# Effects of different sowing dates on growth rate and dry matter production in chickpea (*Cicer arietinum* L.) genotypes

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## Abstract

The experiment was conducted with ten genotypes of chickpea (*Cicer arietinum* L.) *viz* ICCV 88503, ICCV 92944, HC- 1, HC-3, HC-5, H12-64, H13-01, H13-02, H14-01 and H14-04 for three dates of sowing *i.e* 15th October, 15th November and 15th December in the field in randomized block design during *Rabi* season of 2017-18 and 2018-19 at Pulses Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to observe the effect of sowing dates on growth rate and dry matter production of chickpea genotypes at different intervals *i.e* 30, 60, 90, and 120 DAS. The crop growth rate, relative growth rate, dry weight of leaves, stem and pods were minimum in 15th December sowing and maximum in 15th October sowing at all intervals. Among genotypes, maximum growth rate and dry matter were observed in H12-64 and H13-01 while minimum were found in H14-04 and among interactions, maximum growth rate and dry matter were observed in genotype H12-64 when sown on 15th October whereas minimum were observed in genotype H14-04 when sown on 15th December at all intervals.

**Keywords :** Sowing dates, growth rate, dry weight, genotypes, *Cicer arietinum* L.

## Introduction

Chickpea is the second most important legume crop after dry beans in the world with 13.7 million hectare area under cultivation and 14.2 million tonnes are produced annually with average seed yield of 1038 kg $ha^{-1}$ (FAOSTAT, 2019) whereas in India with 9.54 million hectare area under cultivation and 9.93 million tonnes produced with average seed yield of 1041 kg $ha^{-1}$ (FAOSTAT, 2019). In Haryana, it is grown over an area of 105,000 hectare with total production of 85,000 tonnes and productivity of 855 kg $ha^{-1}$ (Anonymous, 2018-19).

In India, Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Andhra Pradesh, Karnataka, Chhattisgarh, Bihar and Jharkhand are major chickpea cultivating and producing states contributing more than 95% to the total chickpea area and production. (Anonymous, 2018-19).

Growth analysis is being used as an important tool for assessing crop productivity in various crops. Analysis of crop growth and development gives an insight not only on the performance of a particular genotype but also impact on crop at particular stages. Sowing time play a vital role in influencing the growth of chickpea particularly through prevailing temperature during germination and reproductive phases.

In northern part of India, it is normally sown during second fortnight of October. Sometime its sowing is delayed depending upon the withdrawal of monsoon and late harvest of preceding *kharif* crop, which ultimately results in poor development (Wang *et al*., 2006).

Traditionally chickpea varieties cultivated in northern India required low temperature and prolonged winter for better growth. Hence chickpea cultivation was confined to the northern and central regions. With the intensification of wheat cultivation during *rabi* season, the pulse area reduced in the northern states, especially where irrigation facilities were available. This has forced, chickpea to shift towards comparative warmer and harsher growing environment of the southern states (Dixit *et al.*, 2019).

Global temperatures are increasing due to climate change which would have detrimental effects on agricultural crops being grown in arid and semi-arid regions (Wahid *et al*,. 2007) and pulses are sensitive to change in temperature and the late-sown crop is exposed to high temperatures (>35$^0$C) at its reproductive stage in the months of February and March (Berger *et al.*, 2011; Kumar *et al.*, 2012).

The high temperature at late sown condition may adversely affect the growth and productivity of crops as both duration and grain filling stages are sensitive to alteration in temperature (Moradshahi *et al*.,2004). However, during early sown conditions, temperature below 10 $^0$C is known to alter a variety of physiological processes ranging from plant water status, photosynthesis to reactive oxygen species (ROS) and solute accumulation, excessive floral abortion and has adverse effect on chickpea yield and results in losses from 15-20 % ( Ali and Kumar, 2005; Bakht *et al.*, 2006; Chaturvedi *et al.*, 2009).Therefore optimum sowing time plays an important role to fully exploit the production potential of a cultivars as it provides optimum growth conditions such as temperature, light, humidity and rainfall (Iraddi, 2008).

## Material and Methods

The experiment was conducted in the field area of Pulses Section, Department of Genetics and Plant Breeding of Chaudhary Charan Singh Haryana Agricultural University, Hisar during *Rabi* 2017-18 and 219-19.

Data were collected on growth rate and dry matter production of chickpea genotypes at different intervals i.e 30, 60, 90, and 120 DAS. The five randomly selected plants from each plot were uprooted and sun dried. The dry weight of stem, leaves and pods were taken and average was recorded at growth stages 30, 60, 90 and 120 DAS. CGR was measured at 30, 60, 90, and 120 DAS by using the following formula (Reddy and Reddy, 2009): CGR = (W2- W1) / P (T2- T1) Where, P is the land area and W1 and W2 are dry weights at $T_1$ and $T_2$ time, respectively. RGR was measured at 30, 60, 90 and 120 DAS by the following formula (Reddy and Reddy, 2009): RGR= (LogeW2- LogeW1) / (T2-T1) Where, W1 and W2 are dry weights at $T_1$ and $T_2$ time, respectively. All the collected data were statistically analyzed by pooled analysis of both year (2017-18 and 2018-19) through OPSTAT software at the Computer Centre, Department of Statistics, CCS HAU, Hisar.

## Results and Discussion

### 4.2.5 Crop growth rate (g $m^{-2}day^{-1}$)

The data recorded for crop growth rate (CGR) at different stages of crop growth are presented in Table 1. An increase in crop growth rate was observed with the advancement of crop age and reached maximum between 61-90 DAS in all three dates of sowings. maximum crop growth rate between 0-30 DAS was observed in genotype H12-64 and H13-01 (0.026 g $m^{-2}day^{-1}$) whereas minimum crop growth rate was observed in genotype H14-04 (0.021 g $m^{-2}day^{-1}$) when considered irrespective of sowing dates. The minimum crop growth rate (0.018 g $m^{-2}day^{-1}$) was observed in plants sown on 15$^{th}$ December and maximum crop growth rate (0.027 g $m^{-2}day^{-1}$) was observed on 15$^{th}$ October sown crop when considered irrespective of genotypes. Among interactions, maximum crop growth rate was observed (0.032 g $m^{-2}day^{-1}$) in genotype H12-64 when sown on 15$^{th}$ October whereas minimum crop growth rate was observed in genotype H14-04 (0.016 g $m^{-2}day^{-1}$) when sown on 15$^{th}$ December.

Similar trends of crop growth rates were observed in between 31-60, 61-90 and 91-120 DAS.

**Table:1 Variation in crop growth rate (g $m^{-2}day^{-1}$) of chickpea genotypes under different sowing dates**

| Genotypes | Crop growth rate (g $m^{-2}day^{-1}$) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-30 DAS | | | | 31-60 DAS | | | | 61-90 DAS | | | | 91-120 DAS | | | |
| | Sowing dates | | | | | | | | | | | | | | | |
| | 15th Oct. | 15th Nov. | 15th Dec. | Mean | 15th Oct. | 15th Nov. | 15th Dec. | Mean | 15th Oct. | 15th Nov. | 15th Dec. | Mean | 15th Oct. | 15th Nov. | 15th Dec. | Mean |
| H12-64 | 0.032 | 0.028 | 0.017 | 0.026 | 0.145 | 0.132 | 0.081 | 0.119 | 0.334 | 0.304 | 0.227 | 0.288 | 0.243 | 0.197 | 0.134 | 0.191 |
| H13-01 | 0.031 | 0.026 | 0.021 | 0.026 | 0.144 | 0.131 | 0.082 | 0.119 | 0.320 | 0.304 | 0.261 | 0.295 | 0.241 | 0.198 | 0.134 | 0.191 |
| H13-02 | 0.031 | 0.028 | 0.016 | 0.025 | 0.145 | 0.131 | 0.081 | 0.119 | 0.324 | 0.304 | 0.227 | 0.285 | 0.242 | 0.198 | 0.132 | 0.191 |
| H14-01 | 0.025 | 0.024 | 0.022 | 0.024 | 0.117 | 0.115 | 0.082 | 0.105 | 0.300 | 0.301 | 0.262 | 0.288 | 0.226 | 0.189 | 0.135 | 0.183 |
| H14-04 | 0.024 | 0.022 | 0.016 | 0.021 | 0.116 | 0.115 | 0.080 | 0.104 | 0.300 | 0.295 | 0.226 | 0.274 | 0.197 | 0.186 | 0.125 | 0.169 |
| HC 1 | 0.025 | 0.023 | 0.017 | 0.022 | 0.117 | 0.115 | 0.081 | 0.104 | 0.300 | 0.300 | 0.227 | 0.276 | 0.199 | 0.187 | 0.134 | 0.173 |
| HC 3 | 0.025 | 0.023 | 0.020 | 0.023 | 0.116 | 0.115 | 0.081 | 0.104 | 0.300 | 0.300 | 0.260 | 0.287 | 0.199 | 0.187 | 0.134 | 0.173 |
| HC 5 | 0.025 | 0.023 | 0.018 | 0.022 | 0.117 | 0.115 | 0.081 | 0.104 | 0.300 | 0.300 | 0.228 | 0.276 | 0.197 | 0.187 | 0.134 | 0.173 |
| ICCV88503 | 0.030 | 0.026 | 0.016 | 0.024 | 0.144 | 0.132 | 0.080 | 0.119 | 0.319 | 0.301 | 0.227 | 0.282 | 0.230 | 0.197 | 0.129 | 0.185 |
| ICCV92944 | 0.025 | 0.022 | 0.018 | 0.022 | 0.117 | 0.115 | 0.081 | 0.104 | 0.300 | 0.300 | 0.228 | 0.276 | 0.199 | 0.186 | 0.134 | 0.173 |
| **Mean** | 0.027 | 0.025 | 0.018 | | 0.128 | 0.122 | 0.081 | | 0.310 | 0.301 | 0.237 | | 0.217 | 0.191 | 0.133 | |
| **CD at 5 %** | Dates of sowing =0.001 Genotypes = 0.001<br>Dates of sowing x Genotypes =0.002 | | | | Dates of sowing =0.002 Genotypes =0.004<br>Dates of sowing x Genotypes =0.007 | | | | Dates of sowing = 0.006 Genotypes =0.009<br>Dates of sowing x Genotypes =0.016 | | | | Dates of sowing =0.003 Genotypes =0.006<br>Dates of sowing x Genotypes =0.011 | | | |

**4.2.6 Relative growth rate (g $g^{-1}$ $day^{-1}$ )**

The relative growth rate (RGR) increased consistently till harvest and reached maximum between 61-90 DAS (Table 2). The differences in relative growth rate under three dates of sowings at four stages of observation (0-30, 31-60, 61-90, 91-120 DAS) differed significantly. Between 0-30 DAS like CGR the maximum relative growth rate was observed in genotype H12-64 and H13-01 (0.0082 g $g^{-1}$ $day^{-1}$) whereas minimum relative growth rate was observed in genotype H14-04 (0.0071 g $g^{-1}$ $day^{-1}$) when considered irrespective of sowing dates. The minimum relative growth rate (0.0063 g $g^{-1}$ $day^{-1}$) was observed in plants sown on 15th December and maximum relative growth rate (0.0087) was
observed on 15th October sown crop when considered irrespective of genotypes. Among interactions, maximum relative growth rate was observed (0.0097 g $g^{-1}$ $day^{-1}$) in genotype H12-64 when sown on 15th October whereas minimum relative growth rate was observed in genotype H14-04 (0.0056 g $g^{-1}$ $day^{-1}$) when sown on 15th December.

Similar trends of relative growth rates were observed in between 31-60, 61-90 and 91-120 DAS.

The data presented in table 1 and 2 indicated that the minimum CGR and RGR were observed in 15th December and maximum CGR and RGR were observed on 15th October sowing at all the growth stages (0-30, 31-60, 61-90 and 91-120 DAS) of crop. This might be due to that the high temperature at initial stages in 15th October sowing resulted into accelerated plant growth that produces more dry matter which resulting into increased plant growth rate (CGR and RGR) while in 15th December sowing, low temperature at vegetative phase and high temperature at reproductive phase could be accounted by low dry matter production that resulted into decreased plant growth rate (CGR and RGR) at all the growth stages. Among the genotypes maximum CGR and RGR were observed in H12-64 and H13-01 and minimum were recorded in H14-04 at all the growth stages (0-30, 31-60, 61-90 and 91-120 DAS). The variation in these genotypes might be due to their genetic makeup. Similar results due to different sowing dates has also been reported earlier in the literature by (Kabir *et al*,. 2009 in chickpea, Alam *et al*,. 2014;Solanki and Mundra, 2015; Khayat *et al*,. 2016 in *Brassica juncea.*

**4.2.2 Dry weight of leaves (g/plant)**

Likewise growth rate, the dry weight of leaves was also influenced with the crop age and time of sowing in all the genotypes during crop season (Table 3). At 30 DAS maximum dry weight of leaves (0.41 g/plant) was observed in genotype H12-64 and H13-01, whereas minimum dry weight of leaves (0.36 g/plant) was observed in genotype H14-04 when considered irrespective of sowing dates

**Table: 2 Variation in relative growth rate (g $g^{-1}$ $day^{-1}$) of chickpea genotypes under different sowing dates**

| Relative growth rate (g $g^{-1}$ $day^{-1}$) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Genotypes** | **0-30 DAS** | | | | **31-60 DAS** | | | | **61-90 DAS** | | | | **91-120 DAS** | | | |
| | **Sowing dates** | | | | | | | | | | | | | | | |
| | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** |
| H12-64 | 0.0097 | 0.0088 | 0.0060 | 0.0082 | 0.0146 | 0.0137 | 0.0096 | 0.0126 | 0.0370 | 0.0361 | 0.0174 | 0.0302 | 0.0063 | 0.0054 | 0.0045 | 0.0053 |
| H13-01 | 0.0096 | 0.0087 | 0.0063 | 0.0082 | 0.0145 | 0.0139 | 0.0095 | 0.0126 | 0.0369 | 0.0363 | 0.0173 | 0.0302 | 0.0058 | 0.0051 | 0.0050 | 0.0053 |
| H13-02 | 0.0094 | 0.0083 | 0.0058 | 0.0078 | 0.0145 | 0.0139 | 0.0095 | 0.0125 | 0.0367 | 0.0359 | 0.0173 | 0.0300 | 0.0055 | 0.0051 | 0.0050 | 0.0052 |
| H14-01 | 0.0082 | 0.0078 | 0.0072 | 0.0077 | 0.0128 | 0.0131 | 0.0096 | 0.0118 | 0.0358 | 0.0357 | 0.0183 | 0.0299 | 0.0054 | 0.0052 | 0.0050 | 0.0052 |
| H14-04 | 0.0081 | 0.0076 | 0.0056 | 0.0071 | 0.0128 | 0.0129 | 0.0090 | 0.0116 | 0.0357 | 0.0357 | 0.0172 | 0.0296 | 0.0053 | 0.0051 | 0.0043 | 0.0049 |
| HC 1 | 0.0080 | 0.0074 | 0.0061 | 0.0072 | 0.0129 | 0.0130 | 0.0099 | 0.0119 | 0.0358 | 0.0357 | 0.0174 | 0.0296 | 0.0054 | 0.0051 | 0.0050 | 0.0052 |
| HC 3 | 0.0079 | 0.0076 | 0.0069 | 0.0075 | 0.0129 | 0.0130 | 0.0091 | 0.0117 | 0.0357 | 0.0357 | 0.0185 | 0.0300 | 0.0054 | 0.0051 | 0.0050 | 0.0052 |
| HC 5 | 0.0080 | 0.0075 | 0.0062 | 0.0072 | 0.0129 | 0.0131 | 0.0095 | 0.0118 | 0.0357 | 0.0357 | 0.0174 | 0.0296 | 0.0054 | 0.0051 | 0.0050 | 0.0052 |
| ICCV88503 | 0.0095 | 0.0084 | 0.0071 | 0.0083 | 0.0145 | 0.0141 | 0.0090 | 0.0125 | 0.0368 | 0.0361 | 0.0185 | 0.0305 | 0.0055 | 0.0051 | 0.0044 | 0.0050 |
| ICCV92944 | 0.0081 | 0.0074 | 0.0058 | 0.0071 | 0.0128 | 0.0131 | 0.0097 | 0.0119 | 0.0357 | 0.0357 | 0.0174 | 0.0296 | 0.0054 | 0.0051 | 0.0050 | 0.0052 |
| **Mean** | 0.0087 | 0.0080 | 0.0063 | | 0.0135 | 0.0134 | 0.0095 | | 0.0362 | 0.0358 | 0.0177 | | 0.0055 | 0.0052 | 0.0048 | |
| **CD at 5 %** | Dates of sowing =0.001 Genotypes = 0.001<br>Dates of sowing x Genotypes =0.002 | | | | Dates of sowing =0.001 Genotypes =0.001<br>Dates of sowing x Genotypes =0.002 | | | | Dates of sowing = 0.001 Genotypes =0.002<br>Dates of sowing x Genotypes =0.003 | | | | Dates of sowing =0.001 Genotypes =0.001<br>Dates of sowing x Genotypes =0.001 | | | |

The minimum dry weight of leaves (0.30 g/plant) was observed in plants sown on 15th December and maximum dry weight of leaves (0.46 g/plant) was observed on 15th October sown crop when considered irrespective of genotypes. Among interactions, maximum dry weight of leaves (0.51 g/plant) was observed in genotype H12-64 when sown on 15th October whereas minimum dry weight of leaves (0.28 g/plant) was observed in genotype H14-04 when sown on 15th December.

Similar trends of dry weight of leaves were observed in between 31-60, 61-90 and 91-120 DAS.

**4.2.3 Dry weight of stem (g/plant)**

The dry weight of stem was also affected with time of sowing in all the genotypes as indicated in table 4. At 30 DAS maximum dry weight of stem (0.20 g/plant) was observed in genotype H12-64, H13-01, H13-02 and H14-01 whereas minimum dry weight of stem (0.17 g/plant) was observed in genotype H14-04 when considered irrespective of sowing dates. The minimum dry weight of stem (0.14 g/plant) was observed in plants sown on 15th December and maximum dry weight of stem (0.23 g/plant) was observed on 15th October sown crop when considered irrespective of genotypes. Among interactions, maximum dry weight of stem (0.25 g/plant) was observed in genotype H12-64 when sown on 15th October whereas minimum dry weight of stem (0.12 g/plant) was observed in genotype H14-04 when sown on 15th December.

Similar trends of dry weight of stem were observed in between 31-60, 61-90 and 91-120 DAS.

**4.2.4 Dry weight of reproductive parts (g/plant)**

The dry weight of pod was also differed significantly with the crop age and time of sowing in all the genotypes during crop season (Table 5). At 100 DAS maximum dry weight of pods (4.80 g/plant) was observed in genotype H12-64 and H13-01 whereas minimum dry weight of pods (4.72 g/plant) was observed in genotype H14-04 when considered irrespective of sowing dates. The minimum dry weight of pods (4.07 g/plant) was observed in plants sown on 15th December and maximum dry weight of pods (5.15 g/plant) was observed on 15th October sown crop when considered irrespective of genotypes. Among interactions, maximum dry weight of pods (5.19 g/plant) was observed in genotype H12-64 when sown on 15th October whereas minimum dry weight of pods (4.02 g/plant) was observed in genotype H14-04 when sown on 15 December.

Similarly at 120 DAS maximum dry weight of pods (7.52 g/plant) was observed in genotype H13-01 whereas minimum dry weight of pods (7.43 g/plant) was observed in genotype H14-04 when considered irrespective of sowing dates. The minimum dry weight of pods (8.15 g/plant) was observed in plants sown on 15th November and maximum dry weight of pods (6.09 g/plant) was observed on 15th December sown crop when considered irrespective of genotypes.

**Table: 3 Variation in dry weight of leaves (g/plant) of chickpea genotypes under different sowing dates**

| Dry weight of leaves (g/plant) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Genotypes** | **30 DAS** | | | | **60 DAS** | | | | **90 DAS** | | | | **120 DAS** | | | |
| | **Sowing dates** | | | | | | | | | | | | | | | |
| | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** |
| H12-64 | 0.51 | 0.42 | 0.29 | 0.41 | 1.52 | 1.45 | 0.95 | 1.31 | 3.91 | 3.86 | 2.59 | 3.45 | 4.86 | 4.71 | 3.29 | 4.29 |
| H13-01 | 0.49 | 0.4 | 0.33 | 0.41 | 1.50 | 1.45 | 0.98 | 1.31 | 3.88 | 3.83 | 2.66 | 3.46 | 4.83 | 4.69 | 3.35 | 4.29 |
| H13-02 | 0.50 | 0.41 | 0.28 | 0.40 | 1.51 | 1.44 | 0.94 | 1.30 | 3.89 | 3.85 | 2.58 | 3.44 | 4.84 | 4.70 | 3.29 | 4.28 |
| H14-01 | 0.45 | 0.37 | 0.33 | 0.38 | 1.46 | 1.41 | 0.98 | 1.28 | 3.87 | 3.81 | 2.67 | 3.45 | 4.82 | 4.67 | 3.36 | 4.28 |
| H14-04 | 0.43 | 0.36 | 0.28 | 0.36 | 1.42 | 1.39 | 0.92 | 1.24 | 3.82 | 3.77 | 2.58 | 3.39 | 4.77 | 4.63 | 3.28 | 4.23 |
| HC 1 | 0.45 | 0.37 | 0.3 | 0.37 | 1.46 | 1.41 | 0.95 | 1.27 | 3.86 | 3.80 | 2.59 | 3.42 | 4.80 | 4.65 | 3.29 | 4.25 |
| HC 3 | 0.44 | 0.36 | 0.32 | 0.37 | 1.44 | 1.40 | 0.97 | 1.27 | 3.82 | 3.78 | 2.65 | 3.42 | 4.78 | 4.64 | 3.34 | 4.25 |
| HC 5 | 0.44 | 0.36 | 0.3 | 0.37 | 1.44 | 1.40 | 0.96 | 1.27 | 3.85 | 3.78 | 2.59 | 3.41 | 4.79 | 4.64 | 3.32 | 4.25 |
| ICCV 88503 | 0.47 | 0.39 | 0.28 | 0.38 | 1.48 | 1.41 | 0.93 | 1.27 | 3.88 | 3.81 | 2.58 | 3.42 | 4.82 | 4.67 | 3.28 | 4.26 |
| ICCV 92944 | 0.45 | 0.36 | 0.32 | 0.38 | 1.45 | 1.39 | 0.96 | 1.27 | 3.86 | 3.77 | 2.62 | 3.42 | 4.79 | 4.63 | 3.32 | 4.25 |
| **Mean** | 0.46 | 0.38 | 0.30 | | 1.47 | 1.42 | 0.95 | | 3.86 | 3.81 | 2.61 | | 4.81 | 4.66 | 3.31 | |
| **CD at 5 %** | Dates of sowing =0.05, Genotypes = 0.09<br>Dates of sowing x Genotypes =1.50 | | | | Dates of sowing =0.01, Genotypes =0.03<br>Dates of sowing x Genotypes =0.05 | | | | Dates of sowing = 0.04, Genotypes =0.08<br>Dates of sowing x Genotypes =0.14 | | | | Dates of sowing =0.05, Genotypes =0.10<br>Dates of sowing x Genotypes =0.17 | | | |

**Table: 4 Variation in dry weight of stem (g/plant) of chickpea genotypes under different sowing dates**

| Dry weight of stem (g/plant) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Genotypes** | **30 DAS** | | | | **60 DAS** | | | | **90 DAS** | | | | **120 DAS** | | | |
| | **Sowing dates** | | | | | | | | | | | | | | | |
| | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** |
| H12-64 | 0.25 | 0.22 | 0.13 | 0.20 | 2.71 | 2.61 | 1.85 | 2.39 | 3.98 | 3.96 | 2.68 | 3.54 | 6.51 | 5.85 | 4.15 | 5.50 |
| H13-01 | 0.24 | 0.21 | 0.15 | 0.20 | 2.69 | 2.59 | 1.89 | 2.39 | 3.96 | 3.95 | 2.71 | 3.54 | 6.49 | 5.83 | 4.19 | 5.50 |
| H13-02 | 0.25 | 0.22 | 0.13 | 0.20 | 2.70 | 2.60 | 1.85 | 2.38 | 3.97 | 3.96 | 2.68 | 3.54 | 6.50 | 5.84 | 4.14 | 5.50 |
| H14-01 | 0.24 | 0.21 | 0.16 | 0.20 | 2.68 | 2.57 | 1.91 | 2.39 | 3.95 | 3.93 | 2.75 | 3.54 | 6.46 | 5.80 | 4.25 | 5.50 |
| H14-04 | 0.21 | 0.18 | 0.12 | 0.17 | 2.65 | 2.54 | 1.85 | 2.35 | 3.92 | 3.90 | 2.66 | 3.49 | 6.41 | 5.77 | 4.11 | 5.44 |
| HC 1 | 0.23 | 0.21 | 0.13 | 0.19 | 2.67 | 2.56 | 1.86 | 2.36 | 3.94 | 3.92 | 2.67 | 3.51 | 6.47 | 5.79 | 4.12 | 5.46 |
| HC 3 | 0.21 | 0.20 | 0.15 | 0.19 | 2.65 | 2.56 | 1.88 | 2.36 | 3.92 | 3.92 | 2.72 | 3.52 | 6.42 | 5.79 | 4.22 | 5.48 |
| HC 5 | 0.21 | 0.20 | 0.14 | 0.18 | 2.65 | 2.56 | 1.87 | 2.36 | 3.92 | 3.91 | 2.69 | 3.51 | 6.44 | 5.78 | 4.17 | 5.46 |
| ICCV 88503 | 0.24 | 0.21 | 0.13 | 0.19 | 2.68 | 2.57 | 1.85 | 2.37 | 3.95 | 3.93 | 2.74 | 3.54 | 6.46 | 5.81 | 4.23 | 5.50 |
| ICCV 92944 | 0.21 | 0.19 | 0.14 | 0.18 | 2.67 | 2.55 | 1.87 | 2.36 | 3.93 | 3.90 | 2.67 | 3.50 | 6.44 | 5.77 | 4.13 | 5.45 |
| **Mean** | 0.23 | 0.20 | 0.14 | | 2.68 | 2.57 | 1.87 | | 3.94 | 3.93 | 2.70 | | 6.46 | 5.80 | 4.18 | |
| **CD at 5 %** | Dates of sowing =0.03, Genotypes = 0.06<br>Dates of sowing x Genotypes =0.10 | | | | Dates of sowing =0.04, Genotypes =0.07<br>Dates of sowing x Genotypes =0.11 | | | | Dates of sowing = 0.05, Genotypes =0.09<br>Dates of sowing x Genotypes =0.17 | | | | Dates of sowing =0.08, Genotypes =0.14<br>Dates of sowing x Genotypes =0.25 | | | |

**Table: 4 Variation in dry weight of pods (g/plant) of chickpea genotypes under different sowing dates**

| Dry weight of pods (g/plant) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Genotypes** | **100 DAS** | | | | **120 DAS** | | | |
| | **Sowing dates** | | | | | | | |
| | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** | **15th Oct.** | **15th Nov.** | **15th Dec.** | **Mean** |
| H12-64 | 5.19 | 5.15 | 4.05 | 4.80 | 8.25 | 8.21 | 6.05 | 7.50 |
| H13-01 | 5.17 | 5.12 | 4.12 | 4.80 | 8.23 | 8.18 | 6.14 | 7.52 |
| H13-02 | 5.18 | 5.13 | 4.04 | 4.78 | 8.24 | 8.19 | 6.05 | 7.49 |
| H14-01 | 5.15 | 5.09 | 4.13 | 4.79 | 8.21 | 8.16 | 6.15 | 7.51 |
| H14-04 | 5.11 | 5.04 | 4.02 | 4.72 | 8.12 | 8.12 | 6.04 | 7.43 |
| HC 1 | 5.15 | 5.08 | 4.06 | 4.76 | 8.17 | 8.14 | 6.07 | 7.46 |
| HC 3 | 5.12 | 5.06 | 4.11 | 4.76 | 8.14 | 8.14 | 6.12 | 7.47 |
| HC 5 | 5.13 | 5.05 | 4.08 | 4.75 | 8.16 | 8.13 | 6.09 | 7.46 |
| ICCV 88503 | 5.16 | 5.11 | 4.02 | 4.76 | 8.21 | 8.16 | 6.04 | 7.47 |
| ICCV 92944 | 5.14 | 5.05 | 4.09 | 4.76 | 8.19 | 8.12 | 6.11 | 7.47 |
| **Mean** | 5.15 | 5.09 | 4.07 | | 8.19 | 8.15 | 6.09 | |
| **CD at 5 %** | Dates of sowing =0.06, Genotypes = 0.11<br>Dates of sowing x Genotypes =0.19 | | | | Dates of sowing =0.10, Genotypes =0.18<br>Dates of sowing x Genotypes =0.32 | | | |

Among interactions, maximum dry weight of pods (8.25 g/plant) was observed in genotype H12-64 when sown on 15th October whereas minimum dry weight of pods (6.04 g/plant) was observed in genotype H14-04 when sown on 15th December.

A decreasing trend was observed for dry matter production and its distribution in component parts with delayed sowing from 15th October. There was decrease in dry weight of all components like leaf, stem and pods. The dry weight of leaf declined towards maturity in all genotypes due to the translocation of stored photosynthates from source towards the sink. The rate of dry matter accumulation in root, stem and leaves at different sowing dates was increased with the advancing age of the crop. The highest dry matter was observed in genotypes sown on 15th October and declined with delayed sowing (Table 3, 4, 5). Among the genotypes maximum dry weight of leaf, stem and pods were observed in H12-64 and H13-01 and minimum were recorded in H14-04 at all the growth stages (30, 60, 90, 120 DAS). This might be due to differential growth potential of the genotypes. The reduction in dry matter beyond 15th October sowing date was due to curtailment of the growth period by 30 days in 15th November and 60 days in 15th December sowing. The later a crop is planted the shorter the potential season for growth and development. Similar results due to different sowing dates on dry matter accumulation in chickpea also observed by (Onyari *et al*,. 2010; Sekhar *et al*,. 2015; Pawar, 2015; Ray *et al*,. 2017).

## Acknowledgement and Conclusion

The author wish to express special thanks to Council of Scientific & Industrial Research (CSIR), India, for the financial support to complete this research work. Growth rate and dry matter production of chickpea genotypes varied due to sowing dates. With delay in sowing from 15th October to 15th December, there were decrease in growth rate and dry matter production of chickpea. Average over sowing dates among genotypes H13-01 produced higher growth rate and dry matter production, whereas H14-04 was the lowest in growth rate and dry matter production. Genotype H13-01 produced higher growth rate and dry matter production in all the three sowing dates but statistically at par with H12-64 in all sowing dates. So it is concluded that chickpea genotype H13-01 was found to be promising in all the sowing dates and can be used in further breeding programme of chickpea for early (cold tolerance) and late (heat tolerance) sown conditions.

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