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Growth behaviour of wheat varieties under restricted irrigation

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Abstract
Water management issue has taken on vital importance and has been at the forefront of world political-economic debates. India has already come into the shadow of the physical & economic water scarcity zone. As wheat is a rabi crop, application of water to the crop through irrigation plays an imperative role for the survival as well as optimum growth and development of wheat crop. Keeping these points in to consideration, the present study entitled "Performance of wheat varieties under restricted irrigation" has been planned to conduct at university research farm BAU, Sabour during 2019-20, rabi season including eighteen treatment combinations of three levels of irrigation in main plot viz. (I_1- No irrigation), (I_2- One irrigation at CRI stage), (I_3-Two irrigation at CRI and boot leaf stages) and six wheat varieties in sub plots. Among different levels of irrigation, maximum plant height, LAI, dry matter accumulation was recorded under two irrigations (I_3) given at CRI and boot leaf stages which was statistically at par with one irrigations (I_2) given at CRI stage. Wheat varieties also differed significantly in respect to dry matter accumulation at all progressive growth stages. Regarding the different wheat varieties, HD 3171 recorded maximum dry matter accumulation at all growth stages followed by DBW 252. The maximum dry matter accumulation (1001.7 g/m^2) was recorded from variety HD 3171 at harvest stage, whereas minimum dry matter accumulation at harvest stage (920.0 g/m^2) was obtained from variety K 1317.

Keywords: boot leaf stage, leaf area index (LAI), wheat, Irrigation, varieties

Introduction
Wheat (*Triticum aestivum* L.) is the most important rabi season cereal grown in our country. It is an annual, hexaploid (6n = 42) crop, belongs to the family *Poaceae* and is most widely cultivated cereal crop of the world which ranks first (30% of all cereals) followed by rice (27%) and maize (25%). It is the crop grown in all the six continents contrary to rice which is grown mostly in Asia. Globally, wheat is cultivated over an area of about 215.44 million hectare with production of 730.90 million ton with a productivity of 3392 kg ha^{-1}. China ranks first position followed by India in both area and production. In India, area under wheat cultivation is 29.65 m ha with a production of 99.87 m ton having productivity 3368 kg ha^{-1}. In India, U.P ranks first in area and production while Punjab ranks first in productivity. In Bihar, area under wheat cultivation is 2.10 m ha with production 6.15 m ton having average yield 2922 kg ha^{-1} (USDA, 2018-19) [3]. Water is essential at every developmental phase starting from seed germination to plant maturation to harvest for the maximum potential yield of wheat. But excess irrigation may also lead to heavy vegetative growth and shortening of reproductive period and ultimately decrease in yield. However, this crop is highly sensitive to water stress during the CRI and flowering. Proper time of irrigation especially during crown root initiation stage is very important for successful growth and higher yield of wheat. Irrigation missing at some critical growth stages, sometimes, drastically reduce grain yield due to lower test weight. Hence, Scheduling of irrigation, which is a process to check when to irrigate the crops & how much water to apply, is one of the important managerial activities which affect the productive & efficient utilization of water by crops. It improves agricultural production with minimizing yield loss due to water shortage & improving performance & sustainability of any irrigation system through conserving water. There are six critical growth stages of wheat i.e. CRI, tillering, booting, anthesis, soft dough & hard dough stage at which water scarcity adversely affect the crop growth and yield. Irrigation scheduling of wheat is based on these phonological stages. Though, more than 70% area under wheat cultivation in India is said to have irrigation facility. But, the entire area of the country do not have assured irrigation as most of the canals in India fail to supply irrigation water adequately during winter

season. However, even under limited supply of irrigation water or in rainfed condition, farmers have no choice to grow cereal other than wheat in rabi season due to their preference to grow wheat. This make a very large area in India where wheat is cultivated under limited irrigation supply. Thus, timing the length of irrigation interval with the stages of crop growth might bring about a reduction in the number of irrigations and results in an economic crop yield. Previous studies have reported better growth and productivity of wheat under restricted irrigation. Rahim *et al.* (2010) [7] observed that when three irrigations were given at CRI, booting and grain development stages, higher yield of wheat was obtained as compared to two irrigations at CRI and grain development stages. Gora *et al.* (2017) [4] reported that four irrigations at CRI, Maximum tillering, Booting and at Milking stage showed positive effects on plant height, grain yield, straw yield and gross return, net return & B:C ratio.

Material and Methods

Experimental Site

The field experiment was carried out in the wheat section of the experimental farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India in *rabi* season during 2019-20. The experimental plots had uniform topography with homogeneous fertility. The geographical location of Bihar Agricultural University, Sabour, Bhagalpur comes under the Middle Gangetic plain region of Agro-climatic Zone III (A) in Bihar. It is situated between 25°50' N latitude and 87°19' E longitude at an altitude of 37.19 meters above mean sea-level. Cool and dry climate along with bright sunny days prevailed at Sabour, Bhagalpur during the crop season. The maximum temperature varied from 17.4 - 32.2 °C and the minimum temperature ranged from 5.8 - 20.5 ^{0}C during the rabi crop season, 2019-2020. The lowest temperature recoded in the 3rd standard week during the month of January, 2020. The temperature during dry season of the year of experimentation remained conducive for the growth and yield of crop**.** The data of rainfall recorded from the meteorological observatory showed that during experimentation, the crops received a well distributed total rainfall of 54.6 mm which is favorable for the crop particularly grown without irrigation.

The field experiment was laid out in split plot design replicated thrice. Altogether, there were 18 treatment combinations consisting of 6 varieties and 3 levels of irrigation. Out of the two test factors, the levels of irrigation were put under main plots and different wheat varieties were placed in sub-plots. The selected wheat varieties for the study were DBW252, HD 3171, HI 1612, HD 2888, HD 3293 and K 1317. These are timely sown as irrigated wheat varieties.

Data were collected on plant height, number of tillers, dry matter accumulation and leaf area index. The Plant height was measured from randomly selected plant in each plot with the help of meter scale from the base of the plant to top of the plant at 30, 60, 90, DAS and at harvest stage leaving border rows. The mean height of the plants for each plot was determined from the measured values by using statistical analysis. Number of tillers at progressive growth stages viz., 30, 60, 90 DAS and at harvest was counted from 1m length of a row at three places in each plot and the average number of tillers m^{-2} was worked out for each plot. Randomly selected plant samples from 25 cm row length were uprooted from two different places in border rows of sub-plots. After sun drying the samples, these were kept in an oven at 60 ± 5 ^{o}C till the weight reaches to constant value to get the total dry matter production, the observation was finally calculated as dry weight of plants per square meter and were taken at all progressive growth stages viz., 30, 60, 90 DAS and at harvest.

Leaf area index: Following formula was used to calculate leaf area index as suggested by Watson (1952).

Leaf area index (LAI) = Leaf Area (cm^2)/Ground area (cm^2) x 100

Further, it was measured by using Ceptometer at 30, 60, 90 DAS.

Result and Discussion

Effect of restricted irrigation on growth parameters of wheat varieties

It is clear from result that different irrigation levels influenced growth parameters. With increasing level of irrigation up to two levels, plant maintained greater height, more number of tillers and maximum value of dry matter accumulation at all progressive growth stages. Of these, the dry matter accumulation assumed more importance, because all other vegetative characters are contained in it. The effect of different levels of irrigation significantly influenced the plant height at progressive growth stages except at 30 DAS (Table 1). Significantly the highest plant height at 60, 90 DAS and at maturity was recorded in the plants receiving two irrigations (I_3) given at CRI and booting stages of crop growth. The corresponding figures of plant height at different growth stages were 66.02 cm, 102.11 cm and 105.67 cm, respectively. Increase in plant height with increasing levels of irrigation could be possible due to maintenance of constant water application to the plants, which helps in maintaining different metabolic processes. The present finding in this respect also find confirmation from the works of Brahman *et. al*. (2007) [2] and Rahman *et. al*. (2016) [8]. In case of varieties plants of variety HD 3171 was found to be the tallest at all the growth stages. While, the plants height of variety HI 1612 was observed to be the shortest one at all the corresponding growth stages. Plant height of all wheat varieties increased with increasing levels of irrigation at all progressive growth stages might be due to the variation of genetic characters among the different wheat varieties as well as healthier plant growth with adequate amount of nutrient having no moisture stress. The findings are in support to those of Thompson and Chase (1992) [10] who reported that levels of irrigation significantly influenced the plant height.

The irrigation levels affected the number of tillers/m^2 significantly at all the stages of crop growth except at 30 DAS (Table 2). At advance stages, (60 DAS, 90 DAS at maturity stages) number of tillers/m^2 increased with increasing the levels of irrigation. The number of tillers/m^2 increased from 30 to 60 DAS, then after it decreased slightly due to mortality of few tillers. At maturity the number of tillers again went down due to mortality of tillers. The maximum number of tillers/m^2 at 60 DAS (358.2) was recorded under I_3, two irrigations given at CRI and booting stages and its minimum value (309.5) with no irrigation. It might be due to irrigations given to crops at important critical growth stages, viz. CRI and boot leaf stages. Due to this the constant moisture level maintained all the metabolic processes which led to profuse tillering. Similar findings were also reported by Aslam *et al.* (2014) [1] and Kumar *et al*. (2015) [5].

Leaf area index at 60 and 90 DAS of crop influenced significantly by different irrigation levels (Table 3). However, at 30 DAS of crop growth leaf area index was not affected by

levels of irrigation which might be due to similar and slower growth rate at initial crop age. It is quite evident from the data that leaf area index increased successively till 60 DAS under different irrigation levels. Among the irrigation levels, two irrigations recorded significantly higher leaf area index at 60 DAS and 90 DAS as compared to one and no irrigation however, one irrigation showed statistical parity to two irrigation level. Due to availability of moisture, LAI increased with increasing levels of irrigation contributed to formation of more number of green leaves and increase in size of leaves, etc., led to higher leaf area and leaf area index. The lowest LAI was recorded under no irrigation. It is very clear that leaf expansion is normal, if relative water content around 90 to 100 percent. If it falls below 70-75 per cent, leaf expansion stops, cell expansion is more influenced by moisture stress than cell division. The present investigation also finds support from the reports of Saren *et al*. (2004) [9] and Rahman *et al*. (2016) [8]. In case of variety, maximum mean value of leaf area index at 90 DAS were recorded from the wheat variety HD 3171 (3.32), which was statistically at par with wheat variety DBW 252.

The dry matter production was significantly influenced by different levels of irrigation (Table 4). However, it was non significantly varied at 30 DAS. Among various growth stages, the highest value of dry matter was recorded at maturity stage. The rate of increase in dry matter production was observed more between 30 to 60 DAS followed by 60 to 90 DAS and 90 DAS to harvest stage, respectively. Higher dry matter accumulation was recorded under two irrigations which was at par with one irrigation but significantly superior over plant grown with no irrigation at all successive growth stages. Increase in dry matter production might be due to increase in plant height, LAI and nutrient uptake through adequate moisture supply contributed for full turgidity and opened leaves, which increased the photosynthetic activity of crops, resulting higher dry matter accumulation while under one and no irrigation lack of optimum moisture, resulted in reduction in the plant height, LAI and nutrient uptake led to reduced photosynthetic activity which ultimately decreased the dry matter accumulation. The findings are in support to those of Saren *et al.* (2004) [9] and Kumar *et al*. (2012) [6]. In case of different wheat varieties, the dry matter accumulation in the plants of variety HD 3171 was found to be maximum which was at par with the variety DBW 252 and were markedly higher than rest of the varieties under test.

Table 1: Effect of restricted irrigation on plant height (cm) of wheat varieties

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At maturity
Main plot - Irrigation levels				
I1- No irrigation	20.51	58.78	93.00	96.11
I2- Two irrigation at CRI stage	21.09	63.62	98.56	101.72
I3- Two irrigation at CRI and boot leaf stage	21.17	66.02	102.11	105.67
SEm±	0.60	1.48	1.95	1.68
CD (P=0.05)	NS	5.83	7.67	6.58
Sub plot – wheat varieties				
V1- K 1317	19.56	62.36	96.44	98.44
V2- HD 3171	27.08	67.94	104.33	107.89
V3- DBW 252	22.33	61.50	99.33	102.67
V4- HD 3293	17.33	61.56	95.33	98.89
V5- HI 1612	18.00	60.22	93.78	97.22
V6- HD 2888	21.22	63.28	98.11	101.89
SEm±	0.72	1.67	2.50	2.49
CD (P=0.05)	NS	4.83	7.21	7.19
I X V	NS	NS	NS	NS

Table 2: Effect of restricted irrigation on number of tillers at different growth stages of wheat varieties

Treatments	No of tillers			
	30 DAS	60 DAS	90 DAS	At maturity
Main plot - Irrigation levels				
I1- No irrigation	232.1	309.5	304.0	252.4
I2- One irrigation at CRI stage	246.6	351.5	345.6	262.94
I3- Two irrigation at CRI and boot leaf stage	262.6	358.2	351.4	266.52
SEm±	8.1	6.3	6.5	3.17
CD (P=0.05)	NS	24.9	25.6	10.98
Sub plot – wheat varieties				
V1- K 1317	205.9	316.9	309.7	295.3
V2- HD 3171	276.4	361.2	355.2	342.3
V3- DBW 252	268.8	351.2	345.8	309.2
V4- HD 3293	227.2	326.9	321.3	318.9
V5- HI 1612	263.9	343.7	338.4	321.9
V6- HD 2888	240.3	338.4	331.6	316.7
SEm±	5.9	9.1	8.9	10.3
CD (P=0.05)	16.9	26.3	25.6	29.6
I X V	NS	NS	NS	NS

Table 3: Effect of restricted irrigation on leaf area index of wheat varieties

Treatments	Leaf Area Index		
	30 DAS	60 DAS	90 DAS
Main plot - Irrigation levels			
I1- No irrigation	0.71	2.02	2.56
I2- One irrigation at CRI stage	0.73	2.33	3.28
I3- Two irrigation at CRI and boot leaf stage	0.74	2.39	3.39
SEm±	0.02	0.06	0.07
CD (P=0.05)	NS	0.24	0.27
Sub plot – wheat varieties			
V1- K 1317	0.70	2.35	3.11
V2- HD 3171	0.77	2.49	3.32
V3- DBW 252	0.71	2.43	3.26
V4- HD 3293	0.72	2.20	3.09
V5- HI 1612	0.73	2.01	2.80
V6- HD 2888	0.71	1.99	2.87
SEm±	**0.02**	**0.07**	**0.09**
CD (P=0.05)	**0.05**	**0.21**	**0.26**
I X V	**NS**	**NS**	**NS**

Table 4: Effect of restricted irrigation on dry matter accumulation (g m^{-2}) of wheat varieties

Treatments	Dry matter accumulation (g m^{-2})			
	30 DAS	60 DAS	90 DAS	At maturity
Main plot - Irrigation levels				
I1- No irrigation	108.1	301.4	616.1	785.3
I2- One irrigation at CRI stage	109.8	320.1	718.6	1024.4
I3- Two irrigation at CRI and boot leaf stage	111.6	330.6	728.6	1080.8
SEm±	2.4	6.7	14.3	21.1
CD (P=0.05)	NS	26.4	56.1	83.1
Sub plot – wheat varieties				
V1- K 1317	106.7	301.1	665.0	920.0
V2- HD 3171	116.3	340.0	710.0	1001.7
V3- DBW 252	111.2	326.1	698.9	983.9
V4- HD 3293	107.00	303.9	676.7	940.0
V5- HI 1612	109.4	318.0	688.9	972.2
V6- HD 2888	108.3	315.2	687.2	963.3
SEm±	3.0	9.4	16.1	12.5
CD (P=0.05)	8.6	27.1	46.6	36.2
I X V	NS	NS	NS	NS

Conclusion

From the observation it could be concluded that two irrigations at crown root initiation and booting stages produced highest plant height maximum number of tillers/m^2, leaf area index and dry matter accumulation **of** wheat. Among six varieties tested, variety HD 3171 performed best in terms of growth attributes followed by variety DBW 252.

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