Ind J Plant Physiol. (January–March 2013) 18(1):79–82
DOI 10.1007/s40502-013-0013-3

SHORT COMMUNICATION

Growth dynamics and temperature sensitivity of late planting chickpea under Delhi conditions

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Received: 3 June 2012 / Accepted: 5 December 2012 / Published online: 19 April 2013

Abstract A field study was conducted to analyze the growth dynamics and temperature sensitivity of late planted chickpea following three staggered sowings viz. late October (S1), late November (S2) and mid December (S3) with selected promising genotypes. Late sown chickpea crops (S2 and S3) experienced ~13.4 °C average daily mean temperature during vegetative stage compared with normal sown crop (S1 with ~17.1 °C average daily mean temperature). On the other hand, average daily mean temperature at mid-flowering to podding stage ranged between ~14.6 to 21.2 °C and ~20.4 to 25.1 °C, respectively for S2 and S3 sown crops. Low temperature during vegetative growth resulted in poor growth, reduced shoot biomass production and seed yield in S2 and S3 sown crops compared with normal sowing (S1). Lower biomass production was associated with yield reductions up to ~27 and ~53 % in S2 and S3 sowings, respectively compared with S1 in all the genotypes. The study concludes that late sown chickpea crop is more vulnerable to low temperature stress during vegetative apart from high temperature stress at flowering and podding stages under Delhi conditions.

Keywords Biomass assimilation · Chickpea · Low and high temperature stress · Vegetative stage · Yield

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Chickpea (*Cicer arietinum* L.) is a cool season crop and has been reported sensitive to low as well as high temperature (Croser et al. 2003; Kumar et al. 2010; Wang et al. 2006). It is an important crop in South Asia, and ranks second among the world's food legumes in terms of area (Berger et al. 2006; FAO 2007). Various studies have reported reductions in chickpea yield under biotic and abiotic stress (Singh et al. 2004). Abiotic stresses viz. moisture stress, low and high temperature, nutrients and salt stress have been accounted for 42 % reduction in chickpea yield among which low temperature has been considered as a major constraint for chickpea productivity (Croser et al. 2003). It is known that rice-chickpea cropping system is more remunerative than rice–wheat system in North-Western parts of India. Following rice-chickpea system, delays the sowing of chickpea till December due to late harvesting of rice crop and late sowing of chickpea results in poor and slow vegetative growth and lower biomass production (Chaturvedi and Dua 2003). There are reports for large variation in the yield between the normal and late sown chickpea crops (Subbarao et al. 2001). On the other hand, in Southern parts of the countary the chickpea crop is sown during the month of December and January, which produces larger yield compared to late planting chickpea in Northern India (Gowda et al. 2009). In view of the above, this investigation was planned to analyze the environmental factors associated with reduction in yield of late planting chickpea at Delhi condition.

Field experiments were conducted during 2010–11 and 2011–12 at Indian Agricultural Research Institute, New Delhi (Latitude: 28° 38′23″N, Longitude: 77° 09′27″E) with fourteen promising chickpea genotypes following three staggered sowings viz. S1 (23rd October, November), S2 (21st November) and S3 (18th December). Seeds of all the genotypes were treated with 0.1 % $HgCl_2$ (w/v) for

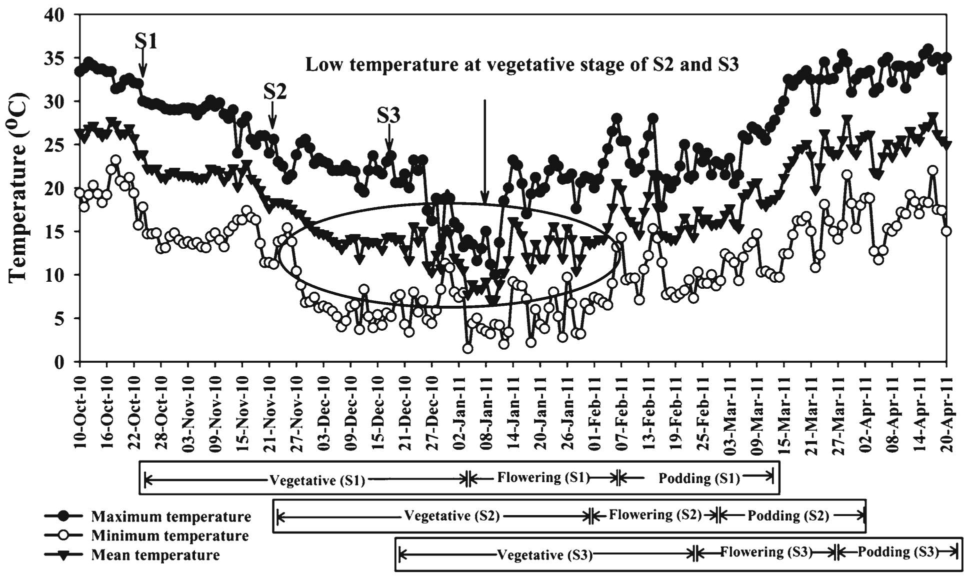

Fig. 1 *Graph* represents the maximum, minimum and mean temperature from October 2010 to April 2011 under *different* sowing conditions (S1-late October, S2-late November and S3-mid December). Each value shown in the graph represents mean of total observations taken between 08.00 and 18.00 h daily at every half an hour interval

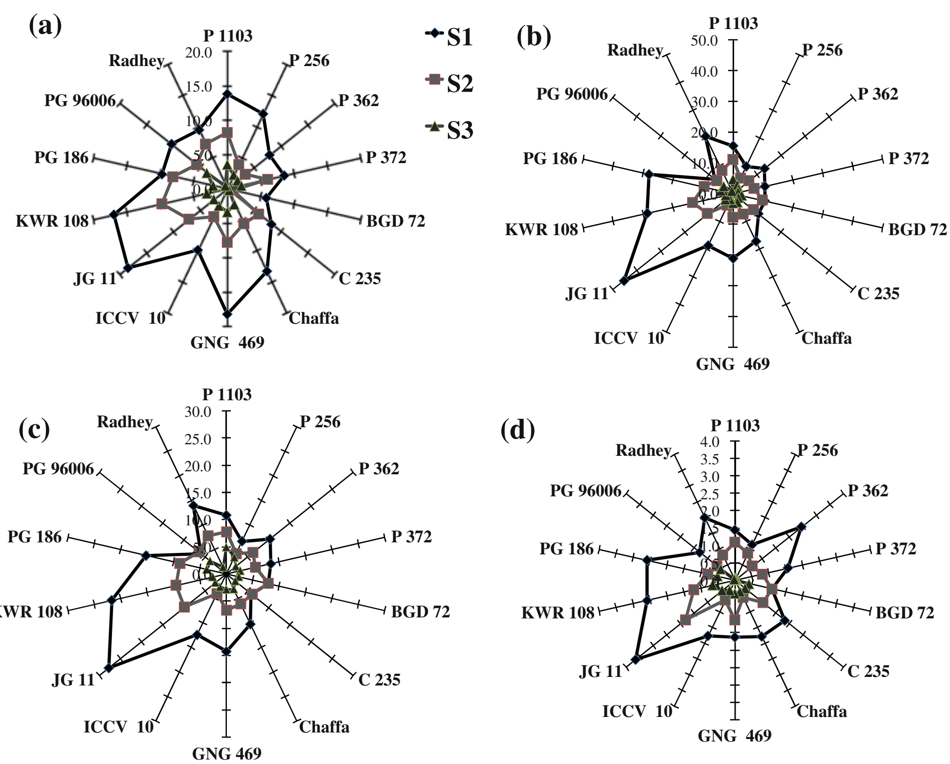

Fig. 2 Radar plots represent dry matter accumulation and partitioning to *different parts* viz., pods (**a**), stem (**b**), leaves (**c**) and roots (**d**) of Chickpea genotypes grown under *different* sowing conditions

60 s followed by 1 % bavistin (w/v) for 300 s to remove surface contamination and thereafter washed thoroughly with double distilled water. The field was divided in 2 × 2 m blocks representing one individual replication of a genotype and each genotype was comprised of three replicates. The soil of the experimental site belongs to the major group of Indo-Gangetic alluvium (Holambi series), which is a member of non-acidic mixed hyperthermic family of typic Haplustept. The soil was non-calcareous, slightly alkaline in reaction, and sandy loam in texture with medium to weak angular blocky structure having bulk density 1.56 Mg m^{-3}, saturated hydraulic conductivity 1.05 cm h^{-1}, pH (1:2.5 soil/water suspension) 7.3, EC 0.49 dS m^{-1}, organic C, 0.3 g kg^{-1}, total N 0.031 %, and available P and K, 6.9 and 279.0 kg ha^{-1}, respectively (Bahuguna et al. 2012). Row to row distance and spacing from plant to plant was maintained at 0.30 and 0.10 m respectively. Temperature sensors (TRH-511, Ambetronics

Table 1 Total biomass and seed yield of different chickpea genotypes grown under different sowing conditions S1 (late October), S2 (late November) and S3 (mid December)

Genotypes	Total biomass (g/plant)			Seed yield (g/plant)		
	S1	S2	S3	S1	S2	S3
P 1103	38.30 ± 0.83[a]	33.30 ± 0.35[b]	16.50 ± 0.53[c]	10.50 ± 0.45[a]	7.71 ± 0.17[b]	6.69 ± 0.06[c]
P 256	37.71 ± 0.02[a]	22.35 ± 0.09[c]	24.59 ± 1.02[b]	12.24 ± 0.20[a]	6.00 ± 0.12[c]	6.03 ± 0.13[b]
P 362	33.60 ± 0.35[a]	31.00 ± 0.58[b]	9.70 ± 0.06[c]	9.70 ± 0.06[a]	7.70 ± 0.06[b]	3.20 ± 0.05[c]
P 372	27.80 ± 0.52[a]	24.20 ± 0.68[b]	19.40 ± 0.69[c]	7.50 ± 0.06[a]	6.90 ± 0.06[b]	6.01 ± 0.06[c]
BGD 72	38.50 ± 0.29[a]	24.00 ± 0.58[b]	10.70 ± 0.06[c]	12.40 ± 0.08[a]	8.18 ± 0.43[b]	4.67 ± 0.28[c]
C 235	25.26 ± 0.57[a]	25.00 ± 0.58[a]	11.30 ± 0.06[b]	7.60 ± 0.02[a]	5.00 ± 0.58[b]	3.10 ± 0.06[c]
Chaffa	37.00 ± 0.58[a]	28.57 ± 0.25[b]	14.50 ± 0.06[c]	4.90 ± 0.13[a]	4.60 ± 0.09[a]	3.98 ± 0.03[b]
GNG 469	30.00 ± 0.58[a]	21.00 ± 0.46[b]	12.30 ± 0.09[c]	8.51 ± 0.29[a]	6.86 ± 0.07[b]	3.66 ± 0.03[c]
ICCV 10	33.23 ± 0.43[a]	32.00 ± 0.38[b]	5.30 ± 0.06[c]	7.02 ± 0.05[a]	4.52 ± 0.04[b]	1.52 ± 0.05[c]
JG 11	34.00 ± 0.58[a]	26.20 ± 0.46[b]	10.50 ± 0.40[c]	9.22 ± 0.05[a]	4.50 ± 0.03[b]	3.30 ± 0.09[c]
KWR 108	36.23 ± 0.29[a]	28.04 ± 0.54[b]	12.80 ± 0.03[c]	9.80 ± 0.12[a]	7.22 ± 0.04[b]	4.03 ± 0.09[c]
PG 186	39.00 ± 0.58[a]	22.70 ± 0.03[b]	8.70 ± 0.03[c]	8.52 ± 0.04[a]	6.70 ± 0.06[b]	3.22 ± 0.04[c]
PG 96006	34.78 ± 0.13[a]	28.37 ± 0.34[b]	9.68 ± 0.05[c]	8.50 ± 0.01[a]	6.60 ± 0.04[b]	2.52 ± 0.04[c]
Radhey	34.20 ± 0.45[a]	29.06 ± 0.09[b]	16.80 ± 0.03[c]	7.34 ± 0.01[a]	6.03 ± 0.04[b]	4.70 ± 0.01[c]

Values are mean ± SEM of three replicates

Different letters in superscript within each row based on Duncan's Post-hoc test indicate significant differences at $p \leq 0.05$

Engg Pvt. Ltd. India) were fixed at 1 m above plant canopy level at each environment and the temperature data was monitored daily using data loggers (TC800) through micro processor based Program Logic Control (PLC) and Supervisory Control and Data Acquisition (SCADA) win-log software (M/s Genesis Technologies). To analyze growth and yield attributes five plants from each genotypes were sampled at physiological maturity from all the treatments. Total biomass, pod, leaf, stem and root biomass per plant were calculated from oven dried (65 °C/7 days) samples. The data was subjected to one way ANOVA followed by Duncan's post hoc test to know the significance. All statistical analysis were done using SPSS v.10 computer package (SPSS Inc. USA).

Temperature pattern recorded during different stages of development of chickpea raised under three different sowings, revealed that normal sown crop (S1) experienced 17.1 °C mean average temperature at vegetative stage whereas average mean temperature during mid-flowering and mid-podding stage was recorded 14.6 and 21.7 °C, respectively. On the other hand, for S2 and S3 sown crops, the mean average temperature at vegetative stage was 13.3 °C and 13.4 °C. At mid-flowering to mid-podding stage mean temperature ranged from 14.7 to 21.2 °C in S2 and 20.4 to 25.2 °C in S3, respectively (Fig. 1). The data indicates that S2 and S3 sown crops experienced low temperature stress during early stages of its development i.e. during vegetative stage as temperature remained lower compared to S1 sowings. The temperature less than 15 °C base temperature has been reported to affect seed germination, normal growth and physiological activities in chickpea (Croser et al. 2003; Nayyar et al. 2007). In our study, we recorded lower temperature during vegetative as well as early flowering stages.

Biomass accumulation and its partitioning towards stem, leaves, roots and pods was lower in S2 and S3 sown crops compared with S1 sowing (Fig. 2). Decreased biomass accumulation in S2 and S3 sowings during vegetative phase resulted in reduced reproductive sinks and variation in response to low temperature existed between the genotypes.

An average reduction of ~21 and ~61 % in total biomass was found in S2 and S3 sown crops, respectively compared with S1. Similarly seed yield decreased by ~27 and ~53 % in S2 and S3 sowings, respectively (Table 1). The decreased biomass and seed yield has been attributed to low temperature sensitivity of chickpea as supported with the facts that a mild high temperature stress in chickpea resulted in higher biomass production but decreased seed yield due to flower abortion (Bahuguna et al. 2012). Reduced yield has been attributed with decreased flow of photoassimilates from source to sink causing less biomass, reduced plant growth and decreased levels of phytohormones (Thakur et al. 2010) caused by cold stress experienced during vegetative stages of chickpea growth. These findings indicate sensitivity of chickpea to low temperature during early vegetative growth and high temperature during post flowering stage. Similarly, Singh et al. (2004) have reported reductions in biomass and yield of late planting chickpea genotypes; however, harvest index was higher followed by medium and early planting due to decreased vegetative growth. In view of the above, this study concludes that late planting chickpea under Delhi conditions is more prone to low temperature during vegetative growth as compared to normal sown crop and to high temperature during post flowering/podding stages of growth.

Acknowledgments Authors are grateful to anonymous reviewers for valuable comments and suggestions in improving the manuscript. Financial support received through National Initiative on Climate Resilient Agriculture (NICRA-IARI) project is duly acknowledged.

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