Journal of Agrometeorology 20 (4) : 293-296 (December 2018)

Phenophasic development of wild *Cicer* species in relation to agroclimatic indices under rainfed and irrigated conditions

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ABSTRACT

The field study was conducted on six wild chickpea accessions to evaluate the influence of agroclimatic indices *viz*., accumulated growing degree days (GDD), photo-thermal unit (PTU) and helio-thermal unit (PTU) at various phenophases of chickpea under irrigated and rainfed conditions on yield of the plant. *C pinnatifidum* 212 witnessed highest accumulation of heat units at all stages of phenophasic development under irrigated and rainfed conditions. Agroclimatic indices depicted positive correlation with yield under rainfed conditions.Path coefficient analysis revealed that under irrigated conditions, yield attributes and agroclimatic indices showed strong positive correlation towards the final grain yield, though HTU at maturity indirectly affected yield via pods per plant (PPP) to the final yield in rainfed treatment. Among all the accessions, *C pinnatifidum* 212 performed better than other accessions by possessing high heat use efficiency (HUE) values, thus displaying their capacity of utilizing GDD and incorporating final yield.

Keywords: Agroclimatic indices, rainfed conditions, yield attributes

Limiting water availability when coupled with daily indices such as sunshine hours, day length and mean temperatureis detrimental to the final productivity.Phenological aspects such as time of germination, flowering and maturity play a vital role in the concluding yield of that plant (Sidhu *et al.* 2017). Assimilation of absolute photothermal and heliothermal units is required for the plant to transit itself from one developmental phase to another.Chickpea (*Cicer arietinum* L.) whose maximum production hails in the rainfed areas is highly influenced by the non-monetary traits such as sowing time and their capacity to give high yields while thriving on residual moisture content of soil. The variation of phenological parameters along with temperature changes are calculated in terms of growing degree days (GDD). The capacity of each accession to relate the former with grain yield is depicted in terms of heat use efficiency (HUE).Agro-climatic indices affect phenological attributes and correlating any change in the aforementioned with grain yield gives an outlook of the variations occurring on daily basis. Adaptive strategy of minimum exposure to stress and maximizing productivity is the main aim of earliness escape adaptive strategy (Daba *et al.* 2015).Though much of the work had been done on chickpea genotypes, less or no data is available on the behavioral changes of wild accessions under irrigated and rainfed water regimes. The present study was conducted to examine the changes that occur in wild chickpea accessions under varied water regimes and to correlate the changes in phenological attributes with grain yield via path coefficient analysis.

MATERIAL AND METHODS

Trials during the *rabi* (2015-16 and 2016-17) were carried out in the experimental area of pulses section, Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana. Six wild accessions *C judaicum* 95, *C judaicum* 182, *C judaicum* 185, *C judaicum* 185B, *C judaicum* 17148 and *C pinnatifidum* 212 were subjected to two treatments- irrigated (lined with water channels on two sides) and rainfed (no irrigation). The field area was irrigated before sowing and rainfed plot was restricted from further irrigation.The crop was sown in randomized block design as per package of practices.Phenological attributes *viz*., days to flower initiation, days to pod initiation and days to maturity were recorded in three replications with five tagged plants per replication. The meteorological data was obtained from School of Climate Change and Agrometeorology, Punjab Agricultural University, Ludhiana and attributes *viz*., GDD, PTU, HTU and HUE were calculated as below:

GDD= (Max. temperature + Min. temperature) / 2 – Base temperature (Tb)

Base temperature for chickpea = 5^0C

PTU=GDD X Day length

HTU= GDD X Actual Sunshine

HUE= Grain yield/GDD ((Aggarwal *et al.* 2016).

Accumulated GDD, HTU and PTU were calculated (Singh *et al*, 1990; Nuttonson, 1957) from the duration of initiation of one phenophaseonto the completion of it.

Statistical analysis

Mean value was calculated from both the seasonal trials and data was subjected to SPSS 16.0 software Tukey's post hoc test to compare the difference between treatments and accessions. Correlation analysis and polynomial regression analysis were calculated using Microsoft office Excel version 2010. Percent increase or decrease data was calculated in rainfed plants against irrigated ones.

RESULTS AND DISCUSSION

Phenology and agroclimatic indices

Flowering was induced early in the rainfed treatment in comparison to the irrigated one in all wild accessions. Wild accession *C judaicum* 185B depicted an early flowering in comparison to all other wild accessions. However, *C judaicum* 95 showed least difference of 3.81 per cent among wild accessions in flowering initiation on exposure to moisture stress condition. Days to pod initiation and maturity followed the same trend of completing the life cycle early before the onset of stress condition in all wild accessions (Table 1). Accumulated GDD, PTU and HTU increased at each stage of growth commencing towards maturity under both irrigated and rainfed regimes. *C pinnatifidum* 212 recorded the longest life cycle among all wild accessions by taking maximum days to flower, podding and to maturity. Daba *et al* (2015) reported early flowering in chickpea accessions on account of deviation from normal temperature and photoperiods.

Post hoc analysis on the agroclimatic indices depicted marked difference between the genotypes at various phenophases. During flower initiation, *C pinnatifidum* 212 was significantly different from the rest of wild accessions in relation to accumulated heat units under irrigated conditions. As the phenophases progressed towards maturity, differences among wild species became more evident under irrigated conditions. However, rainfed treatment was

Table 1 : Duration and agroclimatic indices at different phenophases of chickpea accessions

Accessions	Days to flowering (DAS)	Accumulated heat units at flowering			Days to podding (DAS)	Accumulated heat units at podding			Days to maturity (DAS)	Accumulated heat units at maturity		
		GDD	PTU	HTU		GDD	PTU	HTU		GDD	PTU	HTU
C judaicum 95	116^{b}	1226^{b}	12823^{b}	6879^{b}	131^{bc}	1434^{c}	15246^{c}	8519^{b}	157^{b}	1959^{cd}	21337^{cd}	13298^{b}
C judaicum 182	114^{bc}	1194^{b}	12466^{b}	6631^{b}	131^{c}	1436^{c}	15231^{c}	8608^{b}	157^{b}	1964^{cd}	21417^{cd}	13301^{b}
C judaicum 185B	111^{c}	1165^{b}	12133^{b}	6361^{b}	134^{b}	1490^{b}	15833^{b}	9032^{b}	161^{b}	2052^{b}	22531^{b}	14247^{b}
C judaicum 185	113^{bc}	1187^{b}	12386^{b}	6577^{b}	131^{bc}	1435^{c}	15257^{c}	8543^{b}	159^{b}	2006^{bc}	21947^{c}	13756^{b}
C judaicum 17148	115^{bc}	1215^{b}	12701^{b}	6775^{b}	131^{bc}	1436^{c}	15277^{c}	8580^{b}	156^{b}	1941^{d}	21105^{d}	13107^{b}
C pinnatifidum 212	131^{a}	1439^{a}	15292^{a}	8582^{a}	146^{a}	1731^{a}	18499^{a}	11209^{a}	167^{a}	2180^{a}	24189^{a}	15663^{a}
Mean	117	1238	12967	6968	134	1494	15890	9082	159	2017	22088	13895

Mean values marked with same alphabets are significantly not different; DAS- Days after sowing; Data pooled for both years (2015-16 and 2016-17) and for both irrigated and rainfed treatment.

Table 2: Heat use efficiency (HUE) of chickpea accessions under irrigated and rainfed conditions at maturity

Heat use efficiency (HUE)		
Accessions	Irrigated	Rainfed
C judaicum 95	1.24[b]	0.99[a]
C judaicum182	1.52[a]	0.56[d]
C judaicum185B	1.14[c]	0.88[b]
C judaicum 185	0.98[e]	0.71[c]
C judaicum17148	1.08[d]	0.62[cd]
C pinnatifidum 212	1.09[cd]	0.86[b]
Mean	1.17	0.77

Mean values marked with same alphabets are significantly not different(Data pooled for both years 2015-16 and 2016-17)

embarked with significant differences among accessions in days after sowing (DAS) at flower initiation, pod initiation and maturity stages. Agroclimatic indices also changed significantly in wild species at all the above mentioned stages of growth.

Days to pod initiation required higher photo and helio-thermal units under irrigated treatment as compared to rainfed treatment. Among the accessions *C pinnatifidum* 212 exceeded the requirement of thermal units in both irrigated and rainfed treatment. *C judaicum* 182 though expressed major differences in requirement of GDD, PTU and HTU at pod initiation (13.15, 14.18 and 18.31 %) and maturity (13.41, 15.39 and 20.32%) stages respectively on comparison of both conditions.

The heat use efficiency (HUE) gives direct measure of the GDD and utilization of the accumulated GDD to contribute the final yield. *C judaicum* 182 drastically dropped (63.02%) HUE under rainfed conditions (Table 2) in comparison to irrigated one followed by *C judaicum* 17148 (42.77%). *C judaicum* 95 (20.00%) and *C pinnatifidum* 212 (20.98%) showed higher HUE by being least affected under rainfed conditions. Under rainfed conditions, all the accessions completed the phenophasic development early on account of avoiding stress, thus before accumulating required PTU and HTU which indirectly affects final grain yield (Parthsarthi *et al*., 2013)

Correlation coefficient and path analysis

Correlation analysis was carried out in respect to grain yield for agroclimatic indices and yield attributes at maturity. Agroclimatic indices showed significantly positive

Table 3: Path coefficient analysis depicting the direct effects of accumulated GDD, PTU and HTU at maturity on grain yield (GY) and pods per plant (PPP) under irrigated and rainfed conditions

Agroclimatic	Grain yield (GY)		APTUM	
indices	Irrigated	Rainfed	Irrigated	Rainfed
GDD	P=0.85	P=0.13	r=0.99	r=0.34
PTU	P=0.85	P=0.14	-	-
HTU	P=0.85	P=0.13, P_{PPP}=0.95	r=0.86	r=0.79, r_{PPP}=0.99

and strong correlation at the 0.05 level (Data not mentioned) to grain yield. Accumulated HTU at maturity exhibited highly positive correlation (r=0.74) to grain yield. Accumulated GDD at maturity (r=0.68) and Accumulated PTU at maturity (r=0.67) also witnessed a positive significant correlation with respect to grain yield at maturity.

Path analysis assesses the direct effects of different traits on dependent variable i.e. grain yield under both irrigated and rainfed conditions. Percentage of filled pods (PFP), an important grain yield component, witnessed significant direct effect on grain yield (P=0.93) followed by agroclimatic index Accumulated GDD at maturitywhich contribute equally and significantly to the final yield (P_{14}=0.85) under irrigated conditions. Irrigated treatment corresponds to normal behaviour where agroclimatic indices were in line with yield attributes and all components were strongly correlated with the grain yield (Table 3). Accumulated PTU at maturity was positively and strongly correlated with GDD (r=0.99) and HTU (r=0.86) whereas GDD (r=0.34) hinged under rainfed conditions as DAS were lower than irrigated conditions. Howsoever under rainfed conditions yield of accessions was significantly altered by pods per plant (PPP) (P_{44}=0.95). Agroclimatic indices did not contribute in major proportion under rainfed conditions to the final yield of the plant. Inability to meet the optimal water requirement and early phenophasic phase completion (Gudadhe *et al.,* 2013) reduced the overall yield under rainfed condition. Accumulated HTU at maturity indirectly and directly contributes to the final yield by strongly correlating itself to pods per plant (r=0.99) and PTU (r=0.79).

Early flowering under rainfed conditions in wild *Cicer* accessions could be associated with the evolution during the due course of time that may act as a defense strategy to escape from the stress condition. Screening of wide base for wild *Cicer* species having positive and significant interactions between yield and agroclimatic indices might assist to produce better adapted chickpea genotypes via chickpea breeding.

ACKNOWLEDGEMENT

The authors duly acknowledge financial assistance provided by the UGC (Maulana Azad National Fellowship).

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Received : July 2018 ; Accepted : November 2018