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Effect of temperature regimes on phenological parameters, yield and yield components of chickpea

B. A. KIRAN AND V. P. CHIMMAD

Department of Crop Physiology, College of Agriculture, Dharwad
University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India
E-mails: kiranba816@gmail.com; chimmadvp@uasd.in

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Abstract: A field experiment was conducted at the Main Agricultural Research Station, Dharwad during 2013-14. The experiment consisted of five dates of sowing (D_1, D_2, D_3, D_4 and D_5) and three genotypes (Annigeri-1, JG-11 and JG-14) laid out with factorial RBD design replicated thrice. Among the temperature regimes, D_3 temperature regime recorded significantly highest plant height (45.9 cm), number of primary and secondary branches (9.6 and 12.0), days to physiological maturity (97.5 days), growing degree days (GDD) for days to physiological maturity (1637), seed yield (29.88 q ha^{-1}). Among the genotypes, the genotype JG-11 recorded less plant height (38.8 cm) with optimum days to physiological maturity (92.7 days) but primary and secondary branches (9.1 and 9.9), total dry matter (24.43 g plant^{-1}), GDD (1563), HI (53.19%) and yield recorded was significantly more (28.34 q ha^{-1}). However, JG-14 recorded higher yield and yield components than JG-11 and Annigeri-1 irrespective of dates of sowing. Therefore, JG-14 is considered to be the thermotolerant.

Key words: Chickpea, Growing degree days, Phenological parameters, Temperature regimes

Introduction

Pulses are rich sources of complex protein, carbohydrates, vitamins, minerals, starch and fiber. Among pulses, chickpea (*Cicer arietinum* L.) is one of the most important protein-rich cool season food legumes grown under rainfed condition. India is the largest producer of chickpea in the world, accounting for 70.7 per cent of the world's production with an area 8.56 m ha, which contributes 68 per cent of the global area, 76 per cent of Asia's chickpea area and 35 per cent of total pulses area, with production of 7.58 m t and productivity of 912 kg ha^{-1}.

Among the abiotic stresses drought and heat are the most important constraints to chickpea production globally. It is estimated that drought and heat stresses together account for about 50 per cent of the yield losses. Temperature is an important factor controlling crop growth and development (Zinn *et al.*, 2010) by affecting wide range of physiological processes and altering plant-water relationship. The crop often experiences abnormally high temperature (>35°C) during reproductive phase, which directly has a negative impact on chickpea production. During the last decade, there has been a significant shift in chickpea area in India from northern plains to the southern part of India. In northern plains of India during winter mainly under rainfed condition is now severely threatened by climatic changes. In case of chickpea, the area has been reduced from 3.2 m ha to 1.0 m ha in northern states of India, while increased from 2.6 m ha to 4.3 m ha in central and southern states during the past three decades. Thus, there has been a shift in chickpea area from cooler long duration, highly productive environment to warm, short duration, rainfed and less productive environment. This is an adaptation mechanism to changing climate.

In the view of recent climate change situation, the weather parameters are highly influencing the crop productivity simultaneously due to global warming wherein there is an increase in day temperature and drastic reduction in the night temperature. Among pulses, chickpea is more sensitive to temperature; therefore study was under taken to know the effect of temperature regime on morpho-phenological, yield and yield components of chickpea genotypes.

Material and methods

Field experiment was conducted during *rabi* season 2013-14 at the Main Agricultural Research Station, Dharwad. An investigation was carried to evaluate chickpea genotypes under varied temperature regimes. The experiment consisted 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) and three replications laid out in factorial RBD. The experimental site consisted of medium deep black soil and crop was raised in a plot size of 3.6 x 2.9 m with a spacing of 30 x 10 cm, fertilized with 50:20:0 N:P_2O_5:K_2O. The T_{max} was increasing form 42nd meteorological standard week (MSW) and it reduced till 46th MSW and then it increased up to 9th MSW and reached to 32.1^{o}C and lowest T_{min} (9.7^{o}C) was recorded during the 51st MSW (Fig. 1). The observations on plant height, number of primary and secondary branches, days to physiological maturity, Growing degree days (GDD), yield and yield components were recorded as per the standard procedure in a randomly selected five tagged plants.

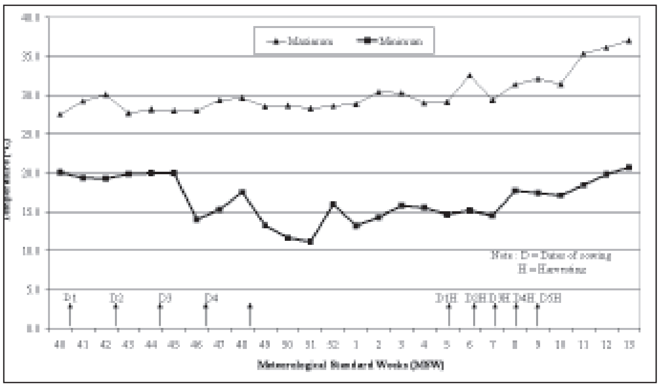

Fig. 1. Weekly meteorological data at the Main Agricultural Research Station, UAS, Dharwad during croping period

Growing degree days was calculated by summation of daily mean temperature above base (T_b=10°C) temperature (Monteith, 1984). The number of days taken from sowing to complete maturity of pod/seed in selected plants was recorded based on yellowing of 50 per cent of plants and pods for days to physiological maturity.

Results and discussion

Delay in sowing of chickpea genotypes reduces their plant height and number of primary and secondary branches significantly because of their earliness and quick growth and longer growing period as autumn sown chickpea had positive effect on plant height and branches per plant (Saim and Ufuk, 2003). Similar results in present study (Table 1) were observed and significantly higher plant height (45.9 cm) and primary and secondary branches (9.6 and 12, respectively) were observed under D_3 temperature regime (44th MSW), which was followed by D_2, D_1 and D_4 temperature regimes. Lower plant height was observed under D_5 temperature regime (40.1 cm). Among the genotypes JG-14 showed highest plant height (46.2 cm) and total dry matter (24.84 g), while, Annigeri-1 recorded more primary and secondary branches (8.8 and 12.0, respectively), whereas, significantly minimum plant height was observed by JG-11 (38.8 cm). JG-14 showed less number of primary and secondary branches (7.2 and 9.6). Among the interactions the genotype JG-14 under D_3 temperature regime recorded significantly higher plant height.

Krishnamurthy *et al.* (2011), Neeraj *et al.* (2012) and Devendra *et al.* (2012) reported that that high temperature (late sown) causes hastening of flowering and maturity, which resulted in reduction in productivity of chickpea as compared to normal sown condition and mean of total heat requirement up to maturity of low yielding genotypes was relatively lower followed by medium and high yielding cultivar. Similar results were obtained here also wherein days to physiological maturity was significantly more with more number of days (97.3 days) with an optimum GDD of 1637 heat units under D_3 temperature regime, while minimum number of days for maturity and GDD was under D_5 temperature regime (84.7 days and 1429 heat units, respectively). Among the genotypes, Annigeri-1 took more number of days (96.7) than the other with higher GDD

Table 1. Effect of temperature regimes on morpho-phenological parameters, growing degree days at physiological maturity and number of pods per plant of chickpea genotypes

Treatment	Plant height (cm)	Primary branches	Secondary branches	Days to physiological maturity	GDD for Physiological maturity	No. of pods Per plant
40th Standard week (D_1)	39.7^{b}	7.6^{d}	10.0^{c}	93.3^{bc}	1603^{ab}	45.2^{d}
42nd Standard week (D_2)	41.7^{b}	9.0^{b}	11.0^{b}	94.7^{ab}	1606^{ab}	66.5^{ab}
44th Standard week (D_3)	45.9^{a}	9.6^{a}	12.0^{a}	97.5^{a}	1637^{a}	69.9^{a}
46th Standard week (D_4)	42.7^{b}	8.1^{c}	9.6^{cd}	88.3^{c}	1467^{ab}	60.8^{b}
48th Standard week (D_5)	40.1^{b}	7.5^{d}	9.1^{d}	84.7^{c}	1429^{b}	56.2^{c}
S.Em.±	0.4	0.1	0.1	0.5	9	0.4
LSD at 5%	1.3	0.3	0.3	1.5	25	1.01
Annigeri-1 (G_1)	41.1^{b}	8.8^{a}	12.0^{a}	96.7^{a}	1637^{a}	58.0^{b}
JG-11 (G_2)	38.8^{c}	9.1^{a}	9.9^{ab}	92.7^{b}	1563^{ab}	64.0^{a}
JG-14 (G_3)	46.2^{a}	7.2^{b}	9.6^{b}	85.9^{c}	1446^{b}	57.1^{b}
S.Em.±	0.6	0.1	0.1	0.6	11	0.5
LSD at 5%	1.3	0.2	0.4	1.9	32	1.31
Interactions (D x G)						
D_1G_1	38.1^{fg}	7.7^{f}	11.2^{c}	98.3^{ab}	1685^{ab}	39.2^{h}
D_1G_2	38.5^{fg}	9.4^{c}	9.8^{e}	96.7^{b-d}	1650^{ab}	47.7^{g}
D_1G_3	42.4^{de}	5.9^{i}	8.9^{fg}	85.0^{fg}	1473de	48.7^{g}
D_2G_1	41.1^{c-e}	9.4^{c}	12.6^{b}	101.3^{ab}	1719^{a}	69.9^{b}
D_2G_2	40.3^{e-g}	9.9^{b}	11.1^{c}	95.2^{cd}	1613^{bc}	70.1^{b}
D_2G_3	43.7^{cd}	7.7^{f}	10.0^{de}	87.7^{ef}	1488de	59.5^{d}
D_3G_1	45.8^{bc}	10.2^{a}	15.0^{a}	103.0^{a}	1735^{a}	65.7^{c}
D_3G_2	39.0^{fg}	10.0^{ab}	10.6^{cd}	98.7^{ab}	1658^{ab}	74.9^{a}
D_3G_3	53.0^{a}	8.6^{d}	12.3^{b}	91.3^{de}	1519de	69.3^{b}
D_4G_1	40.7^{d-f}	8.7^{d}	11.0^{c}	92.2^{de}	1543^{cd}	60.2^{d}
D_4G_2	39.2^{fg}	8.5^{d}	9.4^{ef}	88.3^{ef}	1468de	66.7^{c}
D_4G_3	48.3^{b}	7.1^{g}	8.5^{g}	84.3^{fg}	1392^{fg}	55.8^{e}
D_5G_1	39.6^{fg}	8.4^{ef}	10.1^{de}	88.6^{ef}	1504de	55.2^{e}
D_5G_2	37.3^{g}	7.5^{f}	8.9^{fg}	84.6^{fg}	1426^{ef}	60.7^{d}
D_5G_3	43.6^{cd}	6.8^{h}	8.4^{g}	81.0^{g}	1359^{g}	52.7^{f}
S.Em.±	1.0	0.1	0.3	1.1	19	0.8
LSD at 5%	2.8	0.3	0.7	3.3	55.6	2.26

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, Values in the column followed by the same letter do not differ significantly by DMRT

(1637) and JG-14 took minimum number of days and optimum GDD for physiological maturity (85.9 days and 1446 heat units, respectively).

Mild temperature stress treatment decreases plant biomass/plant, pod number per plant, pod weight (g/plant), seed number per plant and seed weight as compared to the ambient temperature in both the chickpea genotypes. There was 28 per cent reduction in seeds per plant which was higher in Pusa1103 as compared to Pusa 1105 (21%). Seed yield per plant was reduced in both the genotypes because of reduction in the seed size under mild temperature stress in Pusa 1103 caused 19.51 per cent reduction in 100 seed weight. High temperature stress causes much detrimental effects on cellular metabolism, which results in low yield (Bahuguna *et al.,* 2012 and Arun *et al.,* 2012). Wang *et al.* (2006) reported that higher temperature at flowering and pod development stages enhanced maturity and decreased chickpea seed yield by reducing the number of seeds per plant, weight per seed and gave the lowest grain yield. The yield and yield components (Table 2), like number of pods per plant (69.9), number of seeds per plant (60.7), hulm weight (3.36), seed weight (15.62), harvest index (53.58) and seed yield (29.88 q ha^{-1}) differed significantly and found highest in D_3 temperature regime than the D_2, D_1 and D_4 wherein under these dates of sowing the reproductive phases coincided with maximum temperature and resulted in flower abortion and affected fertilization and thereby decreased final yield. Number of seeds, hulm weight, seed weight, HI and seed yield was found minimum under D_5 temperature regime (48.9, 2.41, 7.78, 45.59 % and 21.64 q ha^{-1}, respectively) but number of pods per plant found less under D_1 temperature regime. Among the genotypes, significantly higher pods and seeds per plant, seed weight per plant, HI and seed yield was recorded by the genotype JG-11 (64, 56.5, 13.18, 53.19 % and 28.32 q ha^{-1}) and minimum was recorded by the genotype Annigeri-1 (58, 49.6, 10.09, 48.75 % and 25.51 q ha^{-1}, respectively) but test weight was recorded more by the genotype JG-14 (24.3) under the D_1 (24.9) temperature regimes. These results are in conformity with the results of Devendra *et al.,* (2012) and Neeraj *et al.,* (2012) who reported that different dates of sowing showed significant genotypic differences in

Table 2. Effect of temperature regimes on yield and yield components of chickpea genotypes

Treatment	Seeds $plant^{-1}$	Test weight (g)	Hulm weight (g)	Seed weight $plant^{-1}$	Harvest Index(%)	Seed yield (q ha^{-1})
Dates of sowing (D)						
40th Standard week (D_1)	47.7^{d}	24.9^{a}	2.95^{c}	11.16^{c}	50.42^{a}	27.30^{c}
42nd Standard week (D_2)	55.2^{b}	24.3^{a}	3.39^{a}	13.73^{b}	53.50^{a}	28.43^{b}
44th Standard week (D_3)	60.7^{a}	22.5^{b}	3.36^{ab}	15.62^{a}	53.58^{a}	29.88^{a}
46th Standard week (D_4)	53.5^{c}	20.8^{c}	3.19^{b}	11.34^{c}	50.51^{a}	26.39^{c}
48th Standard week (D_5)	48.9^{d}	18.8^{d}	2.41^{d}	7.78^{d}	45.59^{b}	21.64^{d}
S.Em.±	0.28	0.1	0.06	0.07	0.28	0.15
LSD. at 5%	0.80	0.4	0.19	0.21	0.80	0.42
Genotypes (G)						
Annigeri-1 (G_1)	49.6^{b}	19.7^{b}	2.63^{c}	10.09^{b}	48.75^{b}	25.51^{b}
JG-11 (G_2)	56.5^{a}	22.8^{a}	3.17^{b}	13.18^{a}	53.19^{a}	28.32^{a}
JG-14 (G_3)	54.2^{ab}	24.3^{a}	3.38^{a}	12.50^{a}	50.22^{ab}	26.36^{b}
S.Em.±	0.36	0.17	0.08	0.09	0.36	0.19
LSD. at 5%	1.03	0.50	0.24	0.28	1.03	0.56
Interactions (D x G)						
D_1G_1	42.9^{k}	22.2^{e}	2.45^{e}	8.29^{gh}	46.41^{g}	26.90^{e}
D_1G_2	48.9^{i}	24.9^{c}	3.33^{a-d}	14.21^{c}	55.37^{a}	28.46^{d}
D_1G_3	51.2^{f-h}	27.8^{a}	3.06^{cd}	10.97^{f}	49.47^{e}	26.54^{e}
D_2G_1	52.5^{c-d}	21.3^{f}	2.99^{d}	11.95^{e}	51.86^{cd}	27.23^{e}
D_2G_2	58.0^{cd}	25.1^{c}	3.48^{a-c}	15.32^{b}	55.88^{a}	29.66^{b}
D_2G_3	55.2^{e}	26.6^{b}	3.70^{a}	13.91^{c}	52.75^{bc}	28.40^{d}
D_3G_1	57.0^{cd}	19.6^{g}	3.36^{a-c}	15.29^{b}	54.55^{ab}	28.52^{cd}
D_3G_2	64.3^{a}	23.3^{d}	3.26^{a-c}	15.82^{a}	55.82^{a}	31.63^{a}
D_3G_3	60.8^{b}	24.4^{c}	3.46^{a-c}	15.75^{ab}	50.36^{d-e}	29.50^{bc}
D_4G_1	50.5^{g-i}	18.1^{h}	2.47^{a-d}	8.744^{gh}	47.35^{f-g}	25.02^{f}
D_4G_2	59.0^{c}	21.2^{f}	3.53^{a-c}	13.27^{d}	54.50^{ab}	29.39^{bd}
D_4G_3	51.0^{f-g}	23.2^{d}	3.58^{ab}	11.99^{e}	49.68^{e}	24.76^{f}
D_5G_1	45.2^{i}	17.4^{h}	1.89^{f}	6.202^{j}	43.57^{h}	19.86^{h}
D_5G_2	52.1^{fg}	19.6^{g}	2.23^{ef}	7.254^{i}	44.37^{h}	22.46^{g}
D_5G_3	49.4^{hi}	22.3^{e}	3.10^{bd}	9.873^{g}	48.82^{ef}	22.59^{g}
S.Em.±	0.62	0.30	0.14	0.16	0.67	0.33
LSD at 5%	1.80	0.87	0.42	0.46	1.78	0.96

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, Values in the column followed by the same letter do not differ significantly by DMRT

100-seeds weight in chickpea. This reduction (36.6 to 29.2%) was because of coincidence of high temperature from flowering to maturity that caused reduction in grain filling, which finally reduced yield. Most chickpea genotypes do not set pods when temperatures exceeds >35°C (Basu *et al.*, 2009) and seed yields were highest from sowing made between 29th October and 26th November and closely correlated with number of pods per plant and showed about 53.7 per cent reduction in seed yield under late sowing as compared to normal sowing.

The normal sowing dates for this region is October 1st FN (40th and 41st MSW) due to change in the climate there is slight shift in the sowing. Therefore, from the present study it is concluded that the 44th MSW (D_3 temperature regime) of sowing is best suited meteorological standard week for chickpea genotypes to get higher seed yield by increasing plant height, more number of primary and secondary branches, more number of days taken for physiological maturity with an optimum GDD with higher yield and yield components. Genotypes JG-11 is considered to be selectively temperature tolerant when compared to Annigeri-1.

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