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Kuldeep Singh
Division of Agronomy, Faculty of Agriculture, Khalsa College, Amritsar, Punjab, India

Satvir kaur
Division of Agronomy, Faculty of Agriculture, Khalsa College, Amritsar, Punjab, India

Correspondence
Kuldeep Singh
Division of Agronomy, Faculty of Agriculture, Khalsa College, Amritsar, Punjab, India

Effect of different methods of sowing and row orientation on growth, yield and quality of wheat (*Triticum aestivum* L.)

Kuldeep Singh and Satvir kaur

Abstract
A field experiment was conducted during *Rabi* season of 2015-16 at the Students' Research Farm, Khalsa College Amritsar, on sandy loam soil, low in organic carbon and available N, Medium in available P and high in available K. Field experiment was laid out in split plot design comprising four methods of sowing such as (Bed Planting, Zero tillage, Flat drilling, Happy seeder) and two row orientation as (North-South and East-West) replicated four times. Bed planting recorded 14% and 10.48% higher grain yield over happy seeder and zero tillage sowing respectively. Bed planting method produced significantly higher growth characters (i.e. plant height, leaf area index and dry matter accumulation, yield contributing characters effective tillers, grains ear^{-1}, grain and straw yield, harvest index and B C ratio) than happy seeder and zero tillage sowing. Between row orientation, north-south row orientation, produced higher growth and yield attributes than east-west whereas grain yield and biological yield was 3.86% and 3.77% higher than east-west sowing direction respectively.

Keywords: Wheat, sowing methods, row orientation, growth, yield, quality

Introduction
Wheat (T*riticum aestivum* L.) is the premier cereal crop and is the major staple food of the world [1]. Wheat was grown in India on 31 million ha with production of 86.53 million tonnes whereas, in Punjab it covers 3.5 million ha with a production of 15.05 million tonnes [2]. But the average productivity of wheat crop in India and Punjab is 2791.29 kg/ha and 4300 kg/ha respectively which is quite low as compare to the average production of world. At present the natural resources, viz soil, water and environment are under great stress. Mono cropping system of rice-wheat cultivation has further narrow down the benefit cost ratio of the wheat cultivated districts of Punjab. Mono cropping and conventional tillage caused degradation of our soil [3]. Different changes has taken place in soil physical and chemical properties due to different tillage viz. Puddling and other sowing practices. These changes caused in yield reduction, degradation of soil fertility and productivity. If these practices should be in use as such, then soil may become barren and inherent fertility of soil may be lost. So there is need to evaluate different techniques or methods of tillage and sowing to check further decline in wheat production. Plant stand design affects the availability of various factors viz. harvesting of light, availability of water, uptake of nutrients and suppression of weeds. Plant stand design affects many factors such as light interception, water, nutrients and weeds which are crucial for crop production [4]. Methods of sowing constitute an important component of physical environment of soil and therefore, could affect the crop establishment, growth and yield of crops by its impact on plant rooting, soil nutrients and moisture extraction pattern [5]. The conventional practices of soil cultivation are unable to maintaining the soil physico-chemical properties and sustainability. Therefore, the cultivation of various other methods of sowing such as bed planting, happy seeder, flat drilling, zero tillage is need of the day to enhance productivity apart from maintaining sustainability and soil heath. The above experiment was designed to find out the effect of sowing methods and row orientation on growth, yield and quality characters of wheat.

Materials and methods
A field experiment was conducted during *Rabi* season of 2015-16 at the Students' Research Farm, Khalsa College Amritsar (31º 38′ N, 72º 52′ E and 236 metres above mean sea level). The soil was sandy loam, having ph 7.8, organic carbon 0.49, available nitrogen 164.5 kg/ha, phosphorus 19 kg/ha and potassium 347.5 kg/ha in the plough layer. Experiment was laid out in split plot design comprising four methods of sowing such as (T_1 = Bed Planting, T_2 = Zero tillage, T_3 = Flat drilling, T_4 = Happy seeder) and two row orientation as (T_5 = North-South and

T_6 = East-West) replicated four times with gross plot size 4.5 x 4.5 m. A 0.25 m length on either side of the plots was discarded as border, thus net plot size was 3.9 x 3.9 m. After giving primary tillage to selected field, heavy pre sowing irrigation (rauni) was given to whole field. When field reached proper moisture (water) condition the selected field was ploughed twice with cultivars followed by planking to prepare fine seed bed for drilling. Beds are prepared with the help of bed planter of standard size of 67.5cm and remaining field keep without tillage for zero tillage and happy seeder sowing. Wheat variety HD 2967 was used in the experiments @ seed rate of 100 kg/ha and sowing was done on 12 november 2015. All the required agronomic practices were followed uniformly in all the plots through out the growing period. The plots were thoroughly irrigated 25 days interval. The recommended dose of fertilizers were applied. Phosphorus was applied before sowing and nitrogen was applied in three split doses. Nitrogen and phosphorus nutrients were applied in the form of urea and DAP. To check the weed growth one spray of clodinofop 15WP (400 g/ha) and metsolfuron 20 WP (10 g/ha) herbicide was applied after first irrigation. Growth parameters like emergence count, plant height, leaf area index, dry matter accumulation, number of tillers, yield parameters like, number of grains per ear, test weight, grain yield, straw yield, harvest index, quality parameters like N content in grains and straw, protein content in grains and economics study like benefit cost ratio were recorded:

Statistical analysis

Statistical analysis of the data recorded was done as per Split Plot Design [6] using CPCS-1 software developed by the department of Mathematics and Statistics, PAU, Ludhiana. The comparison was made at five per cent level of significance.

Results and discussion

Emergence count: Different sowing methods and row orientations had not significant effect on emergence count per metre row length.

Plant height: The variation in plant height in responsive to the sowing methods and row orientation were significant. Wheat planted by bed planting resulted in taller plants up to 95.42 cm it may be due to the proper establishment of plants in bed planting. N-S row orientation also resulted 2.18 per cent taller plants than E-W. These results are in agreemented with the results reported by Shekhar [7] and Pandey [8].

Dry matter accumulation: Bed planting recorded 8.36 per cent higher dry matter than happy seeder at harvest. It may be attributed due to proper distribution of plants, more height of plants, number of tillers and LAI. N-S row orientation was significantly produce more dry matter than E-W at harvest and recorded 2.63 per cent more dry matter accumulation than E-W row orientation because of more number of tillers in north-south as compare to east-west. These findings are in tune with Radwan [9] and Kumar [10].

Leaf area index: Leaf area index under bed planting was at par with drilling but significantly higher than others. This was due to significantly more plant height observed under bed planting and flat drilling than others. Among the row orientations N-S had significantly (1.51 per cent) more leaf area index than E-W.

Tillers count: Bed planting and drilling were at par with each other but significantly better than other treatments. Bed planting gave 7.98 per cent more tillers per square metre than happy seeder at harvest may be due to better edaphic environment and proper uniform distribution of plants. North-south row orientation was significantly better than east-west row orientation and produce 1.71 per cent more tillers per metre square. This may be due to the better utilization of available resources and photosynthetically active radiation.

Number of grains per ear: Higher mean number of grains per ear were achieved in plants sown with bed planting and under north-south row orientation [11].

Test weight: Test weight under bed planting were 7.41 per cent more than happy seeder. Bed planting was at par with drilling and zero tillage but significantly better than happy seeder. Wheat sown in north-south row orientation gave 2.05 per cent more 1000 grain weight than sown in east-west row orientation [12].

Grain yield: Effect of different methods of sowing on grain yield was significant. Bed planting (41.10 q/ha) was at par with flat drilling (39.36 q/ha) but significantly higher than other treatments. Minimum (36.00 q/ha) yield was observed under happy seeder. There was yield difference of 14 per cent between bed planting and happy seeder. Row orientation also influenced the grain yield significantly, north-south had significantly higher grain yield than east-west. Maximum (39.14 q ha^{-1}) grain yield was under north-south row orientation and minimum (37.70 q ha^{-1}) under east-west row orientation with a difference of 3.86 per cent. This difference was because of better utilization of light and space, thereby improved the growth parameters viz. plant height, LAI, dry matter accumulation and development of yield components such as number of effective tillers, number of grains per ear and thus finally increased grain yield.

Straw yield: Higher straw yield was observed with bed planting (48.00 q ha^{-1}) and lowest in case of happy seeder (45.68 q ha^{-1}). There was 5.07 per cent higher straw yield than happy seeder when crop sown under bed planting. Between row orientation north-south produced significantly more than east-west. Maximum (47.74 q ha^{-1}) straw yield was under north-south row orientation and minimum (46.02 q ha^{-1}) under east-west row orientation with a difference of 3.73 per cent may be due to more plant height, LAI, dry matter accumulation and number of tillers.

Harvest index: Among methods of sowing highest harvest index were recorded under bed planting (46.01) followed by flat drilling (45.20), zero tillage (44.64) and happy seeder (44.05). North-south row orientation had harvest index 45.05 whereas east-west row orientation had harvest index value 45.03.

Nitrogen content in grains and straw: Although the bed planting method of sowing of wheat gave numerically higher nitrogen content than the other sowing methods of wheat and from row orientation north-south had numerically higher nitrogen content both in grains and in straw than east-west, yet it could not reach the statistical level of significance.

Protein content in grains: The data regarding protein content of grain was not significantly influenced by methods of

sowing and by row orientation. The maximum protein content 10.25 per cent was recorded from bed planting method of sowing than others among row orientation north-south gave numerically higher 10.15 per cent protein content than east-west.

Economics: Economics analysis of different methods of sowing and row orientation was calculated by using cost, returns and net income concepts in Rs. ha^{-1} for year 2015-16. The total cost were categorized into six categories i.e. land rent, seed bed preparation, labour, harvest labour, seeds, manure and fertilizer. Net income was estimated from total cost by deducting total costs from total returns. it was concluded that bed planting gave maximum yield hence treatment gave maximum benefit cost ratio (1.59). Among sowing methods zero tillage had minimum total cost of production. North-south row orientation gave maximum benefit cost ratio (1.58) than east-west (1.55).

Conclusion

In the light of aforementioned results it can be safely concluded that bed planting method of sowing and N-S row orientation is optimal for growth, yield and quality of wheat, because the said sowing method distribute seed uniformly and desired depth for seed germination and crop establishment. Further row orientation and sowing methods provide proper distance for optimum sun light penetration for photosynthesis and proper depth to roots for uptake of water and soil nutrients.

Table 1: Effect of different methods of sowing and row orientation on growth attributes of wheat.

Treatments	Growth attributes of wheat				
Methods of sowing	**Emergence count**	**Plant height**	**Dry matter accumulation**	**Leaf area index**	**Tillers count**
Bed planting T_1	32.00	95.42	88.00	3.46	315.66
Zero tillage T_2	31.48	87.82	82.23	3.25	301.80
Flat drilling T_3	31.70	93.19	86.01	3.40	308.82
Happy seeder T_4	31.10	85.03	80.61	3.15	292.32
C.D (0.05)	NS	2.39	2.12	0.14	7.64
Row orientation					
North-south T_5	31.68	91.30	85.31	3.34	307.24
East-west T_6	31.47	89.42	83.12	3.29	302.06
C.D (0.05)	NS	0.50	1.20	0.02	2.89

Table 2: Effect of different methods of sowing and row orientation on yield parameters of wheat.

Treatments	Yield parameters of wheat				
Methods of sowing	**Number of grains per ear**	**Test weight**	**Grain yield**	**Straw yield**	**Harvest index (per cent)**
Bed planting T_1	38.00	35.80	41.10	48.00	46.01
Zero tillage T_2	36.30	33.35	37.20	46.13	44.64
Flat drilling T_3	37.00	35.31	39.36	47.71	45.20
Happy seeder T_4	36.00	33.03	36.00	45.68	44.07
C.D (0.05)	0.68	1.48	2.15	2.02	
Row orientation					
North-south T_5	37.00	34.72	39.14	47.74	45.05
East-west T_6	36.65	34.02	37.70	46.02	45.03
C.D (0.05)	NS	NS	0.88	0.96	

Table 3: Effect of different methods of sowing and row orientation on quality parameters of wheat and economics of study.

Treatments	Quality parameters of wheat Economics			
Methods of sowing	**Nitrogen content in grains**	**Nitrogen content in straw**	**Protein content in grains**	**Benefit cost ratio**
Bed planting T_1	1.64	0.52	10.25	1.59
Zero tillage T_2	1.61	0.49	10.06	1.56
Flat drilling T_3	1.62	0.50	10.12	1.57
Happy seeder T_4	1.60	0.48	10.00	1.52
C.D (0.05)	NS	NS	NS	
Row orientation				
North-south T_5	1.63	0.51	10.15	1.58
East-west T_6	1.60	0.48	10.06	1.55
C.D (0.05)	NS	NS	NS	

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