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Research Paper

Effect of seed priming and plant geometry on productivity and profitability of wheat (*Triticum aestivum*) in modified system of wheat intensification under subtropical conditions of Jammu

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2018–19 and 2019–20 at Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu, Jammu and Kashmir, to evaluate the effect of seed priming and plant geometry on productivity of wheat (*Triticum aestivum* L.) in modified system of wheat intensification under subtropical conditions of Jammu. The experiment was laid out in a randomized block design with 3 replications. The treatments comprised different combinations of primed and un-primed wheat seed sown at 4 different plant geometries (20 cm × 5 cm, 20 × 10 cm, 20 cm × 15 cm and 20 × 20 cm) along with conventional sown wheat. The results indicated that, primed seed sown at plant geometry of 20 cm × 5 cm exhibited significantly higher number of tillers/m^2 (346.9), dry-matter accumulation (167.4 g), ears/m^2 (359.3), grain yield (5.25t/ha) and straw yield (6.49t/ha) which was at par with the primed wheat seed sown at plant geometry of 20 cm × 10 cm and conventional sowing of primed seed. However, with respect to mean grain and straw yields, the primed seed sown at plant geometry of 20 cm × 5 cm registered 23.87 and 20.43% increment in grain and straw yield over conventional sowing of wheat. Further, the conventional sowing of primed seed recorded the highest net returns (₹85,874/ha) and benefit : cost ratio (3.28).

Key words: Benefit : cost ratio, Modified system of wheat intensification (MSWI), Plant geometry, Seed priming, Yield

Wheat (*Triticum aestivum* L.) is a crop of global significance. It is grown in diversified environment and is staple food for millions of people. Globally, wheat is grown on an area of about 225.62 million ha, with production and productivity of about 749.50 million tonnes and 3,321 kg/ha, respectively (*www.fao.org*). In India, it is cultivated on an area of about 30.6 million ha, with production and productivity of about 98.38 million tonnes and 3,216 kg/ha respectively (DOAC&FW. 2018). During the past 2 decades, productivity gains from the usual wheat sowing methods have unfortunately been declining. The wheat growers are thus facing the difficulties to cope with the high demand of costly inputs to meet the requirements of recommended technologies for increasing production. Under these circumstances, alternative methods of crop establishment and management that could deal with these emerging uneconomical means by enhancing the productivity of wheat with proportionately less escalation in its cost of production is to be adopted (Rana *et al*., 2018; Rajanna *et al*., 2019). System of Wheat Intensification (SWI) is a new practice of wheat cultivation which creates favourable soil environment for the growth of the crop. It is based on the principles of root development and intensive care. Root development is the first step of healthy growth and development of any plant and to attain this, it requires proper nourishment and sufficient inter- and intra-row space. Wider spacing promotes root distribution and nutrient availability that play important role in plant growth (Thapa

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et al., 2011). The SWI has resulted in an enhancement of ~54% in yield and better economic returns than the available best conventional sowing practices (Uphoff *et al.,* 2011). In this study, we modified the SWI which comprised synergistic management techniques such as sowing of single seed/hill by dibbling at wider inter- and intra-row spacings rather than transplanting of wheat seedlings and seed treatment with organic formulations.

Seed priming, a promising technique, has been successfully employed to overcome the problem associated with poor germination and subsequent erratic crop stand under normal and stressful conditions (Rehman *et al.,* 2011). Seed priming with cow-urine increases the activity of enzymes such as amylase, protease and lipase which have great role in breakdown of micro molecules for growth and development of embryo that ultimately resulted in early seedling emergence. It also helps achieve high vigour and better yields in crop plants by initiating metabolic processes necessary for germination and growth. In SWI, greater application of organic source of manures invigorates the microbial population and cycle nutrient and increases fertility status of soil (Dhar *et al*., 2015). Liquid humic acid extract obtained from vermicompost helps in increasing the growth and development of cereals (Rahimabadi *et al.,* 2018). In addition to better crop establishment, seed priming has also been reported to improve tillering, uniformity in emergence, deeper roots, better competition with weed, early flowering and maturity and resistance to environmental stresses (Thakur *et al.,* 2010; Rajanna *et al*., 2017). Considering all these aspects, the effect of seed priming and plant geometry on yield and economics of wheat under modified system of wheat intensification was evaluated in the subtropical conditions of Union Territory of Jammu and Kashmir, India.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season of 2018–19 and 2019–20 at Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu, Jammu and Kashmir. The experimental site is located situated at (32°40′ N, 74°82′ E at an elevation of 293 m above mean sea-level) falling in the subtropical foothill lands of Shiwaliks in Jammu and Kashmir. The climate of this place is bestowed with hot and dry early summers followed by hot and humid monsoon season and cold winters. December and January are usually the coldest months where the mean temperature normally falls as low as 5.5°C. However, the mean temperature varied between 33.9°C and 8.47°C during the study. During the study period, the crop received a total of 301.6 mm rainfall. The soil of the experimental field was sandy clay loam, slightly alkaline (*p*H 7.68), low in organic carbon (4.3 g/kg) and available nitrogen (213.20 kg/ha) but medium in available phosphorus (19.50 kg/ha) and potassium (152.80 kg/ha), with electrical conductivity of 0.14 dS/m in the safer range. The experiment was conducted in a randomized block design, with 3 replications. The treatments consisted of conventional sowing (check), un-primed seed sown at plant geometry of 20 cm × 5 cm, 20 cm × 10 cm, 20 cm ×15 cm and 20 cm × 20 cm, conventional sowing of primed seed, primed seed sown at plant geometry of 20 cm × 5 cm, 20 cm × 10 cm, 20 cm × 15 cm and 20 cm × 20 cm. The wheat variety 'HD 3086' was sown in November using seed rate of 100 kg/ha in conventional sowing, 38 kg/ha for 20 cm × 5 cm, 19 kg/ha for 20 cm × 10 cm, 13 kg/ha for 20 cm × 15 cm and 10 kg/ha for 20 cm × 20 cm. At the time of sowing, furrows were opened with the help of liner at a specified row-to-row distance of 20 cm between the rows and seeds were sown in furrows by *kera* method in case of conventional sown wheat. Under intra-row spacing of 5 cm, 10 cm, 15 cm and 20 cm, sowing was done by dibbling method using a rope tagged with signs indicating required plant spacing. Wheat was fertilized with 100 : 50 : 25 kg/ha of N : P_2O_5 : K_2O respectively. Entire quantity of phosphorus, potassium and one-half of the total nitrogen was applied basal at the time of sowing. Remaining dose of nitrogen was applied 2 in equal splits-at crown-root-initiation stage and just before ear-initiation stage-in all treatments. The crop was grown under assured irrigation without any water stress during crop-growth period.

With respect to seed priming material, different crop seeds were taken and treated with different ratio of vermicompost, water, cow-urine and jaggery for 12 and 8 hr. The ratio of 1.0 : 1.0 : 0.5 : 0.1 occurs to provide best result when seedling were treated. Thus, seed- priming formulation comprised vermicompost, water, cow-urine and jaggery in the ratio of 1.0 : 1.0 : 0.5 : 0.1 was used to treat the seeds before sowing. Wheat seed 5 kg, water 5 litres, vermicompost 5 kg, cow-urine 2.5 litres and jaggery 500 g was taken in a bucket and were kept overnight. The primed material was stirred during preparation period. Thereafter, the material was sieved using cotton cloth and the resultant solution so obtained was used to treat the seeds. The treated seeds were first immersed in water to remove the chaffy seeds which were found floating on the surface of water. The seeds which settled on the surface of the tub were then removed and immersed in the priming solution for 8 hr. The seeds were taken out of the primed solution and dried in shade. Seeds were then treated with *Trichoderma viride* @ 4 g/kg seed. Treated seeds were then again dried in shade for about an hour and thereafter sown directly in the field. *Trichoderma viride* @ 4 g/kg seed was used uniformly to treat the seeds irrespective of the conditions whether the seed used was primed or un-primed.

Data on various growth, yield and yield attributes were recorded. Net returns were calculated by deducting cultivation cost from gross returns. Benefit : cost (B : C) ratio was calculated by dividing net returns with total cost of cultivation. Statistical analysis of data was conducted using OP-STAT developed by the CCSHAU, Hisar. Fisher's test of significance was used to compare the difference between means at 5% probability level.

RESULTS AND DISCUSSION

Growth attributes

Plant height of wheat was significantly influenced by different planting geometry and seed priming. At 60 days after sowing (DAS), plant height increased with the increase in plant geometry (Table 1). This increase in plant height might be due to the fact that wider spacing promotes root distribution and nutrient availability that play important role in plant growth (Thapa *et al*., 2011). Primed seed sown at plant geometry of 20 cm × 20 cm recorded significantly higher plant height which was at par with primed seed sown at 20 cm × 15 cm, 20 cm × 10 cm, un-primed seed sown at 20 cm × 20 cm and 20 cm × 15 cm. The increase in plant height might be owing to the fact that wider spacing promotes root distribution and nutrient availability that play an important role in plant growth (Thakur *et al.,* 2010; Thapa *et al.,* 2011). Likewise, primed seed sown at plant geometry of 20 cm × 5 cm recorded significantly higher number of tillers/m^2 and dry-matter accumulation among all the treatments, which was at par with primed seed sown at plant geometry of 20 cm × 10 cm and conventional sowing of primed seed (Table 1). This might be due to the fact that cow-urine contains physiologically active substances, viz. growth-regulators and nutrients that promote higher number of tillers in plant which further resulted in significant enhancement in dry-matter accumulation. Bhargava *et al*. (2010) also documented increased activity of enzymes such as amylase, protease and lipase which have great role in breakdown of micro-molecules for growth and development of embryo that ultimately resulted in higher growth of seedlings in wheat.

Yield attributes

Yield attributes, viz. ears/m^2, grains/ear, length of ear, seed size and 1,000-grain weight (Table 1), were significantly influenced by seed priming and plant geometry. Primed seed sown at plant geometry of 20 cm × 5 cm resulted in significantly more ears/m^2, being at par with primed seed sown at plant geometry of 20 cm × 10 cm and conventional sowing of primed seed. This was mainly owing to the decrease in number of planting hills/unit area.

Table 1. Effect of modified system of wheat intensification and seed priming on growth and yield attributes of wheat crop in (mean of 2 years data)

Treatment	Plant height (cm) at 60 DAS	Tillers/m^2 at 60 DAS	Dry-matter accumulation (g/m^2) at 60 DAS	Ears/m^2	Grains/earhead	Length of ear (cm)	1,000-grain weight (g)
Conventional sowing	26.3	291	131.0	310.0	37.6	14.0	37.0
Unprimed seed sown at plant geometry of 20 cm × 5 cm	30.9	307	146.0	329.0	37.9	14.4	38.2
Unprimed seed sown at plant geometry of 20 cm × 10 cm	32.4	296	138.0	315.0	37.9	14.7	38.6
Unprimed seed sown at plant geometry of 20 cm × 15 cm	34.4	260	124.5	279.0	38.0	14.9	39.1
Unprimed seed sown at plant geometry of 20 cm × 20 cm	36.3	244	118.1	263.0	38.2	15.6	39.8
Conventional sowing of primed seed	30.9	321	149.4	336.7	38.5	14.5	37.5
Primed seed sown at plant geometry of 20 cm × 5 cm	31.7	346	167.4	359.3	38.7	14.8	39.3
Primed seed sown at plant geometry of 20 cm × 10 cm	34.7	327	154.5	343.3	39.1	14.9	39.7
Primed seed sown at plant geometry of 20 cm × 15 cm	37.2	298	135.4	313.7	39.2	15.8	40.5
Primed seed sown at plant geometry of 20 cm × 20 cm	39.2	264	125.5	281.3	39.7	16.1	41.4
SEm±	2.30	12	6.0	13.0	0.97	0.37	0.61
CD (P=0.05)	6.82	36	19.0	39.0	NS	1.16	1.80

DAS, Days after sowing

Primed seed sown at plant geometry of 20 × 20 cm recorded significantly higher ear length and 1,000-grain weight. This is mainly owing to the fact that wider spaced plant performed better than closed spaced plant because of adequate availability of nutrients, water, space and light interception that contributes better yield-attributing characters (Patil *et al.,* 2014).

Productivity

Crop yield is the resultant of better growth and development of the plant, higher rate of photosynthesis, better translocation of photosynthates and better source-sink association. Grain, straw and biological yield of wheat was significantly influenced by seed priming at different plant geometries in the modified system of wheat intensification. Primed seed sown at plant geometry of 20 cm × 5 cm gave significantly higher grain (5.25 t/ha) and straw (6.49 t/ha) (Table 2) which was at par with primed seed sown at plant geometry of 20 cm × 10 cm and conventional sowing of primed seed. Wider spacing resulted in better performance/hill than narrow spacing owing to reduced competition between plant for nutrient, water, space and light but decreased overall grain and straw yield. The wider spacings of more than 20 cm × 10 cm could not compensate the drastic reduction in plant population and productive tillers/unit area and thus resulted in severe decrease in yield of wheat crop (Thakur *et al*., 2010; Patil *et al*., 2014).

Profitability

Relative economics of wheat, presented in Table 3, revealed that conventional sowing of primed seed was found to be the most economical among different plant geometry in the modified system of wheat intensification. The highest net returns of ₹ 85,874/ha and benefit: cost (B : C) of 3.28 were recorded in conventionally sown primed seed as compared with conventional sowing of unprimed seed which recorded a net return of ₹ 74,253/ha and B : C of 2.99. This may be because of the fact that, requirement of manual labour for sowing of seed is less under conventional sowing as compared to crop sown at different plant geometries (Suryawanshi *et al.,* 2013; Patil *et al*., 2014).

It may be concluded that primed seed sown at plant

Table 2. Effect of modified system of wheat intensification and seed priming on grain and straw of wheat during 2018–19 and 2019–20

Treatment	Grain yield (t/ha)			Straw yield (t/ha)		
	2018–19	2019–20	Mean	2018–19	2019–20	Mean
Conventional sowing (check)	4.11	4.35	4.23	5.26	5.51	5.39
Unprimed seed sown at plant geometry of 20 cm × 5 cm	4.41	4.66	4.54	5.64	5.89	5.77
Unprimed seed sown at plant geometry of 20 cm × 10 cm	4.11	4.36	4.24	5.33	5.58	5.46
Unprimed seed sown at plant geometry of 20 cm × 15 cm	3.77	4.02	3.89	4.79	5.04	4.92
Unprimed seed sown at plant geometry of 20 cm × 20 cm	3.37	3.63	3.50	4.43	4.68	4.56
Conventional sowing of primed seed	4.66	4.96	4.81	5.81	6.11	5.96
Primed seed sown at plant geometry of 20 cm × 5 cm	5.01	5.39	5.24	6.34	6.63	6.48
Primed seed sown at plant geometry of 20 cm × 10 cm	4.71	5.01	4.86	5.98	6.28	6.13
Primed seed sown at plant geometry of 20 cm × 15 cm	4.22	4.52	4.37	5.37	5.67	5.52
Primed seed sown at plant geometry of 20 cm × 20 cm	3.71	4.01	3.86	4.78	5.08	4.93
SEm±	0.18	0.19	0.17	0.23	0.24	0.24
CD (P=0.05)	0.53	0.58	0.50	0.68	0.69	0.72

Table 3. Effect of modified system of wheat intensification and seed priming on relative economics of wheat (mean of 2 years data)

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Conventional sowing	24,844	99,097	74,253	2.99
Unprimed seed sown at plant geometry of 20 cm × 5 cm	41,291	106,246	64,955	1.57
Unprimed seed sown at plant geometry of 20 cm × 10 cm	37,635	99,413	61,780	1.64
Unprimed seed sown at plant geometry of 20 cm × 15 cm	34,293	91,092	56,799	1.65
Unprimed seed sown at plant geometry of 20 cm × 20 cm	31,030	82,357	51,327	1.65
Conventional sowing of primed seed	26,204	112,077	85,874	3.28
Primed seed sown at plant geometry of 20 cm × 5 cm	41,906	122,105	80,199	1.91
Primed seed sown at plant geometry of 20 cm × 10 cm	37,942	113,654	75,712	1.99
Primed seed sown at plant geometry of 20 cm × 15 cm	34,525	102,313	67,788	1.96
Primed seed sown at plant geometry of 20 cm × 20 cm	31,224	90,483	59,259	1.92

geometry of 20 cm × 5 cm in modified system of wheat intensification is a best suitable option for resource-poor farmers for attaining higher wheat yields in irrigated subtropics of Jammu.

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