Original Research Article

Effect of Plant Geometry and Seed Rates on Growth, Yield Attributes, Productivity As Well As Weed Dynamics of Wheat (*Triticum aestivum* L.)

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A B S T R A C T

The experiments were conducted to observe the impact of plant geometry and seed rates on growth, yield attributes, productivity as well as weed dynamics of wheat (*Triticum aestivum* L.). Experiment was laid out in split plot design with total 12 treatment combinations and replicated thrice. The treatment comprises of plant geometry (Broadcasting – M1, 25 cm Spacing – M2, 22.5 cm Spacing – M3 and 20 cm Spacing– M4) and seed rate (100 kg ha^{-1} - S1, 125 kg ha^{-1}- S2 and 150 kg ha^{-1} -S3). The crop responded significantly better growth, yield attributes and yield with 22.5 cm plant geometry rather than other plant arrangement. In case of seed rate, 125 kg ha^{-1} was found most suitable to obtain the maximum yield. The weed population found in sowing of crop 25 cm apart and minimum weed population was observed under the sowing of crop 20 cm apart. The maximum number of weed population viz., *Chenopodium album*, *Anagallis arvensis*, *Phalaris minor* and *Cyperus rotundus* were observed maximum under the seed rate of 100 kg ha^{-1} and minimum number of weed population were also observed under the sowing of 150 kg ha^{-1} of seed rate. The maximum gross income (Rs 71722 ha-1) was obtained at 22.5 cm part which was higher other plant geometry, broadcasting (Rs 39728 ha^{-1}) and 25 cm (Rs 66949 ha^{-1}). The maximum net return was recorded under the seed rate 125 kg ha^{-1} (Rs 47799 ha^{-1}) than other seed 100 kg ha^{-1} and 150 kg ha^{-1}. The highest benefit: cost ratio under 125 kg ha^{-1} seed rate which is significantly higher in comparison to 150 kg (3.30).

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important food grain crops in the world. In our country it is placed just after rice in terms of production and consumption. The overall production of wheat in the country has gone tremendously from mere 12.8 million tons in 1966 to a record highest 86.53 million tons in 2015-116from 31.0million ha area (India stat, 2016). The productivity has increased from 887 to 2900 kg ha^{-1}. India

shares total wheat production in world 13.5%. For the production point of view India is the second wheat growing country after China in the world.

Crop geometry is an ancient agronomic practice. It refers to the spatial arrangement of plants and determines the structure of a given crop community. Non uniform geometry, such as seedling throwing, is aimed at

reducing the labor intensity without concurrent grain yield loss (Peiris, 1956). Contrastingly, uniform geometry, such as row configurations (*e.g.* single, twin, or skip row), is commonly used in large crop production, (*e.g.* corn, sorghum, peanut, soybean, wheat and rice). Such techniques can show marked effects on grain yield if there is efficient weed control (Whish *et al.,* 2005; Mahajan and Chauhan, 2011). Low tillering crops, such as corn and sorghum, see a consistent effect of row configuration. Under favorable conditions, plants arranged in rows with narrow spacing will achieve canopy closure early and maximize both light interception and productivity while reducing the occurrence of weeds. In dry land production systems, wide row spacing increases intra-row competition while providing additional resources in between rows. Early intra-row competition in the plant's life cycle limits the supply of water and nutrients to the plant, thereby suppressing vegetative growth, and delaying access to inter-row reserves of water and nutrients until reproductive growth. In comparison, high-tillering crops like wheat have a more complicated response to both inter and intra-row spacing changes due to their strong tillering ability. In fertile environments, narrow row spacing will cause mutual shading earlier than wide row spacing, thus restricting excess tillering. This progress involves a shortage of carbohydrates, morphogenetic shade-avoidance response, and blue, red, and far-red radiation intensity variations (Luquet *et al.,* 2006; Smith and Whitelam, 1997). Although there is excellent self-regulation by tillering and there exists successful artificial control by row spacing, the effect of row configuration on high-tillering crops is more ambiguous (Chauhan and Johnson, 2010).

Plant stand design is a key parameter for the outcome of weed suppression and grain yield quantity and quality (Kolb *et al.,* 2010;

Kristensen *et al.,* 2008). Recommended seed rates are optimized for the row distance normally used. Increasing the row distance without a seed rate reduction decreases the distance between individual seeds, thereby increasing intraspecific and inter-specific competition between plants. A common assumption is that seed rate should be reduced when row distance is increased, although the optimal magnitude of the reduction is poorly known. Thus, better arrangement of crops with optimum seed rates to agro-ecological condition can be a feasible option in improving the wheat productivity in the in the Northern part of India.

Materials and Methods

An experiment was conducted in sandy loam soil during October to April of 2010-2011 at Students Instructional Farm (SIF) at C.S. Azad University of Agriculture and Technology, Kanpur (U.P.) during Rabi season. Experimental site falls under sub-tropical climate (25^0 56' to 28^0 58' North and longitude 79^0 31' to 80^0 34' East and 125.9 meters above MSL altitude). The seasonal rainfall of about 816 mm received mostly from 2nd Fortnight of June or 1st Fortnight of July to mid October with a few showers in winter season. The soil of experimental site was sandy loam in texture, alkaline in reaction (pH 8.0), and low in organic carbon (Walkley and Black, 0.45%), medium in available nitrogen (alkaline permanganate N, 177 kg ha^{-1}), medium in available phosphorus (Olsen *et al.,* 1954, 19.5 kg ha^{-1}) and available K (Jackson 1967, K 160 kg ha^{-1}). Experiment was laid out in split plot design with total 12 treatment combinations and replicated thrice. The treatment comprises of plant geometry (Broadcasting – M1, 25 cm Spacing – M2, 22.5 cm Spacing – M3 and 20 cm Spacing– M4) and seed rate (100 Kg ha-1 - S1, 125 Kg ha-1- S2 and 150 Kg ha-1 -S3). The crop was sown in the last week of October, 2010.

HUW-234 variety was used for sowing. The crop was harvested on last week of April, 2011. The recommended dose of fertilizer (150:60:40 kg ha^{-1}) were applied, half amount of Nitrogen together with full amount of Phosphorus, Potash and Zinc were applied as basal at the time of sowing in the form of Urea, DAP, MOP and Zinc sulphate respectively. Remaining half dose of nitrogen was top dressed into two split doses at 32 and 56 days after sowing. Each net plot size was 4.50 x 4.0 m (18 m^{-2}).

Results and Discussion

Plant population

The initial plant population significantly higher (132.11 m^{-2}) was recorded under the sowing of plant geometry 20 cm apart than 22.5 cm and 25 cm apart. The significantly differences were not observed among the sowing of 22.5 cm and 25.0 cm apart. The plant population at harvest were recorded (130.66 m^{-2}) higher in sowing at 20 cm apart (Table 1). The minimum plant population were observed under the sowing of 25 cm apart (122.11/m^2). The same results were reported by Tomar and Verma (1980), Prasad (1984).

The seed rate was significantly affected in all the two stage of the crop. The initial plant population higher (129.33 m^{-2}) was recorded under the seed rate of 150 kg ha^{-1}(Table 1). The minimum plant population was recorded (128.50 m^{-2}) under the seed rate 100 kg ha^{-1}. The minimum plant population was recorded (122.33 m^{-2}) under the seed rate of 150 kg ha^{-1}. The same result is reported by Yadav *et al.,* (2001).

Growth attributes

The minimum plant height and dry weight was recorded under the method of broad casting. The plant height and dry weight was not significantly affected due to plant geometry at 30 and 60 DAS days after sowing (DAS). In case of 90 DAS the significantly higher plant height and dry weight was recorded with the sowing 22.5 cm apart (Table 1). The minimum plant height and dry weight was recorded under the sowing of 20 cm apart. Such type result reported by Rao and Bhardwaj (2008) and Yadav *et al.,* (2001).

The maximum plant height (13.66 cm) and dry weight (0.50 g plant^{-1}) was recorded under the sowing 150 kg ha-1 and minimum under the seed rate of 125 kg ha^{-1} at 30 DAS. Similar trends also observed 60 and 90 days after sowing of crop such result was reported by Rao and Bhardwaj (2008) and Jhala *et al.,* (2008).

Yield attributes

The length of ear was maximum under the plant geometry of 22.5 cm apart (9.45 cm) was significantly higher over 20 cm apart (9.12 cm) (Table 2). The number of grain was observed 25 cm (46.66 grain ear^{-1}) wheat was significantly higher over 20 cm (45.41 grains ear^{-1}). The total weight higher at 25 cm apart (45.5 g) significantly higher then broadcasting, these findings are in agreement with Yadav *et al.,* (2001); Makwana and Tank (2008).

The ear length was obtain maximum under the seed rate of 125 kg ha^{-1} (9.30 cm) was significantly higher over 100 and 150kg ha^{-1} (Table 2). The number of grain maximum under 125 kg ha^{-1} of seed rate (45.22 grains ear^{-1}) which was significantly higher over the seed rate of 150 kg ha^{-1} (44.20 grains ear^{-1}). The grain test weight higher under the seed rate of 125 kg ha^{-1} (42.00 g) which was significantly higher than 150 kg ha^{-1} of seed rate (40.55 g) and 100 kg ha^{-1} of seed rate

(41.55 g) (Table 2). Similar result reported by Sukhvinder *et al.,* (2006) and Mahrvar and Asadi (2006).

Yield

The maximum grain yield (41.75 q ha^{-1}) under plant geometry of 22.5 cm apart was significantly higher than 20 cm (40.94 q ha^{-1}) and 25 cm apart (40.61 q ha^{-1}) (Table 2). The straw yield did not affected significantly by plant geometry, however the higher straw yield produce plant geometry with 20 cm (61.11 q ha^{-1}) followed by 22.5 cm apart (59.91 qha^{-1}) and minimum by broad casting plant geometry (55.64 qha^{-1}) (Table 2). The harvest index was significantly affected by plant geometry, however maximum harvest index found under 25 cm apart (45.66%) followed by broadcasting (41.49%). Shrestha *et al.,* (2012) stated that the contribution of individual yield components to the final yield changed with the environmental conditions during their various development stages. Moreover, those exogenous ecological effects may have as stronger influence on final yield totals than genetic control of the individual yield components. Huang *et al.,* (2011, 2013) also reported that spikes per square meter was positively related to grain yield in a range of production regions (low through high), and that the role of ear size should not be ignored if the environment were more favorable for high yields. In accordance with these findings, our results showed that a larger sink size produced more grain. When grain yield was relatively low more effective ears were the main contributors to sink size characteristics were significantly affected by both genetic control and agricultural strategy. Our findings are also in accordance with Goel and Verma (2005) and Meenakshi *et al.,* (2006).

The yield significantly affected by seed rates. The maximum grain yield was produce 125 kg ha^{-1} (45.25 q ha^{-1}) which was higher than 100 kg ha^{-1} (40.14 q ha^{-1}) and 150 kg ha^{-1} (36.68 q ha^{-1}) (Table 2). The straw yield did not affected significantly; however maximum straw yield was produce 150 kg ha^{-1} seed rate (56.91 q ha^{-1}). This results also reported by Reddi and Patel (2003) and Nazir *et al.,* (2005).

Weed dynamics

The population of weeds viz., *Chenopodium album*, *Anagallis arvensis*, *Phalaris minor* and *Cyperus rotundus* were significantly affected by different plant geometer (Table 3). It was also observed maximum weed population found in sowing of crop 25 cm apart and minimum weed population were observed under the sowing of crop 20 cm apart. This finding was also reported by Sanjeev*et al.,* (2008).

The maximum number of weed population viz., *Chenopodium album*, *Anagallis arvensis*, *Phalaris minor* and *Cyperus rotundus* were observed maximum under the seed rate of 100 kg ha^{-1} and minimum number of weed population were also observed under the sowing of 150 kg ha^{-1} of seed rate (Table 3). Such type result reported that Marwat *et al.,* (2011).

Economics

The maximum gross income (Rs 71722 ha-1) was obtained at 22.5 cm part which was higher other plant geometry, broadcasting (Rs 39728ha^{-1}) and 25 cm (Rs 66949 ha^{-1}), however 22.5 cm was significantly higher over broadcasting (Figure 1). The maximum net profit was recorded under the plant geometry 22.5 cm apart at (Rs 51742ha^{-1}) significantly higher than other plant geometry 20 cm apart (45254 Rs ha^{-1}) and 25 cm apart (Rs46865 ha^{-1}). The benefit: cost ratio affected significantly various method of sowing.

Table.1 Effect of plant geometry and seed rates on plant population
and growth attributes of wheat

Treatments	Plant population (m^{-2})		Plant height (cm)			Dry matter production (g/plant)		
	Initial	Final	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Plant geometry								
P1	132.11	130.55	12.83	36.91	88.69	0.25	7.15	13.15
P2	132.11	130.66	13.33	37.83	86.99	0.32	8.15	13.30
P3	126.00	123.11	13.41	38.91	90.12	0.35	8.45	14.15
P4	124.88	124.10	12.93	37.93	89.86	0.37	9.00	14.45
SEm±	0.87	1.32	0.97	0.97	0.94	0.04	0.37	0.42
CD (P=0.05)	2.65	3.99	NS	NS	2.83	0.12	1.15	1.25
Seed rate								
S1	128.50	127.41	13.33	35.23	91.36	0.38	12.15	16.15
S2	128.49	126.41	12.66	36.55	87.95	0.41	10.50	18.30
S3	129.33	127.49	13.66	32.88	87.45	0.50	10.10	20.60
SEm±	1.07	1.06	0.86	0.69	3.77	0.10	0.11	0.71
CD (P=0.05)	NS	NS	NS	2.11	NS	NS	0.34	2.12
Interaction								
P x S (P=0.05)	3.90	3.87	2.10	2.10	2.11	0.22	1.35	2.10

Table.2 Effect of plant geometry and seed rates on yield attributes and yields of wheat

Treatments	Yield attributes			Yield (q ha^{-1})			Harvest index (%)
	Ear length (cm)	1000 grain weight (g)	Grain/ spike	Grain	straw	biological	
Plant geometry							
P1	9.12	40.66	44.75	36.66	58.64	99.62	41.49
P2	8.92	41.33	45.11	40.94	61.11	97.77	39.61
P3	8.92	41.55	45.44	41.75	59.91	102.07	41.014
P4	9.48	42.25	46.35	40.61	48.21	89.99	45.66
SEm±	0.10	0.12	0.28	1.05	0.98	1.45	1.53
CD (P=0.05)	0.29	0.36	0.83	2.94	3.03	4.33	4.57
Seed rate							
S1	9.20	41.55	44.77	40.14	56.04	97.02	41.64
S2	9.30	42.00	45.41	42.28	56.94	97.84	42.00
S3	9.03	40.55	46.16	39.61	57.97	97.23	40.68
SEm±	0.08	0.11	0.18	0.58	1.88	2.96	1.42
CD (P=0.05)	0.25	0.32	0.52	1.73	NS	NS	NS
Interaction							
P x S (P=0.05)	2.10	2.11	2.11	2.10	2.10	2.10	9.86

Table.3 Effect of plant geometry and seed rates on weed population of wheat

Treatments	Weed density (m^{-2})								
	Chenopodium album		*Anagallis arvensis*		*Convolvulus arvensis*		*Phalris minor*		*Cyperus rotundus*
	45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS	
Plant geometry									
P1	6.14	4.48	6.76	4.66	5.06	3.54	6.9	4.54	13.94
P2	6.18	4.24	6.3	4.4	5.2	3.82	6.34	3.66	10.44
P3	5.86	4	5.94	4.3	5.5	3.42	6.34	4.02	13.76
P4	7.34	5.16	6.12	4.14	6.06	4.24	5.78	4.08	10.18
SEm±	0.54	0.62	0.94	0.8	0.64	0.32	0.6	0.36	0.73
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	2.18
Seed rate									
S1	6.3	4.66	6.46	4.48	5.66	3.9	6.32	4.12	12.82
S2	6.38	4.46	6.3	4.32	5.42	3.68	6.32	4.04	12.12
S3	6.4	4.6	6.08	4.32	5.24	3.7	6.38	4.06	11.3
SEm±	0.92	0.68	0.68	0.48	0.92	0.62	0.92	0.64	1.34
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

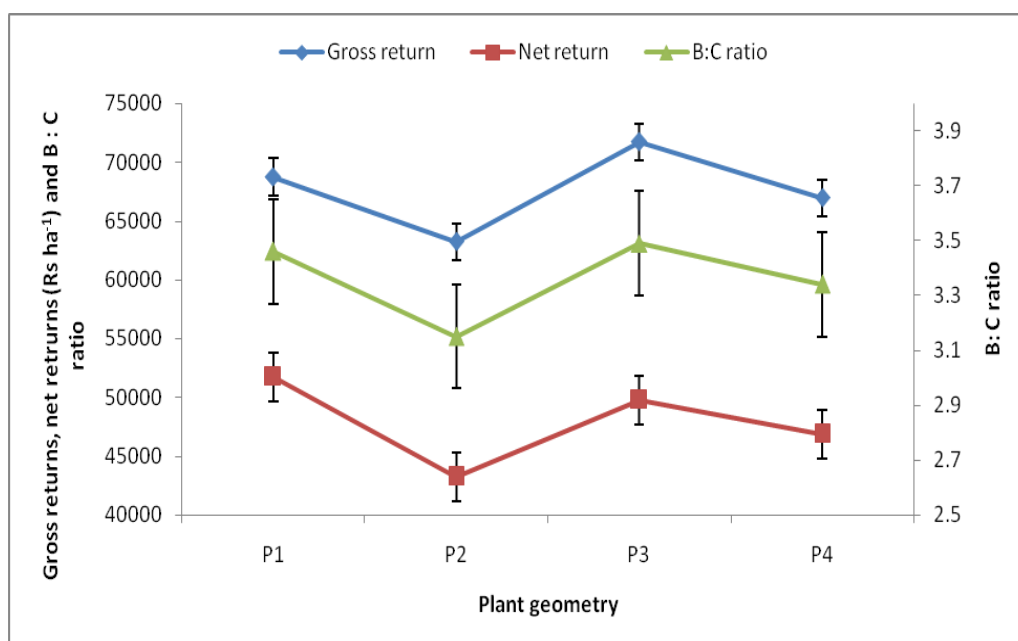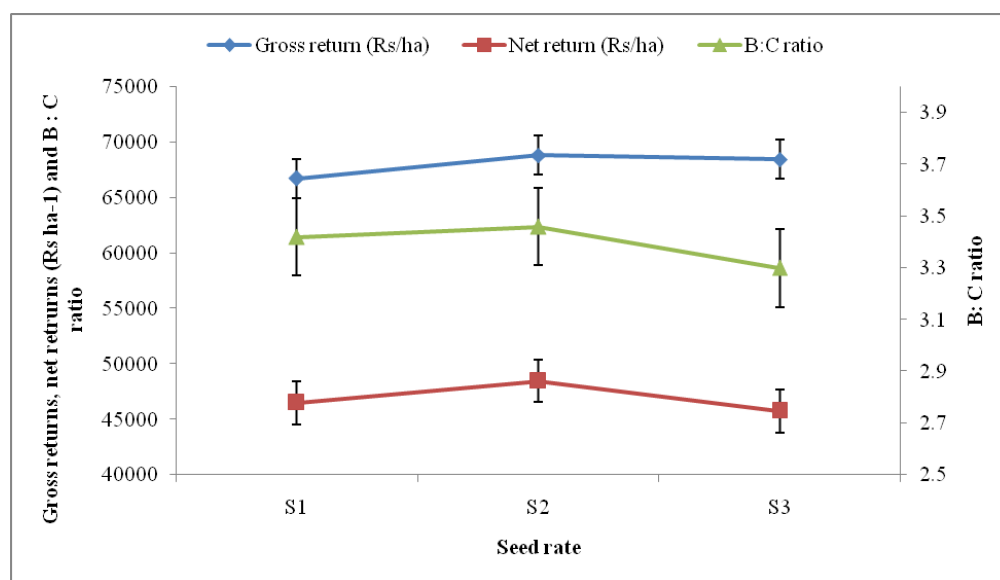**Figure.1** Gross returns based on plant geometry

Figure.2 Gross returns based on seed rate

The higher cost benefit: ratio obtains under the sowing method 22.5 cm apart which is significantly higher (3.49) in compression to 25 cm apart (3.34). The finding is also reported by Meenakshi *et al.,* (2006).

The gross income was significantly affected by seed rate. The maximum gross income (Rs 69522 ha^{-1}) was obtained at 125 kg ha^{-1} of seed rate. It was higher than seed rate of 150 kg ha^{-1} (Rs 68570 ha^{-1}) and 100 kg ha^{-1} (Rs 66729 ha^{-1}) (Figure 2).

The maximum net return was recorded under the seed rate 125 kg ha^{-1} (Rs 47799 ha^{-1}) than other seed 100 kg ha^{-1} and 150kg ha^{-1}. The highest benefit: cost ratio under 125 kg ha^{-1} seed rate which is significantly higher in comparison to 150 kg (3.30).

In conclusion, the results of the present investigation clearly demonstrate that 22.5 cm with 125 kg seed rate can be practiced to achieve better high yield as well as profitability and minimize the weed infestation than other plant geometry and seed rates.

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