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Yield, water use efficiency and economics of wheat (*Triticum aestivum* L.) as influenced by drip irrigation scheduling and nitrogen levels

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Abstract
A field experiment was conducted at the Regional Research Station, Anand Agricultural University, Anand, Gujarat during *rabi* season of 2015-16. The experiment comprised of eight treatment combinations with four irrigation schedules by drip (0.6, 0.8 and 1.0 ADPEF and conventional method) and two levels of nitrogen (100% and 75% RDN). The field experiment was laid out in a split plot design with four replications. Grain and straw yields were significantly higher in irrigation scheduled at 1.0 ADPEF over rest of the treatments but it was at par with 0.8 ADPEF. Water use efficiency was highest under irrigation schedule of 0.8 ADPEF. Highest net realization and BCR were obtained with 1.0 ADPEF closely followed by treatment 0.8 ADPEF. Non-significant influence of nitrogen levels was found on yields. Higher water use efficiency, net realization and BCR were obtained with 100% RDN.

Keywords: wheat, drip irrigation, nitrogen, water use efficiency

Introduction
Wheat (*Triticum aestivum* L.) is one of the most important staple food grains of human race. It contributes substantially to the national food security by providing more than 50% of the calories to the people who mainly depend on it. Its demand is increasing day by day with our ever-increasing population. To meet this rising demand we should work towards maximizing the wheat productivity as there is no scope for increasing the area under production. This can be achieved by adopting high yielding cultivars and appropriate agronomic practices like optimum seed rate, time of sowing, irrigation scheduling, fertilizer uses, weed management, time of harvesting etc. Out of all the above mentioned factors, irrigation scheduling plays a very significant role in enhancing yield. Also, considering the present scenario of water scarcity, emphasis should be given on use of more efficient methods of irrigation like drip irrigation. Along with increased irrigation efficiency, it is also important to provide optimum amount of nutrients to the crop. Nitrogen is the key element for plant growth and development, as it is a constituent of chlorophyll and proteins. Keeping this in view, the present investigation was undertaken to study the yield, water use efficiency and economics of wheat (*Triticum aestivum* L.) as influenced by irrigation scheduling with drip irrigation and nitrogen levels under middle Gujarat conditions.

Materials and Methods
A field experiment was carried out during *rabi* season of the year 2015-2016 at the Regional Research Station farm, Anand Agricultural University, Anand (22^0 - 35' N, 72^0 - 55' E and 45.1 m above the mean sea level), Gujarat. The soil was sandy clay with bulk density 1.43Mg m^{-3}, 0.24dSm^{-1} EC and 7.7 soil pH, having good drainage. It was low in available nitrogen (237 kg ha^{-1}), medium in available phosphorus (50.34 kg ha^{-1}) and potassium (347 kg ha^{-1}). The experiment was laid out in split-plot design with four replications and eight treatment combinations with four irrigation schedules under drip irrigation(0.6, 0.8 and 1.0 ADPEF and conventional method) as well as two levels of nitrogen (100% and 75% RDN).Irrigation schedules were relegated as main plot treatments and two nitrogen levels were allotted as sub-plot treatments. Wheat variety GW-496 was sown on 23 November, 2015 with seed rate of 120 kg ha^{-1} at 20 cm row spacing. The plots were of size 4.8 m × 6 m and crop was raised with recommended package of practices. Irrigations were applied through drip irrigation based on alternate day pan fraction evaporation (ADPEF) approach. The daily pan evaporation values were measured with the help of USWB class 'A' open pan evaporimeter installed in the experimental field. Laterals with emitters of 4 lph discharge capacity were installed at a spacing of 80 cm and the distance between two emitters was 37.5 cm.

Total 42 irrigations of 246, 328 and 372 mm water were applied under 0.6, 0.8 and 1.0 ADPEF treatments respectively whereas, in the conventional method 8 irrigations of 430 mm were applied through irrigation channels at critical growth stages. The entire quantity of phosphorus (60 kg ha^{-1}) in the form of SSP along with 40 percent of nitrogen (as per treatment) in the form of urea was applied uniformly in the furrows as basal dose. The remaining 60 percent of nitrogen was applied in two equal splits as top dressing at 30 and 60 DAS. The annual rainfall recorded during the year in *kharif* season was 539 mm. However, there was no rain during experimental period. The crop was harvested manually with the help of sickle when grains almost 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 to the water utilized. The economics was calculated based on prevailing prices of inputs and output.

Results and Discussion

Yields

Grain and straw yield were registered maximum under irrigation schedule 1.0 ADPEF ratio and schedule 0.8 ADPEF remained at par. Treatment 0.6 ADPEF recorded the lowest grain and straw yield. Irrigation schedule treatments 1.0 and 0.8recorded 14.6 and 12.5 per cent higher grain yield as well as 12.8 and 8.6 per cent higher straw yield than conventional method, respectively (Table 1). Higher grain yield was due to the cumulative effect of improvement in growth and yield attributes. It was also found that with sufficient moisture in the soil profile under higher irrigation frequency with drip irrigation, plant nutrient particularly nitrogen, phosphorus and potash were more available and might have translocated to produce more dry matter. Secondly, 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. Other reason might be due to increase in numbers of irrigation applied at shorter intervals and total consumptive use of water. These results are in conformity with the results of Mahmood *et al.* (2002) [3], Narolia *et al.* (2016) [4] and Patel and Patel (2016) [5].

Water use efficiency

Water use efficiency (kg ha^{-1}-mm) was maximum (15.10) under irrigation schedule 0.8 ADPEF, followed by treatments 0.6 ADPEF (14.29) and 1.0 ADPEF (13.57). The minimum field water use efficiency was registered under Conventional method (10.24) (Table 1). The reason was mainly due to higher grain yield in proportion to the quantity of water used. Similar results were also reported by Singh *et al*. (2010) [6] and Brar *et al.* (2013) [1].

Table 1: Yields and water use efficiency of wheat as influenced by levels of drip irrigation and nitrogen

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Water use efficiency (kg ha^{-1}-mm)
Irrigation (I)			
I_1 : 0.6ADPEF	3948	5079	14.29
I_2 : 0.8 ADPEF	4955	5952	15.10
I_3 : 1.0 ADPEF	5050	6180	13.57
I_4 : conventional method	4405	5480	10.24
S.Em. ±	171.15	205.05	-
C.D. (P=0.05)	54.55	655.98	-
Nitrogen (N)			
N_1: 100 % RDN	4623	5725	13.38
N_2: 75 % RDN	4556	5621	13.22
S.Em. ±	233.97	292.46	-
C.D. (P=0.05)	NS	NS	-
I×N	Non- significant		

Table 2: Economics as influenced by levels of drip irrigation and nitrogen

Treatments	Gross realization (□ ha^{-1})	Total cost (□ ha^{-1})	Net realization (□ ha^{-1})	BCR
Irrigation (I)				
I_1 : 0.6ADPEF	66552	35820	30732	1.86
I_2 : 0.8 ADPEF	82989	35919	47070	2.31
I_3 : 1.0 ADPEF	84738	36017	48720	2.35
I_4 : conventional method	74025	32224	41801	2.30
Nitrogen (N)				
N_1 : 100 % RDN	78159	29068	49091	2.69
N_2 : 75 % RDN	76489	28657	47832	2.67

Price: Wheat grain – □ 15.25 per kg (MSP)
Wheat straw – □1.25 per kg

From Table 1, it is clear that higher water use efficiency was recorded under 100% RDN (13.38) as compared to 75% RDN (13.22). This is due to the fact that yield obtained is higher with 100% RDN as compared to 75% RDN. Similar were the findings of Mallareddy and Padmaja (2014) [2] and Pradhan *et al*. (2014) [6].

Economics

Irrigation schedule1.0 ADPEF fetched maximum net realization with higher BCR value, closely followed by 0.8 ADPEF. The lowest net realization with BCR was observed with irrigation treatment of 0.6 ADPEF. Higher net gain per hectare under irrigation schedule 1.0 ADPEF was due to

higher yield (Table 2). These results are in conformity with the results of Patel *et al*. (2004) [3].
Highest net realization along with higher BCR were obtained with nitrogen level100% RDN) as compared to 75% RDN. Higher yields were obtained due to the application of higher dose of nitrogen which enhanced net income and BCR.

Conclusion
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. Irrigating wheat at 0.8 ADPEF along with 75% RDN is better in terms of water saving along with better yield, net realization and highest water use efficiency as it saves 24% water and gives 12.5% higher yield and 12.6% higher net returns over conventional method of irrigation.

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