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Economization of irrigation schedule in wheat (*Triticum aestivum* L.) cultivation under sub-Himalayan plains of West Bengal

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ABSTRACT

A field experiment was carried out in sub-humid agro-climate of terai zone of West Bengal during rabi seasons of 2009-10 and 2010-11 to assess the performance of wheat genotypes under restricted irrigation. The experiment was laid out in split-plot design with three levels of irrigation and eight wheat genotypes in main and sub plots, respectively. It was revealed that the plant height and biomass production of all the genotypes increased significantly with increase in number of irrigations. Among the levels of irrigation, plots receiving five irrigations recorded maximum number of earhead m^{-2} (251.92) and number of grains earhead^{-1} (42.67). However, the yield attributes recorded under five irrigations were on par with treatment of three irrigations. Application of irrigation water at CRI, tillering and booting stages produced 26.24 per cent higher grain yield compared with single irrigation at CRI stage. Further increase in irrigation level did not increase the yield significantly. Among the genotypes, HD 2967 registered the maximum yield (38.95 q ha^{-1}). The consumptive use increased with increase in number of irrigations. The maximum WUE (10.6 kg ha^{-1} mm^{-1}) was achieved with three irrigations. The moisture contribution of upper layer (0-15 cm) also increased with increase in number of irrigations, Though higher yield and net return were realized under five irrigations, the maximum benefit-cost ratio(1.77) was recorded with three irrigations indicating the cost incurred towards extra two irrigations did not result in considerable yield increase.

***Keywords* :** Economics, restricted irrigation, water productivity, wheat

Wheat occupies a prominent place as an important crop contributing 40 per cent of the total foodgrain production in the country. In *terai* region of West Bengal, wheat is grown in about 25.7 thousand hectares. However, wheat productivity in this zone (1905 kg ha^{-1}) is very low (Anon., 2010).The sowing of the crop gets delayed due to late harvesting of medium to long duration *kharif* paddy. Even after harvesting of paddy, the soil remains saturated with moisture due to receipt of late monsoon rainfall in high intensity and the farmers of this region have to wait for another 15-25 days so that the soil moisture comes to optimum condition for wheat sowing. Among the various factors influencing grain yield, availability of water and weed management are of supreme importance. Water is the key input for all recommended agronomic practices and therefore efficient utilization of irrigation water is essential for wheat. Technological advances are needed to reduce excess nutrient application by improving nutrient use efficiency and reducing losses (Bellido and Bellido, 2001).

In *terai* region of West Bengal, the monsoon shower starts with high intensity in the month of June and continues upto October. During these 4-5 months period, the zone receives high rainfall of 2200-2500 mm. This huge rainfall is highly effective in ground water recharge and there remains a scope to grow *rabi* crops utilizing the residual moisture. Even wheat crop can be raised successfully in this region under rainfed condition with the receipt of a winter rain (Das and Mitra, 2011). However, there is a need to quantify the irrigation need of the crop. The present study was, therefore, undertaken to assess the performance of wheat genotypes under restricted irrigation.

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MATERIALS AND METHODS

The experiment was carried out in sub-humid agro-climate of *terai* zone of West Bengal at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari during *rabi* seasons of 2009-10 and 2010-11. The experimental soil was sandy loam in texture with low in available N (128.3 kg ha^{-1}), P (18.9 kg ha^{-1}) and K (96.8 kg ha^{-1}). The pH of the experimental soil was 5.8.

The experiment was laid out in split-plot design with twenty four treatment combinations replicated thrice. Three different levels of irrigation based on crop growth stages *viz*., one irrigation at CRI stage (I_1), thee irrigations at CRI, tillering and booting stages (I_2) and five irrigations at CRI, tillering, jointing, jooting and milking stages (I_3) were randomly allotted to main-plots, while eight timely sown advance wheat genotypes *viz.,* HD 2997, DBW 46, RSP 561, HD 2733, PBW 343, K 0307, HD 2967 and DBW 39 were allocated randomly to sub-plots.

The genotypes were sown at a distance of 20 cm between the lines with a seed rate of 125 kg ha^{-1} (after adjusting thousand grain weight of 38 g). The recommended dose of fertilizer was 120: 26.3: 24.0 kg ha^{-1} for N: P: K. Full dose of P and K were applied as basal during final land preparation, whereas N was applied in 2 splits ($1/3^{rd}$ as basal and remaining $2/3^{rd}$ at crown root initiation stage). The rainfall received during the period was mentioned in the following table (Table 1).

Table 1: Rainfall received during the growth period of wheat

Dates	Rainfall (mm) 2009-10	Rainfall (mm) 2010-11
Nov. 26-Dec. 10	0.00	0.00
Dec. 11- Dec. 25	0.00	0.00
Dec. 26-Jan. 10	0.00	25.90
Jan. 11- Jan. 25	26.50	0.00
Jan. 26-Feb. 10	0.00	6.60
Feb. 11- Feb. 25	47.70	37.90
Feb. 26- Mar. 10	75.20	49.70
Mar. 11-Mar. 25	121.80	132.70
Mar. 26- April. 08	73.90	53.50

The irrigation was applied as per treatment on different growth stages and other management practices were adopted as per recommendations. The time required to irrigate the plot was recorded and the water requirement was calculated based on discharge rate. Soil moisture was measured periodically by percent dry weight basis. The water productivity for each irrigation levels as well as for each genotype was computed based on grain yield in kilogram divided by water use in cubic metre. The growth and yield parameters as well as yield were recorded at harvest and production economics were calculated based on prevailing market price of inputs like seeds, fertilizers, etc. and sale price of wheat grain.

RESULTS AND DISCUSSION

The plant height and biomass production of wheat increased significantly with increase in number of irrigations. Maximum plant height and biomass production were recorded under five irrigations though they did not differ significantly with the treatments receiving three irrigations. Increased number of irrigation resulted in higher vegetative growth of the plant thereby increasing the plant height and biomass production (Table 2). Moreover, utilization of nutrient elements was better under adequate moisture achieved through increasing number of irrigation. However, optimum utilization of moisture holds the key for increased biomass production. Optimization of water during cropping season is critical for wheat for enhancing crop growth processes and subsequent biomass yield (Pandey *et al.*, 2001). Here three irrigations are supposed to be the optimum level towards production of increased biomass. The genotypes also differed significantly with respect to plant height and biomass production. Among the genotypes, maximum plant height (101.4

Table 2: Growth, yield attributes and yield of wheat genotypes under various levels of irrigation (Mean data of 2 years)

Treatments	Plant height (cm)	Biomass (q ha^{-1})	Earhead m^{-2}	Grain $earhead^{-1}$	Test wt. (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Irrigation levels								
1-irrigation	84.5	51.18	217.25	37.12	35.20	26.79	38.30	0.41
3-irrigations	91.3	56.84	245.54	42.36	36.52	33.82	47.01	0.42
5-irrigations	94.2	58.40	251.92	42.67	36.98	35.15	49.21	0.42
LSD(0.05)	**6.6**	**4.10**	**20.11**	**3.43**	**NS**	**2.98**	**3.57**	**NS**
Wheat genotypes								
HD 2997	96.2	59.04	253.45	48.76	34.49	34.83	48.41	0.42
DBW 46	96.3	53.54	223.23	36.07	36.04	30.73	44.25	0.41
RSP 561	84.7	57.98	243.67	41.59	36.78	33.19	46.13	0.42
HD 2733	92.8	52.07	235.51	38.50	36.04	31.60	47.18	0.40
PBW 343	99.4	55.29	239.77	38.96	36.80	33.11	49.00	0.40
K 0307	91.8	56.09	259.56	47.35	35.84	34.75	52.17	0.39
HD 2967	89.6	63.22	261.22	53.57	34.01	38.95	54.75	0.41
DBW 39	101.4	55.35	197.77	36.44	37.05	28.45	40.11	0.41
LSD(0.05)	**8.7**	**5.32**	**26.82**	**5.16**	**NS**	**3.24**	**4.09**	**NS**

cm) was recorded in DBW 39 while HD 2967 produced maximum biomass.

Apart from the test weight, which was being at par in all the treatments, the major yield attributes of different genotypes differed significantly under various levels of irrigation. Plots receiving five irrigations recorded maximum number of earhead m^{-2} (251.92) and number of grains $earhead^{-1}$ (42.67). The yield attributes recorded with five irrigations were on par with that of three irrigations signifying that three irrigations were sufficient to produce a good crop in the sub-Himalayan plain. The lesser competition and greater availability of water and nutrients resulted in more number of spike bearing tillers as well as number of grains $spike^{-1}$ in wheat (Das and Yaduraju, 1999; Pandey and Verma, 2002).

Irrigation had a significant influence on grain and straw yields of wheat (Table 2). Application of irrigation water at three important growth stages (at CRI, tillering and booting) produced 26.24% and 22.74% higher grain and straw yield, respectively compared with only one irrigation at CRI stage. Application of five irrigations (at CRI, tillering, jointing, booting and milking stages) resulted in only 3.93 per cent yield increment over three irrigations indicating further increase in irrigation level did not increase the yield substantially. In theis *terai* zone of West Bengal the wheat crop received a fair amount of rainfall at the later stages of growth (Table 1) for which good yield was obtained even under three irrigations. At the initial stages of growth there was high residual moisture with the receipt of high intensity late monsoon rainfall. The increased growth and yield attributes might have led to increase in grain yield. Higher irrigation frequency increased the availability of nutrients and thus enhanced the meristamatic activities and size of cell and formation and functioning of protoplasm which consistently improved the crop growth and yield. But application of more water through increasing number of irrigation sometimes becomes wasteful and unproductive for wheat. Restricted use of irrigation water leading to optimum moisture actually improved the growth and yield performances of wheat (Ali *et al*.,2005).Among the genotypes, HD 2967 registered the maximum yield (38.95 q ha^{-1}). However, the harvest index did not vary significantly among the genotypes under various levels of irrigation indicating the proportionate increase in straw yields with increase in grain yield.

The frequency of irrigation caused a significant variation in consumptive use of the crop. A good quantity of rainfall received through early pre-monsoon shower resulted in increased consumptive use. The consumptive use recorded with single irrigation even resulted a value of 288.7 mm (Table 3). With the increase in number of irrigation, the consumptive use was recorded to be increased (336.1 mm with three and 396.4 mm with five irrigations, respectively). These results are in consonance with Nadeem *et al.* (2007). However, the genotypes did not vary significantly in their respective consumptive use. Among the genotypes, the consumptive use varied between 328.5-341.0 mm. The significantly maximum WUE (10.6 kg ha^{-1} mm^{-1}) was achieved with three irrigations as compared to one or five

Table 3 : Consumptive use, WUE and water productivity of wheat genotypes as influenced by various levels of irrigation (Mean data of 2 years)

Treatments	Consumptive use (mm)	WUE (kg ha^{-1} mm^{-1})	Water productivity (kg grain m^{-3} water)
Irrigation levels			
1-irrigation	288.7	9.28	0.93
3-irrigations	336.1	10.06	1.01
5-irrigations	396.4	8.87	0.89
LSD(0.05)	26.7	0.78	0.07
Wheat genotypes			
HD 2997	331.3	10.51	1.05
DBW 46	328.5	9.35	0.94
RSP 561	337.2	9.84	0.98
HD 2733	341.0	9.27	0.93
PBW 343	332.1	9.97	0.99
K 0307	336.7	10.32	1.03
HD 2967	339.2	11.48	1.15
DBW 39	329.4	8.64	0.86
LSD(0.05)	**NS**	**1.03**	**0.10**

irrigations. This might be because of the grain yield increased sharply with increase in number of irrigation from one to three, but further increase in number of irrigation did not result in a significant yield increase. The results are in conformity with the findings of Singh and Bhan (1998).Water productivity computed based on yield in kilogram divided by water used (m^3), indicated a higher value under three irrigation (1.01 kg grain m^{-3} water) than that of one (0.93 kg grain m^{-3} water) or five irrigations (0.89 kg grain m^{-3} water). Pradhan *et al*. (2013) reported increased water productivity in wheat with irrigation to replenish 60% moisture deficit from field capacity than irrigation to replenish 30 per cent moisture deficit without any significant yield loss. It implied that a irrigation schedule comprising three irrigations at CRI, tillering and booting stages is sufficient to achieve a satisfactory wheat yield in this zone. Even the crop can be raised with a single irrigation with higher water productivity with the receipt of a good quantity of rainfall at reproductive growth stages of the crop.

Among the different depths, maximum utilization of water was recorded from 0-15 cm than 15-30 or 30-45 cm soil layer (Table 4). It was because of the root proliferation was maximum in the upper layer (0-15 cm) and maximum water was extracted from this upper layer. With increase in number of irrigation, the contribution of upper layer was increased due to more availability of required soil moisture.

Table 4: Soil moisture extraction pattern (%) from different soil depths (Mean data of 2 years)

Treatment	0-15 cm	15-30 cm	30-45cm
1-irrigation	37.25	36.75	26.00
3-irrigations	42.40	36.50	21.10
5-irrigations	47.50	34.25	18.25

Table 5: Economics of wheat cultivation under various levels of irrigation (Mean data of 2 years)

Treatment	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net Return (Rs ha^{-1})	Benefit: cost
Irrigation levels				
1-irrigation	19,140.00	28,130.00	8,990.00	1.47
3-irrigations	20,040.00	35,511.00	15,471.00	1.77
5-irrigations	20,940.00	36,908.00	15,968.00	1.76
LSD(0.05)	-	-	**1,423.00**	-
Wheat genotypes				
HD 2997	20,040.00	36,572.00	16,532.00	1.82
DBW 46		32,267.00	12,227.00	1.61
RSP 561		34,850.00	14,810.00	1.74
HD 2733		33,180.00	13,140.00	1.66
PBW 343		34,766.00	14,726.00	1.73
K 0307		36,488.00	16,448.00	1.82
HD 2967		40,898.00	20,858.00	2.04
DBW 39		29,873.00	9,833.00	1.49
LSD(0.05)	-	-	**1,671.00**	-

As far as production economics are concerned, maximum net return (Rs. 15,968.00 ha^{-1}) was achieved in treatments received five irrigations though the maximum benefit-cost ratio (1.77) was recorded with treatment consisting of three irrigations (Table 5). The results indicated that five irrigations were less remunerative than three irrigations. Extra cost incurred towards extra two irrigations did not result in considerable yield increase. Among the genotypes, higher net return (Rs. 20,858.00 ha^{-1}) and benefit-cost ratio (2.04) were recorded with HD 2967. Higher yield from this wheat genotype could be the reason for increased income and benefit-cost ratio.

REFERENCES

Ali, M., Sattar, M., Ali, M.K., Yar, K. and Sabbir, S. 2005. Growth and yield of wheat as influenced by different irrigation frequencies. *J. Agric. Res*., **43** : 331-38.

Anonymous. 2010. *Economic Review: Statistical Appendix* (2009-10) Bureau of Applied Economics and Statistics, Development and

Planning Department, Government of West Bengal, pp. 66-69.

Bellido, R. J. L. and Bellido, L. L. 2001. Efficiency of nitrogen in wheat under Mediterranean conditions: effect of tillage, crop rotation and N fertilizers. *Field Crops Res.,* **71**: 31-46.

Das, T. K. and Yaduraju, N. T. 1999. Effect of weed competition on growth, nutrient uptake and yield of wheat as affected by irrigation and fertilizers. *J. Agril. Sci.,* Cambridge, **133**: 45-51.

Das, S. and Mitra, B. 2011. Performance of different wheat genotypes under various levels of nitrogen in rainfed condition of *terai* region of West Bengal. *J. Crop Weed*, **7**: 23-25.

Nadeem, M. A., Tanveer, A., Ali, A., Ayub, M. and Tahir, M. 2007. Effect of weed control practice and irrigation levels on weeds and yield of wheat (*Triticum aestivum*). *Indian J. Agron.,* **52**: 60-63.

Pandey, J. and Verma, A. K. 2002. Effect of atrazinee, metribuzin, sulfosulfuron and trolkoxydim on weeds and yield of wheat (*Triticum aestivum*). *Indian J. Agron.* **47** : 72-76.

Pandey, R. K., Maranville, J. W. and Admou, A. 2001. Tropical wheat response to irrigation and nitrogen in Sahelian environment. *European J. Agron.*, **15** : 93-105.

Pradhan, S., Chopra, U.K., Bandyopadhyay, K. K., Singh, R, Jain, A.K. and Chand, I. 2013. Effect of water and nitrogen management on water productivity and nitrogen use efficiency of wheat in semi-arid environment. *Int. J. Agric. Food Sci. Tech.*, **4**: 727-32.

Singh, S. and Bhan, V.M. 1998. Response of wheat (*Triticum aestivum*) and associated weeds to irrigation regime, nitrogen and 2, 4-D. *Indian J. Agron.,* **43**: 662-67.