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Cotton Crop Response to Thermal Regimes under Surface Irrigation at Stress Free Water Application Level

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ABSTRACT

The field experiments were conducted for consecutive two years to assess the crop performance to thermal regime. Cotton (H-8) variety was irrigated under surface irrigation at moisture stress free condition. Nine treatments were consisted of nine different dates of sowing were May 1, 8, 15, 22, 29, June 5, 12, 19 and 1stJuly. The results were used for modeling the cotton yield response to thermal regimes. The highest and lowest seasonal heat unit's inputs were observed as 2449.10 degree-days and 2224.25 degree-days when cotton was sown on 1stMay and 1stJuly. The highest yield of 2474kg/ha in the earliest date of sowing (1stMay) and lowest of 1564 kg/ha in the last date of sowing were observed. The WUE and HUE was decreased continuously from 3.17 to 1.94 kg/ha.mm. the days required to mature the crop were increased continuously from 177 to 210 when cotton sowing delayed from 1stMay to1stJuly. The exponential relationship (R2=0.65) between seed cotton yield and seasonal heat unit was best fitted.

Keywords : Cotton Crop Yield, Water Consumption, Water Use Efficiency, Thermal Regimes

I. INTRODUCTION

Crop yields under irrigated agriculture are several folds higher than rain fed dry farming system. Investments for irrigation are usually of top priority in all countries of aired and semiarid regions like India. The cotton is highly remunerative crop because of higher yield due to favorable soil and climatic conditions in the Saurashtra region of Gujarat. However water scarcity is the main constraint in its adoption for large scale. Deficit irrigation through water use efficient irrigation method is one of the major ways to increase the cotton acreage and water use efficiency. The irrigation water management planning requires information on optimal thermal regimes (date of sowing).

II. METHODOLOGY

The experiment was carried out at Junagadh Agricultural University campus farm, Junagadh, Gujatat, India to assess the cotton crop response to thermal response. Cotton crop (H-8 variety) was sown at a spacing of 0.45m x 1.22m. The crop was irrigated under moisture stress free conditions throughout the growing periods. Nine treatments of dates of sowing. The sowing date were May 1, 8, 15, 22, 29, June 5, 12, 19 and 1st July. The experiment was conduct undertaken for two consecutive years. To account for the climatic variations. Each treatment was replicated 4 times The gross and net plot size was 6.62m x 4.88m and 5.40m x 3.66m respectively during the second year.

Fig1. Study area (junagadh)

However, during the first year, the gross and net plot size was restricted to 3.92 m x 4.88m and 2.70 m x 3.66m respectively. Various observations of the water consumption, durations of budding/flowering, boll development and boll opening, and cotton yield were observed and recorded. Daily maximum and minimum temperature were collected from the JAU, observatory and utilized for calculating the available heat units. The base temperature was taken as 15.56 ºC (Wanjura et al., 2002). The following expression was used to calculate the heat units.

HU= (Tmax + Tmin) /2-15.56

Where, HU is the heat units, degree-days/day; Tmax is the maximum temperature of the day, ºC; and Tmin is the minimum temperature of the day, ºC.

Table-1 Treatment details for the experiment on cotton response to thermal regimes (date of sowing)

Factor	No	Plot	Net size	Gross size	Statistical Design
Date of sowing	1	Main	5.4m x 3.66m	6.62m x4.88m	Randomized Block Design
replication	4	Block	5.4m x32.94m	6.62m x43.92m	

The mathematical models for the cotton yield response to seasonal heat unit availability (Eq. a) and cotton yield response heat unit availability during growth periods (Eq. b) was developed. The mathematical models on crop yield response to heat units were fitted through regression analysis. Various forms of the mathematical model were tried in the regression analysis and the model having the highest goodness of fit (R^2) was proposed.

Y = f (HU)… (a)

Y = f (hui) … (b)

Where, Y is cotton yield (kg/ha); HU is total seasonal heat unit availability (degree-days); hui, is heat availability (degree-days) during the ith growth stage; and i is an index for the growth period/stage (i = 0, 1, 2, 3 and 4 for establishment, vegetative development, flowering, boll development and 4 boll maturity stage respectively.

III. RESULTS AND DISCUSSION

The period of experiments (May To Jan),the minimum pan evaporation, temperature and relative humidity was observed as 0.1mm, 7.9°C and 25 % respectively while maximum were 13.2mm, 43.8°C and 99.5% respectively during the First year. During the second year the minimum values of those were 0.2mm, 7.4°C and 15.5 % respectively while maximum were 11mm, 45.2°C and 100%

Cotton Yield Response to Thermal Regimes: The thermal energy input for cotton production was computed in terms of HU, using a base air temp. of 15.6°C. The HU for the entire growing season were found max.2476 degree-days and min. 2205degree-days for the cotton sown on 1st May and 1st July of first year. Similarly it varied between 2422 and 2243 degree-days for the cotton sown on 1st May and 1st July of second year. The statistical analysis was carried out for the yield data are presented in Table-2.The maximum yield of 2405 kg/ha and minimum of 1443 kg/ha during the first year. Similarly, for the second year, the yield were 2452 and 1684 kg/ha respectively. The statistical analysis showed significant differences in the cotton yield obtained with different date of sowings.

The water use efficiency and heat use efficiency decreased with the delay in date of sowing on 1st May and 1st July. During the first year, the highest WUE and HUE were found as 2.96 kg/ha.mm and 0.97 kg/ha per degree-days respectively for the date of sowing of 1st May. The lowest were 1.71 kg/ha.mm and 0.65 kg/ha per degree-days respectively on 1st July.

It can be seen that up to seasonal heat inputs of 2400 degree-days, the yield response to heat inputs is nearly linear. For the heat inputs of more than2400 degree-days, the yield response to heat inputs was very rapid. The reason might be stress free moisture condition. The best fitted models are presented in Table-3, the exponential, linear and exponential relationship were found best fitted to the results of the first year, second year and pooled respectively. The heat unit availability during the flowering and boll development stages had reverse effect on the cotton yield.

Table-2 the statistical analysis of cotton yield (kg/ha) observed under different date of sowing

S. No.	Treatment	Cotton yield(kg/ha)		
		First year	Second year	Pooled
1	DOS-1(1st May)	2405	2542	2474
2	DOS-2(8th May)	2213	2347	2280
3	DOS-3(15th May)	2057	2197	2127
4	DOS-4(22nd May)	1956	2098	2027
5	DOS-5(29th May)	1881	2027	1954
6	DOS-6(5th June)	1822	1973	1897
7	DOS-7(12th June)	1787	1939	1863
8	DOS-8(19th June)	1766	1929	1848
9	DOS-9(1st July)	1443	1684	1564
10	SEm	27.57	25.87	18.70
11	CD (5%)	80.47	75.51	52.99
12	CV (%)	2.86	2.48	2.67

DOS: Date of sowing, SEm: Standard error of mean , CD: critical difference, CV: coefficient of variation

Table-3 Developed models for cotton yield response to thermal regimes

Period	Best fitted model		R^2
Whole growth season	First year	$Y = 72.963\ e^{0.0014(HU)}$	0.7615
	Second year	$Y = 2.5761(HU) -4081.6$	0.5114
	Pooled	$Y = 66.474\ e^{0.0014(HU)}$	0.6547
Establishment stage	First year	$Y = 447.76\ e^{0.0021(hu0)}$	0.8878
	Second year	$Y = 488.72\ e^{0.0022(hu0)}$	0.905
	Pooled	$Y = 466.24\ e^{0.0021(hu0)}$	0.9058
Vegetative stage	First year	$Y = 08.6353(hu_1)-2900.2$	0.7149
	Second year	$Y = 05.4237(hu_1)-898.78$	0.6396
	Pooled	$Y = 06.7799(hu_1)-1753.7$	0.6701
Flowering stage	First year	$Y = -14.3920(hu_2)+10119$	0.578
	Second year	$Y = -06.5356(hu_2)+5723.4$	0.237
	Pooled	$Y = -11.4290(hu_2)+8440.9$	0.431
Boll development stage	First year	$Y = -05.1648(hu_3)+3632.4$	0.4185
	Second year	$Y = -04.0249(hu_3)+3427.1$	0.6302
	Pooled	$Y = -04.9780(hu_3)+3658.2$	0.5875
Boll maturity stage	First year	$Y = 52.881(hu_4)^{0.6507}$	0.5662
	Second year	$Y = 567.41(hu_4)^{0.232}$	0.0749
	Pooled	$Y = 105.09(hu_4)^{0.5303}$	0.3371

Where, Y is cotton yield (kg/ha), HU is total seasonal heat unit availability (degree-days), hu_0, hu_1, hu_2, hu_3, hu_4 are heat unit availability during the establishment, vegetative, flowering, boll development and boll maturity stage respectively.

The reason was that higher thermal regimes during these two stages had delayed the cutoff. Therefore continuous vegetative growth during these two stages resulted the shedding of the buds, flowers and also attacks of armyworms.

CONCLUSIONS

(a)The exponential relationship (R2=0.65) between seed cotton yield and seasonal heat unit input was found best fitted. (b) The relationship between cotton yield and heat unit were in the form of exponential during the establishment stage (R2=0.91), power during boll maturity (R2=0.34), and linear during the vegetative development (R2=0.67), flowering (R2=0.43) and boll development (R2=0.58) stages. (c) The seasonal heat inputs to cotton decreased with delay in the date of sowing. It can be seen that the yield was reduced with reduction in seasonal heat input by delaying the sowing. (d) No consistent trend in the seasonal water consumption was found because cotton consumed more water during the period of higher temperature but the higher heat accumulations of this period helped to reduce the maturity Period.

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