EFFECT OF IRRIGATION REGIMES ON PLANT GROWTH PARAMETERS AND YIELD OF WHEAT (Triticum *Aestivum* L.)

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ABSTRACT

In view of the limited water resources in Saurashtra, the effect of magnitude of water deficit on crop growth and yield is of major importance. Keeping this in mind, the study was conducted to find out the effect of irrigation regimes on crop yield and water use efficiency. Five treatments were adopted i.e. 0.6 ET_c, 0.8 ET_c, 1.0 ET_c, 1.2 ET_c and control. ET_c was calculated using daily weather data for wheat crop growth period. Irrigation was applied at 10 to 12 days interval as per the treatments. In control treatment crop 60 mm fixed depth of irrigation was applied. Significantly the higher grain yield (2808.65 kg/ha) and dry matter (3990.76 kg/ha) were attained for control crop. The grain water use efficiency and dry matter water use efficiency were found non-significant.

KEY WORDS: Crop Growth Rate, Irrigation regimes, Water Use Efficiency, Wheat

INTRODUCTION

Water is a crucial input for agriculture, and major resource constraint that limits economic development and food grain production in India. Water is necessary for industrial production, energy generation and navigation. Its availability is becoming scarce and costly.

Planning of the allocation and use of irrigation water needs proper predictive estimation of production output status associated with given input levels. A basic crop production function attempts to estimate the contribution of water, fertilizer and chemical amendments etc. to crop production for the purpose of understanding the nature of crop response to water. Even the water is considered the only controllable input, the crop-water-yield relationship is quite complex. The food production has to be increased through maximization of crops yield per unit of available water for which information on yield response to water for various crops grown under different environmental condition is imperative.

In view of the limited water resources in Saurashtra, the effect of magnitude of water deficit on crop growth and yield is of major importance in scheduling available but limited water supply. Therefore, the efforts are made to find out the effect of irrigation strategies on yield of wheat, considering water use simulation approach during the investigation to study the effect of irrigation regimes on plant growth parameters and yield of wheat.

MATERIALS AND METHODS

The study area is having typically subtropical and semi arid climate, characterized by fairly cold and dry winter, hot and dry summer and warm and

moderately humid during monsoon. Partial failure of monsoon once in three to four years is common in this region. Winter sets in the month of November and continues till the end of February. January is the coldest month of winter. Summer commences in the second fortnight of February and ends in the middle of June. April and May are the hottest months of summer.

The daily weather data was collected from JAU observatory. The climatic variation at the experimental site during the experiment period (Nov. '09 to Mar. '10), the minimum pan evaporation, temperature and relative humidity were observed as 2.4mm, 9.5°C and 5% respectively, while maximum were observed as 8.5mm, 40.2°C and 94%, respectively.

The randomized block design (RBD) was adopted. The following treatments were taken:

1. T_1 : 0.6 ET_c
2. T_2 : 0.8 ET_c
3. T_3 : 1.0 ET_c
4. T_4 : 1.2 ET_c
5. T_5 : control (60 mm depth of water)

All these treatments were replicated six times. The treatment plot was having 12 rows having spacing of 22.5 cm. The gross plot size of treatment was 6.00 m x 3.60 m. The net plot size of treatment was 4.00 m x 2.70 m. The water meters were used to apply the calculated quantity of irrigation water to the treatments. Water meters and valves were connected with flexible 63 mm hosepipes to regulate the water flow.

Crop evapotranspiration

$$ET_C = K_C \text{ X } ET_0 \qquad (1)$$

Where,

K_C is Crop coefficient and ET_0 is Reference evapotranspiration (mm/day)

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \qquad (2)$$

Where,

R_n is net radiation at the crop surface (MJ/m^2/day),
G is soil heat flux density (MJ/m^2/day),
T is mean daily air temperature at 2 m height (^{0} C),
u_2 is wind speed at 2 m height (m/s),
e_s is saturation vapour pressure (kPa),
e_a is actual vapour pressure (kPa),
e_s-e_a is saturation vapour pressure deficit (kPa),
Δ is slope of vapour pressure curve (kPa/^{0}C), and
γ is psychrometric constant (kPa/^{0}C).

Crop Coefficient

Empirically determined crop coefficient (K_c) can be used to relate ET_o to maximum crop evapotranspiration (ET_c) when water supply meets the water requirements of the crop. Crop evapotranspiration is also known as maximum crop evapotranspiration (ET_m). The values of K_c for crop given by Doorenbos and Kassam (1979) are used for calculated the crop evapotranspiration.

Water Use Efficiency

Water use efficiency was calculated by the following relationship.

$$WUE_g = \frac{\text{Grain yield}}{\text{Total amount of water applied}} \quad (3)$$

$$WUE_d = \frac{\text{Dry matter production}}{\text{Total amount of eater applied}} \quad (4)$$

Crop Growth Rate

The values of CGR was calculated for the stage between 60 and 90 DAS with formula (Cheema *et al.*, 1991)

$$CGR\ (g/m^2/day) = \frac{W_2 - W_1}{t_2 - t_1} \quad (5)$$

Where,

W_1 & W_2 are weight of dry matter of plant (g/m^2) at first and second stages and t_1 & t_2 are time in days of first and second stages.

RESULTS AND DISCUSSION

Yield response

Significantly the higher yield was obtained (2808.65 kg/ha) in T_5 (control) as shown in Table 1. By increasing amount of irrigation / levels of irrigation, the grain yield of wheat was not increasing significantly. Among other treatments, T_4 (1.2 ET_c) was found superior but it was at par with T_3 (1.0 ET_c). T_1 (0.6 ET_c) and T_2 (0.8 ET_c) and these were found at par with each other. The results of the present study were in good agreement with findings of Mahdi *et al.* (1997) and Ejaz *et al.* (2008). They reported that as amount of water applied reduced, the grain yield also reduced.

By increasing irrigation amount there was no significant increase in grain yield. Therefore, farmers who have scarcity of water in their area should apply irrigation as per treatment T_1 (0.6 ET_c) to save water, which should be used to increase area under irrigation.

Dry matter production was significantly affected by irrigation regimes. Significantly the higher dry matter was obtained in T_5 (control) (3990.76 kg/ha) and it was lowest in T_1 (0.6 ET_c) (2203.72 kg/ha) (Table 1). By increasing the amount of irrigation/irrigation levels, i.e. T_1 (0.6 ET_c) to T_4 (1.2 ET_c), the dry matter production of wheat was not increased significantly. T_1 (0.6 ET_c), T_2 (0.8 ET_c) and T_3 (1.0 ET_c) were found at par with each other. Similar results were obtained by Mahdi *et al.* (1997) and Pandey *et al.* (2001) that, as amount of irrigation water increased, dry matter production also increased.

Response of plant growth parameters to irrigation regimes

Plant height

As the irrigation levels/amount of irrigation applied increased the height of plants also increased. The plant height was found significantly higher in T_5 (control) as compared to other treatments (Table 2). Treatment T_3 (1.0 ET_c), T_4 (1.2 ET_c) and T_5 (control) were found at par with each other. T_1 (0.6 ET_c) and T_2 (0.8 ET_c) were found at par with each other. Similar results were obtained by, Mirbahar *et al.* (2009) and Ali *et al.* (2010). Richards *et al.* (2001) and Ghodsi (2004) reported that one of the major effects of water stress was to decrease plant height, which also caused a reduction in dry matter accumulation and subsequently plant production.

Number of tillers per plant

Number of tillers per plant was found significantly affected by irrigation regimes. As amount of irrigation increased, number of tillers also increased. It was found significantly higher in T_5 (control) treatment (Table 2). Among the irrigation levels, T_1 (0.6 ET_c) and T_2 (0.8 ET_c), T_3 (1.0 ET_c) and T_4 (1.2 ET_c) were found at par. T_4 (1.2 ET_c) was also found at par with T_5 (control). Similar results were found by Mesbah (2009) that

number of tillers increased significantly with increasing irrigation regimes. The highest values number of tillers was 5.91 for I_3 (1850 m^3) than the 4.17 for I_2 (1600 m^3).

Number of spikelets per spike

Number of spikelets per spike was found significantly higher for T_5 (control) (Table 2). As the irrigation levels increased the spikelet also increased. Treatment T_4 (1.2 ET_c) was found at par with T_3 (1.0 ET_c) as well as with T_5 (control). Also T_1 (0.6 ET_c), T_2 (0.8 ET_c) and T_3 (1.0 ET_c) were found at par with each other. Results obtained in this study were in good agreement with findings of Qadir *et al.* (1999) that, water stress reduced the number of spikelet per spike in wheat crop.

Crop Growth Rate

Crop growth rate was found significantly higher in T_5 (control) (Table 3) as compared to other treatments. It was observed that crop growth rate increase with increase in irrigation levels. T_1 (0.6 ET_c) and T_2 (0.8 ET_c) were found at par with each other.

Water Use Efficiency

At higher irrigation regimes, the grain and dry matter water use efficiencies were obtained less as compare to limited irrigation (Table 4). Similar results were reported by Howell *et al.* (1998) and Li *et al.* (1999), which supported the results of this study.

Wheat yield production function

The wheat yield response function take into account consumptive water use and yield. The observed grain yield, dry matter production and consumptive water use are shown in Figure 1. The developed wheat yield response functions are presented in Table 5. The grain yield and dry matter production both showed increasing trend to irrigation depth. The results revealed that the yield of wheat was not increasing significantly with the increase of irrigation levels. Also T_1 (0.6 ET_c), T_2 (0.8 ET_c) and T_3 (1.0 ET_c) were at par with each other.

CONCLUSION

The major conclusions which were drawn from the study are

- The significantly higher grain yield and dry matter production (2809 kg/ha and 3991 kg/ha) were attained when 60 mm irrigation was applied.
- By increasing the irrigation levels/amount of irrigation, the grain yield and dry matter production was not increased significantly.
- The higher values of grain and dry matter water use efficiencies were observed.
- At higher levels, the grain and dry matter water use efficiencies were observed less as compared to low irrigation levels.

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Table 1: Grain yield (kg/ha) and dry matter production (kg/ha) under different irrigation regimes

Sr. No.	Treatment	Grain Yield (kg/ha)	Dry Matter Production (kg/ha)
1	0.6 ET_c (T_1)	1475.32	2203.72
2	0.8 ET_c (T2)	1527.78	2226.09
3	1.0 ET_c (T3)	1765.44	2513.13
4	1.2 ET_c (T4)	2117.29	2998.47
5	Control (T5)	2808.65	3990.76
6	SEm+	179.0291	191.0286
7	CD at 5%	528.15	563.54
8	CV%	22.62	16.79

Table 2: Effect of irrigation regimes on plant height, number of tillers per plant and number of spikelet per spike

Sr. No.	Treatment	Plant Height (cm)	Number of Tillers per Plant	Number of Spikelets per Spike
1	0.6 ET_c (T_1)	56.66	2.33	12.50
2	0.8 ET_c (T2)	57.33	2.67	12.08
3	1.0 ET_c (T3)	62.78	4.17	13.33
4	1.2 ET_c (T4)	64.15	4.67	14.33
5	Control (T5)	66.56	5.17	15
6	SEm+	1.65	0.2392	0.5307
7	CD at 5%	4.876	0.7057	1.5656
8	CV%	6.583	15.42	9.67

Table 3: Effect of irrigation regimes on crop growth rate

Sr. No.	Treatment	CGR ($g/m^2/day$)
1	0.6 ET_c (T_1)	4.95
2	0.8 ET_c (T2)	5.29
3	1.0 ET_c (T3)	7.64
4	1.2 ET_c (T4)	9.3
5	Control (T5)	12.34
6	SEm+	0.4746
7	CD at 5%	1.40
8	CV%	14.71

Table 4: Effect of irrigation regimes on water use efficiency of wheat crop

Sr. No.	Treatment	Grain WUE (kg/ha-mm)	Dry Matter WUE (kg/ha-mm)
1	0.6 ET_c (T_1)	6.67	9.96
2	0.8 ET_c (T2)	5.55	8.09
3	1.0 ET_c (T3)	5.36	7.64
4	1.2 ET_c (T4)	5.53	7.83
5	Control (T5)	5.85	8.31

Table 5: Wheat yield response function for grain and dry matter production

Yield	Wheat Yield Response Function	R^2 value
Grain	Y = 5.349 W + 133.2	0.948
Dry matter	Y = 7.188 W + 360.1	0.925

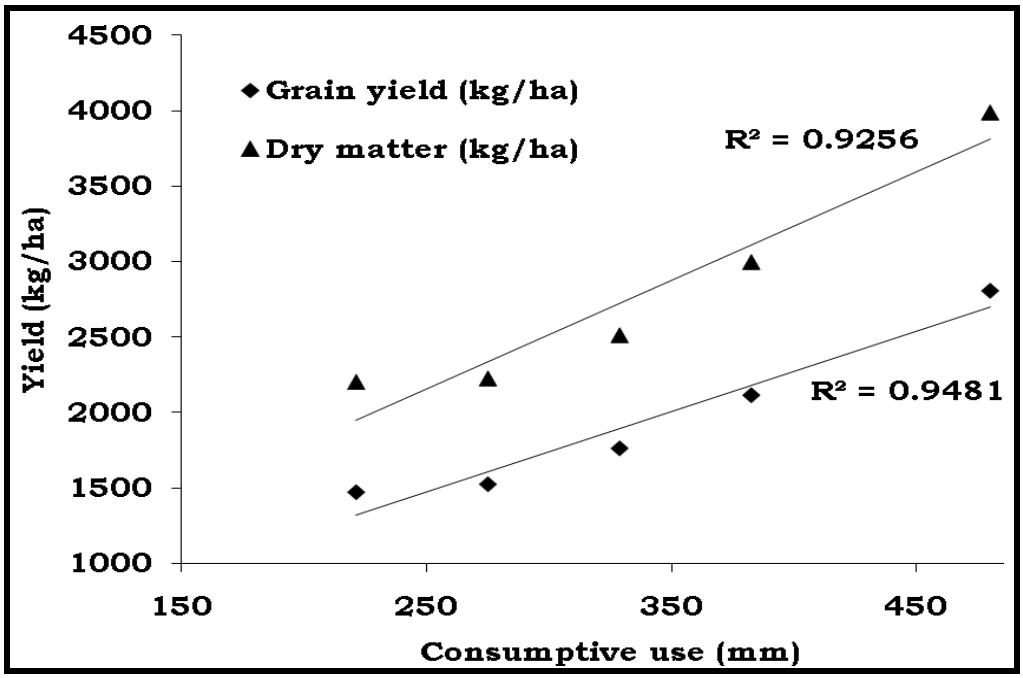

Figure 1: Relationship between observed grain yield and water consumption

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