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Effect of Sowing Methods and Irrigation Levels on wheat (*Triticum aestivum* L.)

Satybhan Singh, Virendra Singh*, Ramesh Pal, Himanshu Trivedi, Ashesh Narayan and Mohit Gautam

School of Agricultural Sciences & Engineering, IFTM University, Moradabad 244 102, U.P., India

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ABSTRACT

The field experiment was carried out at agricultural research farm of IFTM University Moradabad (U.P.), India during rabi season 2018-19 to study the effect of sowing methods and irrigation levels on wheat. Sowing method and irrigation being a major constraint to reduces the potential of wheat yield. The treatments were arranged in split plot design in three replications, sowing methods in main plots and irrigation levels in sub-plots. The experiment treatments included two sowing methods, i.e. [S_1 – conventional sowing method and S_2 - furrow irrigated raised bed (FIRB) system] in main plots and six irrigation levels [I_0 – (control), I_1 – (one irrigation at CRI stage), I_2 – (two irrigation at CRI and tillering stage), I_3 – (three irrigations at CRI, tillering and late jointing stage), I_4 – (four irrigations at CRI, tillering, late jointing and milking stage) and I_5 – (five irrigations at CRI, tillering, late jointing, milking and dough stage). Wheat crop was sown by traditional method and furrow irrigated raised beds (FIRB) method. Raised beds were accommodating 3 rows of wheat at 20 cm wide. Furrows that are in between the beds are used for irrigation. This system permits adequate saving of irrigation water. Results indicated that sowing of wheat on FIRB system surpassed the conventional method of sowing for plant height, number of tillers plant$^{-1,}$ dry weight (g plant^{-1}), number of effective tillers plant^{-1}, spike length, number of grain spike^{-1}, 1000 grain weight, grain yield, straw yield and biological yield followed by conventional sowing method. On the other hand irrigation levels I_5 - (five irrigations at CRI, tillering, late jointing, milking and doughing stage) recorded the highest values for most of growth, yield components and yield of wheat. In FIRB system beds gave the opportunity for mechanical weeding and fertilizer placement and also improved the fertilizer and water use efficiencies. The role of sowing methods and level of irrigation in plant health and growth has been investigated in crop and it seemed significantly affecting with treatment.

Key words: *Wheat, Sowing methods, FIRB, Irrigation levels, Growth and yield*

Introduction

Wheat (*Triticum aestivum* L.) belongs to the poaceae family and widely cultivated for its seed, it is one of the leading cereal grain which is a worldwide staple food. Wheat is one of the most widely cultivated cereal crop which ranks first followed by rice in world. In 2020, world production of wheat was 761 million tonnes, making it the second most-produced cereal after maize (FAO, 2014). Since 1960, world production of wheat and other grain crops has tripled and is expected to grow further through the middle of the 21st century (Godfray, 2010). Wheat is preferable than rice for its higher seed protein content and it is an important source of carbohydrates (Shewry and Hey, 2015). Wheat is world's major cereal crop, which was cultivated near about 216.6 million hectares with a production of 674.88 million tonnes with the productivity of 3115 kg ha^{-1} (2012-13). In 2020, world wheat production was 761 mil-

Corresponding author's email: virendra.singhed@gmail.com

lion tonnes, led by China, India, and Russia collectively providing 38% of the world's total production (FAO 2022). India's ranks first in area coverage (29.90 m ha) followed by China (24.13 m ha), while in production China stands first with the production of 120.50 million tones and India ranks second with the production of 94.8 million tonnes. The share of Wheat in total food grain production is around 36.25% and share in area is about 24.83%of the total area under food grains. In the domestic scenario, the states *viz.* Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, Bihar, Haryana, West Bengal, Maharashtra and Gujarat have been the major wheat growing states in the country. In India, Uttar Pradesh has the largest acreage and highest production of wheat (Anonymous, 2016).Wheat is also known as the 'King of Cereals' due to its acreage occupies, high productivity and the dominant position it holds in the international food grain trade FAO (2017).

About 30% of wheat production is lost due to lack of irrigation water (Uddin *et al.*, 2016 and Sarker *et al.*, 2018). For the successful growth of wheat, proper irrigation is very important especially at crown root initiation (CRI) stage, and it has a significant impact on higher grain yield (Randhawa *et al*., 2004). The furrow-irrigated raised bed (FIRB) system was developed and is being promoted by the Rice-Wheat Consortium of the CGIAR Institutes. In FIRB system, wheat is sown on raised beds accommodating 2 or 3 rows of wheat. Between the beds, furrows are formed that are used for irrigation. This system permits adequate saving of irrigation water. The yield obtained are similar to or more than conventional seeding method. The FIRB technology has potential to reduce the cost of cultivation and also to minimize dependence on herbicides for weed control. Feasible agronomic benefits of beds are improve soil structure, reduce water logging and timely machinery operations due to better surface drainage. Beds also create the opportunity for mechanical weed control and improved fertilizer placement (Singh *et al*., 2002).

The objectives of the experiment were to evaluate the sowing methods and irrigation levels on growth and grain yield of wheat and also find out the best treatment combination to increase the grain yield.

Materials and Methods

A field experiment was conducted during rabi season 2018-19 at experimental farm of IFTM University, Lodhipur Rajput, Delhi Road NH-24, Moradabad, Uttar Pradesh lies between 28°21' N, 78°4' E and 119.23 m above mean sea level in the heart of the vast Indo-gangetic plains of India. The soil of the experimental site was sandy loam in texture, having pH7.0 with 0.30 per cent of organic carbon. The treatments were comprised of two methods of sowing viz., conventional system (flat bed sowing in line 22 cm apart) and furrow irrigated raised bed system (FIRBS) with accommodating 3 rows per bed 20 cm apart; six irrigation levels viz., [I_0 – (control), I_1 – (one irrigation at CRI stage), I_2 – (two irrigation at CRI and tillering stage), I_3 – (three irrigations at CRI, tillering and late jointing stage), I_4 – (four irrigations at CRI, tillering, late jointing and milking stage) and I_5 – (five irrigations at CRI, tillering, late jointing, milking and dough stage)]. The experiment was laid out in split-plot design replicated thrice having combination of sowing methods in main plots and irrigation levels in the subplots. The field was well prepared by applying 3-4 ploughings followed by planking both under conventional sowing as well as FIRBS. However, under FIRBS, beds were prepared after field preparation and then it was followed by wheat sowing in second pass. Wheat variety *HD 2967* was sown on 12 December 2018 at 5-6 cm seeding depth using 100 kg seed ha^{-1} with the help of seed cum fertilizers drill under conventional sowing and with the help of bed planter under FIRBS. The half dose of nitrogen was applied as basal and remaining half was applied in two splits after sowing whereas phosphorus and potash was drilled uniformly as basal dose as per the state recommendations. To find out the effect of different sowing methods and irrigation levels, numbers of observations were recorded on growth and yield components of crop.

Data were subjected to the analysis of variance (ANOVA) appropriate for split-plot design and the treatment means were compared by the critical difference (CD) at 5 per cent level of significance.

Results and Discussion

Growth Parameters

Sowing Methods

Sowing methods were found significant on the plant height, number of tillers $plant^{-1}$, dry matter accumulation (g $plant^{-1}$) of wheat and the results are pre-

sented in Table 1. Though, the both sowing methods were statistically at par for plant height. However, maximum plant height (84.55 cm) at harvesting stage was attained under S_2 – [furrow irrigated raised bed (FIRB) system] in comparison to (80.11 cm) under S_1 – (conventional sowing method). Maximum number of tillers (8.04 plant^{-1}) were found under S_2 – [furrow irrigated raised bed (FIRB) system]. Among the methods FIRB system crop produced higher number of tillers than the conventional sowing method. Similar trends was followed in case of dry weight (99.17 g plant^{-1}) in S_2 – [furrow irrigated raised bed (FIRB) system] as compared to conventional sowing method (82.84 g plant^{-1}). It may be attributed due to the beds are improved soil structure, more soil moisture conserved in root zone, reduced water logging and induced the root system of wheat. Ultimately all growth parameters were increased. Hossain *et al.* (2006) was also reported the same findings.

Irrigation Levels

Irrigation levels had significant effect on plant height, number of tillers plant^{-1}, dry matter accumulation (g plant^{-1}) of wheat and the results are presented in Table 1. The maximum plant height at harvest stage (84.53 cm) was recorded with the application of I_5 – (CRI, tillering, late jointing, milking and dough stage) while the minimum (79.28 cm) was under control. All the irrigation levels were statistically at par for number of tillers plant^{-1}. However, the application of I_5 – (CRI, tillering, late jointing, milking and doughing stage) attainted maximum number of tillers plant^{-1}(8.05).

The application of five irrigation also enhanced the dry matter accumulation (101.15 g plant^{-1}) over the rest levels of irrigation. Water is a main constituent of plant protoplasm and its adequate supply is essential for cell division and cell elongation. Therefore, optimum availability of water with the application of I_5 – (CRI, tillering, late jointing, milking and dough stage) to wheat crop might have enhanced the photosynthetic activity of plants that cumulatively contributed to higher plant height, number of tillers plant^{-1} and dry matter accumulation of the crop. The results are in close conformity with those already reported by Jalota *et al*. (2006), Sarwar *et al*. (2010), Kharrou *et al*. (2011) and Kumar *et al.* (2019).

Yield attributes

Sowing Methods

The analysis of variance of data indicated that sowing methods had significant effect on yield attributing characters of wheat, *viz*. number of effective tillers plant^{-1}, spike length, number of grains spike^{-1} and test weight (Table 2). The maximum number of effective tillers (5.24 plant^{-1}), spike length (9.36 cm), number of grains spike^{-1} (54.26) and test weight (38.53 g) were registered under the S_2 – [furrow irrigated raised bed (FIRB) system]. Whereas, minimum number of effective tillers (4.01 plant^{-1}), spike length (8.03 cm), number of grains spike^{-1} (46.51) and test weight (35.21 g) were recorded under S_1 – (conventional sowing method). The furrow irrigated

Table 1. Growth parameters of wheat as influenced by sowing methods and irrigation levels

Treatments	Plant height (cm) at harvesting stage	No. of tillers plant^{-1} at harvesting stage	Dry weight (g plant^{-1}) at harvesting stage
Sowing methods			
S_1 - Conventional Sowing Method	80.11	6.43	82.84
S_2 - Furrow Irrigated Raised Bed (FIRB) system	84.55	8.04	99.17
SE m±	0.69	0.09	0.073
CD at 5%	4.57	0.51	0.476
Irrigation levels			
I_0 - Control (No irrigation)	79.28	6.13	79.47
I_1 – CRI	82.64	6.93	88.00
I_2 - CRI, Tillering	82.53	7.30	90.25
I_3 - CRI, Tillering, late jointing	83.49	7.40	92.50
I_4 - CRI, Tillering, late jointing, Milking	81.51	7.60	94.67
I_5 - CRI, Tillering, late jointing, Milking, Doughing	84.53	8.05	101.15
SE m±	0.99	0.19	1.465
CD at 5%	2.94	0.55	4.353

raised bed (FIRB) system facilitates optimum moisture level, better fertilizers placement and reduced crop lodging which increases the growth and development of plants and enhanced photosynthetic efficiency by improving source-sink relationship of the plants foremost higher growth and development reflected by higher yield attributes of plants. Same findings were also reported by Dhillon *et al.* (2005), Kabir *et al.* (2009), Mollah *et al.* (2009), Gupta *et al.* (2010) and Kumar *et al.* (2019).

Irrigation Levels

Irrigation levels had significant effect on yield attributes of wheat, *viz.* number of effective tillers plant^{-1}, spike length, number of grains spike^{-1} and test weight (Table 2). The maximum number of effective tillers (5.73 plant^{-1}), spike length (9.99 cm), number of grains spike^{-1} (55.46) and test weight (38.99 g) were recorded under the application of I_5 - (CRI, Tillering, late jointing, Milking and Dough stage). Whereas, minimum number of effective tillers (4.06 plant^{-1}), minimum spike length (6.49 cm), less number of grains spke^{-1} (40.01) and minimum test weight (32.27 g) were recorded under I_0 - (control). It may be attributed due to the application of five irrigation to wheat crop facilitate optimum moisture level for maximum growth and development of the plants which improved photosynthetic efficiency by improving source-sink relationship of the plants leading higher growth and development reflected by higher yield attributes of plants. These results are in accordance with those of Maqsood *et al*. (2002), Sarwar *et al*. (2010), Ali *et al*. (2012), Mubeen *et al*. (2013) and Kumar *et al.* (2019).

Yield

Sowing Methods

Results revealed that sowing method had significant effect on yield of wheat (Table 3). The maximum grain yield (4.85 t ha^{-1}), straw yield (7.37 t ha^{-1}) and biological yield (12.22 t ha^{-1}) of wheat were recorded with S_2 – [furrow irrigated raised bed (FIRB) system] as compared to grain yield (3.83 t ha^{-1}), straw yield (5.83 t ha^{-1}) and biological yield (9.67 t ha^{-1}) with S_1 – (conventional sowing method). The harvest index of wheat was found non-significant with different sowing methods.Among the sowing methods, FIRB planting produced higher grain yield as compared to conventional sowing. It may be attributed due to the FIRB planting gives better crop stand, better interception of solar radiation, modified micro-climatic conditions due to the adjustment of the crop geometry on the beds resulting in significant improvement in yield attributing characters (number of effective tillers, spikes length, number of grains spike^{-1} and test weight), reduced lodging and insect-pests incidence owing to reduced canopy humidity which finally contributed towards enhanced crop yield. These results are also supported by Angiras (1984), Limon-Ortega *et al.,* (2000), Rinwa (2003), Kumar *et al.* (2004), Kabir *et al.* (2009) and Kumar *et al.* (2019).

Irrigation Levels

Results indicated that irrigation levels had significant effect on wheat yield (Table 3). The maximum grain yield (5.17 t ha^{1}), straw yield (7.86 t ha^{-1}) and

Table 2. Yield attributes of wheat as influenced by sowing methods and irrigation levels

Treatments	No. of effective tillers plant^{-1}	Spike length (cm)	No. of grains spike^{-1}	Test weight (g)
Sowing methods				
S_1 - Conventional Sowing Method	4.01	8.03	46.51	35.21
S_2 - Furrow Irrigated Raised Bed (FIRB) system	5.24	9.36	54.26	38.53
SE m±	0.13	0.05	1.04	0.47
CD at 5%	0.86	0.32	6.84	3.10
Irrigation levels				
I_0 - Control (No irrigation)	4.06	6.49	40.01	32.27
I_{1-} CRI	4.42	8.47	48.12	36.02
I_2 - CRI, Tillering	4.49	8.69	51.64	37.27
I_3 - CRI, Tillering, late jointing	4.52	9.10	52.86	37.97
I_4 - CRI, Tillering, late jointing, Milking	4.51	9.43	54.23	38.78
I_5 - CRI, Tillering, late jointing, Milking, Dough	5.73	9.99	55.46	38.99
SE m±	0.21	0.30	1.00	0.45
CD at 5%	0.62	0.89	2.97	1.34

maximum biological yield (13.03 t ha^{-1}) of wheat were recorded with the application of I_5 – (CRI, tillering, late jointing, milking, dough stage) as compared to control and other levels of irrigation. The harvest index (%) of wheat was found non-significant with different irrigation levels. The higher yield of wheat with the application of I_5 – (CRI, tillering, late jointing, milking, dough stage) may be attributed due to the higher photosynthetic activity of plants due to optimum soil moisture for all the metabolic activities which leads to greater growth and development of the plants. Whereas moisture stress in crops due to shortage of water may cause a decrease in translocation of carbohydrates, disturb nitrogen metabolism and forced maturity. These results are in conformity with the findings of Sarwar *et al*. (2010), Yadav *et al.* (2010), Rahim *et al*. (2010) and Kumar *et al.* (2019).

Economics

Sowing Methods

Among the sowing methods, the highest cost of cultivation (Rs. 26063/- ha^{-1}), gross returns (Rs. 100727/- ha^{-1}), net returns (Rs. 74664/- ha^{-1}) and B: C ratio (2.86) were recorded with S_2 – [furrow irrigated raised bed (FIRB) system] (Table 4). Whereas, minimum values for cost of cultivation (Rs. 23846/-ha^{-1}), gross returns (Rs. 79643/- ha^{-1}), net returns (Rs. 55797/- ha^{-1}) and B: C ratio (2.34) were recorded under S_1 – (conventional sowing method).The higher profitability of wheat might be the main reason for higher net returns under S_2 – [furrow irrigated raised bed (FIRB) system] as compared to S_1 – (conventional sowing method). These results are in conformity with those already reported by Hassan *et al.* (2005) and Abdul *et al.* (2015).

Table 3. Yield of wheat as influenced by sowing methods and irrigation levels

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	H.I. (%)
Sowing methods				
S_1- Conventional Sowing Method	3.83	5.83	9.67	39.68
S_2- Furrow Irrigated Raised Bed (FIRB) system	4.85	7.37	12.22	39.63
SE m±	0.09	0.11	0.20	0.11
CD at 5%	0.59	0.73	1.32	N.S.
Irrigation levels				
I_0- Control (No irrigation)	3.46	5.34	8.80	39.32
I_1 – CRI	3.74	5.71	9.45	39.62
I_2- CRI, Tillering	4.35	6.54	10.89	39.96
I_3 - CRI, Tillering, late jointing	4.59	6.94	11.54	39.80
I_4 - CRI, Tillering, late jointing, Milking	4.73	7.22	11.96	39.58
I_5 - CRI, Tillering, late jointing, Milking, Doughing	5.17	7.86	13.03	39.65
SE m±	0.22	0.34	0.56	0.19
CD at 5%	0.66	1.01	1.67	N.S.

Table 4. Economics of wheat as influenced by sowing methods and irrigation levels

Treatments	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{1})	Net return (Rs ha^{-1})	B: C ratio
Sowing methods				
S_1- Conventional Sowing Method	23846/-	79643/-	55797/-	2.34
S_2- Furrow Irrigated Raised Bed (FIRB) system	26063/-	100727/-	74664/-	2.86
Irrigation levels				
I_0- Control (No irrigation)	23171/-	71918/-	48747/-	2.10
I_1- CRI	24351/-	77836/-	53485/-	2.20
I_2- CRI, Tillering	24531/-	90289/-	65758/-	2.68
I_3 - CRI, Tillering, late jointing	25211/-	95389/-	70178/-	2.78
I_4 - CRI, Tillering, late jointing, Milking	25891/-	98353/-	72462/-	2.80
I_5- CRI, Tillering, late jointing, Milking, Doughing	26571/-	107326/-	80755/-	3.04

Irrigation Levels

Among the irrigation levels, the highest cost of cultivation (Rs. 26571/- ha^{-1}), gross returns (Rs. 107326/- ha^{-1}), net returns (Rs. 80755/- ha^{-1}) and B: C ratio (3.04) were recorded under I_5 - (CRI, Tillering, late jointing, Milking, Dough stage). Whereas, minimum values for cost of cultivation (Rs. 23171/- ha^{-1}), gross returns (Rs. 71918/- ha^{-1}), net returns (Rs. 48747/- ha^{-1}) and B: C ratio (2.10) were recorded under I_0 - (control). The higher crop productivity might be the principal reason for higher net returns with application of I_5 – (CRI, Tillering, late jointing, Milking, Dough stage) compared to other levels of irrigation. Similar results were also reported by Parihar and Tiwari (2003) and Kumar *et al.* (2019).

Conclusion

On the basis of experimental findings, it may be conclude that the furrow irrigated raised bed (FIRB) system with five irrigation at CRI, tillering, late jointing, milking and dough stages was best treatment for production of wheat. This treatment has given more monetary returns. It may be further concluded and suggested to wheat farmers of this region that the use of furrow irrigated raised bed (FIRB) system with five irrigation at CRI, tillering, late jointing, milking and dough stages should be used in wheat crop for better productivity and higher economic returns in sustainable manner.

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