

Original Research Article

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Productivity, Water Use Efficiency and Profitability of Drip Irrigated Wheat (*Triticum aestivum*) in Indo-Gangatic Plains of Uttarakhand, India

Tanmoy Bhowmik^{1*}, A.K. Bhardwaj², T. Pandiaraj³ and Arnab Roy⁴

¹Department of Agronomy, University of Agricultural Science, GKVK, Bengaluru, Karnataka-560065, India

²Department of Agronomy, G. B. Pant University of Agriculture and Technology (GBPUA&T), Pantnagar, Uttarakhand, India

³Central Tasar Research and Training Institute, Piska-Nagri, Ranchi, Jharkhand, India

⁴Department of Agricultural Economics, University of Agricultural Science, GKVK, Karnataka-560065, India

*Corresponding author

ABSTRACT

A field experiment was conducted during *Rabi* season of 2016-17 in G.B. Pant University of Agriculture and Technology, Pantnagar to study the effect of drip irrigation on grain yield and their attributing characters, water use efficiency and monetary benefits of wheat crop. The treatments consisted of drip irrigation with 50, 75 and 100% CPE on each 2 days and 4 days interval period. Apart from drip irrigation treatments, two conventional irrigation methods were also included i.e. as absolute control and farmers' practice. These eight treatments were designed in Randomized Block Design with four replications. Results revealed that water use efficiency and water savings in all drip irrigated treatments recorded significantly higher than the farmers' method of irrigation. Wheat with drip irrigation at 100% CPE on two days interval resulted in higher grain yield (5825kg ha⁻¹) with less water requirement(207.90 mm) compared to conventionally irrigated wheat with less grain yield (4485 kg ha⁻¹) and high water requirement (300 mm). So, it is clear that drip irrigation treatments based on CPE performed better than conventionally irrigated wheat. On the basis of above results, it can be concluded that Drip irrigation at 75 or 100% CPE on two days interval can be a better alternative over conventionally irrigated wheat.

Keywords

CPE, Drip irrigation, Farmers' practice, Irrigation, Monetary, Yield

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Introduction

Water is considered to be a scarce resource in Indian agriculture. Agriculture is the largest water user consuming about 83 % of the total available water. Increasing demand for industrial and domestic water will result in reduction in water diversion to agriculture. This brings us the message that with increasing demand for food production under resource-poor situations where agriculture

becomes more and more competitive, cultivation must be geared to achieve higher productivity (yield per unit land and /or water resource) in order to meet the market demand for the commodity. In this context, judicious management of all the inputs in an agricultural production system is vital. The agriculture, which depends purely on rainfall, will not be a viable venture since we cannot totally rely on the rainfall which is beyond human control. In

India, wheat (*Triticum aestivum*) is the second important staple crop after rice producing 93 mt from 30 m. ha area with average productivity of 2.98 t/ha (Directorate of Economics and Statistics, 2014). According to Singh *et al.*, (2012) the demand for wheat in India by 2020 has been estimated to be between 105 to 109 million tonnes as against present day production i.e., 93 million tonnes. Wheat crop in India is grown during winter months when rains are normally scarce. It mainly depends on the supplementary irrigation for its water use. Irrational irrigation practice leads to either under or over irrigation. Therefore, to maintain the optimum soil moisture in the root zone of the wheat crop, it is important to work out an effective and economic schedule of irrigation under a given agro-climatic zone.

Micro-irrigation, especially drip irrigation system can control the rate of water application to achieve application efficiency as high as 90-100%. As the entire soil surface does not get wet, weed growth is checked by drip systems. The system is also excellent for soils with higher infiltration rates. Unlike surface and sprinkler irrigation, the drip system can keep the soil water content always near the field capacity without creating any soil moisture deficit to the crop. Drip irrigation systems are designed to apply only the required amount of water. Therefore, it would minimize water losses from runoff, percolation, and seepage. This would be the crux for future green revolution and food security through water and energy security. Keeping all these points in view the present experiment was conducted to study the irrigation scheduling for better yield, water use efficiency (WUE) and monetary benefits for wheat.

Materials and Methods

The field experiment was conducted during rabi season at University Farm, G.B. Pant University of Agriculture and Technology,

Pantnagar, India located at 29°N latitude, 79°29'E longitude and at an altitude of 243.84 meters from mean sea level. During the experimental period year, the mean maximum and minimum temperature were 35.31 and 4.28 ° C, respectively, mean relative humidity was maximum 93% in morning and minimum 20% in evening, total rainfall was 76.2 mm. The soil was classified as mollisol was silty clay loam in nature high in organic carbon and available P and medium in K and low in available N with neutral to alkaline in reaction.

The experiment was laid out in randomized block design with four replications. The treatments were consisted of conventional and drip irrigation practices for wheat crop. A conventional irrigation practice includes wheat grown without fertilizers as absolute control (T₁) and with fertilizers as farmer's practice (T₂). Whereas, under drip irrigation method, irrigation provided at 50% CPE on two days interval (T₃); at 75% CPE on two days interval (T₄); at 100% CPE on two days interval (T₅); at 50% CPE on four days interval (T₆); at 75% CPE on four days interval (T₇) and at 100% CPE on four days interval (T₈)

Wheat variety WH-1124 was grown in 2016 with seed rate 100 kg ha⁻¹ at 20 cm row spacing with recommended package of practices. In order to ensure ideal condition for proper germination, pre sowing irrigation was given. Irrigations were applied through drip irrigation based on daily pan evaporation values were measured with the help of USWB class 'A' open pan evaporimeter installed in the Crop Research Centre of university. While, conventional method, 5 irrigations were applied with 6cm depth in each irrigation through irrigation channels at critical growth stages. The amounts of irrigation water by one lateral in different irrigation treatments were calculated as

$$V = r \cdot E_o \cdot K_{pan} \cdot K_c \cdot A$$

Where, V - Volume of water to be delivered by one lateral (lpH), E_o is USWA open pan evaporation (mm/day), K_{pan} is Pan coefficient, K_c is Crop co efficient, r is Unit constant, A is Area covered by one lateral (m^2).

Then, time of operation of drip system to deliver the required volume of water per lateral as per the irrigation treatment was computed based on the formula

$$\text{Time of operation (Hours)} = \frac{\text{Volume of water to be delivered (V) By one lateral (l)}}{\text{Emitter discharge rate (lpH) x Number of emitters}}$$

The entire quantity of phosphorus (60 kg ha^{-1}) in the form of DAP and potash as MOP along with 50 percent of nitrogen were applied uniformly in the furrows as basal dose.

The remaining 50 percent of nitrogen was applied as top dressing at tillering stage as per treatments.

All the cultural operations were carried out as per recommendations.

The crop was harvested manually with the help of sickle when grains matured and straw had turned yellow and data on test weight, grain yield, straw yield and harvest index were recorded.

The sun-dried bundles were threshed and winnowed and grains obtained were weighed. The straw yield was obtained by subtracting the grain yield from the biological yield. Water use efficiency was calculated by dividing grain yield on the amount of water used. The economics was calculated based on prevailing prices of inputs and output.

The obtained data were statistically analysed by two-way Analysis of Variance (ANOVA) following the method of Gomez and Gomez (1984).

Results and Discussion

Yield attributing characters

Yield components of wheat including effective tillers m^{-2} , number of ears m^{-2} , number of grains ear^{-1} , grain weight ear^{-1} , number of spikelets m^{-2} , and 1000 grain weight at harvest were differently affected by various irrigation methods (Table 1). Significantly higher effective tillers m^{-2} under drip irrigation as compared to conventional irrigation methods indicates that optimum soil moisture ensures better plant population and stand establishment of wheat. In T_5 treatment had recorded higher effective tillers among different drip irrigation methods followed by T_4 treatment, however, it was on par with all drip irrigation and T_2 treatments. Similar results were also observed for number of grains ear^{-1} of wheat in this experiment. Number of grains ear^{-1} and grain weight ear^{-1} are considered two important components directly related to wheat grain yield. Drip irrigation treatments brought about significant higher value of number of grains ear^{-1} and grain weight ear^{-1} than conventional irrigation method. Among drip irrigation, the both number of grains ear^{-1} and grain weight ear^{-1} value were gradually and significantly increased with T_5 treatment followed by T_4 and T_8 treatments. In the present study, T_1 treatment showed comparatively lower number of grains ear^{-1} and grain weight ear^{-1} value of 34 and 1.2g, respectively.

Both drip irrigation and farmers practice treatments gave about equally significant higher number of spikelets m^{-2} than T_1 treatment. The T_5 treatment produced significantly higher total number of spikelets m^{-2} over other treatments. The number of spikelets m^{-2} was least under T_1 treatment. Irrespective of irrigation treatments, 1000 grain weight of wheat was statistically similar in all drip and farmers irrigation method over

T₁ treatment. In general, all wheat attributing characters under drip irrigation was found to be superior over farmers' practice. This might be due to uniform and adequate availability of water and better conducive rhizosphere for higher uptake of nutrients which in turn boost the growth, leading to the development of higher yield attributes through supply of more photosynthates towards the sink. These results are in close conformity with Chouhan *et al.*, (2015).

Yield characters of wheat

The effects of irrigation method treatments on grain yield of wheat were significant for present experiment period (Table 2). There was significant difference in grain yield between drip and farmers practice treatments.

As observed that, wheat yield was higher in the T₅ treatment; however, it was statistically at par with all drip irrigation method treatment except T₆ treatment. Further it showing that

the grain yield was higher by 29.8% in T₅ treatment over farmer practice followed by 23.6% in T₄ and 20.6% in T₈ treatments. In the present study, both T₆ and T₂ treatments statistically produced equal grain yield of wheat. There was no significant difference in straw yield, total biological yield, harvest index and grain-straw ratio of wheat between drip and farmers practice treatments. Wheat had the highest straw and total biological yield, harvest index and grain-straw ratio in T₅ treatment; it was increased by 9.79% and 17.76% in T₅ treatment over farmers' method for straw yield and total biological yield, respectively.

Higher grain yield was due to the cumulative effect of improvement in growth and yield attributes. Increase in yield might be due to more irrigations providing constant wetting of root zone which might have favoured greater release of nutrients from soil. Similar findings were also reported by (Kumar *et al.*, 2013 and Rao *et al.*, 2014).

Table.1 Yield contributing characters of wheat as influenced by different drip irrigation treatments

Treatments	Total no of shoots m ⁻²	No. of ear m ⁻²	No. of grains ear ⁻¹	Grain weight ear ⁻¹ (g)	Total no. of spikelets m ⁻²	1000 grain weight (g)
T ₁	324	301	34	1.21	4480	35.80
T ₂	515	506	46	1.84	9014	40.07
T ₃	560	544	48	1.93	9962	40.19
T ₄	635	611	54	2.22	11509	41.22
T ₅	668	656	57	2.39	12892	41.92
T ₆	526	512	47	1.88	9275	39.98
T ₇	577	561	51	2.08	10340	40.76
T ₈	612	597	53	2.18	11150	41.26
S.Em.±	28	21	0.6	0.02	421	0.73
CD (P=0.05)	84	64	1.9	0.05	1247	2.14

Table.2 Yield characters of wheat as influenced by different drip irrigation treatments

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Total biological yield (kg/ha)	Harvest Index%	Grain: Straw ratio
T ₁	2887	3840	6727	43.09	0.75
T ₂	4485	6822	11307	39.70	0.66
T ₃	5180	7120	12300	42.13	0.72
T ₄	5545	7347	12892	43.05	0.75
T ₅	5825	7490	13315	43.75	0.78
T ₆	4537	6882	11420	39.72	0.66
T ₇	5370	7205	12575	42.73	0.74
T ₈	5410	7257	12667	42.73	0.74
S.Em.±	164.54	271.98	312.24	1.26	
CD (P=0.05)	487.17	805.30	924.51	3.71	

Table.3 Total water use (mm) and Water use efficiency (kg ha⁻¹mm) as influenced by different drip irrigation treatments

Treatments	Water used by irrigation (mm)	Effective rainfall (mm)	Total water used (mm)	Water saving (%)	WUE (kg ha ⁻¹ mm)
T ₁	300	38.1	338.1	-	8.54
T ₂	300	38.1	338.1	-	13.26
T ₃	103.95	38.1	142.05	57.98	36.47
T ₄	155.86	38.1	193.96	42.63	28.59
T ₅	207.90	38.1	246	27.24	23.68
T ₆	100.15	38.1	138.25	59.1	32.82
T ₇	150.15	38.1	188.25	44.32	28.53
T ₈	200.3	38.1	238.4	29.49	22.69
S.Em.±				-	0.79
CD (P=0.05)				-	2.33

Table.4 Economic analysis of wheat as influenced by different drip irrigation treatments

Treatments	Cost of cultivation in ₹/ha	Gross return in ₹/ha	Net return in ₹/ha	B:C ratio
T ₁	17100	67811	50711	2.96
T ₂	20690	123103	92404	3.01
T ₃	27804	122690	94886	3.41
T ₄	28454	130098	101644	3.57
T ₅	29104	135642	106538	3.66
T ₆	27767	110375	82608	2.97
T ₇	28392	126397	98005	3.45
T ₈	29017	127331	98314	3.39

Total water use and Water Use Efficiency (WUE)

Total water use as irrigation water during the whole crop growing season ranged from 100.5 mm to 300 mm in different treatments (Table 3). The total water used inclusive of effective rainfall in T₁ and T₂ treatments with recommend irrigations during critical growth stages of crop was 338.1 mm whereas drip irrigation treatments varied from 138.25 to 246 mm. Among the drip irrigation treatments, minimum water used (138.25 mm) was recorded in T₆ treatment which was closely followed by 142.05 in T₃ treatment. Highest water use i.e. 246 mm was recorded with T₅ treatment. This resulted in saving of water which ranged from 27.2% with T₅ to 59.1% with T₆ under different treatments. The drip irrigation methods showed less water requirement due to restriction of water loss through evaporation from large amount of ground, conveyance losses resulted in maximum water use by crops. WUE kg ha⁻¹ mm was significantly influenced by different treatments. The supply of irrigation water in T₂ treatment was found to be significantly lower WUE (13.26%) and T₃ treatment showed higher WUE (36.47%) was found with i.e. drip irrigation with 50% CPE at two days interval. The increased WUE observed under drip irrigation was due to increase in grain yield and reduced water consumption compared to farmers' practice. Through drip irrigation method water and nutrients to the plant can be applied very efficiently to the effective root zones of the plants. Drip irrigation system had minimum water requirement as the loss of water is minimum in this process Vanitha (2008).

Monetary benefits

In our study, the total cost of cultivation for raising wheat crop ranged from ₹ 17100 ha⁻¹ in T₁ treatment and ₹ 20690 ha⁻¹ in T₂ to highest ₹ 29100 ha⁻¹ in T₅ treatment. Consequent to the influence of treatments and variation in yield, the gross return also varied within the treatments. The higher gross return ₹ 135642 ha⁻¹ was obtained from T₅ treatment which is

closely followed by T₄ treatment (₹ 130098 ha⁻¹). Gross return in conventional wheat with recommended irrigation and fertilizers was ₹ 123103 ha⁻¹. The net return varied ₹ 50711 ha⁻¹ in T₁ treatment to ₹ 106538 in T₅ treatment.

The net return with T₂ treatment was ₹ 92404. Among the drip irrigation treatments, the lower net return ₹ 82608 was found in treatment T₆. In case of B: C ratio among the drip irrigated treatments, ranged from 2.97 to 3.66. The B: C ratio of T₂ treatment was showed 3.01 and T₅ treatment had record higher B: C ratio.

Both net return and B: C ratio had increased due to the high increase in grain yield which is the results of adequate water supply and nutrient availability to the root zone area of the crop under drip irrigation system Ashoka *et al.*, (2004) (Table 4).

Based on the results obtained from the study conducted, it can be concluded that drip irrigation was found profitable for getting higher yield and economic returns over conventional method. Water supply with 75% or 100% CPE through drip irrigation on two days interval is better in terms of water saving along with better yield, net realization and highest water use efficiency as it saves 43% water and gives 29.8% higher yield and 15.3% higher net returns over conventional method of irrigation.

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