

Effect of Different Photothermal Regimes on Morpho-Physiological Traits in Chickpea (*Cicer arietinum* L.)

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Received: 13.01.2021 | Revised: 17.02.2021 | Accepted: 24.02.2021

ABSTRACT

A field experiment was conducted to study the photothermal requirement of chickpea cultivars during rabi season of 2018-19 and 2019-20 at Regional Agricultural Research Station, Nandyal. The experiment was laid out in factorial RBD with three replications consisted three sowing dates 1st fortnight of October, November and December and fifteen genotypes viz., NBeG 47, NBeG 49, JG 11, Jaki, NBeG 452, NBeG 738, NBeG 776, NBeG 779, NBeG 857, NBeG 119, NBeG 399, NBeG 440, NBeG 458, Vihar and KAK2. The genotypes were evaluated for various morpho-phenological and heat units accumulation under different dates of sowing. A significant genotypic variability was recorded in plant height, number of branches, phenological stages and photothermal indices viz growing degree days (GDD), heliothermal units, photothermal units and heat use efficiency. Results revealed that duration of phenological stages and thermal unit from sowing to maturity decreased with successive delay in sowing. Crop sown during November produced significantly higher seed yield as compared to October and December sowings. Among the desi genotypes NBeG 779 and in kabuli genotypes NBeG 440 exhibited significantly higher seed yield.

Keywords: Chickpea, Sowing dates, Photothermal unit, Yield attributes.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) or Bengalgram is the third most important grain legume cum pulse crop in the world, whereas in India chickpea is important pulse crop placed in first

position with an area of 9.55 million hectares producing 9.94 million tones with an average productivity of 1041 kg ha⁻¹ (www.indiastat.com, 2020).

Cite this article: Raghavendra, T., Sudhakar, P., Sandhya rani, P., Jayalakshmi, V., & Reddy, B.R. (2021). Effect of Different Photothermal Regimes on Morpho-Physiological Traits in Chickpea (*Cicer arietinum* L.), *Ind. J. Pure App. Biosci.* 9(1), 501-506. doi: <http://dx.doi.org/10.18782/2582-2845.8611>

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 (www.indiastat.com, 2020).

Among pulses, chickpea is preferred to food legumes in some regions because of its multiple uses. Chickpea is considered to be unique because of its high level of protein content that accounts for almost 40% of its weight. Moreover, the grain chickpea legume crop has potential health benefits, which include reducing cardiovascular, diabetic, and cancer risks. Chickpea is a highly nutritious and an inexpensive source of protein that is estimated at 24% and ranges from 15% to 30% depending on variety and environmental conditions.

Temperature is an important factor controlling plant growth and development in chickpea. Daily seasonal temperature above optimum becomes a limiting factor for crop production when they coincide with critical stages of development. IPCC (2007) has projected 1.6 to 3.8°C increase in global average air temperature at the critical stage may cause considerable yield losses. Moreover, the rise in temperature is reported to be a greater during the *rabi* season and thus, crops grown in the *rabi* season like chickpea are more vulnerable. Photoperiod is another major environmental factor determining time to flower initiation and first flower appearance in plants. In chickpea, photoperiod sensitivity, expressed as delayed to flower under short days (SD) as compared to long days (LD), may change with the growth stage of the crop.

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 objective of the investigation is to study the influence of photoperiod and temperature on various growth attributes, dry matter partitioning and yield in chickpea genotypes in scarce rainfall zone of Andhra Pradesh.

MATERIALS AND METHODS

A field experiment was conducted to study the photothermal requirement of chickpea cultivars during rabi season of 2018-19 and 2019-20 at Regional Agricultural Research Station, Nandyal. The experiment was laid out in factorial RBD with three replications consisted of fifteen genotypes *viz.*, Desi-NBeG 47, NBeG 49, JG 11, Jaki, NBeG 452, NBeG 738, NBeG 776, NBeG 779, NBeG 857 and kabuli- NBeG 119, NBeG 399, NBeG 440, NBeG 458, Vihar and KAK2 as factor one and three sowing dates 1st FN of October, 1st FN of November and 1st FN of December 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).

Observations recorded

Morphological characters: The observations on plant height and the number of primary and secondary branches were recorded as per the standard procedure in five tagged plants in the plot. Phenological parameter *viz.*, days to flower initiation, days to fifty per cent flowering, days to pod initiation and days to maturity were recorded randomly in the plot and was expressed in days.

Thermal indices: The growing degree days (GDD), heliothermal units (HTU), photothermal units (PTU) and heat use efficiency (HUE) were calculated by using phenological data and weather data are as follows.

Growing degree days (GDD) (Monteith, 1984)

Growing degree days (GDD) is an arithmetic accumulation of daily mean temperature above

certain threshold temperature (base temperature) and is calculated using the formula.

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

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:

$$\text{HTU } (^{\circ}\text{C day hr}) = \text{GDD} \times \text{Actual sunshine hours}$$

Photothermal units (PTU)

Photothermal units (PTU) is the product of GDD and corresponding day length for that day were computed on daily basis as follows:

$$\text{PTU } (^{\circ}\text{C day hr}) = \text{GDD} \times \text{Day length}$$

where, day length refers to maximum possible sunshine hours.

Heat use efficiency (HUE) (Monteith, 1984)

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

$$\text{Thermal use efficiency (HUE)} = \frac{\text{Seed yield (Kg ha}^{-1}\text{)}}{\text{Growing degree days } (^{\circ}\text{Cday)}}$$

RESULTS AND DISCUSSION

Morphological parameters like plant height, number of primary and secondary branches, phenology and physiological maturity significantly differed due to different dates of sowing, genotypes and their interactions. Plant height is an important morphological character controlled genetically but the environmental factors also influence these characters.

Significant variability for plant height (Table 1) among the genotypes, dates of sowing and their interactions were recorded. Among the varieties, phenotypic variability for plant height ranges from 34.73 cm (NBeG 452) to 50.12 cm (NBeG 47). Similar result in chickpea was reported by Kiran and Chimmad (2015). Among the desi varieties, NBeG 47 recorded highest plant height (50.12 cm) followed by NBeG 779 (43.88 cm) respectively whereas lowest plant height of (34.73) cm was recorded by NBeG 452. Among the Kabuli's NBeG-399 recorded plant height of (42.06 cm) which is at par with NBeG-458 (42.03). Similarly the increase in plant height was attributed to the increased duration of the crop *i.e.* growing period, which is evident by the number of days taken for

maturity was higher in these sowing dates was reported by Saim and Ufuk (2003).

Secondary branches per plant differed significantly due to different dates of sowing (Table 1). Among the genotypes, phenotypic variability for secondary branches ranges from 4.76 (NBeG 440) to 9.79 (NBeG-776). Among the desi genotypes, NBeG 776 (9.79) recorded more number of secondary branches followed by NBeG-779 (9.73) and NBeG 49 (9.64) respectively whereas in kabuli genotypes more number of secondary branches was recorded by NBeG-119 (7.85) followed by Vihar (6.89). Similar result in chickpea was reported by Kiran and Chimmad (2018). All the dates of sowing showed significant variability throughout the crop growth stages. Among the three dates of sowing October 1st FN sowing (8.80) exhibited more number of secondary branches followed by November 1st FN sowing (7.54) whereas lowest number of secondary branches was recorded in December 1stFN (5.65). Similar variability for secondary branches with respective delayed sowing in chickpea was reported by Rathod and Chimmad (2016).

Phenological parameters

Phenological parameters (Table 1) like days to fifty per cent flowering and days to physiological maturity are differed significantly with respect to genotypes, dates of sowing and their interactions.

The number of days taken for 50 per cent flowering differ significantly among the genotypes and also at different dates of sowing and their interactions. Among kabuli genotypes, Vihar took significantly maximum number of days (43.1 days) for 50 per cent flowering followed by, KAK-2 (42.7 days) and NBeG-399 (42.3), where as minimum number of days (36.4 days) was recorded in NBeG-119. Among the desi genotypes Jaki recorded maximum number of days (40.8 days) followed by NBeG-47 (39.6 days) and minimum number of days recorded by NBeG-779 (37.6 days).

Days to 50% flowering in chickpea was significantly reduced with faster accumulation of both photo-thermal and thermal units. This is similar to the results of Trudgill et al. (2005) in which they reported that rapid development results from a small overall degree day increase in diverse plant species with short generation times. All the dates of sowing showed significant variability throughout the crop growth stages. Among the three dates of sowing October 1st FN sowing recorded (41.7 days), followed by November 1st FN sowing (39.4 days) and December 1st FN sowing (37.5 days).

The results observed from (Table 1) indicated that genotypes, dates of sowing and their interactions differed significantly with respect to days to physiological maturity. Among the kabuli genotypes, Vihar took significantly maximum number of days (105.3 days) for physiological maturity followed by, KAK-2 (103.6 days), where as minimum number of days (90.1 days) was recorded in NBeG 119. Similar results were reported by Purushothaman et al. (2014). Among the desi genotypes NBeG 857 took significantly maximum number of days (92.2 days) for physiological maturity followed by, Jaki (91.7 days) and minimum number of days

(88.1days) was recorded in NBeG 452. These results are in agreement with Berger et al. (2011) and Suresh Mhaske et al. (2019).

The days taken to attain different phenological stages and total duration were differed significantly by changing the date of sowing. Among the three dates of sowing October 1st FN sowing recorded (101.0 days), followed by November 1st FN sowing (94.3 days) and December 1st FN sowing (87.3 days). The crop sown on October 1st FN taken highest number of days to attain different growth stages i.e from start of flowering to physiological maturity followed by November 1st FN and December 1st FN during both the crop season. In the present study higher temperature and long photoperiod shorten the developmental growth phases and high rainfall at early sown crop have extended growth phase with poor growth was observed.

Photothermal indices

GDD significantly varied among the varieties, from sowing to physiological maturity, accumulated Growing degree days (GDD) ranges 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 Kiran and chimmad (2018). Heat use efficiency (HUE) ranges from 0.60 kg/ha/°C day to 0.93 kg/ha/°C day at physiological maturity, across the three dates of sowing, HUE ranges from 0.63 kg/ha/°C day (D1) to 0.88 kg/ha/°C day (D2).

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), 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).

Table 1: Effect of temperature and photoperiod on growth and phenology of chickpea genotypes at different dates of sowing

| Treatments | Plant height (cm) | Secondary branches | Days to 50 % flowering | Days to physiological maturity |
|------------------------------------|-------------------|--------------------|------------------------|--------------------------------|
| Genotypes (G) | | | | |
| G1 : NBeG 47 | 50.12 | 7.43 | 39.6 | 90.8 |
| G2 : NBeG 49 | 38.22 | 9.64 | 38.7 | 89.1 |
| G3 : JG 11 | 34.92 | 9.25 | 37.8 | 88.9 |
| G4 : Jaki | 37.98 | 7.33 | 40.8 | 91.7 |
| G5 : NBeG 452 | 34.73 | 7.77 | 37.8 | 88.1 |
| G6 : NBeG 738 | 39.22 | 8.31 | 37.8 | 89.3 |
| G7 : NBeG 776 | 43.51 | 9.79 | 38.1 | 90.8 |
| G8 : NBeG 779 | 43.88 | 9.73 | 37.6 | 89.0 |
| G9 : NBeG 857 | 37.27 | 8.62 | 38.1 | 92.2 |
| G10 : NBeG 119 | 40.02 | 7.85 | 36.4 | 90.1 |
| G11 : NBeG 399 | 42.06 | 5.30 | 42.3 | 99.8 |
| G12 : NBeG 440 | 40.87 | 4.76 | 40.3 | 102.0 |
| G13 : NBeG 458 | 42.03 | 5.83 | 41.5 | 102.1 |
| G14 : Vihar | 40.27 | 6.89 | 43.1 | 105.3 |
| G15 : KAK2 | 41.52 | 5.35 | 42.7 | 103.6 |
| SE(m) | 0.64 | 0.40 | 0.16 | 0.35 |
| CD (P=0.05) | 1.80 | 1.13 | 0.47 | 0.98 |
| Dates of Sowing (D) | | | | |
| D1:1 st FN of October | 39.50 | 7.54 | 41.7 | 101.0 |
| D2:1 st FN of November | 40.46 | 8.80 | 39.4 | 94.3 |
| D3: 1 st FN of December | 41.37 | 5.65 | 37.5 | 87.3 |
| SE(m) | 0.28 | 0.17 | 0.07 | 0.15 |
| CD (P=0.05) | 0.80 | 0.53 | 0.21 | 0.44 |
| Interactions (GXD) | | | | |
| SE(m) | 1.10 | 0.68 | 0.29 | 0.60 |
| CD (P=0.05) | NS | 2.03 | 0.82 | 1.70 |

NS- Non Significant

Table 2: Effect of temperature and photoperiod on photothermal indices, heat use efficiency (HUE kg/ha/°C) and yield (Kg/ha) in chickpea genotypes at different dates of sowing

| Treatments | Growing degree days (GDD) °C | Heliothermal units (HTU °C day hrs) | Photothermal units (PTU °C day hrs) | Heat use efficiency (HUE kg/ha/°C) | Yield (Kg/ha) |
|------------------------------------|------------------------------|-------------------------------------|-------------------------------------|------------------------------------|---------------|
| Genotypes (G) | | | | | |
| G1 : NBeG 47 | 1910 | 14432 | 21613 | 0.74 | 1498 |
| G2 : NBeG 49 | 1911 | 14452 | 21028 | 0.76 | 1548 |
| G3 : JG 11 | 1894 | 14311 | 21562 | 0.83 | 1659 |
| G4 : Jaki | 1981 | 15076 | 22594 | 0.74 | 1572 |
| G5 : NBeG 452 | 1852 | 13950 | 21099 | 0.84 | 1635 |
| G6 : NBeG 738 | 1913 | 14468 | 21797 | 0.80 | 1634 |
| G7 : NBeG 776 | 1896 | 14345 | 21782 | 0.85 | 1722 |
| G8 : NBeG 779 | 1845 | 13884 | 21996 | 0.93 | 1811 |
| G9 : NBeG 857 | 1930 | 14604 | 21721 | 0.83 | 1704 |
| G10 : NBeG 119 | 1818 | 13657 | 20683 | 0.76 | 1465 |
| G11 : NBeG 399 | 2022 | 15506 | 23034 | 0.68 | 1463 |
| G12 : NBeG 440 | 2059 | 15801 | 23395 | 0.77 | 1662 |
| G13 : NBeG 458 | 2114 | 16299 | 24105 | 0.65 | 1465 |
| G14 : Vihar | 2180 | 16961 | 24848 | 0.61 | 1411 |
| G15 : KAK2 | 2154 | 16725 | 24543 | 0.60 | 1380 |
| SE(m) | 5.6 | 48.6 | 65.4 | 0.02 | 39.9 |
| CD (P=0.05) | 15.8 | 136.9 | 184.2 | 0.05 | 112.4 |
| Dates of Sowing (D) | | | | | |
| D1:1 st FN of October | 2112 | 15080 | 24176 | 0.63 | 1400 |
| D2:1 st FN of November | 1954 | 14551 | 22103 | 0.88 | 1831 |
| D3: 1 st FN of December | 1830 | 14262 | 20880 | 0.78 | 1494 |
| SE(m) | 2.51 | 21.75 | 29.27 | 0.009 | 17.86 |
| CD (P=0.05) | 7.08 | 61.24 | 82.40 | 0.025 | 50.29 |
| Interactions (GXD) | | | | | |
| SE(m) | 9.7 | 84.2 | 113.3 | 0.03 | 69.1 |
| CD (P=0.05) | 27.4 | 237.1 | 319.1 | 0.09 | 194.7 |

CONCLUSION

The genotype NBeG 779 recorded higher physiological efficiency 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 physiological efficiency and yield compared to NBeG 119, NBeG 399, NBeG 458, Vihar and KAK2. Among the three dates of sowing, November 1st FN sowing found favourable interms of higher accumulation of GDD specially at grain filling stage and recorded higher HUE and yield compared to December 1st FN sowing and October 1st FN sowing.

Acknowledgements

The authors wish to thank the AICRP-Chickpea, RARS Nandyal for providing seed material and research facility for this study.

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