Environment and Ecology 42 (2A) : 681—686, April—June 2024
Article DOI: https://doi.org/10.60151/envec/JKRM9819
ISSN 0970-0420

Effect of Sowing Direction and Wheat Cultivars on Growth and Yield in Indo-Gangetic Plains of India

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Received 3 October 2023, Accepted 16 March 2024, Published on 6 May 2024

ABSTRACT

A field experiment was carried out during *rabi* season where different wheat cultivars (PBW-343, HUW-234 and NW-1012) and direction of sowing (E-W and N-S) were taken in Factorial Randomized Block Design replicated four times. All the yield attributing characters like number of effective tillers, spike length, number of grains spike^{-1}, grain weight spike^{-1} were significantly higher under East-West direction of sowing over North-South direction of sowing. Among the all cultivars PBW-343 was found significantly superior over NW-1012 and HUW-234. The grain yield, straw yield and light intensity were increased significantly under East-West direction of sowing and among the cultivars PBW-343 recorded significantly higher value of above characters over NW-1012 and HUW-234. Maximum heat unit requirement and days taken to 50% ear emergence and maturity was recorded under North-South direction of sowing and among the cultivars it was found maximum in PBW-343. The maximum net return and B:C ratio were obtained in E-W direction of sowing along with PBW-343 cultivar. Thus it may be revealed that sowing in East-West direction with cultivar PBW-343 was found most suitable for cultivation under Indo-Gangetic Plains of India.

Keywords Cultivars, Direction of sowing, Light intensity, Wheat, Yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most prominent growing crop belonging to the family Gramineae (Poaceae). Due to its prominent position and high production in the international food grain trade it is known as 'King of Cereals'. It is a staple food of the world. Wheat is a C_3 plant primarily grown in temperate regions and also at higher altitude under tropical climatic areas in winter season. Wheat ranks first in the world among the cereals both in respect of area and production. Globally, wheat occupies around 220 m ha area, holding the highest position of acreage among all crops with an annual production of 764.4 million tons with the average productivity of 3.53 tonnes/ha. India is the second largest producer of wheat after the China, and has been growing in about 29.32 mha (14% of total global area) to produce 103.6 million tonnes of wheat (12.92% of world production) with a record average productivity of 3.53 tons/ha in 2019-20 (USDA 2020).

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For improvement in the wheat crop production it is very important to introduce varieties with a high yield potential. In India, numbers of wheat varieties are cultivated but due to fast changing ecosystem these varieties become susceptible to different insects, pests, diseases and less input responsive which cause a decline in yield. It was thus decided to generate a steady flow of new varieties, deriving resistant from diverse sources, to replace the old varieties for sustainable higher production. Wheat revolution was used with the introduction of high yielding dwarf varieties which need high level of management.

A good crop production depends upon the two types of input. First is monetary and second is non-monetary input. Monetary inputs like seed rate, tillage operation, amount of fertilization, amount of irrigation, amount of herbicide that is used to achieve higher yield. Non-monetary inputs like, proper sowing date, direction of sowing, time of irrigation and fertilizer application, are also important factor for crop production of wheat. In north-western and central part of the country the wheat is generally grown in winter season because it requires cool climate during the early part of its growth and development. The crop growth and yield of wheat crop is adversely affected due to any environmental stresses such as high temperature, soil moisture deficit, low light intensity and among these stresses high temperature is the crucial one of decline the production and productivity (Kajla *et al*. 2015).

In minor changes in temperature regimes during the developmental stages it highly influence the quality and yield of wheat (Sandhu and Dhaliwal 2018). Due to climate change affect it shrinking the cooling period. Within the growing season itself, warmer temperature shortens the total crop duration. Sandhu and Dhaliwal (2018), observed that intercepted PAR and total biomass production was found a linear relationship between it. A good agronomic technique that produce both a high level of intercepted radiation and a high rate of conversion of intercepted PAR to grain or the economical part to provide good yield and high economic return. East-West (E-W) sowing direction increased yield over north-south (N-S) direction of sowing in an average season. Due to weed competition, decline in yield found, but no effect on weed competition found due to row direction. Sowing in E-W direction may give a better yield benefit with no difference in weed seed set (Cook *et al.* 2015). Keeping these aspects in view, this study was planned to find out the better direction of sowing and better cultivars of wheat crop.

MATERIALS AND METHODS

A field experiment was planned to conduct during *rabi* season of 2016-17 at Agromet Research Farm of Narendra Deva University of Agricultural and Technology, Kumarganj, Ayodhya (UP) India. Geographically, the experimental site falls under sub humid, sub-tropical climate of Indo-Gangetic alluvial plains having alluvial calcareous soil (26.47º North latitude and 82.12º East longitudes with an altitude of 113 meters above the mean sea level). The weekly mean minimum and maximum temperatures were 4.9 to 25.3°C and 18.0 to 39.6°C. Total rainfall received was 17.5 mm, total evaporation was 1033.9 mm, relative humidity was 18.2 to 88.2%, and sunshine hours were 1.0 to 9.5 hrs, during the entire crop season, respectively. The soil of the experimental site was silt-loamy texture and it has slightly alkaline in reaction (8.2 pH), low in organic carbon (0.37%) and available nitrogen (194.3 kg/ha), medium in available phosphorus (15.2 kg/ha) and potassium (250.3 kg/ha). Sowing was done on 29 November 2016. Healthy and viable seeds were selected @ 100 kg seed/ha keeping spacing between row 20 cm apart with the help of seed drill. Uniform dose of 120 kg Nitrogen, 60 kg P_2O_5 and 40 kg K_2O/ha was applied at basal and Urea, Di-ammonium phosphate (DAP) and muriate of potash were used as fertilizer sources. Half dose of nitrogen and full dose of P_2O_5 and K_2O were applied at the time of sowing as a basal dose. Rest amount of nitrogen was applied as in two splits 1/4 after first irrigation or 30 DAS and 1/4 dose of nitrogen was applied after second irrigation. The crop was harvested manually by serrated edged sickles on 25th April 2017.

The experiment was carried out in Factorial Randomized Block Design with (A) three cultivars viz., HUW-234 (V_1), PBW-343 (V_2) and NW-1012 (V_3) and two direction of sowing viz., East-West direction (S_1) and North-South direction (S_2) and replicated four times.

Light intensity was measured by Lux meter.

$$LI (\%) = \frac{\text{LI at top of canopy} - \text{LI at bottom of canopy}}{\text{LI at top of canopy}} \times 100$$

Where, LI = Light intensity.

Heat unit requirement or Growing Degree Days (GDD) was measured by fallowing formula (Nuttonson 1995).

$$\text{Accu. GDD} = \sum \frac{T_{max} + T_{min}}{2} - T_b$$

Where, T_{max} and T_{min} are the daily maximum and minimum temperature. 'T_b' is the base temperature below which physiological activities are ceased. For wheat crop 'T_b' is considered as 5°C.

Heat Use Efficiency (HUE (g/m^2/°Days)) = Total dry matter (g/m^2)/heat unit requirement (°days).

Cost of cultivation for different treatments were worked out by considering all the expenses incurred in the cultivation of experimental crop and added with variable cost due to treatments. Gross return was worked out by multiplying grain and straw yield separately under various treatments to their existing market price. The money value of both grain and straw yield was added together in order to achieve gross return (US $/ha). Net return was calculated by deducting the cost of cultivation from the gross return of the individual treatments. Benefit : Cost ratio was calculated by dividing net return by cost of cultivation of treatment. The critical difference was found by using p=0.05 that shows the results were significantly different (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Time taken to 50% ear emergence and maturity were significantly affected by direction of sowing and different wheat cultivars (Table 1). Maximum days (93.6 days) taken to 50% ear emergence and maturity (132.5 days) recorded in cultivars PBW-343 and minimum time taken to 50% ear emergence (90.9 days) and maturity (125.1 days) in cultivar Malviya-234. Variation in time taken to 50% ear emergence among cultivars might also be probably due to their genetic characters as well as climatic requirement of the different cultivars. Maximum time (93.0 days) taken to 50% ear emergence and maturity (129.8 days) recorded in N-S direction and minimum time taken to 50% ear emergence (90.8 days) and maturity (126.8 days) in E–W direction. Variation in time taken to 50% ear emergence and maturity among cultivars might also be probably due to hot air passed between the plant row lead to early maturity in E-W direction while N-S direction of sowing act as barrier of hot air flowing between the row of crop. The results are corroborated with Maurya *et al.* (2014).

Yield was the resultant of co-ordinated interplay of yield attributes. Vigorously growing plants are able to absorb larger quantity of mineral nutrients through well-developed root system. The PBW-343 gave higher number of tillers/m^2, length of spike and number of grain/spike than other cultivars (Table 1). It might be due to the genetic character of the variety like more reproductive tillers producing capacity, more spike length. Minimum yield contributing characters were credited to Malviya-234. It was due to less reproductive tillers, less spike length as well as less number of grains/spike. The results were in conformity with those of Madhulika *et al.* (2015).

The yield contributing characters viz., number of effective tillers, spike length, number of grains/spike and grain weight/spike increased with E–W direction. Reduction in weed biomass and increase in crop yield likely resulted from the increased light (photosynthetically active radiation) interception by crops oriented East–West (i.e., light interception by the crop canopy as opposed to the weed canopy was 28 and 18% greater in wheat and barley crops oriented East–West, compared with North–South crops). Similar research findings were reported by Borger and Pathan (2010).

The data presented in Table 1 revealed that 1000-grain weight was not influenced significantly by cultivars and with the direction of sowing. Different cultivars tested during experimentation could not reach to the level of significance in increasing the test

Table 1. Effect of direction of sowing on days taken to 50% ear emergence, days taken to maturity, yield and yield attributing characters of wheat cultivars.

Treatment	Days taken to 50% ear emergence	Days taken to maturity	Number of spikes/m^2	Spike length (cm)	No. of grains /spike	Grain weight/ spike (g)	1000-grain weight	Grain yield (t/ha)	Straw yield (t/ha)
Cultivars									
Malviya 234	90.88	125.13	347.75	8.50	47.38	1.99	39.40	3.56	4.88
PBW–343	93.63	132.50	393.13	10.40	53.30	2.26	41.92	4.49	5.55
NW– 1012	91.25	127.13	367.88	9.11	49.50	2.05	40.04	3.98	5.21
SEm±	0.77	1.13	6.87	0.18	0.94	0.05	1.20	0.11	0.14
CD at 5%	2.33	3.52	20.72	0.55	2.83	0.15	NS	0.33	0.41
Direction of sowing									
E–W	90.83	126.75	397.75	9.69	52.02	2.27	41.66	4.27	5.49
N–S	93.00	129.75	341.42	8.98	48.10	1.93	37.01	3.78	4.93
SEm±	0.63	0.95	5.61	0.15	0.77	0.04	0.98	0.10	0.11
CD (p=0.05)	1.90	2.88	16.92	0.45	2.31	0.12	NS	0.30	0.34

Table 2. Effect of direction of sowing on light intensity and heat unit requirement of wheat cultivars.

Treatment	Accumulated heat unit								Heat use efficiency
	Emergence	CRI	Tillering	Jointing	Ear emergence	Milking	Dough	Maturity	(g/m^2/^{0}days)
Cultivars									
Malviya–234	75.9	227.8	445.7	604.9	946.0	1210.7	1404.6	1607.0	1.90
PBW–343	78.1	231.6	453.3	613.5	913.2	1231.6	1420.8	1781.7	1.78
NW–1012	75.8	230.3	450.7	607.3	907.4	1212.9	1415.2	1653.0	1.80
Direction of sowing									
E–W	76.6	229.5	445.5	598.1	907.0	1202.4	1388.3	1646.2	1.69
N–S	76.6	230.3	454.3	619.0	937.4	1234.4	1438.4	1715.0	1.97

weight. The direction of sowing also did not influence the test-weight significantly.

The data pertaining to grain and straw yield has been presented in Table 1 and it was found that the grain and straw yield was affected significantly due to cultivars and direction of sowing. Among varieties, the maximum grain (4.49 t/ha) and straw yield (5.55 t/ha) was recorded in PBW–343. The reason behind this may be because of good plant stand, more number of spike bearing tillers, long shoots head and more number of grains/spike. Minimum grain (3.56 t/ha) and straw yield (4.88 t/ha) recorded with Malviya–234 due to less number of spike bearing tillers, small shoots head and less number of grains/ spike. Similar findings were obtained by Maurya *et al.* (2014) and Madhulika *et al.* (2015).

The grain and straw yield significantly increased by direction of sowing having higher yield in E–W direction (4.27 t/ha) than the N-S direction (3.78 t/

Table 3. Effect of direction of sowing on solar light interception of wheat cultivars.

Treatment	Light intensity (%)			
	30 DAS	60 DAS	90 DAS	120 DAS
Cultivars				
Malviya–234	50.4	69.1	72.0	73.5
PBW–343	51.8	74.4	80.0	82.6
NW–1012	51.4	70.9	73.0	75.0
Direction of sowing				
E–W	52.2	75.0	80.1	82.1
N–S	50.2	68.0	70.5	71.7

Table 4. Effect of direction of sowing on economics of wheat cultivars.

Treatment	Cost of cultivation (US $/ha)	Gross return (US $/ha)	Net return (US $/ha)	B:C ratio
Cultivars				
Malviya–234	640.94	1264.27	623.34	0.97
PBW–343	640.94	1546.28	905.34	1.41
NW–1012	640.94	1393.60	752.66	1.17
Direction of sowing				
E–W	640.94	1481.85	840.91	1.31
N–S	640.94	1320.91	679.97	1.06

ha). This might be due to more spike length, number of grains/spike, grain weight/spike, maximum solar radiation interception and cooling effect. Straw yield also significantly influenced by direction of sowing having higher yield in E–W direction (5.49 t/ha) than the N-S direction. This may be probably due to higher tillers and increased rate of dry matter accumulation.It corroborated with results of Madhulika *et al.* (2015).

Heat unit requirement of wheat cultivars at different phenophases as affected by different wheat cultivars and direction of sowing have been presented in Table 2. The maximum heat unit (GDD) requirement from emergence to maturity stages were recorded 1781.7°C days in PBW-343 while minimum accumulated growing degree days from emergence to maturity stages 1607.0°C days was observed in Malviya-234. Maximum GDD/heat unit requirement from emergence to maturity stage 1715.0°C days were obtained under N-S direction while minimum GDD was obtained under E–W direction (1646.2 °C days) due to delayed maturity. The results are corroborated with Sandhu and Dhaliwal (2018) and Seif and Saad (2015).

Light interception of wheat cultivars at different phenophases as affected by different wheat cultivars and direction of sowing have been presented in Table 3. The light intensity of wheat cultivars from 30 DAS to 90 DAS were recorded 80.0% in PBW-343 while minimum light intensity 72.0% was observed in cultivar Malviya-234. The light interception of wheat cultivars from 30 DAS to 90 DAS were recorded 80.1 % in E–W direction while minimum light interception 70.5% was observed in N-S direction. Sandhu and Dhaliwal (2018) and Pal *et al.* (2021) reported similar trends of results.

The data presented in Table 4, revealed that similar cost of cultivation (US $ 640.94/ha) was computed at cultivars with both direction of sowing. The maximum gross return (US $ 1546.28/ha), net return (US $ 905.34/ha) and B:C ratio (1.41) was recorded in PBW-343. The minimum gross return (US $ 1264.27/ha), net return (US $ 623.34/ha) and B:C ratio (0.97) was found in Malviya-234.

The higher gross return (US $ 1481.85/ha), net return (US $ 840.91/ha) and B: C ratio (1.31) was recorded in East-West direction of sowing as comparison to lower gross return (US $ 1320.91/ha), net return (US $ 679.97 .94/ha) and B:C ratio (1.06) recorded in North–South direction of sowing.

Based on the results obtained, it can be concluded that E–W direction of sowing with PBW-343 is a better variety and direction of sowing of wheat because it reduces days taken to maturity and promotes yields and yield attributing characters like number of spikes/m^2, spike length (cm), number of grains/spike, grain weight/spike (g) and it has also absorbed high light intensity and finally it provided good monetary return with high B:C ratio.

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