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Thermal and radiation use efficiency of *Bt* cotton under varying irrigations and nutrient management practices

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ABSTRACT : A filed experiment was conducted during 2015-2016 to compution of agrometeorological indices *i.e.* growing degree days (GDD), heat use efficiency (HUE), hello thermal use efficiency (HTUE), and radiation use efficiency (RUE) for Bt cotton under varying irrigation frequencies and nitrogen levels. Four levels of irrigation applications (I_1 = 0.60 Epan, I_2 =0.80 Epan, I_3 = 1.00 Epan and I_4 control) and four different levels of nitrogen (F_1 = RDN + K, F_2 = Extra (75%) RDN + K, F_3 = Extra (50%) RDN +K and F_4 = Extra (25%) RDN + K) were placed in randomized block design with replications. Results revealed that the dry matter accumulation, *Kapas* yield, heat use efficiency (HUE), hello thermal use efficiency (HTUE) and radiation use efficiency (RUE) were significantly influenced by irrigation and nitrogen levels on *Bt* cotton. Irrigation tried at 0.60 Epan and nitrogen applied at RDN + K significantly recorded higher agrometeorological indices and *on a par* with irrigation at 0.80 Epan and 25 per cent extra RDN + K applied.

Key words : *Bt* cotton, GDD, HTU, HTUE, HUE, RUE

Cotton is important commercial crop grown in Guntur district of Andra Pradesh in an area of 2 lack ha in *kharif* season (Commissioner of Agriculture, Government of AP). The climate in Guntur district is sub tropical in nature. Cotton yield is highly sensitive to weather variables, soil, irrigation water and management practices. Weather elements such as temperature and agrometeorological indices *i.e.* photo thermal, helio thermal and intercepted radiation, in addition to irrigation and nitrogen levels are to be limiting factors for growth and yield of cotton under rainfed conditions (Ratnam *et al.*, 2014) . These deficiencies reduce vegetative and reproductive growth and reducing yield due to senescence. On other hand excessive irrigation and nitrogen levels may shift the balance between vegetative and reproductive growth towards excessive development, thus delay the crop maturity and reducing seed cotton yield. Lint yield response to increased N levels and radiation use efficiency has a linear relationship in growth and development of cotton. In Krishna agro climatic conditions no data are available on yield response of *Bt* cotton to thermal indices, irrigation and nitrogen.

Temperature based thermal indices *viz.,* growing degree days (GDD) or heat unit requirement has been used to characterize the response of any crop to the thermal status of the microclimate within and around the crop canopy (Singh *et al.*,2008b). GDD are based on the concept that, the real time to attained a phonological stage of any crop are linearly related to temperature range between base temperature (Tb) and optimum temperature. Besides GDD, heliothermal unit (HTU) is also being used as an indicator to predict the growth and yield of any crop (Srinivas *et al.*, 2008). Radiation energy as PAR a crucial role in photosynthesis process and thus it's use efficiency is an important indicator to assess the influence of microclimate on crop productivity. Crop variety and irrigation rigimes play crucial role in canopy structure and thus influenced different components of photosynthetic active radiation (PAR) and monitor the status of radiation use efficiency (Han *et al.*, 2008). The amount of heat and radiant energy available to the crop is not fully convertible into dry matter. Efficiency of conversion of these energies into dry matter also depends on the genetic characteristics of the crop as well as status of water and nutrients in the root zone profile.

Therefore, the present study was taken to know thermal and radiation use efficiency of Bt cotton under varying irrigations and nutrient management practices under rainfed conditions.

Field experiment was framed during 2015-2016 at Regional Agricultural Research Station, Lam, Guntur (latitude:$16^0 18^1$ N, longitude $80^0 29^1$ E), Andhra Pradesh. The climate is subtropical with annual rainfall of 950 mm. The soil of the experiment field was clay loam in texture, neutral to slightly alkaline in reaction (pH 7.8 to 8.2) medium in organic carbon content (0.51%), low in available K (1099 kg/ha). The trial was laid out in factorial RBD with three replications. The treatments consists of four irrigations levels *viz.,* I_1= 0.60 E pan, I_2= 0.80 E pan, I_3= 1.00 E pan and control as factor : four nitrogen levels *viz.,* F_1= RDN (150+K Kg N/ ha) + K, F_2= (75%) , RDN+K ,F_3= (50%), RDN+K andF_4= (25%) RDN+K as factor : B. During the experimentation crop received an amount of 605.8 mm rainfall in 36 rainy days, mean maximum temperature (T mean) of 34.04 °C, mean minimum temperature of 21.7 °C, mean sun shine hours of 5.8 (Fig.1). Sowing was done by dibbling one seed/hill the gap filling was done on fifteen days after sowing. *Bt* cotton hybrid, Jaadoo was sown on 30th SMW and harvested on 6th SMW. Entire phosphorus was applied in the form of single super phosphate as basal, whereas nitrogen and potassium were applied in three split doses at 30, 60, 90 days after sowing as per the treatments in the form of urea and muriate of potash. Necessary and need based plant protection was taken up during the crop growth. The data pertaining to temperature, other temperature derivative weather parameters and yield was collected and analysed the growing degree days (GDD), hello thermal units (HTU), hello thermal use efficiency (HTUE), heat use efficiency (HUE), and radiation use efficiency (RUE) were computed by following equations as proposed by (Sreenivas *et al.*, 2008) The base temperature (T_b) 15.5 ° C (Ratnam *et al* ., 2014) was used for calculation of GDD.

$$GDD = \frac{\text{“ }(Tmax+Tmin)}{2} - T\ base$$

HUE = Yield ÷ “GDD

HTU= GDD x SSH (bright)

HTUE (kg ha^{-1} $^oC^{-1}$ hr^{-1}) = Yield ÷ HTU

Radiation use efficiency (RUE) = yield ÷ Solar radiation (MJm^{-2})

Solar radiation= 1SSH =3.66 (MJm^{-2})

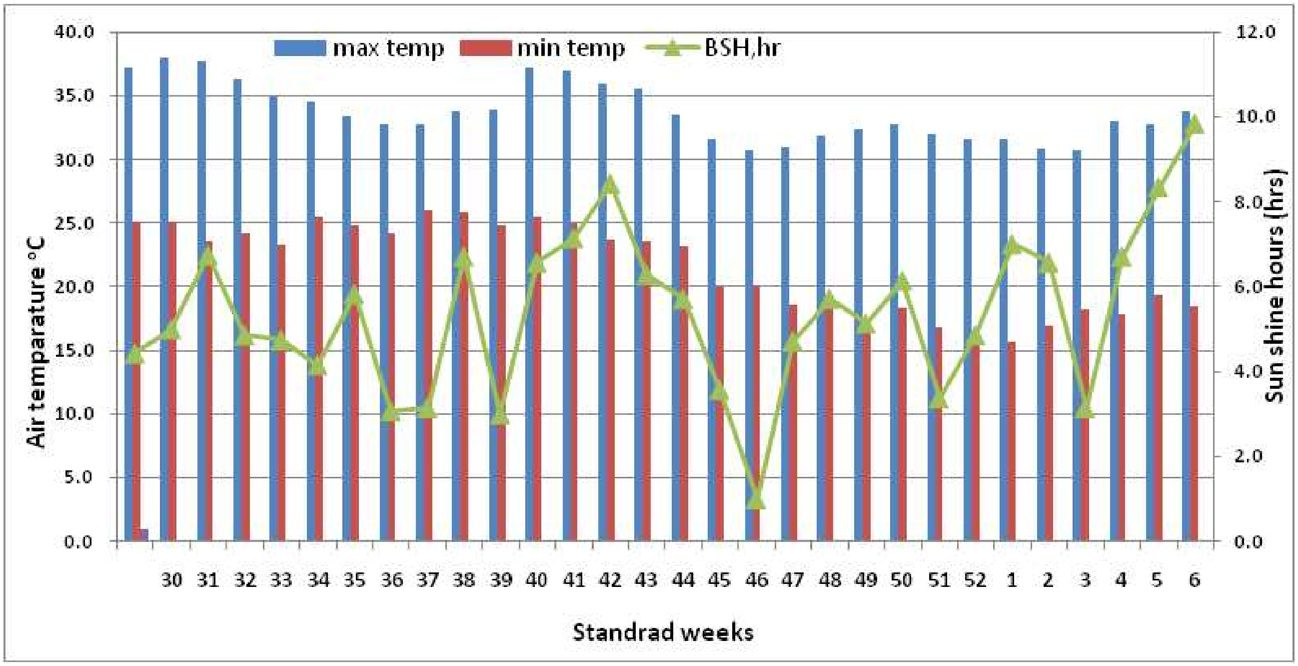

Fig. 1. Temporal variation of air temperature and bright sun shine hours during crop growing period

RESULTS AND DISCUSSION

Drymatter accumulation : Drymatter accumulation was by both irrigation and nitrogen levels. However, their interactions was non significant (Table 1).

The highest (176 gm^{-2}) DM was obtained with 0.60 Epan which was significantly superior over control and 1.0 Epan, while, it was at par with 0.80 Epan. Frequently irrigated crop significantly increased the DM production compared to lower no of irrigations. Significantly the higher DM accumulation (178 gm^{-2}) was registered by applying RDN+K and it was *on a par* with (25%) RDN+K. Optimum irrigation levels and recommended dose of N+K and favourable weather conditions have favoured the better assimilation rate, and translocation of photosynthates as CHO of cotton during different phenophases may be the reason for highest DM accumulation.

Seed cotton yield : The highest (3887 kg/ha) seed cotton yield was recorded under 0.6 Epan frequency. The seed cotton yield increased by 13 and 19 per cent when two and one additional irrigation was given under 0.80 and 1.0 Epan, respectively.

Heat use efficiency (HUE) : Dry matter accumulation was found to be significant during crop growth. Significantly higher dry matter accumulation was recorded when irrigation was applied at 0.60 Epan and fertilizer applied at RDN+K. The significantly the highest HUE value of 0.29 and 0.29 kg/ha/C/d under 0.6 Epan irrigation frequency in combination with RDN+K respectively was reported during the experimentation and these value were *on a par* with 0.8 Epan and extra (25%) RDN+K respectively. The *Bt* cotton irrigated at 0.60 Epan and fertilizer applied at RDN+K resulted in more drymatter this could be the reason for more heat

Table 1. Thermal and radiation use efficiency of *Bt* cotton under varying irrigations and nutrient management practices

Treats	Cumul GDD (°C)	Cumul ssh (hd^{-1})	Cumul HTU	*Kapas* yield (kg/ha)	HTUE (kg/HTU)	Dry matter (gm^{-2})	HUE (HTU)	Solar radiation (MJm^{-1})	RUE (MJm^{-2})
Factor-I Irrigation Levels									
I_1= 0.60 E pan	614	182	2922	3887	1.33	179	0.292	665.0	21.27
I_2= 0.80 E pan	614	182	2922	3392	1.16	168	0.274	665.0	18.62
I_3= 1.00 E pan	614	182	2922	3160	1.08	153	0.248	665.0	17.36
I_4= Control (RF)	614	182	2922	2749	0.94	132	0.215	665.0	15.12
SEm ±				90.00	0.03	8.80	0.004		0.51
CD (p=0.05)				312.23	0.11	30.46	0.013		1.78
CV(%)				6.71	6.73	13.62	3.70		6.95
Factor-II N Levels									
F_1= RDN+K	614	182	2922	3474	1.19	178	0.294	665.0	19.09
F_2= (75%) RDN+K	614	182	2922	3002	1.03	151	0.243	665.0	16.50
F_3= (50%) RDN+K	614	182	2922	3304	1.13	169	0.273	665.0	18.07
F_4= (25%) RDN+K	614	182	2922	3406	1.17	135	0.219	665.0	18.70
SEm ±				125.00	0.42	6.48	0.011		0.674
CD (p=0.05)				364.83	0.12	18.90	0.032		1.98
CV (%)				9.29	9.21	10.02	10.28		9.13
I L x NL									
SEm ±				176.79	0.060	9.16	0.015		0.954
CD (p=0.05)				NS	NS	NS	NS		NS
CV (%)				9.30	9.20	10.00	10.30		9.10

use efficacy.

Heliothermal use efficiency : Present study shows that HTU followed similar trend like that of HUE. Magnitude of HTUE was highest (1.33 kg/ha/C/hr) under 0.6 Epan irrigation frequency and this was 19 and (29%) higher over 1.0 Epan and control. An increment in nitrogen level not enhanced the status of HTUE.

Radiation use efficiency : Present study shows that RUE followed similar trend like that of HUE and HTUE magnitude of RUE was highest (21.27 MJm^{-2})) under 0.60 Epan irrigation frequency and this was 13, 18 and 29 per cent higher over to 0.80, 1.0 Epan irrigation frequency and control respectively. An increment in nitrogen level was not enhanced in the status of RUE but the highest value of 19.09 mjm^{-2} was noticed with nitrogen applied at RDN+K it was *on a par* with (25%) extra RDN+K applied to the crop during the experimentation. These results are in conformation with the findings of Aftab *et al.*, (2010).

From the above study, it can be concluded that heliothermal and radiation use efficiency of *Bt* cotton under 0.60 Epan irrigation and recommended dose of N + K resulted higher cotton yield and that was *on a par* with irrigation at 0.80 Epan and extra (25%) RDN+K.

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