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MORPHO-PHENOLOGICAL STUDIES AND FLOWERING PATTERN OF CHICKPEA GENOTYPES UNDER DIFFERENT TEMPERATURE REGIMES

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Abstract- An experiment was two factorial design with a three set of genotypes *viz*., Annigeri-1, JG-11 and JG-14 were sown under different dates of sowing (D1, D2, D3 D4 and D5) from 40th standard meteorological week (SMW) to 48th SMW and a study was conducted to know the effect of temperature regimes on morpho-phenological character, flowering pattern and flowering duration and their contribution to yield of chickpea genotypes. Among the dates, D3 temperature regimes took significantly higher primary and secondary branches (9.6 and 12.0 respectively) with optimum phenological parameter like days to flower initiation (37.9 days), days to fifty per cent flowering (42.9 days) and more number of flowers per day per plant (172), with all these character which produces higher yield by minimizing flower drop and floral abortion under maximum of minimum temperature compare to other temperature regimes and the genotypes JG-11 recorded significantly higher yield (28.32 q ha-1) due to higher primary branches (9.1), took less number of days to flower initiation (36.1 days) and fifty percent flowering (40.7 days) with the optimum duration of flowering (26.2 days) and total number of flowers (156) and recorded higher yield. But the genotype, JG-14 is thermo tolerant recorded optimum yield under D3 temperature regime, which was having less number of flowers than the others and also there was no much variation in the yield from D1 to D5 temperature regime compared to other genotypes.

Keywords- Chickpea, Phenology, Flowering pattern, Yield.

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Introduction

Chickpea is a major grain legume used for food from ancient days. It is one of the essential semi-arid tropical legume crops and is valued for its nutritive seeds with high protein content, 25.3-28.9 % after de-hulling [8]. It is a cool season legume crop and is grown in several countries worldwide as a food source. Seed is the main edible part of the plant and is a rich source of protein, carbohydrates and minerals especially for the vegetarian population. Chickpea is either grown during the post-rainy season on stored soil moisture (South Asia) in this instances the crop is exposed to terminal drought, which is accompanied by rising temperatures. The South Asian crop may also experience high temperatures in the seedling phase if planted early [3]. Chickpea productivity is constrained by several abiotic stresses [15,5] and temperature is one of the most important determinants of crop growth over a range of environments [18], heat stress (≥ 35˚C during flowering and pod development) results in severe yield losses due to the impact of high temperatures on different physiological processes.

The chickpea grain yield is related to its phenology, which is influenced by temperature. The timing and duration of flowering has an important role in determining crop duration and grain yield at high temperature. The crop is forced into maturity under hot and dry condition (>30ºC) by reducing the crop duration [17]. Prolonged exposure of chickpea to high temperature in the growing season mainly reproductive [11] of chickpea made floral abortion due to pollen sterility, lack of pollination and stigma receptivity, poor pollen germination, tube growth and fertilization [7,12,9] and heat stress during post an thesis stage reduces flower and pod production, increased flower and pod abortion and therefore reduced seed yield in both chickpea cultivars, indicating that both flower and pod abortion are important in determining seed yield [14]. The studies on the impact of climate change on chickpea production highlighted the effect of warmer temperatures on crop development and subsequent chickpea yield. Therefore, it is essential to study the effect of temperature regimes on phenological stages of chickpea genotypes.

Materials and Methods

Field experiment was conducted during *rabi* season 2013-14 at Main Agriculture Research Station (MARS), UAS, Dharwad, to study the flowering pattern under varied temperature regimes. The factorial experiment consists of three genotypes (Annigeri-1, JG-11 and JG-14) with combination of five dates of sowing (D_1, D_2, D_3, D_4 and D_5) with three replications. Total number of branches (primary and secondary branches), days to flower initiation, days to 50 percent flowering, duration of flowering, total number of flowers per plant, number of flowers produced per day, and seed yield, were recorded as per the standard procedure. The plant height, total number of primary branches and secondary branches per plant were recorded at harvest and mean values of five plants were expressed as number of primary branches per plant. The number of days taken from sowing to

the opening of first flower in an experimental plot and days to 50 per cent flowering were noted when 50 per cent of plants in each plot flowered and was expressed in days. The number of flowers per plant was counted daily; total and mean values of five plants were expressed as number of flowers per plant per day and the ratio of total numbers of flowers and numbers of pods per plant counted at the time of harvest. The data collected from the experiment was subjected to statistical analysis as described by [6]. The levels of significance used in '*F*' and '*t*'-tests was P=0.05. The least significant differences (LSD) values were calculated wherever the '*F*' test was significant by Duncan's Multiple Range Test (DMRT).

Result and Discussion

Morpho-phenological parameters like, plant height, number of primary and secondary branches and phenological parameters controlled genetically but the environmental factors also influence these characters which are differed significantly. Variation in the plant height and branches was observed [Table-1] because of the effect of temperature regime. In the present study where, higher plant height (45.9 cm) was noticed in D_3 (44th standard week) temperature regime, followed by D_4 (46th standard week) with 42.7 cm and there was also a significant difference in primary and secondary branches were recorded in D_3 (44th standard week) and D_2, D_4 and D_5 temperature regimes (42nd, 46th and 48th standard week) showing on par. Highest plant height is because of the increase in duration of the growth period at autumn sown chickpea had positive effect on plant height and branches per plant [13]. The genotypes JG-14 and JG-11 recorded significantly maximum and minimum plant height, respectively, because of genotypic character [11].

Table 1: *Effect of temperature regimes on branches and phenological parameters of chickpea genotypes*

Treatment	Plant height	Primary branches	Secondary branches	Days to flower initiation	Days to 50 % flowering	Duration of flowering	Flowers per plant	Seed yield (q ha^{-1})
Dates of sowing (D)								
40th Standard week (D_1)	39.7^{b}	7.6^{d}	10.0^{c}	36.2	40.3^{b}	25.7	116 ^{c}	27.30 ^{c}
42nd Standard week (D_2)	41.7^{b}	9.0^{b}	11.0^{b}	37.3	41.1^{ab}	31.7	148 $^{a-c}$	28.43 ^{b}
44th Standard week (D_3)	45.9^{a}	9.6^{a}	12.0^{a}	37.9	42.9^{a}	29.7	172 ^{ab}	29.88^{a}
46th Standard week (D_4)	42.7^{b}	8.1^{c}	9.6^{cd}	36.8	40.8^{b}	25.3	189 ^{a}	26.39^{c}
48th Standard week (D_5)	40.1^{b}	7.5^{d}	9.1^{d}	36.0	39.2^{b}	21.3	127 ^{bc}	21.64^{d}
S.Em±	0.4	0.1	0.1	0.1	0.2	0.09	7.5	0.15
LSD @5%	1.3	0.3	0.3	NS	0.5	0.27	21	0.42
Genotypes (G)								
Annigeri-1 (G_1)	41.1^{b}	8.8^{a}	12.0^{a}	38.7^{a}	44.6^{a}	26.6	186 ^{a}	25.51 ^{b}
JG-11 (G_2)	38.8^{c}	9.1^{a}	9.9^{ab}	36.1^{b}	40.7^{b}	26.2	156 ^{ab}	28.32 ^{a}
JG-14 (G_3)	46.2^{a}	7.2^{b}	9.6^{b}	35.7^{b}	37.3^{c}	27.4	109 ^{b}	26.36 ^{b}
S.Em±	0.6	0.1	0.1	0.2	0.2	0.07	9.7	0.19
LSD @ 5%	1.3	0.2	0.4	0.5	0.6	0.21	28	0.56
Interactions (DxS)								
D_1G_1	38.1^{fg}	7.7^{f}	11.2^{c}	38.0^{b-d}	44.0^{ab}	29	120 ^{ef}	26.90 ^{e}
D_1G_2	38.5^{fg}	9.4^{c}	9.8^{e}	35.5^{e-g}	39.5^{c-e}	23	141 $^{c-f}$	28.46 ^{d}
D_1G_3	42.4^{de}	5.9^{i}	8.9^{fg}	35.1^{fg}	39.1^{cd}	25	87 ^{f}	26.54 ^{e}
D_2G_1	41.1^{c-e}	9.4^{c}	12.6^{b}	39.1^{ab}	45.7^{a}	34	206 ^{ab}	27.23 ^{e}
D_2G_2	40.3^{e-g}	9.9^{b}	11.1^{c}	36.5^{d-f}	44.3^{ab}	30	134 $^{d-f}$	29.66 ^{b}
D_2G_3	43.7^{cd}	7.7^{f}	10.0^{de}	36.2^{e-g}	38.7^{c-e}	31	106 ^{f}	28.40 ^{d}
D_3G_1	45.8^{bc}	10.2^{a}	15.0^{a}	39.8^{a}	45.7^{a}	25	225 ^{a}	28.52 ^{cd}
D_3G_2	39.0^{fg}	10.0^{ab}	10.6^{cd}	37.1^{c-e}	40.0^{c}	32	195 $^{a-c}$	31.63 ^{a}
D_3G_3	53.0^{a}	8.6^{d}	12.3^{b}	36.8^{d-f}	37.7^{de}	32	97 ^{f}	29.50 ^{bc}
D_4G_1	40.7^{d-f}	8.7^{d}	11.0^{c}	38.6^{a-c}	44.3^{ab}	23	219 ^{a}	25.02 ^{f}
D_4G_2	39.2^{fg}	8.5^{d}	9.4^{ef}	36.1^{e-g}	40.7^{c}	27	185 $^{a-d}$	29.39 ^{bd}
D_4G_3	48.3^{b}	7.1^{g}	8.5^{g}	35.7^{e-g}	37.3^{ef}	26	164 $^{b-e}$	24.76 ^{f}
D_5G_1	39.6^{fg}	8.4^{ef}	10.1^{de}	37.9^{b-d}	43.3^{b}	22	163 $^{b-e}$	19.86 ^{h}
D_5G_2	37.3^{g}	7.5^{f}	8.9^{fg}	35.4^{e-g}	38.7^{c-e}	19	127 ^{ef}	22.46 ^{g}
D_5G_3	43.6^{cd}	6.8^{h}	8.4^{g}	34.6^{g}	35.7^{f}	23	92 ^{f}	22.59 ^{g}
S.Em±	1.0	0.1	0.3	0.3	0.4	0.16	17	0.33
LSD @ 5%	2.8	0.3	0.7	0.9	1.1	0.46	49	0.96

Note: D_1 (29-09-13 to 05-10-13), D_2 (14-10-13 to 20-10-13), D_3 (28-10-13 to 3-11-13), D_4 (11-11-13 to 17-11-13), D_5 (25-11-13 to 01-12-13), DAS- Days after sowing ,DMRT-Values in the column followed by the same letter do not differ significantly.

As Chickpea reproductive phase is concern, the phase is sensitive to temperature change and can be delayed by prolonged low temperature or high temperature exposure. Cold temperature is known to delay flowering, while high temperature can induce early flower initiation [20&2]. In studied genotypes, Annigeri-1 took significantly maximum number of days (38.7 days) for flower initiation followed by genotype JG-11 (36.1 days) and the genotype JG-14 (35.7), which was on par with each other and Among the interaction effects, the genotype Annigeri-1 under 44th standard week (D_3 temperature regime) recorded significantly higher number of days (39.8 days) and significantly minimum number of days for flower initiation was recorded by JG-14 (34.6 days) under 48th standard week (D_5 temperature regime). Similar to flower initiation, the number of days for 50 percent flowering was more for D_3 and less for D_5 temperature regimes. The most advantageous minimum temperature for normal flowering is 10 to 14°C while 25 to 31°C is the average maximum temperature. Among the genotypes, Annigeri-1 (44.6) and JG-14 (37.3) took more and less number of days for 50 percent flowering, respectively. The genotype, Annigeri-1 under D_3 and D_2 temperature regime took significantly more no of days for 50 per cent flowering. The minimum number of days for 50% flowering was recorded by JG-14 under D_5 temperature regime significantly. The result is agreement with [16, 10&4] established that temperature plays a greater role in altering days to fifty per cent flowering in chickpea though the genotypes have their own genetic makeup.

The maximum rate of flower production per plant increased to reach maximum rate in about 15 days after first flower initiation, but was higher under ambient temperature than the mild temperature stress in the genotypes. Flowering is known to be very sensitive to change in external environment and can lead to drastic reduction in seed yields. The number of flowers per plant of chickpea genotypes as influenced by dates of sowing, the flower initiation differed among the genotypes under different dates of sowing, under D_1 temperature regime maximum number of flowers were observed between 20th November to 27th November, 2013 [Fig-1a,1b,1c,1d & 1e] and [Table 2]. For D_2 temperature regime maximum number of flowers was observed between 3rd December to 11th December, 2013 and under D_3 temperature regime between these dates 21st December to 27th December, 2013. Genotypes showed maximum number of flowers, under D_4temperature regime, at 1st January to 9th January, 2014 and under D_5 temperature regime between the dates 13th January to 22nd January, 2014. Among the genotypes, Annigeri-1 produced maximum number of flowers compared to JG-11 and JG-14.

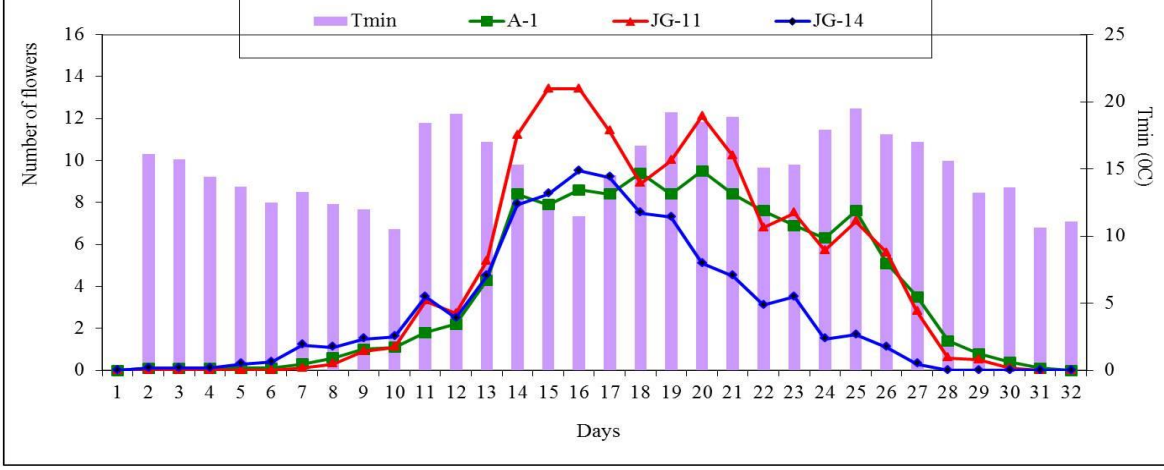

Fig. 1a: Effect of minimum temperature on flower count (Nos.) in different genotypes under different dates of sowing

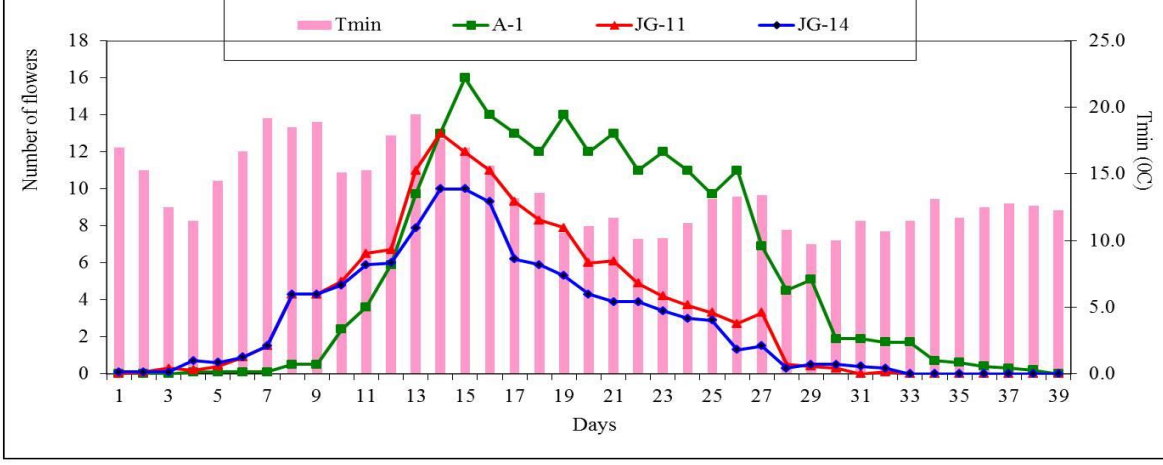

Fig. 1b: Effect of minimum temperature on flower count (Nos.) in different genotypes under different dates of sowing

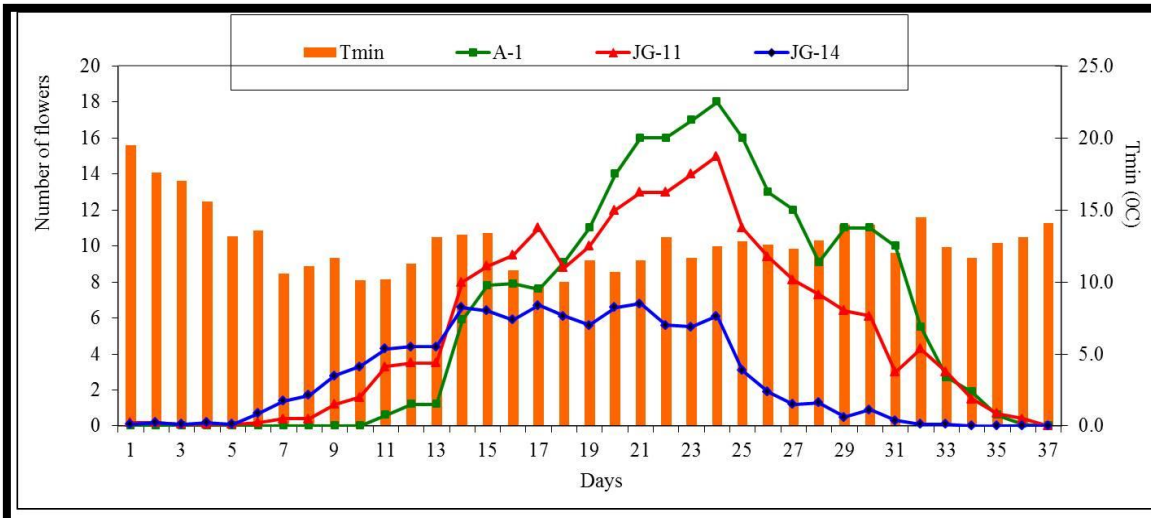

Fig. 1c: Effect of minimum temperature on flower count (Nos.) in different genotypes under different dates of sowing

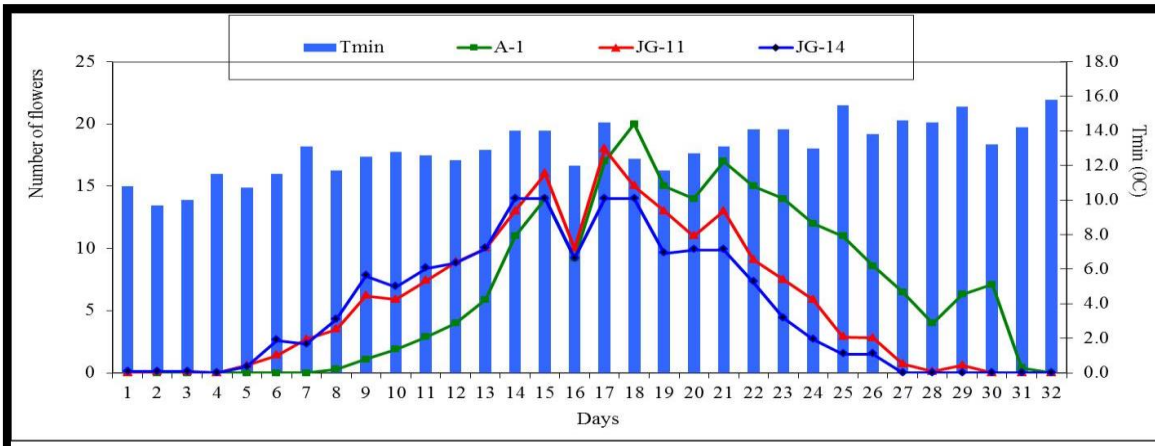

Fig. 1d: Effect of minimum temperature on flower count (Nos.) in different genotypes under different dates of sowing

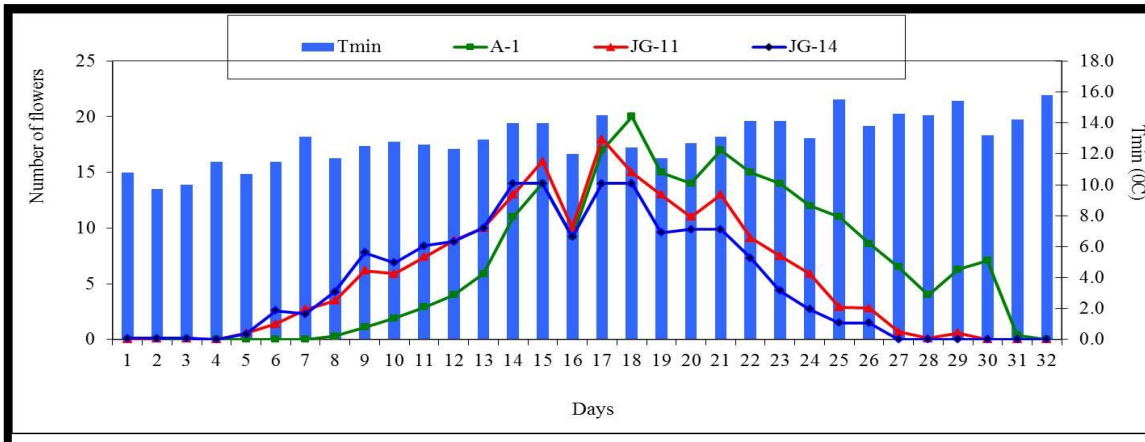

Fig. 1e: Effect of minimum temperature on flower count (Nos.) in different genotypes under different dates of sowing

The genotype Annigeri-1 under D_3 temperature regime recorded significantly maximum total number of flowers per plant (224.9), which was on par with the same genotype under D_4 (219) and D_2 (206) temperature regime [Table-1] and, genotype JG-14 during D_1 recorded significantly minimum total number of flowers per plant (87). Whereas the genotype is concerned, Annigeri-1 recorded significantly higher number of flowers per plant (186) followed by JG-11 (156) significantly minimum number of flowers per plant was observed by the genotype JG-14 (109).

The reproductive phase in chickpea 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 [17]. Grain yield reduces because of cold temperature induced flower abortion, leads to low seed set. Among the sowing dates maximum seed yield per plant (15.62) were observed under D_3 temperature regime, where the

Table 2: *Effect of temperature on average flowers produced per day and flowering pattern in of chickpea genotypes during D_1, D_2, D_3, $D_4$and D_5 dates of sowing*

Days / variety	D_1			D_2			D_3			D_4			D_5		
	(10/11/2013-8/12/2013)*			(23/11/2013-26/12/2013)			(3/12/2013-5/1/2014)			(18/12/2013-13/1/2014)			(31/12/2013-27/1/2014)		
	A-1	JG-11	JG-14	A-1	JG-11	JG-14	A-1	JG-11	JG-14	A-1	JG-11	JG-14	A-1	JG-11	JG-14
1	0.1	-	0.1	-	0.0	0.1	-	0.2	0.1	-	0.0	0.1	-	-	0.3
2	0.1	-	0.1	-	0.1	0.1	-	0.2	0.2	-	0.1	0.1	-	-	0.5
3	0.1	-	0.1	-	0.3	0.1	-	0.1	0.1	-	0.1	0.1	-	-	0.5
4	0.1	-	0.3	0.1	0.2	0.7	-	0.1	0.2	-	0.0	0.0	-	-	0.5
5	0.1	-	0.4	0.1	0.4	0.6	-	0.1	0.1	-	0.6	0.5	-	-	0.9
6	0.3	0.1	1.2	0.1	0.9	0.9	-	0.2	0.7	-	1.4	2.6	-	0.3	1.5
7	0.6	0.3	1.1	0.1	1.5	1.5	-	0.4	1.4	-	2.7	2.3	-	0.7	1.7
8	1.0	0.9	1.5	0.5	4.3	4.3	-	0.4	1.7	0.3	3.5	4.3	0.4	1.5	2.7
9	1.1	1.1	1.6	0.5	4.3	4.3	-	1.2	2.8	1.1	6.2	7.8	0.9	3.1	4.2
10	1.8	3.3	3.5	2.4	5.0	4.8	-	1.6	3.3	1.9	5.9	6.9	1.7	4.5	5.9
11	2.2	2.7	2.5	3.6	6.5	5.9	0.6	3.3	4.3	2.9	7.4	8.4	1.7	4.5	5.9
12	4.3	5.2	4.5	5.9	6.7	6.0	1.2	3.5	4.4	4.0	8.9	8.8	5.8	8.0	7.3
13	8.4	11.2	7.9	9.7	11	7.9	1.2	3.5	4.4	5.9	10	10	8.9	10	7.4
14	7.9	13.4	8.4	13	13	10	5.9	8.0	6.6	11	13	14	13	14	10
15	8.6	13.4	9.5	16	12	10	7.8	8.9	6.4	14	16	14	11	13	11
16	8.4	11.4	9.2	14	11	9.3	7.9	9.5	5.9	9.2	10	9.2	12	12	8.1
17	9.4	8.9	7.5	13	9.3	6.2	7.6	11	6.7	17	18	14	12	9.2	5.9
18	8.4	10.0	7.3	12	8.3	5.9	9.1	8.8	6.1	20	15	14	14	11	7.5
19	9.5	12.1	5.1	14	7.9	5.3	11	10	5.6	15	13	9.6	16	12	5.7
20	8.4	10.2	4.5	12	6.0	4.3	14	12	6.6	14	11	9.9	15	9.5	5.3
21	7.6	6.8	3.1	13	6.1	3.9	16	13	6.8	17	13	9.9	11	6.8	2.7
22	6.9	7.5	3.5	11	4.9	3.9	16	13	5.6	15	9.1	7.3	13	5.3	1.5
23	6.3	5.7	1.5	12	4.2	3.4	17	14	5.5	14	7.5	4.4	9.8	3.6	0.8
24	7.6	7.1	1.7	11	3.7	3.0	18	15	6.1	12	5.9	2.7	8.0	1.9	0.2
25	5.1	5.6	1.1	9.7	3.3	2.9	16	11	3.1	11	2.9	1.5	5.9	0.7	-
26	3.5	2.8	0.3	11	2.7	1.3	13	9.4	1.9	8.6	2.8	1.5	3.1	-	-
27	1.4	0.6	0.0	6.9	3.3	1.5	12	8.1	1.2	6.5	0.7	-	1.4	-	-
28	0.8	0.5	0.0	4.5	0.5	0.3	9.1	7.3	1.3	4.0	0.1	-	0.3	-	-
29	0.4	0.1	0.0	5.1	0.4	0.5	11	6.4	0.5	6.3	0.6	-	0.2	-	-
30	0.1	0.0	0.0	1.9	0.3	0.5	11	6.1	0.9	7.1	-	-	0.1	-	-
31	-	-	-	1.9	0.0	0.4	10	3.0	0.3	0.4	-	-	0.0	-	-
32	-	-	-	1.7	0.1	0.3	5.5	4.3	0.1	-	-	-	-	-	-
33	-	-	-	1.7	-	-	2.7	3.0	0.1	-	-	-	-	-	-
34	-	-	-	0.7	-	-	1.9	1.5	-	-	-	-	-	-	-
35	-	-	-	0.6	-	-	0.6	0.7	-	-	-	-	-	-	-
36	-	-	-	0.4	-	-	0.1	0.4	-	-	-	-	-	-	-
37	-	-	-	0.3	-	-	0.0	-	-	-	-	-	-	-	-
38	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-
S.Em±	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.4**	**0.2**	**0.2**	**0.1**	**0.1**	**0.2**	**0.1**	**0.2**
LSD at 5%	**0.5**	**0.5**	**0.3**	**0.6**	**0.5**	**0.4**	**0.7**	**1.0**	**0.6**	**0.6**	**0.3**	**0.3**	**0.5**	**0.3**	**0.4**

Note: D_1 (29-09-13 to 05-10-13), D_2 (14-10-13 to 20-10-13), D_3 (28-10-13 to 3-11-13) , D_4 (11-11-13 to 17-11-13), D_5 (25-11-13 to 01-12-13), DOS-date of sowing, *Dates of first to last flower initiation

minimum seed yield (7.78) were observed under D_5 temperature regime. In present study, a large variation in grain yield ranging from 29.88 to 21.64 q ha^{-1} was noticed among the temperature regimes. The lowest grain yield (21.64 q ha^{-1}) was observed under D_5 temperature regime and highest grain yield (29.88 q ha^{-1}) was recorded under D_3 temperature regime. Among the genotype JG-11 recorded (28.32 q ha^{-1}) significantly higher grain yield and lower grain yield recorded in Annigeri-1 (25.51 q ha^{-1}). These results were found to be similar to the results of [1], [19] and [17], who observed that mainly day lengths and temperatures influenced chickpea phenology, growth and yield, but increased day length coupled with exposure to higher temperature (30 to 35 ^oC) at flowering and pod development stages of late sown crops enhanced maturity and gave the lowest grain yield and its reduction was greater due to heat stress during pod development compared to early flowering.

Yield is a polygenic trait, which depends on plant height, branches, phenological character like flower initiation date, number of flowers produced per plant, total number of flowers by plant and flowering duration. The genotype, JG-11 recorded significantly higher yield under D_3 temperature regime, but the genotype JG-14 showed no much variation in the yield from D_1 to D_5 temperature regime compared to other genotypes. Higher grain yield is because of highest plant height with more productive branches and optimum number of flowering. Other important parameters directly related to yield were flowering duration and total number of flowers. More number of flowers per plant was observed under D_4 temperature regime, but D_3 was on par and optimum, which finally yielded maximum because of less flower abortion under different temperature regimes with maximum duration of flower production. The genotype JG-14 is thermo tolerant, which was having less number of flowers than the other genotypes at different temperature regimes. This temperature helps to set pods, seed and more grain-filling period, which increases seed weight and this ultimately increased the yield.

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