The Pharma Innovation Journal 2022; 11(2): 1803-1806

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 1803-1806

www.thepharmajournal.com
Received: 01-11-2021
Accepted: 07-12-2021

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Performance of various cultivars of wheat (*Triticum aestivum* L.) under irrigation levels at different growth stages in indo-gangetic plains

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Abstract
The present study was carried out at the student's instructional farm of CSA University of Agriculture and Technology, Kanpur, (U.P.) during *Rabi* season of 2015-16. The experiment was conducted under split plot design with three replications, treatments comprising of two irrigation levels (I_1- CRI, Booting and Milking stages and I_2-CRI, Maximum Tillering, Booting and Milking stages) in main plots, two varieties (K-402 and K-1006) in sub-plots. Results of present study revealed that four irrigation CRI, Maximum Tillering, Booting and Milking stages shown its superiority in plant height, fresh weight and dry weight, total no of spike per meter length, Grain weight per panicle, test weight. It was also revealed from the data that four irrigation CRI, Maximum Tillering, Booting and Milking stages shown its superiority in grain yield (5.15 t ha^{-1}), straw yield (7.38 t ha^{-1}) and gross return (USD 1678.1 ha^{-1}) net return (USD 1109.2 ha^{-1}) and B:C ratio (1:2.5).

Keywords: Irrigation, CRI, Booting, Tillering, Milking

Introduction
Wheat (*Triticum aestivum* L.) belonging to family poaceae is the single most important cereal crop, that has been considered as integral component of the food security system of several nations. It is important staples of nearly 2.5 billion (36%) of world population and improvement in its productivity has played a key role in making the country self-sufficient in food grains. Worldwide, it provides nearly 55% carbohydrates and 20% food calories. Wheat is consumed mostly in the form of bread as "Chapati". Wheat straw is used for feeding the cattle. Wheat contains more protein than other cereals and has relatively high content of Niacin and Thiamine. It is basically concerned in providing the characteristics substance "Glutien" which is very essential for bakery (Sharma and Sendil, 2016) [8]. The cultivation of wheat crop about 30 m ha (14% of global area) and produce highest output of 99.70 m tonnes of wheat (13.64% of world) with the average productivity of 3371 kg ha^{-1} (MoA&FW, 2018) [2]. In India, Uttar Pradesh (32.59 m tonnes) is highest producer of wheat followed by Madhya Pradesh (19.61 Mt), Punjab (17.57 Mt) etc. (Agricultural Statistics at a Glance, 2020) [1]. Irrigation plays an important role in exploiting yield potential of high yielding wheat varieties. Advantage of optimum dose of fertilizer application is possible only under assured irrigated condition. It has been well established that dwarf wheat produce their potential yields when it is irrigated at all critical stages of plant growth *viz*. crown root initiation, late tillering and jointing, flowering, milk and dough stages. In most wheat growing state like Uttar Pradesh, sufficient and assured irrigation water is not available for irrigation at all critical stages, so is the main reason for low productivity of wheat in the state.

Materials and Methods
Climate conditions: The field experiment was conducted at students' instruction at farm of the C.S. Azad University of Agriculture and Technology, Kanpur. The field selected for experiment was well leveled and homogenous fertility having irrigation facility of tube well. The soil of experimental field was sandy loam in texture and neutral in pH. The climate of Kanpur is sub-tropical, semi-arid with hot dry summer and severe cold in winter. Maximum temperature during summer reaches up to 46 ^oC, while during winter it fall up to 4 ^oC. The mean annual precipitation of the district is about 815.6 mm which is mostly received in the month of July to mid-September with occasional few showers of cyclonic rains during

December and January. The total rainfall received 5.60 mm during crop growth period.

Cultivars details

Two varieties were used (i) K-1006 is a new high yielding variety of wheat developed by CSA University of Agriculture and Technology, Kanpur, suitable NW Indo-gangetic plain zone that including state like eastern U.P., Bihar, West Bengal, Jharkhand & Assam. It has consistently shown high degree of resistant to yellow rust, brown rust and black rust are most common disease that are found in wheat crop. (ii) K-402 (Mahi) was released from CSA University of Agriculture and Technology, Kanpur (U.P.). The variety is recommended for Punjab, Haryana, Rajasthan and West U.P. etc. The varietal characters possess plant height varies between 80–90 cm, average days for maturity is 130–135 and test weight ranges 38–40 gm. This variety also characterized as heat tolerant.

Experimental details

This experiment included scheduling of two irrigation levels and two cultivars. The experiment was evaluated in split plot design with three replications. In each treatment, nitrogen was applied 50% as basal and remaining 50% in two split as top dressing at as CRI stage and tillering stage. The required quantity of phosphorous and potassium was applied at the time of sowing in all the treatments. After pre–sowing irrigation, at proper moisture condition of soil, three ploughing were done with tractor drawn harrow followed by planking to achieve good tilth. The sowing of wheat seed (var. K-402, K-1006 @100kg/ha) is done with desi plough on 28 November 2015. The spacing between row kept 20 cm and depth of sowing was 4-5 cm. The irrigation was applied on physiological stages of crop growth. The irrigation depth was kept as 6 cm for all the irrigation treatment. The irrigation was applied at CRI stage on-21 December 2015, maximum tillering stage-15 January 2016, botting stage-10 February 2016, milking stage-1 March 2016. Harvesting of crop was done manually with sickle at maturity on 5 April 2016.

Results and Discussion

Growth attributes

It is evident from the data showed in Table 1 that the Initial plant population of wheat crop does not show significantly difference to various scheduling of irrigation was applied to the wheat crop. Plant height (96.0 and 96.3 cm) of wheat at different physiological stages of crop growth was significantly influenced by different scheduling of irrigations. Application of irrigation water to wheat at Irrigation at crown root initiation (CRI) + maximum tillering (MT) + booting (BT) + milking (MK) Stages produced significantly tallest plants at all stage of crop growth as compared to other scheduling of irrigations (Table 1). The possible reason could have been attributed that adequate supply of soil moisture to plant at its four critical stages might have increased the succulence in the meristematic cells and maintained turgor with favored better proliferation of leaf buds and plant height as compare to that under stressed conditions with irrigation given at CRI + BT + MK Stage. Similar results have been reported by Mandal *et al.,* (2005) [3].

Plant fresh weight (351.9 g m^{-2}) of wheat at different physiological stage of crop growth was significantly influenced by different scheduling of irrigation application of irrigation water to wheat growth at CRI + MT + BT + MK Stage produced significantly highest plant weight (96.3 cm) at all the stages of crop growth as a compare to other irrigation scheduling (Table 1). Dry weight (71.8 g m^{-2}) of wheat at different physiological stage of crop growth was significantly influenced by different scheduling of irrigation application of irrigation water to wheat growth at CRI + MT+ BT + MK Stage produced significantly highest plant weight at all the stages of crop growth as a compare to other irrigation scheduling (Table 1). Greater number of irrigations and more water supply with irrigation at CRI + MT + BT + MK Stage might have stimulated the plants to have quick cell division and cell elongation of nodes and internodes results in higher fresh and dry matter production. These results are in close conformity with the findings of Mandal *et al.,* (2006) [4].

Yield attributes

No. of spikes square meter (55.74) significantly influenced by different scheduling of irrigation. Significantly higher no. of spikes per meter length of wheat was produced with four irrigation given at CRI + MT + BT + MK stage as compare to irrigation applied at three stage CRI + BT + MK. Earlier and frequent supply of irrigation water with four irrigations applied at CRI + MT + BT + MK stage might have been responsible for better pollen maturity and fertilization, which results in greater number of spikes per meter length as comparison to three irrigation applied at CRI + BT + MK stage. The similar results have also been reported by Mubeen *et al.,* (2013) [6].

Grain weight per panicle (2.72 g) of wheat was significantly influenced by different scheduling of irrigation. Significantly maximum grain weight per panicle of wheat was produced with four irrigation given at CRI + MT + BT + MK stage as compare to irrigation applied at three stage CRI + BT + MK. Minimum grain weight per panicle of wheat was obtained in three irrigation applied at CRI + BT + MK stage. It might be due to the fact that timely irrigation given to wheat plant is helpful to increase grain weight of panicle in comparison to delayed irrigation. Similar observations are also reported by Youssef *et al.* (2013) [9].

Table 1: Growth and yield attributes of wheat under different irrigation levels

Particulars	Irrigation at CRI + BT + MK Stage	Irrigation at CRI + MT + BT + MK Stage
Growth attributes		
Plant population (no. m^{-2})	263.1	263.9
Plant height (cm)	96.0	96.3
Fresh weight (g m^{-2})	350.7	351.9
Dry weight (g m^{-2})	69.9	71.8
Yield attributes		
No. of spike m^{-2}	55.07	55.74
Grain weight per panicle (g)	2.46	2.72
1000-grain weight (g)	45.51	46.34

Significant increase in number of spike m^{-2}, length of ear per plant, number of grains per ear and higher 1000-grain weight obtained with four irrigation might have resulted in significantly higher grain yield. Significantly tall plants, more fresh weight per plant, dry matter accumulation per plant and higher no. of shoots were obtained with four irrigation at CRI+ MT + BT + MK stages as compared to three irrigations applied at CRI + BT + MK stages might have led to the significant increase in straw yield. The increase in the grain yield with the increase in the number of irrigation was followed with the proportionate increase in dry matter production. The variation in harvest index values among the treatments was possibly thus minimized. Similar observations are also reported by Meena *et al.* (2015) [5]. Various scheduling of irrigation significantly influenced test weight of wheat. Four irrigations applied at CRI + MT + BT + MK Stage produced higher test weight (46.34 g) of wheat as compare to three irrigation applied at CRI + BT + MK Stage. It could be due to the fact that the plant under adequate moisture condition with four irrigations given in CRI + MT + BT + MK Stage might have produced sound and bolder seed thereby increasing the 1000-grain weight of seeds as compared to the three irrigation given at CRI + BT + MK Stage. These results are in agreement with those reported by Sharma and Ashok (2014) [7].

Yield

Various scheduling of irrigation significantly influenced the grain yield of wheat. Significantly higher grain yield (5.15 t ha^{-1}) of wheat was obtained with four irrigation applied at CRI + MT + BT + MK stages of crop growth as compared to three irrigation given at CRI + BT + MK stages.

Table 2: Yield, economics and moisture studies of wheat under different irrigation levels

Particulars	Irrigation at CRI + BT + MK Stage	Irrigation at CRI + MT + BT + MK Stage
Yield		
Grain yield (t ha^{-1})	4.97	5.15
Straw yield (t ha^{-1})	6.42	7.38
Biological yield (t ha^{-1})	11.38	12.53
Harvest index (%)	43.68	41.07
Economics		
Cost of cultivation (USD* ha^{-1})	654.4	673.8
Gross return (USD ha^{-1})	1559.2	1666.8
Net return (USD ha^{-1})	904.8	992.9
B:C Ratio	1:2.38	1:2.47
Moisture studies		
Consumptive use of water	40	42
Total water use	553.4	558.4
Water use efficiency (WUE)	8.99	9.22

*1 USD rate- 70 Indian Rupees

Various scheduling of irrigation significantly influenced the straw yield of wheat. Significantly highest straw yield (7.38 t ha^{-1}) of wheat was obtained with four irrigation applied at CRI + MT + BT + MK stages of crop growth as compared to three irrigation given at CRI + BT + MK stages. Various scheduling of irrigation significantly influenced the biological yield of wheat. Significantly highest biological yield (12.53 t ha^{-1}) of wheat was obtained with four irrigation applied at CRI+ MT + BT + MK stages of crop growth as compared to three irrigation given at CRI + BT+ MK stages. Application of four irrigation given at CRI + MT + BT + MK stages recorded maximum harvest index of wheat, which was significantly at per that crop was irrigated four stages more than three irrigation stages.

Economics

Four irrigation applied at CRI + MT + BT + MK stages registered maximum total cost of cultivation (673.8 USD ha^{-1}) of wheat followed by irrigation given at three stages CRI + BT + MK of crop growth. Gross return (1666.8 USD ha^{-1}) and net return (992.9 USD ha^{-1}) registered maximum for irrigation applied at four stages. Benefit: cost ratio (1:2.47) of wheat produced maximum with irrigations applied at CRI + MT + BT + MK stages as compared to irrigation applied at CRI + MT + BT + MK stages. The increase in gross return and net return in irrigation applied at four stages might be due to increase in grain and straw yield of wheat.

Moisture studies

The varying levels of irrigation had profound effect on consumptive use of water. Increased irrigation levels had higher consumptive water use efficiency (9.22) as compared to lower irrigation levels. Total water use and water use efficiency were maximum with irrigation given at CRI + MT + BT + MK stages followed by irrigation applied at three stages CRI + BT + MK.

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