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Full Research Article

Effect of Planting Geometry and Seed Treatment on Growth and Yield of Wheat (*Triticum aestivum* L.) under System of Wheat Intensification

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Abstract

A field experiment was conducted during *rabi* season of 2011-12 and 2012-13 at Bihar Agricultural college, Sabour, Bhagalpur, Bihar, to study the effect of planting geometry and seed treatment on growth and yield of wheat under System of Wheat Intensification. The results indicated that maximum grain yield of wheat i.e., 48.71 and 51.17 q ha^{-1} during 2011-12 and 2012-13, respectively were recorded when the crop was sown in a fashion of 15×15 cm^2 planting geometry which was significantly higher than the grain yield recorded under conventional and 10×10 cm^2 planting geometry but was at par with that obtained under the 20×20 cm^2 planting geometry. It was also observed that grain yield of wheat was significantly higher with treated seeds i.e., 44.55 and 47.41 q ha^{-1} during 2011-12 and 2012-13 respectively, as compared to that obtained with untreated seed. With respect to grain yield, the treatment 15×15 cm^2 geometry registered highest % increment in grain yield, having values 16.6% and 14.8% followed by 20×20 cm^2 with values 11.4% and 7.7% in 2011-12 and 2012-13 respectively, over conventional sowing, the % increase in B:C ratio also followed the same trend during both the years of experimentation.

1. Introduction

Worsening of primary resources and excessive use of agrochemicals to increase the production become a threat to the environment. It is very necessary to meet the future need for food, feed and fuel without excessive resource use. Wheat is the main field crop in many temperate and subtropical areas (Rasmussen et al., 2015) and efficient use of primary resources is of high concern. Wheat crop plays a pivotal role in India's food security after rice. In India, wheat occupies an area of 29.65 million ha with the production of 92.46 million t, contributing 36% of the total food grain production (Anonymous, 2013). The low productivity of wheat in India is mainly due to delayed sowing, short winter, application of input at right time at right place and terminal heat particularly in North Eastern Plain Zone of India, leading to shy tillering, inadequate crop establishment and shrivelled grains. Traditionally, wheat is grown by broadcasting and continuously sowing of seeds in line without maintaining any specific planting geometry, which have been served well for long tracts but the limitations like non uniformity in crop stand leads to dilution effect of input and reflects in crop yield. System of Wheat Intensification (SWI) is a technique of wheat production which is based on manipulation of soil environment with minimum external inputs and very low seed rate. SWI is based on the principles of system of rice intensification in a new cultivation technique which demands to maintain optimum plant population, allowing sufficient aeration, moisture, sunlight and nutrient availability, leading to proper root system development for early stage of crop growth. SWI is a synergistic management technique involving components of wheat farming such as planting less number of seeds per hill with wider spacing and seed treatment with specific organic formulations like vermicompost, cow urine and jaggery, along with carbendazim. The management practices under SWI provide better conditions for growth of wheat crop due to greater proliferation of root hair and root length than those grown under traditional wheat farming. Seed treatment also plays an important role in early germination of seedling in SWI. SWI enhances the grain yield to the tune of 20-25% over that of conventional sowing (ATMA, 2008). Khadka and Raut (2011) reported positive response of seed priming and line sowing in wheat crop over conventional practice. However, a very little information regarding the effect of SWI technique on growth and productivity of wheat is available. Therefore, the present experiment was conducted to investigate the effect of planting geometry coupled with seed treatment on the growth and productivity of wheat under SWI.

2. Materials and Methods

A field experiment was conducted during *rabi* season of 2011-12 and 2012-13 at Bihar Agricultural College, Sabour, Bhagalpur, Bihar, to study the effect of planting geometry and seed treatment on growth and productivity of wheat under SWI. Bihar Agricultural College, Sabour is situated at a longitude of 87°2′42″ E, latitude of 25°15′40″ N and at an altitude of 46 meters above mean sea level in the heart of the vast Indo-Gangetic plains of North India. The climate of this place is tropical to subtropical and is characterized by very dry summer, moderate rainfall and very cold winter. December and January are usually the coldest months where the mean temperature normally falls as low as 8.2 °C. However, the mean temperature varied between 30.2 to 11.2 °C and 28.4 to 9.75 °C during the experimentation of 2011-12 and 2012-13 respectively. The crops received a total of 27.7 mm and 94.5 mm rainfall during the two consecutive *rabi* seasons respectively. The soil of the experimental plot was sandy loam in texture (49.01% sand, 36.6% silt and 13.6% clay), neutral in reaction (pH=7.45), medium in organic carbon (0.55%), low in available N (157 kg ha^{-1}) and medium in available P (22.40 kg ha^{-1}) and K (162 kg ha^{-1}).

The experiment was laid out in split plot design replicated four times. The planting geometry treatments like conventional i.e., row-row distance of 23 cm with continuous sowing (P_1), 10×10 cm^2 (P_2), 15×15 cm^2 (P_3) and 20×20 cm^2 (P_4) were taken in main plot and the seed treatments like treated seed (T) and untreated seed (UT) were taken in sub plot. For seed treatment, 10 kg seed of wheat were poured in 20 litres of hot water with 2.25 kg vermicompost, 1100 g jaggery and 4 litre cow urine and kept for 8 hours. Seed mixture was separated from the solution and treated with 4 g carbendazim per kg seed. Treated seeds were kept in wet jute bag for 8-10 hours and were then dried in shade for about an hour. The wheat variety for timely sown irrigated condition i.e., HD 2733 was used in the eperiment. A seed rate of 100 kg ha^{-1} in conventional sowing, 80 kg ha^{-1} in 10×10 cm^2, 34 kg ha^{-1} in 15×15 cm^2 and 20 kg ha^{-1} in 20×20 cm^2 planting were used. All the plots were fertilized with a fertilizer dose of 120:60:40 kg N:P_2O_5:K_2O ha^{-1}. Half of the N and full P and K were applied as basal and remain N were applied in 2 equal splits after 25 and 50 days after sowing (DAS). Four irrigations were given at 25, 50, 75 and 85 DAS.

The observation on growth parameters like plant height and leaf area index (LAI) were recorded at 30, 60 and 90 DAS, whereas, number of tillers m^{-2} was worked out at 60 DAS. For LAI, leaves were separated from the plants, treatment wise and kept in paper packets which were then dried by placing the packets in a hot air oven at a temperature of 60 °C till constant weight were reached. The dry weight of leaves was used for determining LAI as suggested by Watson (1952). Various yield parameters like numbers of earhead m^{-2}, numbers of grains $earhead^{-1}$, test weight along with grain yield were recorded at maturity. The data thus obtained were statistically analyzed as per procedure of analysis of variance technique and the significance of different source of variations were tested by error mean square of Fischer's F test at probability level 0.05 (Cochran and Cox, 1977). The economics of the experiment was calculated and analyzed by taking market price of inputs and produces for the respective years of experimentation.

3. Results and Discussion

3.1. Effect of planting geometry on growth attributes of wheat

Growth parameters like plant height, number of tillers m^{-2} and LAI were found to be significantly influenced by different planting geometry and seed treatment during both the years of experimentation. At 30 DAS, the plant height was not significantly influenced by planting geometry, whereas, at 60 and 90 DAS, the plant height was significantly influenced, with the highest value recorded for 20×20 cm^2 geometry, which was in turn statistically at par with that recorded under 15×15 cm^2 planting geometry (Table 1). It was also revealed that in all the cases, plant height under 20×20 cm^2 and 15×15 cm^2 were higher than the conventional sowing of wheat which might be due to the fact that wider spacing decreased competition among plants for light, water, space and nutrients due to higher light interception, root distribution and nutrient availability that play important role in plant growth (Tej Thapa et al., 2011; Thakur et al., 2010). Similar type of result was also obtained by Mondal et al. (2013) in West Bengal. Likewise, maximum number of tillers m^{-2} i.e., 277 and 285 respectively, during 2011-12 and 2012-13 were recorded from the treatment 15×15 cm^2 geometry and was in turn significantly superior to the rest of the planting geometries except 20×20 cm^2.

The LAI of 4.17 and 4.55 during 2011-12 and 2012-13, respectively at 60 DAS and 5.67 and 5.91 during 2011-12 and 2012-13, respectively at 90 DAS, were recorded from the treatments of 15×15 cm^2 and was in turn significantly superior to the rest of the planting geometries except the 20×20 cm^2 geometry. This might be due to the fact that wider spacing under SWI technique facilitated optimum plant population per unit area and leaf area per plant which might have contributed to the maximum values of tillers per square meter and LAI in the treatments under 15×15 cm^2. This is in conformity with result of Thakur et al. (2010).

3.2. Effect of seed treatment on growth attributes of wheat

The seed treatment significantly influenced the plant height, tillers m^{-2} and LAI at all the growth stages in comparison to untreated with higher values recorded under treated condition. This profound effect of seed treatment with the specific organic formulation on all the growth attributes of the crop has been attributed due to the fact that cow urine contains physiologically active substances viz., growth regulators, nutrients and trace elements (Kamalam and Rajappan, 1989). Dell-Aquila and Tritto (1990) also supported the findings of this study through their reports whereby they 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 early and higher growth of seedlings of wheat.

3.3. Effect of planting geometries and seed treatment on yield components of wheat

Different planting geometry significantly influenced the yield contributing characters viz. earhead m^{-2}, grains earhead^{-1} and 1000 seed weight (Table 2). Maximum number of earhead m^{-2} i.e., 275.8 and 281.6 during 2011-12 and 2012-13 respectively and 1000 seed weight 39.0 g, 39.5 g during 2011-12 and 2012-13 respectively, were recorded under 15×15 cm^2 planting geometry and was found to be significantly superior to conventional sowing and 10×10 cm^2 but was at par with 20×20 cm^2 planting geometry. The increase in earhead m^{-2} under SWI with wider spacing was due to production of more number of effective tillers. Kanakadurga (2012) also reported that wider spacing facilitates plants for better utilization of nutrient, water, light and space leading to produced maximum number of effective tillers per unit area than conventional practices. With respect to grains earhead^{-1}, maximum number i.e., 42.63 and 45.13 during 2011-12 and 2012-13, respectively, were obtained from 20×20 cm^2 planting geometry and was found to be at par with values of 42.38 and 44.50 during 2011-12 and 2012-13, respectively, recorded under 15×15 cm^2 planting geometry. Effect of Seed treatment on yield components was also found to be significant during both the years in comparison to untreated.

3.4. Effect of planting geometries and seed treatment on grain yield of wheat

Significant influence of planting geometry on grain yield was also recorded during both the years of experimentation. Maximum grain yield of 48.71 and 51.17 q ha^{-1} was recorded during 2011-12 and 2012-13, respectively under 15×15 cm^2 planting geometry and was found to be significantly superior to conventional sowing and 10×10 cm^2 geometry but was at par with 20×20 cm^2. This was due to maximum number of earhead m^{-2}, 1000 seed weight and grains earhead^{-1} of the crop observed under the planting geometry 15×15 cm^2. Besides, a significantly increasing trend was recorded in grain yield of wheat under wider spacing upto 15×15 cm^2 and decreased further in 20×20 cm^2 during both the years. This was mainly due to the fact that wider spacing of 20×20 cm^2 recorded lesser plant population and productive tillers resulting in decrease in number of ear head per unit area. This was in conformity with the finding of Jayawardena and Abeysekera (2011) and Thakur et al. (2010).

Table 1: Effect of planting geometries and seed treatment on growth attributes of wheat under SWI

Treatments	Plant height (cm)						Tiller m^{-2} (60 DAS)		LAI					
	2011-12			2012-13					2011-12			2012-13		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	2011-12	2012-13	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Planting geometry														
P_1	24.2	44.4	91.8	24.9	45.6	93.3	251	260	0.61	3.47	4.54	0.62	3.87	5.21
P_2	23.6	41.4	85.6	24.4	42.3	86.8	236	244	0.60	3.07	3.53	0.61	3.24	4.12
P_3	25.3	47.9	98.8	25.7	47.9	101.1	277	285	0.59	4.17	5.67	0.59	4.55	5.91
P_4	25.7	48.0	98.9	25.9	48.3	100.8	267	276	0.58	4.13	5.59	0.59	4.50	5.80
SEm±	0.49	1.02	1.41	0.33	0.88	1.35	3.47	3.02	0.007	0.21	0.22	0.01	0.17	0.17
CD (p=0.05)	NS	3.28	4.52	NS	2.82	4.32	11.11	9.68	0.02	0.67	0.72	0.04	0.53	0.55
Seed treatment														
T	25.4	46.8	96.2	26.3	47.2	98.2	261	271	0.60	3.87	5.15	0.61	4.30	5.58
UT	24.0	44.1	91.4	24.2	44.8	92.8	254	261	0.59	3.54	4.52	0.59	3.77	4.94
SEm±	0.19	0.18	0.20	0.15	0.20	0.24	0.40	0.55	0.004	0.03	0.06	0.004	0.06	0.05
CD (p=0.05)	0.58	0.55	0.62	0.47	0.63	0.74	1.24	1.70	0.01	0.09	0.20	0.01	0.19	0.17

P_1: Conventional sowing; P_2: 10×10 cm^2; P_3: 15×15 cm^2; P_4: 20×20 cm^2; T: Treated seed; UT: Untreated seed

With respect to % increment in grain yield, the treatment 15×15 cm^2 geometry registered highest values of 16.6% and 14.8% followed by 20×20 cm^2 having values, 11.4% and 7.7% respectively, over conventional sowing, during the consecutive years of experimentation (Figure 1).

Seed treatment also imparted positive influence on grain yield of wheat during both the years. Maximum grain yield of 44.55 and 47.41 q ha^{-1} was recorded during 2011-12 and 2012-13 respectively from the treatments of treated seeds and was found to be significantly superior to the grain yield obtained from untreated. Similar type of findings were also reported by Khadka and Raut (2011); Misra et al. (2002).

3.5. Interaction effect of planting geometries and seed treatment on yield attributes and grain yield of wheat

Interaction effect of different planting geometry and seed treatment on yield contributing characters and grain yield of wheat was found to be significant during both the years of experimentation (Table 3). Treated seeds dibbled in a fashion of 15×15 cm^2 planting geometry produced significantly higher earhead m^{-2} (280.5 and 291.0 during 2011-12 and 2012-13, respectively) than all other treatment combinations. The highest grains earhead^{-1} i.e., 43.8 and 46.0 during 2011-12 and 2012-13, respectively was recorded under 20×20 cm^2 planting geometry along with seed treatment but was statistically at par with 15×15 cm^2 geometry with seed treatment, with values 43.0 and 45.0 during 2011-12 and 2012-13, respectively. The highest grain yield of wheat (50.22 and 52.63 q ha^{-1} during 2011-12 and 2012-13, respectively) was recorded under 15×15 cm^2 geometry with seed treatment which was statistically at par with the grain yield obtained from the treatment where treated seeds were sown in a fashion of 20×20 cm^2 planting geometry i.e., 47.94 and 50.13 q ha^{-1} during 2011-12 and 2012-13, respectively but was significantly superior to that of the rest of the treatment combinations. The treated seeds along with 15×15 cm^2 geometry recorded 18% and 21% increase in grain yield during 2011-12 and 2012-13, respectively in comparison to treated conventional planting. This increase in grain yield might be due to the synergistic effect of seed treatment with bio-formulation along with optimum planting geometry.

3.6. Economics

Net return of wheat was significantly affected by planting geometry and seed treatments under SWI techniques during both the years of experimentation. Maximum net return of ₹ 46440 and ₹ 50835 during 2011-12 and 2012-13, respectively, was obtained under 15×15 cm^2 geometry with seed treatment, followed by 20×20 cm^2 geometry with seed treatment, during both the years and was higher than other treatment combinations (Table 4). The highest net returns, obtained in the above combination of treatments, were mainly due to higher economic yield. The results corroborated the findings of Suryawanshi et al. (2013).

The benefit cost ratio (B:C ratio) of wheat was also significantly affected by planting geometry under SWI techniques. Maximum B:C ratio of 1.68 and 1.69 during 2011-12 and 2012-13 respectively was obtained under 20×20 cm^2 geometry with seed treatment followed by 15×15 cm^2 geometry with seed treatment during both the years and were higher than other treatment combinations. The results corroborated the findings of Das and Choudhury (1996).

The % increase in B:C ratio also followed the same trend

Table 2: Effect of planting geometries and seed treatment on yield attributing characters and grain yield (q ha^{-1}) of wheat under SWI

Treatments	Earhead m^{-2}		Grains earhead^{-1}		1000 seed weight (g)		Grain yield q ha^{-1}	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Planting geometry								
P_1	248.3	256.0	41.38	43.38	37.4	38.5	41.76	44.57
P_2	234.0	240.3	39.13	41.13	37.1	38.3	36.54	40.74
P_3	275.8	281.6	42.38	44.50	39.0	39.5	48.71	51.17
P_4	263.9	269.9	42.63	45.13	38.9	39.0	46.54	48.01
SEm±	3.97	4.24	0.50	0.49	0.45	0.26	0.76	1.27
CD (p=0.05)	12.71	13.56	1.59	1.57	1.44	0.83	2.44	4.05
Seed treatment								
T	258.7	266.3	42.19	44.25	38.8	39.3	44.55	47.41
UT	252.3	257.6	40.56	42.81	37.4	38.4	42.22	44.83
SEm±	0.41	1.26	0.14	0.13	0.18	0.13	0.13	0.22
CD (p=0.05)	1.28	3.89	0.42	0.39	0.55	0.41	0.39	0.6

P_1: Conventional sowing; P_2: 10×10 cm^2; P_3: 15×15 cm^2; P_4: 20×20 cm^2; T: Treated seed; UT: Untreated seed

Table 3: Interaction effect of planting geometries and seed treatment on yield attributes and grain yield (q ha^{-1}) of wheat under SWI

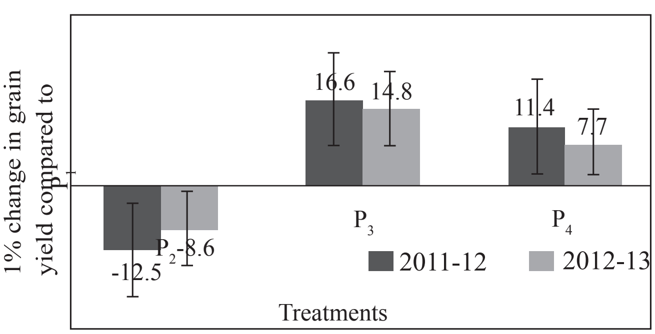
Planting geometry	Seed treatment	Earhead m^{-2}		Grains $earhead^{-1}$		Test weight (g)		Grain yield (q ha^{-1})	
		2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
P_1	T	250	257	42.5	44.5	38.63	38.75	42.53	45.35
	UT	247	255	40.3	42.3	36.25	38.25	41	43.79
P_2	T	237	244	39.5	41.5	37.50	38.3	37.53	41.55
	UT	231	237	38.75	40.8	36.75	38.25	35.55	39.94
P_3	T	281	291	43	45	40.00	40.25	50.22	52.63
	UT	271	272	41.8	44	38.00	38.75	47.21	49.71
P_4	T	267	274	43.8	46	39.13	39.75	47.94	50.13
	UT	261	266	41.5	44.3	38.75	38.25	45.13	45.9
P at same T	SEm±	4.02	4.6	0.53	0.52	0.51	0.32	0.78	1.3
	CD (p=0.05)	12.37	14.17	1.63	1.6	1.58	0.98	2.41	4.01
T at same P	SEm±	0.83	2.53	0.27	0.25	0.35	0.26	0.25	0.43
	CD (p=0.05)	2.55	7.78	0.83	0.78	1.39	0.82	0.78	1.34

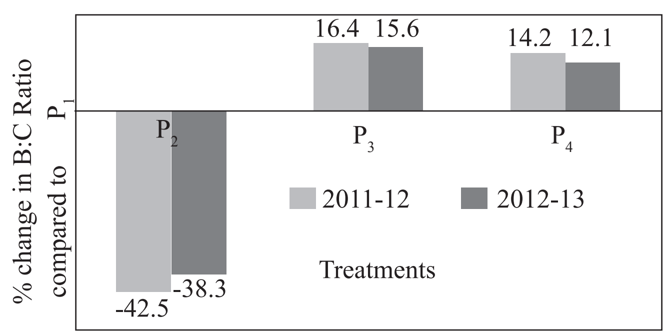
P_1: Conventional sowing; P_2: 10×10 cm^2; P_3: 15×15 cm^2; P_4: 20×20 cm^2; T: Treated seed; UT: Untreated seed

Table 4: Effect of planting geometries and seed treatment on economics of wheat under SWI

Planting geometry	Seed treatment	Gross income (₹ ha^{-1})		Cost of cultivation (₹ ha^{-1})		Net income (₹ ha^{-1})		B:C Ratio	
		2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
P_1	T	63436.6	67439.8	26930	28968	36507	38472	1.36	1.33
	UT	61220	67854.0	26235	28273	34985	39581	1.33	1.40
P_2	T	56363.6	64426.5	31163	33801	25201	30626	0.81	0.91
	UT	67821.4	61258.5	30635	33273	37186	27986	1.21	0.84
P_3	T	74860.2	81487.5	28420	30653	46440	50835	1.63	1.66
	UT	70182.4	76738.5	28185	29633	41997	47106	1.49	1.59
P_4	T	71202.9	77524.5	26576	28872	44627	48653	1.68	1.69
	UT	66917.1	70965.0	26435	28733	40482	42232	1.53	1.47

P_1: Conventional sowing; P_2: 10×10 cm^2; P_3: 15×15 cm^2; P_4: 20×20 cm^2; T: Treated seed; UT: Untreated seed; 1US $= ₹ 52.36 and ₹ 52.36 during March, 2012 and 2013, respectively





P_1: Conventional sowing; P_2: 10×10 cm^2; P_3: 15×15 cm^2; P_4: 20×20 cm^2; The vertical line represents standard error of mean

Figure 1: Percentage change in grain yield of wheat as influenced by planting geometry compared to conventional sowing

Figure 2: Percentage change in B:C Ratio of wheat as influenced by planting geometry compared to conventional sowing

as that of grain yield, with highest values of 16.4% and 15.6% observed under 15×15 cm^2 geometry as compared to conventional sowing (Figure 2).

4. Conclusion

Raising wheat under SWI with a moderately closer planting geometry of 15×15 cm^2 and seed treatment with cow urine, vermicompost, jaggery and carbendazim optimised growth and yield attributes of wheat like plant population, earheads m^{-2} and 1000 grain weight, through efficient utilization of space, nutrients and moisture maintaining an edge over conventional technique, thereby enhancing the grain yield of wheat. The low input requirement of the technique can enhance economic benefit of the resource poor farmers.

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