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RESEARCH ARTICLE — Legume Research- An International Journal

Studies on Leaf Characteristics of Chickpea (*Cicer arietinum* L.) and Their Contribution to Seed Yield under Different Temperature Stress in North West India

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ABSTRACT

Background: Temperature stress (heat or cold) is becoming a major area of concern due to climate change affecting crop production worldwide. Chickpea leaves are most sensitive to variation in temperature so any variation in temperature (High or Low) causes substantial losses in yield due to disruption in physiological processes of the plant cell. Therefore to achieve maximum production under current scenario of climate change a better understanding of stress induced responses in leaves of chickpea and interrelationship between seed yield and leaf traits can prove to be useful.

Methods: The field trials was conducted with ten genotypes of chickpea for two consecutive years (2017-2019) at Pulses Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to study various traits of leaf at 50% flowering stage (80-90 DAS). Temperature stress (cold or heat) was given by manipulating the sowing dates that is 15th October (early sown condition in Haryana), 15th November (Normal sown condition in Haryana) and 15th December (late sown condition in Haryana). Data were recorded when temperature was (<5$^{238}_{92}$C for 7 days) in early sown and (>35$^{238}_{92}$C for 7 days) in late sown crops.

Result: Results indicated that early sown crops experienced low temperature stress in the month of December-January while late sown crops showed high temperature stress in the month of March- April. The maximum values of leaf parameters were found in crops sown on 15th Novemberand minimum in15th December sown crops and no significant differences in seed yield was recorded between 15th October and 15th November sowing, however, further delay in sowing to 15th December showed significant reduction in seed yield. Among genotypes maximum leaf parameters and seed yield were observed in H12-64 and H13-01 while minimum were found in H14-04. Seed yield exhibited significant positive correlation with all traits in 15th October and 15th November sowing while non-significant was on 15th December sowing.

Key words: Chickpea, Temperature, Sowing dates, Physiology, Stress.

INTRODUCTION

In arid and semi-arid regions of India the increasing temperature causes climate change that lead to adverse effects on agricultural crops (Wahid and Close, 2007). Chickpea (*Cicer arietinum* L.) is cool season crops and it is normally sown during second fortnight of October and November in Northern India. Due to the fluctuations in the pattern of monsoon and late harvest of preceding *kharif*crop like rice and sugarcane its sowing is delayed which ultimately results in poor seed yield (Wang *et al*., 2006). Any variation in temperature causes significant changes in legume crops because they are very sensitive to variation in temperature as the late-sown crop is exposed to high temperatures (>35$^{238}_{92}$C) at its reproductive stage in the months of March-April and early sown crops experienced low temperature (<5$^{238}_{92}$C) in the month of December-January (Kumar *et al*., 2012). The adoption of good management practices like sowing dates and tolerant genotypes can enhance the seed yield of chickpea under current scenario of climate change. Sowing time of any crop depends upon specific varieties and particular area so optimum sowing time and highly productive cultivars can boost growth, development and yield of particular crops because sowing time can influence many climatic factors like temperature, moisture, rainfall and sunshine hours (Bazvand *et al*., 2015). Optimum sowing time coordinates all environmental factors throughout the life cycle of plants from germination to the harvesting. Among all environmental factors the temperature stress is main concerns in agriculture from last decades. High temperature stress can affect important physiological processes of plant cell like photosynthesis, membrane stability, source sink relationship, water status and production of reactive oxygen

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species (Wahid and Close, 2007) leading to poor seed yield. In other hand low Temperature (<10°C)also causes adverse effects on physiological processes ranging from plant water status, photosynthesis to reactive oxygen species (ROS) resulted into losses in chickpea yield from 15-20% (Chaturvedi *et al.,* 2009). In response to temperature stress the plant leaves plays important role by production of photosynthates, metabolites, antioxidants, phytohormones and accumulation of pigments like carotenoids and anthocyanin for repair, defense and physiological recovery of plant cells (Bita and Gerats, 2013). Therefore, it is very important to study leaves traits to overcome the impact of high or low temperature on chickpea productivity with identification of new chickpea varieties having higher tolerance to temperature stress are needed.

MATERIALS AND METHODS

The field trials was conducted at Pulses Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar for two consecutive years (2017-2019) with three sowing dates (15th October, 15th November and 15th December) and ten chickpea genotypes namely HC- 1, HC-3, HC-5 (Released varieties), H12-64, H13-01, H13-02, H14-01 and H14-04 (From AVT- advanced varietal trials) ICCV 88503 (Check), ICCV 92944 (Check) were taken in a randomized block design (RBD) with three replications to study the leaf characteristics of chickpea under different temperature stress. Five plants were randomly selected in each plot and sampling was done at 50% flowering stage. The actual mean weekly meteorological data of both years (2017-18 and 2018-19), recorded at observatory located at field of Agro meteorological department, Chaudhary Charan Singh Haryana Agricultural University, Hisar are depicted in Fig 1 and 2. Analysis of soil parameters was done by adopting standard analytical methods. The nutrient and moisture status were controlled by the application of recommended dose of fertilisers and irrigation according to package and practices given by Chaudhary Charan Singh Haryana Agricultural University.

Specific leaf area (SLA)

Specific leaf area calculated by formula of Kvet *et al.* (1971).

$$SLA = \frac{\text{Leaf area}}{\text{Leaf weight}}$$

Leaf area index (LAI)

Leaf Area Index (LAI)calculated by formula of Williams (1946).

$$LAI = \frac{\text{Total leaf area of a plant}}{\text{Ground area occupied by the plant}}$$

Net assimilation rate (NAR) (g $g^{-1}day^{-1}$)

NAR was calculated by formula given by Williams (1946).

$$NAR = \frac{(W_2\text{-}W_1)}{(t_2\text{-}t_1)} \times \frac{(\log e\ L_2 - \log e\ L_1)}{(L_2\text{-}L_1)},$$

Where,

W_1 and W_2= Dry weight of whole plant at time.

t_1 and t_2= Respectively.

L_1 and L_2= Leaf weights or leaf area at t_1 and t_2 respectivey.

t_1-t_2= Time interval in days. Here NAR was calculated between 60 and 90 DAS.

Chlorophyll a and Carotenoids content (mg/gm DW) were calculated by the method of Hiscox and Israelstam (1979).

Anthocyanin content (mg/gm DW) was estimated according to the method of Lobos *et al*., (2014).

Photochemical efficiency/quantum yield of PS-II (Fv/Fm) was measured as the chlorophyll fluorescence using a chlorofluorometer.

Statistical analysis

Data were analysed through (ANOVA) using Online Statistical Analysis Package (OPSTAT) software of Computer Section, CCS Haryana Agricultural University, Hisar by pooled analysis of both year (2017-18 and 2018-19).

RESULTS AND DISCUSSION

In the present investigation the maximum specific leaf area (SLA) was observed in genotype H13-01 and H12-64 whereas minimum in H14-04 at 50% flowering stages (80-90 DAS). This might be due to genetic potential of genotypes. Among sowing dates, maximum specific leaf area (SLA) were observed in 15th December and minimum were observed in 15th November sowing (Table 1). This might be due to higher accumulation of dry matter in proportionate with leaf area in 15th November sowing as compared to15th October and 15th December sowing due to suitable environmental condition prevailing at 15th November sown crop. Similar results due to different sowing dates has also has been reported earlier in the literature by Mrudula *et al*., (2013); Patil *et al*., (2017) in chiPckpea.

The results of the present investigation showed that delayed sowing significantly decreased the leaf area index (Table 1). In present investigation, the minimum leaf area index (LAI) was observed in plants sown on 15th December and maximum leaf area index was observed on 15thNovember sowing followed by 15th October sowing. This variation in leaf area index might be due to optimum temperature (maximum temp. 21.9°C, minimum temp. 7.2°C) prevailing at 15th November sown crop that resulted into increased leaf area while low temperature (maximum temp. 17.1°C, minimum temp. 4.8°C) at 15thOctober sowing and high temperature (maximum temp. 38°C, minimum temp. 18.2°C) in 15th December sowing at 50% flowering stages (80-90 DAS) resulted into decreased leaf area index. The maximum leaf area index was observed in genotype H12-64 and H13-01 whereas minimum leaf area index was observed in genotype H14-04. This variation in genotypes might be due their tolerance behavior against temperature stress. Similar results also observed due to different sowing dates (Mrudula *et al*., 2013; Patil *et al*., 2017) in chickpea.

The minimum net assimilation rate (NAR) was observed in plants sown on 15th December and maximum was on 15th November sown crop. This might be due to suitable environmental conditions that resulted into more accumulation of dry matter in 15thNovember sowing at 50% flowering stages (80-90 DAS) as compared to other sowing dates. The maximum net assimilation rate was observed in genotype H12-64 and H13-01 whereas, minimum was in H14-04. The variation in genotypes might be due their high leaf area index and tolerance behavior against temperature stress.Similar results due to sowing dates has also reported earlier in the literature (Mrudula *et al*., 2013; Patil *et al*., 2017) in chickpea.

In present investigation, minimum chlorophyll (CHL) and carotenoids (CHR) contents were observed in plants sown on 15th December and maximum were observed on 15th November sowing followed by 15th October sowing. This variation in chlorophyll and carotenoids contents due to optimum temperature (maximum temp. 21.9°C, minimum temp. 7.2°C) prevailing at 15th November sown crop and high leaf area index while low temperature (maximum temp. 17.1°C, minimum temp. 4.8°C) at 15thOctober and high temperature (maximum temp. 38°C, minimum temp. 18.2°C) in 15th December sowing at 50% flowering stages (80-90 DAS) resulted into decreased chlorophyll and carotenoids contents (Table 1). These results also in the same line as observed by Kumar *et al*. (2011) in mungbean; Kaushal *et al*., 2011 in chickpea). Among genotypes, highest chlorophylland carotenoids contentwere recorded in genotype H13-01 and H12-64 whereas minimum were in

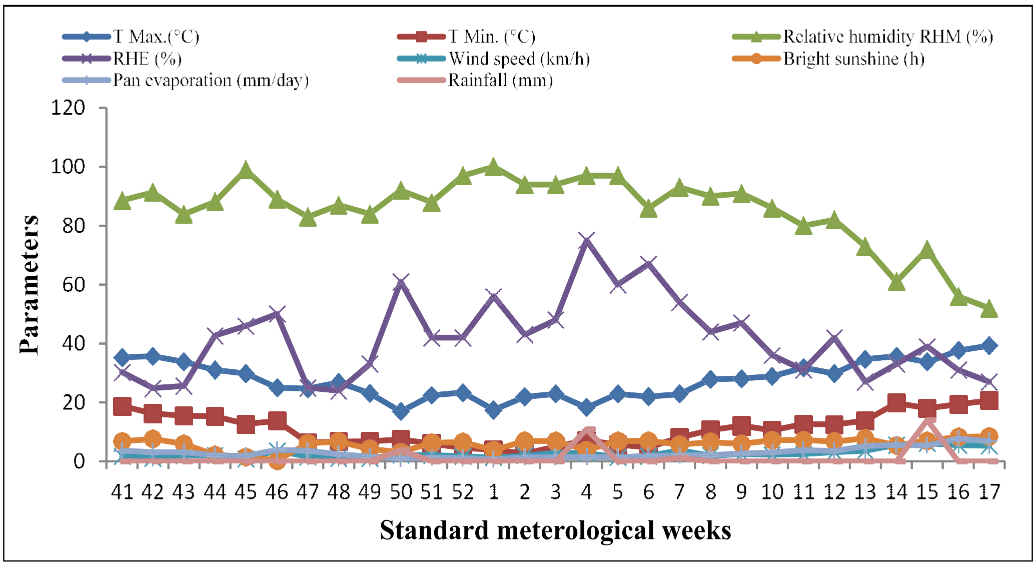

Fig 1: Values of weather parameters during cropping season of 2017-18.

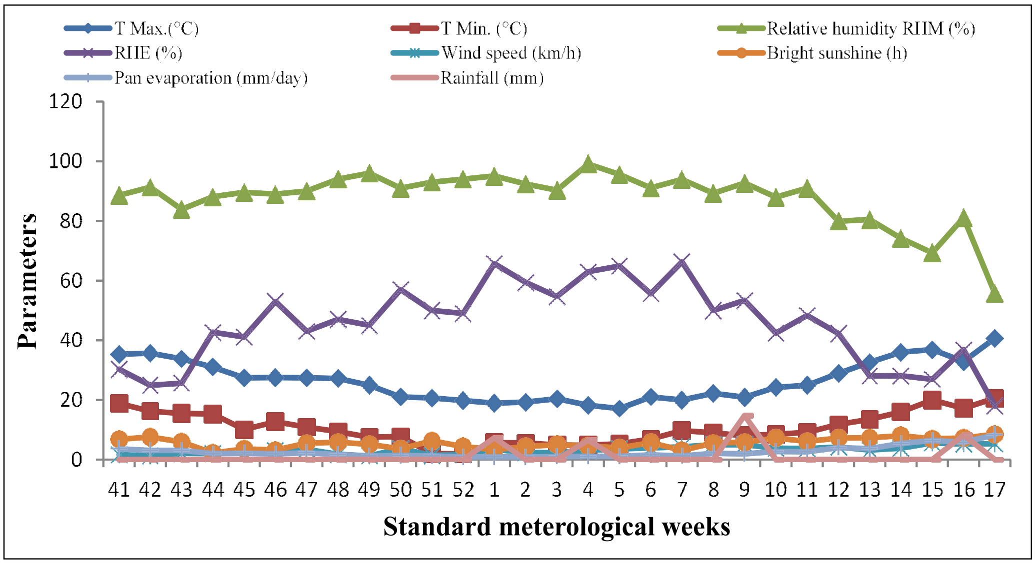

Fig 2: Values of weather parameters during cropping season of 2018-19.

H14-04.This variation among genotypes might be due their tolerance behaviour against temperature stress.

The production and accumulation of anthocyanin (ANTH) in plant tissues especially in leaves leads to development of resistance against various environmental stresses. In present investigation, among three dates of sowings, lowest anthocyanin contentwas recorded in crop sown on 15th November and highest in December 15th sowing at 50% flowering stage (Table 1). This variation in anthocyanin content might be due to comparatively high temperature (maximum temp. 38°C, minimum temp. 18.2°C) at 50% flowering in 15th December sowing and low temperature (maximum temp. 17.1°C, minimum temp. 4.8°C) in 15th October sowing resulted into more accumulation of anthocyanin. Among genotypes, highest anthocyanin was recorded in genotype H12-64 and H13-01, whereas minimum was in H14-04 and this might be due to different genetic potential of genotypes to combat with environmental stresses. Similar results also observed by Qiu *et al*., 2016 in tomato; Bhasker *et al*., 2018 in chickpea.

Data presented in Table 1 indicated that among three dates of sowings, lowest chlorophyll a fluorescence (Fv/Fm) was recorded in crop sown on 15th December and highest in November 15th sowing at 50% flowering stages. This variation among sowing dates might be due to low net assimilation rate and low production of photosynthates as well as low chlorophyll contents in 15th December and15th October sowings as compared to 15th November sowing at 50% flowering stages. The data in Table 1 showed that highest chlorophyll a fluorescencein genotypes was recorded in genotype H13-01 and H12-64 whereas minimum was in H14-04 this could be due to differences in leaf area and production potential of photosynthates in different genotypes. Similar results also confirmed by Basu *et al*., (2011); Kumar *et al*., (2013) in chickpea.

The main functions of leaves are *photosynthesis, exchange of gasses and transpiration*. Photosynthesis is the primary determinant of crop yield and the efficiency by which a crop captures light and converts it into biomass over the growing season is a key determinant of final yield. Leaf area and production of pigments like chlorophyll, carotenoids and anthocyanin causes enhancement in seed yield through improvement in photosynthetic efficiency. In the present investigation all the traits of chickpea leaves plays significant role in the enhancement of seed yield. The minimum seed yield were observed in plants sown on 15th December and maximum were observed on 15th November sown crop. This might be due to comparatively favorable climatic conditions such as temperature, photoperiod, sunshine hours and higher values of leaf area, total dry matter, photosynthetic rate and chlorophyll content in 15th November sowing than 15th October and 15th December sowing. Lower seed yield during late sowing (15th December) might be due to shorter grain filling period as a result of high temperature at grain filling stages and low temperature at vegetative and flowering stages in 15th October sowing causes reduced yield (Table 1). Among genotypes, highest seed yield was recorded in genotype H12-64 and H13-01, whereas minimum was in H14-04 and this might be due to different tolerance behavior of genotypes against temperature stress. Similar result also reported earlier in the literature (Krishnamurthy *et al.,* 2011; Mrudula *et al*., 2013; Patil *et al*., 2017; Bhasker *et al.,* 2018) in chickpea and Meena *et al.* (2018) in cluster bean and Chaudhary *et al.,* (2020) in Indian beanat different sowing dates.

Table 1: Effect of different temperature regimes on leaf traits of chickpea (*Cicer arietinum* L.).

Sowing dates	SLA	LAI	NAR	CHL	CHR	ANTH	Fv/Fm	SY
15th Oct	16.3	0.185	1.473	3.909	3.567	2.60	0.679	2090
15th Nov	14.6	0.210	1.626	4.219	3.742	1.51	0.689	2114
15th Dec	18.7	0.163	1.459	2.659	2.967	2.79	0.667	1890
CD at 5%	0.3	0.003	0.031	0.112	0.111	0.32	0.005	36
Genotypes								
H12-64	17.0	0.193	1.520	3.774	3.683	2.41	0.713	2255
H13-01	17.1	0.194	1.524	3.866	3.859	2.41	0.717	2326
H13-02	16.7	0.189	1.503	3.746	3.618	2.39	0.710	2191
H14-01	16.9	0.191	1.308	3.637	3.534	2.32	0.693	2063
H14-04	15.6	0.173	1.304	3.180	2.858	2.19	0.638	1594
HC 1	16.5	0.185	1.491	3.549	3.226	2.29	0.657	1926
HC 3	16.5	0.184	1.509	3.686	3.507	2.26	0.672	2046
HC 5	16.4	0.183	1.502	3.569	3.359	2.25	0.659	2021
ICCV88503	16.5	0.186	1.503	3.491	3.413	2.31	0.668	1988
ICCV92944	16.4	0.183	1.511	3.459	3.195	2.26	0.657	1903
CD at 5%	0.5	0.005	0.051	0.157	0.154	0.05	0.009	66

SLA = Specific leaf area (cm^2 g^{-1}), LAI= Leaf area index, NAR= Net assimilation rate (g g^{-1} day^{-1}), CHL= Chlorophyll (mg g^{-1} DW), CHR= Chrotenoid (mg g^{-1} DW), ANTH= Anthocyanin (mg g^{-1} DW), Fv/Fm= Chlorophyll a fluorescence, SY= Seed Yield (kg/ha).

Table 2: Correlation coefficient of leaf traits with seed yield at different sowing dates.

Characters	Seed Yield	15th October	15th November	15th December
Specific leaf area (SLA)		0.829**	0.859**	0.346NS
		1.000	1.000	1.000
Leaf Area Index (LAI)	Seed Yield	0.811**	0.867**	0.389NS
		1.000	1.000	1.000
Net Assimilation Rate (NAR)	Seed Yield	0.301**	0.825**	0.229NS
		1.000	1.000	1.000
Chlorophyll a	Seed Yield	0.941**	0.963**	0.547NS
		1.000	1.000	1.000
Carotenoid	Seed Yield	0.931**	0.933**	0.567NS
		1.000	1.000	1.000
Anthocyanin	Seed Yield	0.802**	0.806**	0.605NS
		1.000	1.000	1.000
Chlorophyll Fluorescence (Fv/Fm)	Seed Yield	0.723*	0.744*	0.546NS
		1.000	1.000	1.000

Here * and ** significant at 5% and 1%, respectively.

Correlation analysis

The correlations between different leaf parameters with seed yield in 15th October, 15th November and 15th December sowing dates are shown in Table 2. Seed yield was significant and positively correlated with all traits of leaf in all three dates of sowing but significant correlation was found only in 15th October and 15th November sowing while non-significant was on 15th December sowing.

CONCLUSION

The present study showed variation in most of the leaf traits which can be exploited in various breeding programmes for the improvement of seed yield. Maximum leaf parameters and seed yield were recorded between 15th October and 15th November sowing, however, further delay in sowing to 15th December, significant reduction in leaf parameters as well as seed yield were recorded. The promising genotypes identified in this study are H13-01 and H12-64 which could serve as potential source in breeding programmes for high and low temperature tolerance. These leaves traits are easy to evaluate and further can be used as best indices for screening of genotypes against temperature tolerance at other developmental stages.

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Conflict of interest: None.

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