield. Among seeding methods (seeding at optimum moisture level, sub-optimal moisture and in air dry soil followed by irrigation) except number of effective tillers, all yield attributing characters were found non-significant. The highest number of effective tillers/m^2 were recorded under treatment seeding at optimum soil moisture level, which was statistically superior to seeding at optimum moisture level and seeding at sub optimal moisture.

Grain and biological yields

The grain and biomass yields of wheat varied significantly due to seed priming and sprouted seeds (Table 2). These were the highest under sprouted seeds followed by seed priming. Sprouted seed was significantly better than unprimed seeds. Sprouted seeds and matriconditioning showed 9.2 and 5.2% higher grain yield than non-primed seeds, respectively. Increase in grain yield of wheat under sprouted seeds and matriconditioning treatments could be attributed to higher yield attributes, whereas the increase in biological yield was owing to higher plant density and plant height. Higher grain and biomass yields in sprouted seeds could also be attributed to early germination and vigorous growth, consequently good crop establishment. Harris *et al.,* (2001) and Rashid *et al.,* (2002) also reported higher grain yield with seed priming of wheat. Harris *et al.* (1999) reported that early emergence and maturity in seed-priming treatment could be due to advancement in metabolic state. Musa *et al*. (1999) also concluded that priming improves plant stand and provides benefits in term of maturity. This view was further supported by Rashid *et al.* (2002).

Water productivity

Total irrigation water (tube-well water + rainfall) applied for crop under different treatments. During the four years, water productivity per hectare was the highest in the case of sprouted seed technique coupled with seeding in air dry soil-moisture level (M_2S_3). Productivity was higher during 2011–12 in spite of low rainfall in comparison to 2010–11; it could be due to early sowing as compared to 2010–11, favourable weather and prolonged winter etc.

Cost of irrigation per hectare of wheat was more in 2011–12 owing to marginal increase in the wages of labourers (Table 3). The quantum of water used for irrigation was low in the case of seeding at sub-optimal soil-moisture level under matriconditioning techniques. The cost of irrigation ranged from as high as ₹2,232/ha to as low as 1860/ha due to sacrificing irrigation at the rate of 600 m^3/ha for seeding at sub-optimal soil moisture level

Table 1. Effect of seed priming on growth, yield and attributing characters and economics of wheat crop sown under different moisture levels (pooled data of 4 Years)

Treatment	Germination indices/m^2	Tillers/ m^2	Ear length (cm)	Plant height (cm)	1,000-grain weight (g)	Grain yield (t/ha)	Biomass yield (t/ha)
Seeding at different moisture levels							
M_1	88	491	10.2	87.8	38.9	5.28	12.49
M_2	107	456	10.2	88.4	38.4	5.20	12.45
M_3	224	504	9.5	88.0	38.8	5.33	12.79
SEm±	4.8	7.3	0.224	0.92	0.18	0.043	0.019
CD (P=.05)	18.6	28.5	NS	NS	NS	NS	0.076
Seed priming							
S_1	102	464	9.6	87.8	38.3	5.02	12.37
S_2	142	482	10.1	88.3	38.7	5.30	12.58
S_3	174	500	10.2	87.9	39.1	5.49	12.74
SEm±	3.7	6.1	0.175	0.17	0.13	0.057	0.072
CD (P=.05)	11.5	19.1	NS	NS	0.4	0.175	0.221

M_1, Seeding at optimum moisture level; M_2, seeding at sub optimal soil moisture level; M_3, seeding in air dry soil followed by irrigation. S_1, No seed priming; S_2, seed priming; S_3, sprouted seed

Table 2. Interaction effects of seed priming on crop establishment, growth and yield of wheat sown under different moisture levels (pooled data of 4 years)

Treatment	Plant height (cm)	Tillers/m^2	1,000-grain weight (g)	Biomass (t/ha)	Grain yield (t/ha)
M_1S_1	87.6	469.7	38.7	12.25	4.98
M_1S_2	88.8	485.1	38.2	12.66	5.25
M_1S_3	86.9	520.4	39.8	12.56	5.61
M_2S_1	88.5	424.7	38.4	12.53	5.09
M_2S_2	88.1	449.9	38.6	12.17	5.16
M_2S_3	88.5	496.1	38.2	12.55	5.37
M_3S_1	87.4	500.5	37.9	12.33	5.01
M_3S_2	88.2	512.4	39.2	12.91	5.51
M_3S_3	88.4	485.7	39.2	13.12	5.49
SEm$\pm$	0.59	10.73	0.23	0.12	0.09
CD (P=0.05)	0.95	33.06	0.72	0.38	NS

M_1, Seeding at optimum moisture level; M_2, seeding at sub optimal soil moisture level; M_3, seeding in air dry soil followed by irrigation. S_1, No seed priming; S_2, seed priming; S_3, sprouted seed

under different seed-priming techniques.

Economics

Results of four years study indicated that sprouted and matriconditioning seeds may be practiced to enhance crop establishment, growth and yield of wheat crop under moisture-stress conditions. Poor establishment of crop due to delayed sowing and lack of optimum soil moisture could be a major constraint in some of area. Therefore, creating irrigation facility, early sowing, minimum tillage and sowing of sprouted and matriconditioning are some effective technologies for enhancing wheat productivity. From above mentioned technologies, matriconditioning and sprouted seeds are simple and cost-effective technologies to establish the crop under moisture-stress conditions. Proper crop establishment increases competitiveness against weeds, increases tolerance to other abiotic stress. Clark *et al.* (2001) also expressed their views in the same manner.

The results of this investigation indicates that seed priming enhanced the growth and yield-contributing characters of wheat sown under the sub-optimal and dry conditions. So, it can be concluded that the practices of sowing of sprouted seeds or with matriconditioning technique under moisture stress condition can help to get the higher productivity of wheat.

Table 3. Cost of Irrigation influenced by seeding of primed and sprouted wheat seeds

Treatment	*Total irrigation water application (m_3/ha)	Water productivity/ha (kg grain/m^3 water)	Quantity (m^3/ha)	Cost of irrigation (₹/ha)
M_1S_1	3,627	1.37	3,600	2,232
M_1S_2	3,627	1.45	3,600	2,232
M_1S_3	3,627	1.55	3,600	2,232
M_2S_1	3,627	1.68	3,000	1,860
M_2S_2	3,627	1.70	3,000	1,860
M_2S_3	3,627	1.77	3,000	1,860
M_3S_1	3,627	1.38	3,600	2,232
M_3S_2	3,627	1.52	3,600	2,232
M_3S_3	3,627	1.51	3,600	2,232

*Calculated on the basis of irrigation water @ 600 m^3/ha per irrigation + rainfall during the crop season, 2010–11, 2011-12, 2012-13 and 2013-14 was 129.7, 36.3, 203 and 189.2 mm, respectively; M_1, Seeding at optimum moisture level; M_2, seeding at sub-optimal soil moisture level; M_3, seeding in air dry soil followed by irrigation; S_1, no seed priming; S_2, seed priming; S_3, sprouted seeds

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