Journal of Agrometeorology 9(1) : 96-99 (June 2007)

Thermal time requirement and heat use efficiency in summer green gram

RAVI KIRAN* and G S BAINS
Department of Agronomy and Agro meteorology, Punjab Agricultural University, Ludhiana-141004, India

ABSTRACT

The investigation was carried out to study the thermal requirement and heat use efficiency (HUE) in summer green gram (*Vigna radiata* L. Wilczek) cv. SML-134 during summer season 1999 and 2000 under changed hydrothermal regimes at Punjab Agricultural Universitry, Ludhiana. The treatments included 3 dates of sowing viz. 12th April (D_1), 19th April (D_2) and 26th April (D_3) (in main plots); 3 irrigation levels viz. 0.5 IW: CPE ratio (I_1), 0.75 IW: CPE ratio (I_2) and 1.0 IW : CPE ratio (I_3) (in sub plots); and mulched (M_1) (@ 5t ha^{-1} wheat straw mulch) and unmulched crop (in sub-sub plots), in a split-split plot design. Thermal indices based predictive models explained 61%to 64% of the variations in the grain yield, during these years. Varied amount and distribution in the rainfall during years affected grain-HUE considerably, but, the effect was slight in biomass-HUE.

Key Words : Thermal indices, Irrigation, Straw mulching, Yield predictive models, Heat use efficiency.

Prevailing weather condition has direct bearing upon the phenological events of any crop during the whole crop growing season, which ultimately affect the yield of crop. The effect of temperature, which is most probably one of the most dominant weather elements determining the phenological behavior the crop can be assessed by accumulated heat units. Thermal time has been described as the independent variable to delineate plant growth and development (Dwyer and Stewart, 1986). Temperature based agrometeorological indices such as Growing Degree Days (GDD), HelioThermal Units (HTU) and Photo Thermal Units (PTU) are based on the concept that real time to attain the phenological stage is linearly related to temperature in the range between base temperature and optimum temperature (Monteith, 1981). Heat Use Efficiency (HUE) *ie*. utilization of heat in terms of dry matter accumulation has great practical application as total energy is never converted into dry matter even under the

***Present Address :** Assistant Professor (Agrometeorology), VCSG College of Horticulture (G.B.Pant University of Agriculture & Technology, Pantnagar) BHARSAR-246123

most favorable agro climatic conditions. Efficiency of conversion of heat energy into dry matter depends upon genetic factors, sowing time and crop type (Rao et al, 1999).

Summer green gram (*Vigna radiata* L. Wilczek) is an important pulse crop in north India. This crop is sown from mid March to first week of April after the harvest of *Brassica* spp., lentil, potato, toria; and in the second fortnight of April after the harvest of wheat in most of the northern part of India. Sowing dates and irrigation regimes depict varied performance and productivity of summer green gram due to changed environment plant interactions. Therefore, the present investigation was conducted to access the thermal requirement of the crop and develop the yield predictive models for summer green gram under different hydro thermal regimes.

MATERIALS AND METHODS

The field experiment was carried out at the Research Farm, Department of Agricultural Meteorology, Punjab Agricultural University, Ludhiana, during summer season 1999 and 2000. Ludhiana in located at 30° 54'N and 75° 56'E, at an altitude of 247 m, a m s l. The area is characterized by semi arid subtropical climate with very hot summer and cold winters during April - June and December - January, respectively. During summer maximum temperature ranges between 40-45°C and occasionally going up to 47°C while during winter, the minimum air temperature ranges between 5-8°C and occasionally goes as low as 0°C. This region in dominated by hot dry westerly winds during summer season. The treatments included 3 dates of sowing viz. 12th April (D_1), 19th April (D_2) and 26th April (D_3) (in main plots); 3 irrigation levels viz. 0.5 IW: CPE ratio (I_1), 0.75 IW: CPE ratio (I_2) and 1.0 IW: CPE ratio (I_3) (in sub plots); and mulched (M_1) (@ 5 t ha^{-1} wheat straw mulch) and unmulched crop (in sub-sub plots), in a split-split plot design. All the recommended practices were followed as per the Package and Practices, Punjab Agricultural University, Ludhiana. The agrometeorological indices based on temperature were calculated using a base temperature of 10° C.

Heat use efficiency was calculated as:

$$\text{HUE (kg ha}^{-1}\,{}^{\circ}\text{C day}^{-1}) = \frac{\text{Grain or biomass yield (kg ha}^{-1})}{\text{Cumulative growing degree days (}^{\circ}\text{C days)}}$$

Predictive regression relations were worked out between agrometeorological indices and yield of crop under different treatments.

RESULTS AND DISCUSSION

Thermal time requirement

Thermal time requirement for maturity of the crop has been depicted for

Table 1 : Thermal time requirement in green gram during whole crop growth under changed hydrothermal regimes during 1999 and 2000

Treatment	AGDD*		AHTU*		APTU*	
	1999	2000	1999	2000	1999	2000
D1	1519	1612	15852	13593	21182	21636
D2	1483	1581	14897	13225	20272	20900
D3	1432	1531	13120	12729	20043	19824
I1	1480	1494	14533	12519	19980	20958
I2	1498	1610	15041	13051	20739	21502
I3	1502	1616	15763	13157	21452	21984
M1	1506	1613	15110	13221	21404	21650
M2	1471	1579	14648	12773	19861	21494

various treatments in Table 1. Among sowing dates treatments D_1 required higher AGDD, APTU, and APTU followed by D_2 and D_3, respectively. However, in general, the variation in the thermal requirement was found higher in 1999 than that of 2000, among sowing dates. Among irrigation treatments I_3 had highest thermal units requirements followed by I_2 and I_1, respectively. This may be due to forced maturity in case of I_1 (1.00 IW: CPE ratio) followed by I_2 (0.75 IW: CPE) during both the years. Although, the difference in the heat units requirement were lower in case of I_2 and I_3.treatments during 2000. This may be attributed to the rainfall in 2000 during reproductive phase of crop and thereby re-growth of the crop. In case of mulching treatments mulched crop (M_1) registered higher thermal time requirement than that of unmulched crop treatment (M_2) during both the years. However, the difference between the heat unit requirements in M_1 and M_2 treatments was not very much different except in case of APTU. The difference in requirement was found lower in case of 2000 due to more frequent rainfall in comparison to 1999. This might had shaded the mulching effect on the crop performance. The findings are in conformity with the results of heat unit requirements of green gram by Singh et al (1994) and in chick pea by Bal (1997) under varied hydrothermal regimes.

Predictive models were developed for grain yield (Y)

$$Y = 0.0224(AGDD) - 25.12 \; Y \qquad (R^2 = 0.61^*)$$

$$Y = 0.0015(AHTU) - 10.91 \; Y \qquad (R^2 = 0.64^*)$$

$$Y = 0.0022(APTU) - 40.09 \; Y \qquad (R^2 = 0.62^*)$$

Significant (at 5 % level) linear relationship between grain yield and AGDD, AHTU and APTU were obtained. The study shows that various agro meteorological indices explained the 61% to 64% variation in grain yield of summer green gram under varied hydrothermal regimes.

Table 2: Grain and biomass heat use efficiency (HUE) of green gram as influenced by different treatments in years 1999 and 2000

Treatments	Grain HUE		Biomass HUE	
	1999	2000	1999	2000
D1	0.57	0.51	2.88	2.89
D2	0.53	0.49	2.82	2.73
D3	0.53	0.46	2.84	2.65
I1	0.45	0.44	2.58	2.49
I2	0.50	0.50	2.77	2.68
I3	0.64	0.52	3.10	2.98
M1	0.57	0.51	2.94	2.76
M2	0.50	0.45	2.71	2.70

Heat use efficiency

Among sowing dates D_1 had higher HUE followed by D_2 and D_3, respectively, during both the years (Table 2). Among irrigation treatments I_3 had highest HUE followed by I_2 and I_1, respectively. Mulched crop showed higher HUE than that of unmulched crop. Interestingly, the varied amount and frequency of rainfall in 1999 and 2000 affected considerably the grain HUE, but, not the biomass HUE. Not much difference was registered in case of grain and biomass HUE of I_2 and I_3 and M_1 and M_2 treatments. This may be due to frequent rainfall in2000 during reproductive phase of crop. It may be concluded that the changing water application frequency affected more the grain HUE than that of biomass HUE in the crop.

REFERENCES

Bal, S. K. 1997. A study of microclimate, water use and crop response to gram and raya using a line source sprinkler system. M. Sc. Thesis, Punjab Agri. Univ., Ludhiana, India. 97 p.

Dwyer L. M. and Steward D.W. 1986. Leaf area development in field grown maize. *Agron. J.*, 78 : 334-348.

Monteith J.L.1981 climate variation and growth of crops. *Quart J. Royal Meteorol Soc.*,107:602-07.

Rao V.U.M., Singh D. and Singh, R.1999. Heat use efficiency of winter crops in *Haryana. J. Agrometeorol.*, 1 : 143-148.

Singh R., Tripathi, R.P. and Singh, R. 1994. Stress degree days and yield of rice varieties under irrigated and unirrigated conditions. *Agric. Science Digest.*, Karnal.14:97-98.