Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2915

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (2):** 248-252 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Correlation Studies on Effect of Temperature Regimes on Phenology, Growing Degree Days, Heat Use Efficiency and Seed Yield in Chickpea (*Cicer arietinum* L.) Genotypes

Kiran, B. O.* and V. P. Chimmad

Department of Crop Physiology University of Agricultural sciences, Dharwad. 58005

*Corresponding Author E-mail: kiran4714@gmail.com

Received: 26.04.2017 | Revised: 30.05.2017 | Accepted: 5.06.2017

ABSTRACT

*The present study was carried out with forty four chickpea genotypes sown under three dates of sowing (41st, 45th and 49th SMW). Flower initiation, days to 50 per cent flowering, pod initiation, days to physiological maturity, GDD at flower initiation, GDD at 50 per cent flowering, GDD at pod initiation, and GDD at physiological maturity showed a strong positive association among each other. However, the degree of association decreased as the dates of sowing was delayed from 41st SMW to 49th SMW. Further, heat use efficiency (HUE) was strongly associated with phenological parameters in all the dates of sowing. While, it was highly positively associated with seed yield under D_1 and D_2dates of sowing. The results also indicated that, higher temperatures were associated with decrease in duration of phenological parameters with delayed dates of sowing. Higher seed yields were recorded under earlier sowing dates (D_1) than late sown condition (D_2 and D_3). This indicates that, the association was significantly positive under D_1 (0.442**) and D_2 (0.589**) with HUE. However, it was non-significant under delayed sowing (D_3).*

Key words: *Chickpea, Yield, Pollen, Anthers*

INTRODUCTION

The major abiotic stresses affecting chickpea production are high and low temperature, drought and salinity. In case of extreme temperatures, chickpea is very sensitive during the reproductive phase of plant growth. The negative effect of high temperature (>30^0C) on grain yield is expected to increase due to global warming. A minimum decrease of 53 kg ha^{-1} of chickpea yield was observed in India per 1˚C increase in seasonal temperature[5]. Heat stress during reproductive development in legumes is generally allied with lack of pollination and abscission of flower buds, flowers and pods, leading to substantial yield loss. A short period (10 day) of high temperatures (≥ 35˚C) during early flowering and pod development of chickpea are known to cause significant reduction in pod number, seed set and grain yield[3]. Pre-anthesis and post-anthesis development and pollination processes are highly sensitive to higher temperature.

Cite this article: Kiran, B.O. and Chimmad, V.P., Correlation Studies on Effect of Temperature Regimes on Phenology, Growing Degree Days, Heat Use Efficiency and Seed Yield in Chickpea (*Cicer arietinum* L.) genotypes. *Int. J. Pure App. Biosci.* **6(2):** 248-252 (2018). doi: http://dx.doi.org/10.18782/2320-7051.2915

Nayyar *et al.*[9] suggested that the male (pollen, anthers) and female (stigma-style, ovary) organs in chickpea are most sensitive to temperature stress. Phenology is one of the important component in plant adaptation to the changing environments. Heat unit concept has been applied to correlate phenological development in crops to predict sowing and maturity dates. The Growing degree days (GDD) and Heat Use Efficiency (HUE) varied with different stages of crop growth under different dates of sowing. Gan *et al*[3] reported that higher temperature during vegetative stage promotes fast branching. Efficiency is quite useful in predicting growth and yield of chickpea. Utilization of heat in terms of dry matter accumulation is also an important aspect. Efficiency of conversion of heat energy into dry matter depends upon genetic factors, sowing time and type of crop. Changes in seasonal temperature affect the grain yield mainly through changes in phenological development processes. Present study was an attempt to understand the association of phenology, GDD, HUE and seed yield under varying sowing dates in chickpea genotypes.

MATERIAL AND METHODS

Chickpea genotypes (44) were evaluated for heat tolerance under three temperature regimes: (D_1: 41[st], D_2: 45[th]and D^3: 49[th] SMW). The temperature regimes are denoted by the change in temperature prevailing for D_1, D_2 and D_3in field condition during *rabi*, 2015-16 at Main Agricultural Research Station (MARS), Dharwad as detailed bellow. The crop was raised with a spacing of 30 x 10 cm, fertilized with 50:20:0 N:P_2O_5:K_2O. The observation on phenology parameters were recorded as per standard procedures. The Growing degree days (GDD) and Heat use efficiency (HUE) were calculated as follows.

Growing degree days at different phenological stages were calculated by summation of daily mean temperature above base (T_b=10^{o}C) temperature for a corresponding period from sowing, as suggested by Monteith[8] and expressed in ^{o}C days.

$$GDD = \sum \frac{(T_{max} + T_{min})}{2} - T_{base}$$

Heat use efficiency is useful for the assessment of yield potential of a treatment in different environment and calculated as follows[6].

$$\text{Heat use efficiency} = \frac{\text{Seed or biomass yield (kg ha}^{-1}\text{)}}{\text{GDD (day)}}$$

Table 1: The temperature prevailing during the crop period under varied dates of sowing is as follows

	T_{max} ^{o}C (Range)		T_{min} ^{o}C (Range)	
	T_{max}	T_{min}	T_{max}	T min
41[st] SMW (D_1)	34.21 - 25.11		23.00 - 10.90	
45[th] SMW (D_2)	37.00 - 25.00		22.00 - 10.90	
49[th] SMW (D_3)	38.26 - 25.00		24.00 - 10.90	

RESULTS AND DISCUSSION

The correlation ‘r’ values for phenology, growing degree days, heat use efficiency and yield for different dates of sowing recorded significantly strong positive correlation (Table 2 and 3)among flower initiation, days to 50 per cent flowering, pod initiation, days to physiological maturity, GDD at flower initiation, GDD at 50 per cent flowering, GDD at pod initiation, and GDD at physiological maturity under 41[th]SMW (D_1).Similar trend was observed under 45[th], 49[nd]SMW and pooled dates of sowing. The degree of association decreased as the dates of sowing was delayed from 41[st]SMW to 49[th] SMW. The late sowing under D_2 (T_{max} 37^{o}C) and D_3T_{max} 38.26^{o}C) the degree of association was decreased, which may be attributed to higher temperatures during terminal pod filling period. The higher temperatures might have reduced growth parameters *viz.* leaf area and its associated characters as reported by Sing *et al*[10] Further, the association of phenological parameters among themselves for pooled (D_1, D_2 and D_3) was also similar to individual dates of sowing. Heat use efficiency (HUE) indicates that efficient utilization of heat units for the growth and development specifically for dry matter accumulation. Chickpea being a cool season crop, the higher temperature than the optimum (32-35^{o}C) always inhibits the dry matter accumulation and decrease the duration of phenological parameters. Hence, in the present study, heat use efficiency represented a strong negative correlation with days to flower initiation, days to 50 per cent flowering, pod initiation, days to physiological maturity, GDD at flower initiation, GDD at 50 per cent flowering, GDD at pod initiation, and GDD at physiological maturity(-0.580**, -0.591**, -0.611**,-0.658**,-0.531**,-0.592**, -0.629** and -0.668**, respectively).The seed yield was higher in earlier sowing (D_1) than late sown (D_2 and D_3) condition. The association between yield and HUE was significantly positive under D_1 (0.442**) and D_2 (0.589**) dates of sowing while, it was not significant under D_3 (0.223) date of sowing. Similar to other parameters, the degree of association decreased from 41stto 49th SMW dates of sowing. Devasirvatham *et al*[2] also reported that there existed significantly negative association under higher temperature between seed yield and crop phenology in chickpea genotypes. Further, the association was significantly negative between seed yield and pod initiation, days to physiological maturity, GDD at pod initiation, and GDD at physiological maturity (-0.309*, -0.344**, -0.392** and -0.349*, respectively).On the contrary D_3 date of sowing did not record significant association with yield and other phenological parameters except GDD for physiological maturity (-0.335*). However, all the parameters did show significant negative association with yield under D_2 and pooled dates of sowing. This indicates that, the degree of association of heat use efficiency with yield was higher under 45thSMW (D_2) compared to other dates of sowing. Under 41stSMW pod initiation, days to physiological maturity, GDD at pod initiation and GDD at physiological maturity represented strong negative correlation with yield (-0.309*,-0.344*,-0.392** and -0.394*, respectively). Similar results were also noticed by Mishra and Babbar[7] who reported that under timely sown condition flower initiation, days to 50 % flowering and pod initiation were negatively associated with yield. However, under pooled dates of sowing, days to flower initiation, days to 50 per cent flowering, pod initiation, physiological maturity, GDD at pod initiation and GDD at physiological maturity recorded significantly strong negative correlation with yield (-0.238**,-0.249**, -0.289**, -0.272**, -0.245** and -0.275**, respectively). The growing degree day (GDD) concept is minimum and maximum temperatures that are being considered for calculating GDD, which are the events occurring at a particular point of time in a day. As the planting is delayed beyond optimum date/ideal time, the yields go down. The variation in GDD requirement depends on the duration of a particular phenophase[1]. Currently, no significant relationship was observed between GDD at flower initiation and days to 50% flowering with yield (-0.150 and -0.161 respectively). Further, heat use efficiency was found significant and positive correlation with yield (0.357**) under pooled condition. The interrelationship between flower initiation, days to 50 per cent flowering, pod initiation, days to physiological maturity, GDD at flower initiation, GDD at 50 per cent flowering, GDD at pod initiation, and GDD at physiological maturity showed strong negative correlation with heat use efficiency under pooled condition (-0.477**, -0.531**, -0.521**, -0.472**, -0.543**, -0.556** and -0.662**, respectively). Significantly positive association was observed among phenology and its associated characters.

Table 2: Correlation coefficient ‘r’ values among different phenological, GDD, HUE and seed yield in chickpea genotypes

	Days to Flower initiation	Days to 50 % flowering	Days to Pod initiation	Days to Physiological maturity	GDD for Flower initiation	GDD for 50 % flowering	GDD for Pod initiation	GDD for Physiological maturity	HUE	Seed Yield (g plant^{-1})
					41st SMW (D_1)					
Days to flower initiation	1									
Days to 50 % flowering	0.989**	1								
Days to pod initiation	0.970**	0.986**	1							
Days to physiological maturity	0.950**	0.969**	0.985**	1						
GDD for flower initiation	0.876**	0.876**	0.862**	0.852**	1					
GDD for 50 % flowering	0.867**	0.890**	0.887**	0.887**	0.759**	1				
GDD for pod initiation	0.944**	0.961**	0.968**	0.948**	0.830**	0.863**	1			
GDD for physiological maturity	0.935**	0.958**	0.976**	0.998**	0.842**	0.880**	0.941**	1		
HUE	-0.580**	-0.591**	-0.611**	-0.658**	-0.531**	-0.592**	-0.629**	-0.668**	1	
Seed yield plant^{-1} (g)	-0.291	-0.279	-0.309*	-0.344*	-0.261	-0.272	-0.392**	-0.349*	0.442**	1
					45th SMW (D_2)					
Days to flower initiation	1									
Days to 50 % flowering	0.979**	1								
Days to pod initiation	0.929**	0.965**	1							
Days to physiological maturity	0.660**	0.714**	0.785**	1						
GDD for flower initiation	0.999**	0.974**	0.918**	0.638**	1					
GDD for 50 % flowering	0.977**	0.999**	0.964**	0.704**	0.973**	1				
GDD for pod initiation	0.927**	0.964**	0.999**	0.782**	0.916**	0.964**	1			
GDD for physiological maturity	0.660**	0.718**	0.792**	0.996**	0.638**	0.707**	0.788**	1		
HUE	-0.466**	-0.540**	-0.573**	-0.683**	-0.450**	-0.519**	-0.561**	-0.697**	1	
Seed yield plant^{-1} (g)	-0.483**	-0.512**	-0.530**	-0.582**	-0.472**	-0.497**	-0.520**	-0.606**	0.589**	1

*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed). n = 44

Table 3: Correlation coefficient ‘r’ values among different phenological, GDD, HUE and seed yield in chickpea genotypes

	Days to Flower initiation	Days to 50 % flowering	Days to Pod initiation	Days to Physiological maturity	GDD for Flower initiation	GDD for 50 % flowering	GDD for Pod initiation	GDD for Physiological maturity	HUE	Seed Yield (g plant^{-1})
					49th SMW (D_3)					
Days to flower initiation	1									n=44
Days to 50 % flowering	0.808**	1								
Days to pod initiation	0.671**	0.646**	1							
Days to physiological maturity	0.667**	0.631**	0.593**	1						
GDD forflower initiation	0.999**	0.806**	0.673**	0.672**	1					
GDD for 50 % flowering	0.809**	0.999**	0.636**	0.637**	0.808**	1				
GDD for pod initiation	0.680**	0.653**	0.998**	0.606**	0.683**	0.645**	1			
GDD for physiological maturity	0.668**	0.627**	0.591**	0.999**	0.673**	0.634**	0.606**	1		
HUE	-0.475**	-0.569**	-0.479**	-0.566**	-0.480**	-0.578**	-0.493**	-0.578**	1	
Seed yield plant^{-1} (g)	-0.128	-0.207	-0.163	-0.319*	-0.136	-0.225	-0.197	-0.335*	0.223	1
					Pooled dates of sowing (D_1, D_2 and D_3)					
Days to flower initiation	1									
Days to 50 % flowering	0.955**	1								
Days to pod initiation	0.905**	0.918**	1							
Days to physiological maturity	0.815**	0.839**	0.844**	1						
GDD for flower initiation	0.915**	0.885**	0.823**	0.796**	1					
GDD for 50 % flowering	0.866**	0.918**	0.829**	0.824**	0.856**	1				
GDD for pod initiation	0.881**	0.898**	0.953**	0.862**	0.854**	0.874**	1			
GDD for physiological maturity	0.775**	0.802**	0.804**	0.981**	0.781**	0.816**	0.850**	1		
HUE	-0.477**	-0.531**	-0.521**	-0.611**	-0.478**	-0.543**	-0.556**	-0.662**	1	
Seed yield plant^{-1} (g)	-0.238**	-0.249**	-0.289**	-0.272**	-0.150	-0.161	-0.245**	-0.275**	0.357**	1

However, heat use efficiency was strongly positive associated with phenological parameters and seed yield under D_1 and D_2 dates of sowing. Heat use efficiency plays an important role in productivity of chickpea under favourable temperature regimes while it may have ill effect on seed yield under higher temperature regimes.

REFERENCES

1. Basu, S., Parya, M., Dutta, S. K., Jena, S., Maji, S., Nath, R., Mazumdar, D. and Chakraborty, P. K., Effect of growing degree day on different growth processes of wheat (*Triticum aestivum L*.). *J. Crop Weed*.**8:**18-22 (2012).
2. Devasirvathama, V.,Gaurb, P.M., Rajua, T.N., Trethowana, R.M. and TanD. K.Y., Field response of chickpea (*Cicer arietinum* L.) to high temperature. *Field Crops Research*., **172:** 59–71(2015).
3. Gan, Y. T., Wang, J. and Poppy, L. B., Node and branch development of chickpea in a semiarid environment.*Can. J. Plant sci*.**86:** 1333–1337(2006).
4. Girijesh, G.K., Kumara swamy, A.S., Sridhara, S., Dinesh Kumar, M., Vageesh, T.S. and Nataraju, S.P., Heat use efficiency and helio-thermal units for maize genotypes as influenced by dates of sowing under southern transitional zone of Karnataka state., *I. J. S. N.*,**2(3):** 529-533 (2011).
5. Kalra, N., Chakraborty, D., Sharma, A., Rai, H. K., Jolly, M., Chander, S., Kumar, P. R., Bhadraray, S., Barman, D., Mittal, R. B., Lal, M. and Sehgal, M., Effect of temperature on yield of some winter crops in northwest India. *Current Sci.*, **94:** 82-88 (2008).
6. Masle, J., Doussinault, G., Farquhar, G. D. and Sun, B., Foliar stage in wheat correlates better to photothermal time than to thermal time. *Pl. Cell Envi.*, **12:**235-24 (1989).
7. Mishra, S. and Babbar, A., Selection to assess the promising chickpea promising lines under normal and heat stress environments. *Electronic Journal of Plant Breeding*., **5(2):** 260-267 (2014).
8. Monteith, J. C., Consistency and convenience in the choice of units for agricultural Science. *Exptl. Agri*., **20:** 115-117 (1984).
9. Nayyar, H. and Gupta, D., Differential sensitivity of C_3 and C_4 plants to water deficit stress: association with oxidative stress and antioxidants. *Environ. Exptl. Bot*., **58:**106-113 (2005).
10. Singh, P., Nedumaran, S., Boote, K. J., Gaur, P. M., Srinicvas, K. and Bantilan, M. C. S., Climate change impacts and potential benefits of drought and heat tolerance in chickpea in South Asia and East Africa. *Europ. J. Agronomy*., **52:**123-137 (2014).
11. Wang, J., Gan, Y. T., Clarke, F. and McDonald, C. L., Response of chickpea yield to high temperature stress during reproductive development. *Crop Sci.,* **46(5):**2171-2178 (2006).