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Agronomic Evaluation of Heat Tolerant Chickpea (*Cicer arietinum* L.) Cultivars under Late Sown Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment entitled "Agronomic evaluation of heat tolerant chickpea (*Cicer arietinum* L.) cultivars under late sown conditions" was carried out during *Rabi*, 2022 in sandy clay loam soils of college farm at Agricultural College, Jagtial. The experiment was laid out in a split-plot design and replicated thrice. The treatments included six dates of sowing viz., November 1st, November 15th December 1st, December 15th, January 1st and January 15th in main plots and three varieties viz., JG 14, NBeG-3 and NBeG-47 in sub plots. The outcome of the research revealed that crop sown on1st November showed significantly higher plant height (51.7 cm), dry matter production (477 g m^{-2}) and yield attributes like number of branches plant^{-1} (8.9), number of pods plant^{-1} (27.9), seed yield (2265 kg ha^{-1}) and haulm yield (5479 kg ha^{-1}) yield compared to other dates of sowing but it was also statistically on par with crop sown on 15th November for most of the parameters.

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Significantly, the lowest growth parameters and yield attributes was noticed for crop sown on 15th January. Among three varieties plant height was significantly highest with NBeG-47 (51.1 cm) due to its genetic character however, significantly higher dry matter production (403.8 g m^{-2}), yield attributes like number of branches $plant^{-1}$ (8.1), number of pods $plant^{-1}$ (23.9), seed yield (1898 kg ha^{-1}), haulm yield (4432 kg ha^{-1}) and harvest index (30%) was recorded with NBeG-3 which in turn on par with NBeG-14 for most of the characters.

Keywords: Chickpea; dates of sowing; varieties; seed yield.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a major legume crop, commonly known as gram, bengal gram, chana. It is the second-most prominent pulse crop in the world for the human diet, following pigeon pea [1]. It is a significant contributor to human nutrition for millions of people in under developed countries and is a rich source of protein. It has high nutritive value with protein (18-22%), carbohydrate (52-70%), fat (4-10%), crude fibre (1.37%), lysine (195-205 mg^{-1}), carotene (89-94 mg^{-1}), fibre (3%), minerals (calcium, magnesium, phosphorus, iron, zinc) and vitamins [2].

Chickpea is an annual, self-pollinated diploid legume crop, which is beneficial for both human and soil health. They meet 80% of their nitrogen (N) requirement through symbiotic rhizobial interaction that allows them to fix up to 140 kg N ha^{-1} from the atmosphere, leaving significant amounts of residual nitrogen for succeeding crops and adding much-needed organic matter to maintain and improve soil health, long-term fertility, and sustainability of the ecosystem.

In view of crop diversification chickpea can be grown under rice fallows as it is a premier pulse crop and profitable for farmers. Higher yields arise from sowing within the optimal period, which gives the crop more time to grow and develop, as compared to early and late sowing, that reduces crop yields [3].

Chickpea is normally sown during 2nd FN of October to 1st FN of November in Telangana state. However, chickpea sowing is often delayed due to late transplanting of paddy in *Kharif*, growing long duration rice varieties and higher soil moisture during rice harvesting, fields take another 15 to 20 days to reach proper soil moisture to take up sowing of chickpea. These conditions lead to exposure of crop to higher temperature at critical stages like flowering and pod development ultimately resulted in drastic yield reduction. Under late sown conditions high temperatures at reproductive stage limit the crop yield. In India chickpea yield reduced by 53 kg ha^{-1} for each 1^0C increase in seasonal temperature [4]. In this context, the study was conducted to study the performance of heat-tolerant chickpea cultivars under delayed conditions.

2. MATERIALS AND METHODS

The experiment was carried out at the College Farm, Agricultural College, Jagtial, Professor Jaya Shankar Telangana State Agricultural University. The farm is geographically situated in Northern Telangana Zone of Telangana State at an altitude of 243.4 m above mean sea level at 18º 50'37" N latitude and 78º 57'6" E longitude. According to Troll's climatic classification it falls under semi-arid tropics (SAT). The soil texture of experimental field was sandy clay loam, medium in organic carbon (0.5%), low available nitrogen (270.9 kg ha^{-1}), and high in available phosphorus (36 kg ha^{-1}) and high in available potassium (416.25 kg ha^{-1}). The experiment consists of eighteen treatment combinations with six dates of sowing *viz.,* 1st November, 15th November, 1st December, 15th December, 1st January and 15th January and three varieties *viz.,* JG-14, NBeG-3 and NBeG-47 in split plot design, replicated thrice. Three varieties of chickpea were sown at different dates as per the treatments at a spacing of 30 x 10 cm. Recommended dose of fertilizers i.e., 20-50-20 NPK kg ha^{-1} were applied as basal dose in the form of urea, single super phosphate and muriate of potash. All recommended package of practices done pertaining to other management practices.

The data collected on growth parameters at different phenological stages, seed and haulm yield from the experiment was statistically analysed by analysis of variance utilizing split plot design [5].

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Plant height of the crop increased as the crop age advanced. At branching initiation, dates of sowing showed no significant influence on the plant height. Significantly highest plant height at flowering (39.9cm), pod development (48.5cm) and physiological maturity (51.7cm) was observed with November 1st sowing compared to other dates of sowing while, the lowest plant height at flowering (34.0cm) for crop sown on 1st January and at pod development (37.9 cm) and physiological maturity (39.0 cm) was observed with 15th January sowing (Table 1). Delay in sowing drastically reduced the plant height of the crop due to adverse weather conditions. The results were similar to the findings of Eshan et al. [6] and Sekhar et al. [7].

Significantly higher plant height was observed for NBeG-47 variety at branching initiation (30.4 cm), flowering (40.6 cm), pod development (48.3 cm) and physiological maturity (51.1 cm) compared to JG-14 and NBeG-3 which inturn, on par with each other. Higher plant height of NBeG-47 might be due to its genotype as the variety is developed to have higher plant height to make it suitable for mechanical harvesting.

Interaction effect showed no significant impact on plant height at branching initiation but showed significant effect at flowering, pod development and harvest. At flowering highest plant height was observed for November 1st sowing with NBeG-47 variety (47.1 cm) which was on par with 15th November sowing of NBeG-47 variety (43.7 cm) and lowest in case of 15th November sowing with NBeG-3 (31 cm). At pod development and physiological maturity significantly highest plant height was recorded with 1st November sowing of NBeG-47 variety (59.7 and 63.2 cm) and lowest for 15th January sowing of NBeG-3 variety (35.8 and 36.5 cm).

3.2 Dry Matter Production (g m^{-2})

At all the crop growth stages dry matter production is significantly affected by date of sowing. At branching initiation, flowering, pod development and physiological maturity dry matter production of crop sown on November 1st (26.4, 58.8, 357.3 and 477.7 g m^{-2} respectively) is significantly higher which is also on par with crop sown on 15th November (24.7, 54.8, 333.2, and 456.8 gm^{-2}) while, significantly the lowest dry matter production was observed in case of crop sown January 15th (16.4, 34.8, 163.3, and 190.3 gm^{-2} respectively) (Table 2). These results were corroborative the findings of Ragavendra et al. [8], Suryakala et al. [9], Sekhar et al. [7] and Singh et al. [10].

Significantly higher dry matter production was observed with NBeG-3 variety at branching initiation (22.9 gm^{-2}), flowering (51.2 gm^{-2}), pod development (293.5 gm^{-2}) and at physiological maturity (403.8 gm^{-2}). However, it was on par with JG-14 while the lowest dry matter production was noticed with NBeG-47.

3.3 Yield Attributes

3.3.1 Number of branches $plant^{-1}$

Higher number of branches $plant^{-1}$ of chickpea was noticed for crop sown on November 1st (8.9) but it was comparable with 15th November (8.2) sowing. Significantly lower number of branches $plant^{-1}$ was recorded for January 15th (5.6) sowing which was inturn, equitable with1st January (6.5) sowing (Table 3). The results are in concurrence with findings of Kumar et al. [11] and Kumar et al. [12].

Among three varieties, significantly higher number of branches $plant^{-1}$ was recorded with NBeG-3 (8.1) compared to JG-14 (7.3) and NBeG-47 (6.8) which in turn recorded the lowest number of branches $plant^{-1}$. The lower number of branches $plant^{-1}$ in JG-14 and NBeG-47 are due to the genotype's erect nature and compact structure as well as peculiar branching habit. These were similar as shown by Niveditha et al. [13] and Basha et al. [14].

3.3.2 Number of pods $plant^{-1}$

Maximum number of pods $plant^{-1}$ was noticed in November 1st (27.9) sown crop compared to other dates of sowing. In turn it is also on par with November 15th (25.5) sowing while significantly lowest pods $plant^{-1}$ was recorded for 15th January sowing (13.2). Results were in conformity with the findings of Kumar et al. [12], Kumar et al. [2] and Sekhar et al. [7]. Early sowing resulted in favourable weather factors such as plant water status, temperature, photoperiod, sunshine hours, photosynthetic rate, and chlorophyll concentration resulted more number of pods $plant^{-1}$ [11].

Maximum number of pods plant^{-1} was obtained with NBeG-3 (23.9) which was on par with JG-14 (22.8) and significantly superior over NBeG-47 (16.6) which in turn, recorded the lowest number of pods plant^{-1}.

3.3.3 Number of seeds pod^{-1}

Number of seed pod^{-1} was not significantly influenced by the date of sowing. This may be due to the fact the producing number of seeds per pod is genetical character of chickpea which was less influenced by dates of sowing.

Number of seeds pod^{-1} was influenced by varieties as it is a genetical character. Among three varieties NBeG-47 noticed higher seeds pod^{-1} (1.2) and significantly superior to JG-14 (1.1) and NBeG-47 (1.1) which in turn, on par with each other.

3.3.4 Seed index (100 seed weight) (g)

Among different sowing dates higher seed index is observed for November 15th (27.7g) sown crop which in turn on par with 1st November, 1st December and 15th December sowings while, significantly the lowest seed index was observed for January 15th (20.3g) due to prevailing higher temperatures during pod development which leads to shrivelling of grains. Shorter grain filling period, high temperatures during the grain filling stages and longer photoperiod due to delay in sowing might be the reason for the reduced seed index of chickpea [11].

Maximum seed index was recorded with NBeG-47 (27.3 g) which was on par with NBeG-3 (26.8 g) and significantly lowest seed index was observed for JG-14 (24.3 g). Highest seed index of NBeG-47 might be due to genotypic variation.

3.3.5 Seed yield (kg ha^{-1})

Significantly the highest seed yield was obtained with November 1st (2265 kg ha^{-1}) sowing which is equitable with 15th November (2034 kg ha^{-1}) sown crop. While, the significantly lowest seed yield of chickpea was recorded with 15th January (553 kg ha^{-1}) due to delayed sowing (Table 4). The higher seed yield of chickpeas sown during the first week of November is due to lower maximum temperatures and higher relative humidity similar findings were reported by Kumar et al. [11]. Under delayed sowing, reproductive stage of chickpea coincides with heat stress, chickpea being sensitive to fluctuating temperatures yields of the crop get effected [13].

Among three varieties higher seed yield was obtained for NBeG-3 (1898 kg ha^{-1}) which is on par with JG-14 (1785 kg ha^{-1}) these two varieties were heat tolerant performed better under normal sown and delayed conditions also. While, significantly the lowest seed yield was observed for NBeG-47 (1307 kg ha^{-1}). Similarly, Sekhar et al. (2015) claimed that NBeG-3 produced significantly higher yields under different dates of sowing. The higher yield of NBeG-3 and JG-14 is due to its heat and drought tolerant capability hence recommended for late sowing conditions was noticed by Niveditha et al. [13] and Dhote et al. (2019).

3.3.6 Haulm yield (kg ha^{-1})

Significantly the highest haulm yield was noted with November 1st (5479 kg ha^{-1}) sowing compared to other dates of sowing however, it was on par with 15th November (5095 kg ha^{-1}). While, the lowest haulm yield (173 kg ha^{-1}) was observed for 15th January sowing. Increased dry matter accumulation and improved yield attributing traits due to the accumulation of more photosynthates in sinks may be the causes of increased stover and biological yield under normal sowing [15].

Among the three varieties, NBeG-3 showed highest haulm yield (4432 kg ha^{-1}) and significantly superior to NBeG-47 (3710 kg ha^{-1}) while it was at par with JG-14 (4268 kg ha^{-1}). Even under late sown conditions, NBeG-3 followed by JG-14 genotypes produced a consistent yield because of heat tolerance hence, they can be employed in breeding programmes going forward.

3.3.7 Harvest index (HI)

Harvest index of chickpea was not significantly affected by different dates of sowing. However numerically maximum harvest index was noticed under January 15th (30.3%) sowing. Delayed sowing reduced the biomass production but increased the harvest index similarly stated by the findings of Singh et al. [16].

Among the three varieties NBeG-3 (30.0%) showed higher harvest index which is on par with JG-14 (29.9%) and the lowest harvest index was observed for NBeG-47 (26.1%). This variation among genotypes might be due to differences in physiological traits that might be responsible for production potential Kumar et al. [11].

Table 1. Plant height (cm) of chickpea as influenced by different dates of sowing and varieties at different growth stages

Treatments	Branching initiation	50 % flowering	Pod development	harvest
Dates of sowing (D)				
D_1: 1st November	27.0	39.9	48.5	51.7
D_2: 15th November	27.6	36.7	44.1	46.3
D_3: 1st December	27.0	35.8	42.1	43.7
D_4: 15th December	26.2	35.2	41.6	43.6
D_5: 1st January	27.4	34.0	38.9	39.9
D_6: 15th January	25.9	34.5	37.9	39.0
SEm ±	0.5	0.8	0.9	0.9
CD	NS	2.78	3.0	3.0
Varieties (V)				
V_1: JG-14	25.6	34.3	39.2	40.5
V_2: NBeG-3	24.6	33.2	39.2	40.4
V_3: NBeG-47	30.4	40.6	48.5	51.1
SEm ±	0.4	0.4	0.5	0.6
CD	1.3	1.4	1.7	1.8
Interaction (D x V)				
D_1V_1	25.9	37.8	41.4	45.8
D_1V_2	25.0	34.8	44.6	46.3
D_1V_3	30.2	47.1	59.7	63.2
D_2V_1	25.7	35.6	40.4	42.0
D_2V_2	24.3	31.0	40.1	41.4
D_2V_3	32.8	43.7	52.1	55.6
D_3V_1	26.0	33.2	37.9	38.5
D_3V_2	26.0	33.9	41.7	43.1
D_3V_3	29.0	40.6	47.0	49.5
D_4V_1	26.1	32.4	39.9	40.2
D_4V_2	22.7	33.2	37.0	38.1
D_4V_3	29.8	40.1	48.2	52.6
D_5V_1	25.7	33.2	38.8	39.3
D_5V_2	25.3	32.8	36.1	37.3
D_5V_3	31.3	36.1	41.8	43.1
D_6V_1	24.2	33.9	37.0	37.6
D_6V_2	24.4	33.5	35.8	36.5
D_6V_3	29.2	36.3	41.0	43.0
SEm ±	1.1	1.2	1.4	1.5
CD	NS	3.5	4.2	4.6

Table 2. Dry matter (g m^{-2}) production of chickpea as influenced by different dates of sowing and varieties at different growth stages

Treatments	Branching initiation	50 % flowering	Pod development	harvest
Dates of sowing (D)				
D_1: 1st November	26.4	58.8	357.3	477.7
D_2: 15th November	24.7	54.8	333.2	456.8
D_3: 1st December	22.6	50.1	307.2	431.3
D_4: 15th December	20.8	43.4	255.7	377.8
D_5: 1st January	18.7	39.7	234.7	348.1
D_6: 15th January	16.4	34.8	163.3	190.3
SEm ±	0.7	1.9	9.0	10.9
CD	2.2	6.0	28.5	34.4
Varieties (V)				
V_1: JG-14	22.3	48.0	284.9	391.8

Treatments	Branching initiation	50 % flowering	Pod development	harvest
V_2: NBeG-3	22.9	51.2	293.5	403.8
V_3: NBeG-47	19.6	41.6	247.3	345.5
SEm ±	0.5	1.3	7.1	7.4
CD	1.6	3.9	20.8	21.5
Interaction (D x V)				
D_1V_1	27.1	58.2	347.6	496.6
D_1V_2	28.4	61.7	401.9	478.7
D_1V_3	23.9	56.7	322.7	457.9
D_2V_1	25.5	55.1	346.0	462.5
D_2V_2	25.8	61.8	347.3	481.9
D_2V_3	22.8	47.6	306.3	426.3
D_3V_1	23.8	54.6	317.7	435.3
D_3V_2	23.7	53.9	316.4	468.1
D_3V_3	20.5	42.0	287.8	390.6
D_4V_1	21.8	43.2	268.7	376.0
D_4V_2	22.1	51.3	268.0	412.0
D_4V_3	18.7	35.9	230.5	345.7
D_5V_1	19.5	42.3	265.7	407.9
D_5V_2	20.2	42.0	264.0	366.3
D_5V_3	16.7	35.0	174.4	270.4
D_6V_1	16.2	34.8	164.0	172.5
D_6V_2	17.7	36.7	163.9	216.4
D_6V_3	15.4	32.9	162.3	182.2
SEm ±	1.4	3.2	17.4	18.1
CD	NS	NS	NS	NS

Table 3. Yield attributes of chickpea as influenced by different dates of sowing and varieties

Treatments	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed index
Dates of sowing (D)				
D_1: 1st November	8.9	27.9	1.2	27.2
D_2: 15th November	8.2	25.5	1.2	27.7
D_3: 1st December	7.7	21.7	1.2	27.7
D_4: 15th December	7.4	20.5	1.1	27.7
D_5: 1st January	6.5	17.8	1.1	26.2
D_6: 15th January	5.6	13.2	1.1	20.3
SEm ±	0.30	1.42	0.07	0.50
CD	0.93	4.47	NS	1.58
Varieties (V)				
V_1: JG-14	7.3	22.8	1.1	24.3
V_2: NBeG-3	8.1	23.9	1.1	26.8
V_3: NBeG-47	6.8	16.6	1.2	27.3
SEm ±	0.2	0.7	0.05	0.4
CD	0.5	2.2	0.14	1.2
Interaction (D x V)				
D_1V_1	8.9	29.5	1.2	26.8
D_1V_2	10.3	33.4	1.1	28.4
D_1V_3	7.7	20.9	1.3	27.6
D_2V_1	8.1	28.8	1.1	25.6

Treatments	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed index
D_2V_2	9.0	27.9	1.1	27.5
D_2V_3	7.3	19.8	1.3	30.1
D_3V_1	7.9	24.6	1.1	25.0
D_3V_2	8.3	24.3	1.1	28.8
D_3V_3	7.0	16.3	1.2	29.1
D_4V_1	7.7	21.5	1.1	25.7
D_4V_2	7.9	22.2	1.1	29.0
D_4V_3	6.7	17.9	1.3	28.5
D_5V_1	6.2	16.3	1.0	24.1
D_5V_2	6.8	21.8	1.1	27.1
D_5V_3	6.5	15.3	1.2	27.5
D_6V_1	5.2	16.3	1.0	20.0
D_6V_2	6.3	13.9	1.1	19.9
D_6V_3	5.4	9.2	1.2	21.1
SEm ±	0.5	1.8	0.1	1.0
CD	NS	NS	NS	NS

Table 4. Seed yield, haulm yield (kg ha^{-1}) and harvest index of chickpea as influenced by different dates of sowing and varieties

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
Dates of sowing (D)			
D_1: 1st November	2265	5479	29.1
D_2: 15th November	2034	5095	28.2
D_3: 1st December	1916	4858	27.9
D_4: 15th December	1619	4319	27.2
D_5: 1st January	1591	3828	29.4
D_6: 15th January	553	1239	30.3
SEm ±	108	173	1.4
CD	342	546	NS
Varieties (V)			
V_1: JG-14	1785	4268	29.9
V_2: NBeG-3	1898	4432	30.0
V_3: NBeG-47	1307	3710	26.1
SEm ±	50	97	0.7
CD	147	283	2.1
Interaction (D x V)			
D_1V_1	2383	5683	29.6
D_1V_2	2525	5892	30.0
D_1V_3	1887	4861	28.0
D_2V_1	2325	5260	30.7
D_2V_2	2318	5370	30.0
D_2V_3	1460	4655	24.0
D_3V_1	1931	5010	27.8
D_3V_2	2426	5026	32.5
D_3V_3	1391	4539	23.5
D_4V_1	1749	4457	28.3
D_4V_2	1789	4700	27.5
D_4V_3	1319	3801	26.1
D_5V_1	1679	3945	29.7
D_5V_2	1702	4264	28.5
D_5V_3	1392	3276	30.0
D_6V_1	641	1255	33.6
D_6V_2	628	1336	31.7
D_6V_3	390	1126	25.6

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
SEm ±	123	238	1.8
CD	NS	NS	NS

4. CONCLUSIONS

Based on the above results, it is concluded that the optimum sowing window for chickpea crop is November 1st and November 15th with heat tolerant chickpea cultivars i.e., NBeG-3 and JG-14. However, under delayed condition chickpea can be sown up to 1st December with heat tolerant cultivars as less than 20 percent yield reduction observed over normal sowing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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