*Andhra Pradesh J Agril. Sci* : 7(1): 49-54, 2021

# PHOTOTHERMAL REQUIREMENTS AND RESPONSE OF CHICKPEA (*Cicer arietinum* L.) GENOTYPES UNDER DIFFERENT DATES OF SOWING

**T. RAGHAVENDRA*, P. SUDHAKAR, P. SANDHYA RANI, V. JAYALAKSHMI AND B. RAVINDRA REDDY**

Department of Crop Physiology, S.V. Agricultural College, ANGRAU, Tirupati.

Date of Receipt: 30-12-2020 Date of Acceptance: 25-02-2021

## ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station, Nandyal during rabi season of 2018-19 and 2019-20 to find out optimum time of sowing and suitable genotypes of chickpea in scarce rainfall zone of Andhra Pradesh. The experiment consisted of three sowing dates 1st FN of October, 1st FN of November and 1st FN of December and fifteen genotypes was laid out in factorial randomized block design with three replications. Among the genotypes, desi genotypes are NBeG 47, NBeG 49, JG 11, Jaki, NBeG 452, NBeG 738, NBeG 776, NBeG 779, NBeG 857, and kabuli types are NBeG 119, NBeG 399, NBeG 440, NBeG 458, Vihar and KAK2. Results revealed that desi genotypes, NBeG-779 recorded higher total drymatter and in kabuli genotypes, NBeG-440 recorded higher total drymatter. Among the dates of sowing, 1st fortnight of November (D2) recorded higher total drymatter. Higher total dry matter in November sowing can be due to higher accumulation of GDD during flowering and pod development stage and higher GDD and PTU during the grain filling stage compared to other two sowings. The genotypes which recorded higher yields i.e NBeG-779 (1811 kg $ha^{-1}$) desi genotype and NBeG-440 (1662 kg $ha^{-1}$) kabuli genotype also recorded highest HUE values of 0.93 kg $ha^{-1}$ $^oC$ $day^{-1}$ and 0.77 kg $ha^{-1}$ $^oC$ $day^{-1}$ respectively. Similarly the genotypes sown during 1st FN of November recorded higher HUE followed by December and October sowings.

**KEYWORDS**: Chickpea, Growing degree days, Heat use efficiency

## INTRODUCTION

The world faces the growing challenge of feeding over 9.5 billion people by 2050 under the looming threat of climate change. To address this challenge while reducing the carbon footprint and conserving water, our reliance on protein from plants will need to increase significantly. Chickpea is the third most important protein rich grain legume which is directly consumed as human food in the poorer countries where the projected population increases are most likely to occur. The crop is also important for sustainability of farming systems due to its nitrogen fixing ability. Chickpea yields are constrained by the crop's high sensitivity to a number of abiotic stresses including frost, drought and heat stress. The major chickpea-growing states in India are Madhya Pradesh, Uttar Pradesh, Rajasthan, Andhra Pradesh, Haryana and Maharashtra, which constitute 85 per cent area with 89 per cent production. Andhra Pradesh is one of the major chickpea producing states in India. In terms of area and production chickpea occupies 5th position, with an area of 4.78 lakh hectares producing 2.42 lakh tones with an average productivity of 508 kg $ha^{-1}$ (Anonymous, 2020).

The exposure of crop to low temperatures during germination and seedling establishment and to high temperature during flowering and seed formation phases under delay-sown chickpea results in drastic reduction in yield. Yield loss in chickpea can vary between 30 and 60% depending on genotype, sowing time, location, and climatic conditions during sowing season. Some chickpea genotypes have capacity to tolerate drought and in that case sowing time can be delayed. Agro-climatic factors that influence crop phenology may also have a major effect on crop growth rate and the partitioning of dry matter. It is therefore useful to integrate phenological and growth responses. Optimum date of sowing provides favourable environmental conditions for growth, development and yield of crops through optimum utilization of available natural resources. The present study was an attempt to understand phenology and agro-meterological indices influence on various growth attributes, dry matter partitioning and yield in chickpea genotypes.

*Corresponding author, E-mail: raghavendraagrico@gmail.com

## MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Nandyal during rabi season of 2018-19 and 2019-20 to find out optimum time of sowing and suitable genotypes of chickpea in scarce rainfall zone of Andhra Pradesh. The experiment was laid out in factorial randomized block design with three replications and consisted of three sowing dates i.e., 1st fortnight of October, November and December and fifteen genotypes. Among them, desi genotypes are NBeG 47, NBeG 49, JG 11, JAKI, NBeG 452, NBeG 738, NBeG 776, NBeG 779, NBeG 857, and kabuli genotypes are NBeG 119, NBeG 399, NBeG 440, NBeG 458, Vihar and KAK2.Genotypes considered as factor one and three sowing dates as factor two. The soil of the experimental field is black cotton soil, with $P^H$ 8.3 and EC 0.26 $dS^{-m}$. The data collected from the experiment was subjected to statistical analysis as described by Gomez and Gomez (1984).

### Growing degree days (GDD)

Growing degree days (GDD) is an arithmetic accumulation of daily mean temperature above certain threshold temperature (base temperature) and is calculated using the formula.

$$GDD = \frac{(Tmax + Tmin)}{2} \text{ - Base temperature}$$

### Heliothermal units (HTU)

Heliothermal units (HTU) is the product of GDD and corresponding actual sunshine hours for that day were computed on daily basis as:

HTU (°C day hr) = GDD × Actual sunshine hours

### Heat use efficiency (HUE)

Heat use efficiency (HUE) for seed was obtained as under:

Thermal use efficiency (HUE) =

$$\frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Growing degree days (°C day)}}$$

## RESULTS AND DISCUSSION

The data on stem dry weight were collected at 20 days interval from fifteen chickpea varieties sown at three dates of sowing are presented in Table 1.

Phenotypic variability for stem dry weight ranges from 9.71 g to 14.22 g at 80 DAS. Among the kabuli genotypes, significantly higher stem dry weight was recorded by NBeG-440 (13.19 g) followed by Vihar (12.86 g), whereas lowest stem dry weight was recorded by NBeG-458 (12.00 g) at 80 DAS. Among the desi genotypes, NBeG-779 recorded (14.22 g) higher stem dry weight followed by NBeG-776 (13.07 g) and lowest stem dry weight was recorded by NBeG-49 (9.71 g).The stem dry weight of chickpea for all the three dates of sowing showed exponential increase from 20 DAS to 80 DAS. Highest stem dry weight was recorded in $D_2$ (November 1st FN) sowing (12.48 g) followed by $D_3$ (December 1st FN) sowing (11.48 g) whereas lowest stem dry weight was recorded in $D_1$ (October 1st FN) sowing (10.98 g) at 80 DAS.

Chickpea GDD, and other heat units were numerically higher with first sown crop ($D_1$) compared to rest of times of sowing crop. But drymatter was less than $D_2$ and $D_3$ sown chickpea crop, because of higher GDD from sowing to emergence and comparable GDD for emergence to 50 per cent flowering than $D_2$. More over during second year an amount of 74.8 mm of rainfall received in eight rainy days at 44 to 46 standard weeks coincided with germination to vegetative stage of October 1st FN ($D_1$) sown crop, which might had suppressed the photosynthesis. Whereas November 1st FN sown ($D_2$) crop utilized the favourable weather condition for plant growth and recorded higher drymatter. Chickpea being a long day plant, delayed flowering increased dry matter production and accumulation, whereas condition favouring early flowering adversely affected dry matter accumulation (Pradeep and Hemantaranjan, 2012).

Phenotypic variability for leaf dry weight ranges from 4.80 g to 6.08 g at 80 DAS. Among the desi genotypes, highest leaf dry weight was recorded by NBeG-779 (6.08 g) followed by NBeG-776 (6.00 g) and NBeG-857 (5.94 g) and lowest were recorded in JG-11 (4.86 g). Among kabuli genotypes NBeG-440 (5.64 g) recorded higher dry weight followed by KAK-2 (5.60 g) whereas lowest leaf dry weight was recorded by Vihar (5.05 g) at 80 DAS. The ability of a genotype in utilizing

**Table 1. Effect of temperature and photoperiod on drymatter partitioning in chickpea genotypes at different dates of sowing (*Rabi* season 2018-19 and 2019-20)**

| Treatments | Stem dry weight (g) | | Leaf dry weight (g) | | Pod dry weight (g) | | Total dry matter (g) | |
|---|---|---|---|---|---|---|---|---|
| | 60 DAS | 80 DAS | 60 DAS | 80 DAS | 60 DAS | At Harvest | 60 DAS | 80 DAS |
| **Genotypes (G)** | | | | | | | | |
| G1 : NBeG 47 | 8.07 | 11.06 | 3.68 | 5.18 | 3.90 | 12.64 | 15.97 | 22.42 |
| G2 : NBeG 49 | 6.70 | 9.71 | 3.99 | 5.49 | 2.93 | 10.67 | 15.93 | 22.38 |
| G3 : JG 11 | 8.35 | 11.35 | 3.36 | 4.86 | 3.46 | 12.20 | 15.17 | 21.61 |
| G4 : JAKI | 7.24 | 10.24 | 3.75 | 5.25 | 4.46 | 13.20 | 15.45 | 21.90 |
| G5 : NBeG 452 | 8.24 | 11.25 | 3.47 | 4.97 | 3.10 | 11.84 | 14.81 | 21.26 |
| G6 : NBeG 738 | 8.39 | 11.39 | 4.08 | 5.58 | 4.44 | 13.18 | 17.37 | 23.82 |
| G7 : NBeG 776 | 9.01 | 12.01 | 4.50 | 6.00 | 4.00 | 14.74 | 17.78 | 24.71 |
| G8 : NBeG 779 | 9.26 | 14.22 | 4.58 | 6.08 | 4.04 | 15.78 | 18.49 | 25.42 |
| G9 : NBeG 857 | 8.71 | 13.07 | 4.44 | 5.94 | 3.87 | 14.11 | 17.65 | 23.95 |
| G10 : NBeG 119 | 8.79 | 12.28 | 3.30 | 4.80 | 3.75 | 11.95 | 15.86 | 22.31 |
| G11 : NBeG 399 | 9.04 | 12.04 | 3.57 | 5.07 | 3.25 | 11.99 | 15.75 | 21.70 |
| G12 : NBeG 440 | 9.70 | 13.19 | 4.10 | 5.64 | 3.21 | 13.32 | 16.10 | 22.55 |
| G13 : NBeG 458 | 9.01 | 12.00 | 3.67 | 5.17 | 3.19 | 11.93 | 15.87 | 21.80 |
| G14 : VIHAR | 9.87 | 12.86 | 3.55 | 5.05 | 3.26 | 12.99 | 15.57 | 21.01 |
| G15 : KAK2 | 9.34 | 12.34 | 4.14 | 5.60 | 3.08 | 12.49 | 16.10 | 21.05 |
| SE(m) | 0.54 | 0.80 | 0.06 | 0.07 | 0.035 | 0.095 | 0.28 | 0.38 |
| CD (P=0.05) | 1.54 | 2.38 | 0.19 | 0.23 | 0.105 | 0.285 | 0.83 | 1.18 |
| **Dates of Sowing (D)** | | | | | | | | |
| $D_1$ : 1$^{st}$ FN of October | 7.99 | 10.98 | 3.72 | 5.22 | 3.28 | 12.02 | 14.99 | 20.42 |
| $D_2$ : 1$^{st}$ FN of November | 9.47 | 12.48 | 4.77 | 6.27 | 4.03 | 13.26 | 18.27 | 24.72 |
| $D_3$ : 1$^{st}$ FN of December | 8.48 | 11.48 | 4.10 | 5.60 | 3.89 | 12.63 | 16.47 | 22.91 |
| SE(m) | 0.24 | 0.57 | 0.08 | 0.13 | 0.045 | 0.075 | 0.25 | 0.31 |
| CD (P=0.05) | 0.69 | 1.68 | 0.24 | 0.40 | 0.135 | 0.215 | 0.76 | 0.93 |
| **Interactions (G × D)** | | | | | | | | |
| SE(m) | 0.95 | 0.62 | 0.07 | 0.12 | 0.06 | 0.09 | 0.28 | 0.38 |
| CD (P=0.05) | NS | 1.77 | 0.22 | 0.35 | 0.20 | 0.29 | 0.86 | 1.16 |

**Table 2. Effect of temperature and photoperiod on photothermal indices, heat use efficiency (kg ha $^{-1}$ $^{o}$C day$^{-1}$) and yield (kg ha$^{-1}$) in chickpea genotypes at different dates of sowing (*Rabi* season 2018-19 and 2019-20)**

| Treatments | Growing degree days (GDD) $^{o}$C | Heliothermal units ($^{o}$C day hrs) | Heat use efficiency (kg ha$^{-1}$ $^{o}$C day$^{-1}$) | Yield (kg ha$^{-1}$) |
|---|---|---|---|---|
| **Genotypes (G)** | | | | |
| G1: NBeG 47 | 1910 | 14432 | 0.74 | 1498 |
| G2: NBeG 49 | 1911 | 14452 | 0.76 | 1548 |
| G3: JG 11 | 1894 | 14311 | 0.83 | 1659 |
| G4: JAKI | 1981 | 15076 | 0.74 | 1572 |
| G5: NBeG 452 | 1852 | 13950 | 0.84 | 1635 |
| G6: NBeG 738 | 1913 | 14468 | 0.80 | 1634 |
| G7: NBeG 776 | 1896 | 14345 | 0.85 | 1722 |
| G8: NBeG 779 | 1845 | 13884 | 0.93 | 1811 |
| G9: NBeG 857 | 1930 | 14604 | 0.83 | 1704 |
| G10 : NBeG 119 | 1818 | 13657 | 0.76 | 1465 |
| G11 : NBeG 399 | 2022 | 15506 | 0.68 | 1463 |
| G12 : NBeG 440 | 2059 | 15801 | 0.77 | 1662 |
| G13 : NBeG 458 | 2114 | 16299 | 0.65 | 1465 |
| G14 : VIHAR | 2180 | 16961 | 0.61 | 1411 |
| G15 : KAK2 | 2154 | 16725 | 0.60 | 1380 |
| SE(m) | 5.6 | 48.6 | 0.02 | 39.9 |
| CD (P=0.05) | 15.8 | 136.9 | 0.05 | 112.4 |
| **Dates of Sowing (D)** | | | | |
| D1: 1$^{st}$ FN of October | 2112 | 15080 | 0.63 | 1400 |
| D2: 1$^{st}$ FN of November | 1954 | 14551 | 0.88 | 1831 |
| D3: 1$^{st}$ FN of December | 1830 | 14262 | 0.78 | 1494 |
| SE(m) | 2.51 | 21.75 | 0.009 | 17.86 |
| CD (P=0.05) | 7.08 | 61.24 | 0.025 | 50.29 |
| **Interactions (G × D)** | | | | |
| SE(m) | 9.7 | 84.2 | 0.03 | 69.1 |
| CD (P=0.05) | 27.4 | 237.1 | 0.09 | 194.7 |

heat energy greatly influences its photosynthetic ability and physiological efficiency. The leaf dry weight of chickpea for all the three dates of sowing showed exponential increase from 20 DAS to 80 DAS. Highest leaf dry weight was recorded in November1st FN ($D_2$) sowing (6.27 g) followed by December 1st FN ($D_3$) sowing (5.60 g) whereas lowest leaf dry weight was recorded in October 1st FN ($D_1$) sowing (5.22 g) at 80 DAS.

In the present study similar to stem dry weight, leaf dry weight was also higher during November 1st FN ($D_2$) sowing because of higher heat utilizing ability and it further support that adequate rainfall, accumulated GDD during vegetative growth favours crop growth in terms of plant height, leaf area and stem dry weight compared to other two sowings.

It is clear from the experimental results that higher temperature during crop growth period lowered the drymatter accumulation under late and early planted chickpea crop. The results are in synchronous with Tripati *et al*. (2008) and Singh and Shono (2012) and they reported that high temperature during the reproductive stage induces increase in rate of respiration, resulting in loss of stored food material, which in turn reduces fresh weight and there was decline in shoot length and dry weight with corresponding decrease in dry weight of leaf, stem and pod.

The pod dry weight of chickpea at all the three dates of sowing increased from 60 DAS to harvest. Highest pod dry weight was recorded in November 1st FN ($D_2$) sowing (13.26 g) followed by December 1st FN ($D_3$) sowing (12.63 g) whereas lowest leaf dry weight was recorded in October 1st FN ($D_1$) sowing (12.02 g) at harvest due to high temperatures and low soil moisture availability. The higher pod dry weight in November sown crop may be attributed due to sufficient soil moisture available in root zone at reproductive stage and increased the partitioning efficiency from source to sink i.e., from stem and leaves to pods.

Phenotypic variability for total dry matter ranges from 21.01 g to 25.42 g at 80 DAS. Among desi genotypes highest total dry matter was recorded by NBeG-779 (25.42 g) followed by NBeG-776 (24.71 g) and NBeG-857(23.95 g) and lowest dry matter were recorded in NBeG-452 (21.26 g). Among kabuli genotypes highest total dry matter was recorded by NBeG-440 (22.55 g) followed by NBeG-458 (21.80 g) and was at par with NBeG119 (21.70 g) respectively whereas lowest total dry matter was recorded in Vihar (21.01 g). Different genotypes had significant effect on dry matter accumulation at all stages of chickpea. The results are in accordance with Mrudula *et al*. (2012).

The total dry weight of chickpea at all the three dates of sowing showed exponential increase from 20 DAS to 80 DAS. Highest total dry matter was recorded in November 1st FN sowing (24.72 g) followed by in December 1st FN sowing (22.91 g) whereas lowest total dry matter was recorded in October 1st FN sowing (20.42 g) at 60 DAS.

GDD significantly varied among the genotypes, from sowing to physiological maturity, and the accumulated Growing degree days (GDD) ranged from 1818° day to 2180° day across all the three dates of sowing, whereas among the dates of sowing, GDD ranges from 1830° day to 2112° day (Table 2). Under late sown conditions, lower GDD was required by the crop to attain maturity. However, when dates of sowing were advanced, higher GDD was needed by the chickpea crop to attain maturity. Similar results were reported by Rathod and Chimmad (2016) and Kiran and Chimmad (2018). Heat use efficiency (HUE) ranges from 0.60 kg $ha^{-1}$ °C $day^{-1}$ to 0.93 kg $ha^{-1}$ °C $day^{-1}$ at physiological maturity, across the three dates of sowing, HUE ranges from 0.63 kg $ha^{-1}$ °C $day^{-1}$ ($D_1$) to 0.88 kg $ha^{-1}$ °C $day^{-1}$ ($D_2$). Mhaske *et al*. (2019) reported that HUE was significantly superior in desi genotype compared to kabuli genotype and also envisaged that increase in dry matter resulted in proportionate increment in HUE.

Variability for grain yield ranges from 1380 kg $ha^{-1}$ to 1811 kg $ha^{-1}$. Among the desi genotypes, NBeG 779 (1811 kg $ha^{-1}$) recorded significantly higher yield followed by NBeG 776 (1722 kg $ha^{-1}$) and was at par with NBeG 857 (1704 kg $ha^{-1}$) and lowest was recorded in NBeG 47 (1498 kg $ha^{-1}$). Among kabuli genotypes NBeG 440 (1662 kg $ha^{-1}$) recorded higher yield followed by NBeG 458 and NBeG 119 (1465 kg $ha^{-1}$) whereas lowest grain yield were recorded by KAK-2 (1380 kg $ha^{-1}$). Under delayed sowings chickpea reproductive phase suffers considerably due to high temperatures (35/18 °C, day/night), and under such thermal conditions, grain yield is reduced to 33% compared to that of normal conditions such as 30/10°C day/night (Summerfield *et al*., 1984).

## CONCLUSION

The genotype NBeG 779 recorded higher total drymatter production and yield and its components compared to other desi genotypes like NBeG 47, NBeG 49, JG 11, JAKI, NBeG 452, NBeG 738, NBeG 776, NBeG 857 and in kabuli genotypes, NBeG 440 recorded higher total drymatter production and yield compared to NBeG 119, NBeG 399, NBeG 458, Vihar and KAK2. Among the three dates of sowing, D2 November 1st FN sowing found favourable interms of higher accumulation of GDD especially at critical phenophase and recorded higher HUE and yield compared to December and October sowing.

## LITERATURE CITED

Anonymous, 2020. www.Indiastat.com.

Kiran B.A and Chimmad V.P. 2018. Studies on morpho-phenological traits and heat unit accumulation in chickpea genotypes under different temperature regimes. *Journal of Pharmacognosy and Phytochemistry*. 7(3): 2956-2961.

Kiran, B.A and Chimmad, V.P. 2015. Effect of temperature regimes on phenological parameters, yield and yield components of chickpea. *Karnataka Journal of Agricultural Science*. 28(2): 168-171

Rathod, M.K and Chimmad, V.P. 2016. Influence of temperature regime on heat unit accumulation in relation to phenology and yield of chickpea. *Journal of Farm Science*. 29(1): 28-31

Singh, I and Shono, M. 2012. Heat-stress effects on dry matter partitioning, pollen viability and fruit yield in tomato genotypes. *Indain Journal of Plant Physiology*. 17(2): 103-112

Summerfield, R.J., Hadley, P., Roberts, E.H., Minchin, F.R. and Rawsthorne, S. 1984. Sensitivities of chickpeas (*Cicer arietinum* L.) to hot temperatures during the reproductive period. *Experimental Agriculture*. 20: 77-93.

Mhaske, S., Agrawal, K.K and Manish, B. 2019. Heat unit requirements, heat use efficiency of chickpea types under different thermal environment and irrigation. *International journal of Chemical Studies*. 7(5):1573-1576

Mrudula, G., Ashokarani, Y and Rao, S.B.S.N. 2012. Quantification of heat units for chickpea under coastal environment of Andhra Pradesh. *Journal of Agrometeorology*. 14 (1): 82-84.

Pradeep, K.P and Hemantaranjan. 2012. Salicylic acid induced alteration in dry matter partitioning antioxidant defense system and yield in chickpea (*Cicer arietinum* L.) under drought stress. *Asian Journal of Crop Science*. 4(3): 86-102.

Tripati, P., Singh, A.K., Sheobardan, K and Shabd, A. 2008. Growth and thermal unit of chickpea (*Cicer arietinum* L.) genotypes under variable weather conditions of Eastern Uttar Pradesh. *Asian Journal of Environmental Science*. 3(2):164-168