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Phonological growth and development of chickpea (*Cicer arietinum* L.) cultivars at climatic condition

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Abstract
A field experiment was conducted during *rabi season* of 2016 on the topic entitled "Study the crop-weather interaction on chickpea (*Cicer arietinum* L.) Cultivars" in sandy loam soil of N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P). The experimental consisted of nine treatment combinations comprised of three growing environment *viz*., sowing on Oct.25th with temperature 24.2 ^{0}C, Nov.4th with temperature 22.5 ^{0}C and Nov.14th with temperature 22.2 ^{0}C and three varieties viz. Radhey, Pusa-372, and BG-256. Results revealed that Heat use efficiency (0.62 gm^{-2} ^{0}C day^{-1})and radiation use efficiency (1.6 g/MJ) was recorded when sowing was done sown Oct.25thwith temperature 24.2 ^{0}C followed by sowing done on Nov.4th while lowest heat use efficiency and radiation use efficiency was recorded when sowing was done on Nov.14th with sowing temperature 22.2 ^{0}C. Radhey cultivar was found more conducive and remunerative for growth development seed yield radiation use efficiency and heat use efficiency.

Keywords: Phenological stages, GDD, Dry matter accumulation, HUE, RUE

Introduction
Chickpea (*Cicer arietinum* L.) is one of most important pulse crop of India. Chickpea probably originated in south-eastern Turkey and spread west and south via the silk route. Four centres of diversity have been identified in the Mediterranean, Central Asia, near East Asia and India, as well as a secondary centre of originated Ethiopia. It is the world third most important food legume and India is placed first in production. Chickpea cultivated with medium and long duration varieties is generally delayed. All the chickpea varieties are sensitive to photo and thermal-period. Delay in sowing causes early maturity of the cultivars resulting in drastic reduction of the yield. Optimum sowing time is considered for maximum advantages of environmental condition, especially in the terms of the thermal requirement by the crop canopy. The productivity of chickpea in eastern U.P. is quite below than the national average due to which suitable varieties will therefore, be quite helpful in increasing the yield (Shendge *et al*., 2002) [9]. The most important factors affecting chickpea development are generally temperature, photoperiod, and moisture. Temperature (Singh & Dhaliwal 1972; Siddique & Sedgley 1986) [11, 10], moisture (Saxena 1990) [8], and depth of sowing (Saxena 1987) [7] mainly control the duration from sowing to emergence. After emergence, temperature, and photoperiod (Sandhu & Hodges 1971) [6] coupled with the availability of soil moisture (Khanna-Chopra & Sinha 1987; Piara Singh 1991) [1, 3] control the rate of progress towards any phenological stage. In chickpeas, flowering is considered the critical stage, because environmental conditions that prevail at flowering and the duration of the reproductive phase determine, to a large extent, the percentage of fruit set and the final yield (Savithri *et al*. 1980) [5]. Therefore, being able to predict the time of flowering may be more important than any of the other phenological stages. Considerable work has been done on the photothermal responses of chickpeas to predict time to flowering (Summerfield & Roberts 1988) [12]. As in most grain legumes, increased temperatures speed up the rate of development of all developmental stages of chickpeas (Summerfield *et al*. 1984; Roberts *et al*. 1985) [12, 4].

Materials and Methods
The experiment comprised three different types of Cheakpea varieties Radhey (V_1), Pusa-372 (V_2), and BG-256 (V_3) at three growing environment *viz.*, October. 25th growing environment 24.2 °C (D_1), Nov.4th growing environment 22.5 °C (D_2), Nov.14th growing environment 22.2 °C (D_3) during 2016. The experiment was conducted in Randomized Block Design (RBD) and replicated the three times. The different growth parameters studied were measured as follows;

Days taken to different phenological stages, Heat unit Heat unit of different phenological stages were calculated by using following formula (Nuttonsoon, 1955) [2], Heat use efficiency (g m^{-1} degree $days^{-1}$), Radiation use efficiency (g/MJ).

Results

Data pertaining to different phenological stages of chickpea as affected by growing environment and cultivars have been presented in table 1. Days taken from sowing to pod maturity varied from 155 to 143 days irrespective of dates of sowing. When crop was sown on Oct.25th with sowing temperature 24.2 ^{0}C recorded higher days from vegetative to maturity followed by Nov.4th sown crop with 22.5 ^{0}C sowing temp. Delay in sowing (on Nov.14th) reduced the vegetative phase by 15 days over Oct 25th sowing and 7 days over Nov 4th sowing. While from sowing to pod maturity reduced the duration by 21 days over Oct.25th and 12 days over Nov.4th sowing. Maximum days taken from sowing to maturity (150 days) were recorded under sowing temp. 24.2 ^{0}C (occurred on Oct.25th) followed by sowing temperature 22.5 ^{0}C (exist on Nov.4th). Delay in sowing recorded higher days taken to emergence. Different cultivars influenced markedly at all the phenological stages of chickpea. Higher days taken from sowing to pod maturity were obtained in Radhey (150 days) followed by BG-256 while lowest days at all phenophases were recorded in Pusa-372.

Data pertaining to accumulated thermal unit requirement of chickpea at different Phenophases as affected by growing environment and cultivars have been presented in table 1.1. The maximum heat Unit (GDD) requirement from sowing to maturity 1785.4 ^{0}C days were recorded in sowing temperature 24.2 ^{0}C (occurred on Oct.25th) followed by 1728.5 ^{0}C days at sowing temperature 22.5 ^{0}C (exist on Nov.4th) while minimum accumulated growing degree days from sowing to maturity 1689.5 ^{0}C days was observed under sowing temperature of 22.2 ^{0}C (occurred on Nov.14th). Delay in sowing recorded minimum GDD requirement at all the stages. Different cultivars had marked influence on the growing degree days of chickpea at all the phenophases. GDD ranged from 1766.3 ^{0}C days to 1721.6 ^{0}C days irrespective of different cultivars. Maximum G.D.D/heat Unit requirement from sowing to maturity 1785.4 ^{0}C days were obtained in Radhey while minimum GDD was obtained in Pusa-372 cultivar 1512.3 ^{0}C days) from sowing to maturity of chickpea.

Data regarding dry matter accumulation as influenced by growing environment and cultivars has been presented in table 1.2. It is quite obvious from the data that dry matter accumulation varied significantly due to growing environment at all the stages of chickpea. It was recorded higher under the treatment when chickpea was sown on Oct.25th with sowing temperature 24.2 ^{0}C which was at while significantly superior over rest both of the sowing dates. Delayed sowing recorded lowest dry matter at all the stages. Relationship between GDD and dry matter of chickpea sown on Oct. 25th have been developed and Dry matter was linearly correlated with GDD (R^2=0.976) and dry matter accumulation (2.48). Dry matter accumulation was affected significantly at all the stages due to cultivars table 1.2. Highest dry matter accumulation was recorded in Radhey cultivar which was at par with BG-256 while significant with Pusa-372 at all the stages of chickpea. Data also reveal that Pusa-372 cultivar recorded lowest dry matter accumulation at all the growth stages.

Data pertaining to heat use efficiency as affected by growing environment and cultivars have been presented in table 1.3. Heat use efficiency increased successfully till 90 DAS and there after declined gradually up to maturity irrespective of treatments. Higher heat use efficiency was recorded when sowing was done on Oct.25th with temperature 24.2^{0}C followed by sowing done on Nov.4th while lowest heat use efficiency was recorded when sowing was done on Nov.14th with sowing temperature 22.2 ^{0}C. Among the cultivars, maximum heat use efficiency was recorded under Radhey followed by Pusa-372 while minimum heat use efficiency was recorded under BG-256 cultivar of chickpea.

The data pertaining to radiation use efficiency as affected by growing environment and cultivars are given in table 1.4. Results indicated that radiation use efficiency increased successively till 90 days after sowing and thereafter gradually declined irrespective of treatments. Chickpea sown on Oct.25th recorded higher radiation use efficiency during all the stages followed by Nov.4th sowing and lowest in radiation use efficiency was recorded in Nov.14th sown of Chickpea. Different cultivars had significant variation on radiation use efficiency (RUE) as given in table 1.4. Higher radiation use efficiency was recorded under Radhey followed by Pusa-372 at all the stages of chickpea while the lowest RUE was recorded in BG-256 cultivars.

Table 1: Days taken to different Phenological stage of chickpea cultivars as affected by growing environment.

Treatments	Phenophases (Days)				
	Emergence	Vegetative	50% flowering	Pod formation	Pod maturity
Growing environment					
Oct. 25/24.2 ^{0}C	8	95	120	132	155
Nov. 4/22.5 ^{0}C	8	90	115	127	149
Nov. 14/22.2 ^{0}C	7	86	111	122	143
Cultivars					
Radhey	8	104	116	131	153
Pusa-372	8	99	114	126	148
BG-256	7	98	113	125	146

Table 1.1: Accumulated thermal unit at different phenophases of chickpea cultivars as affected by growing environment.

Treatments	Accumulated (GDD ^{0}C days)				
	Emergence	Vegetative	50% flowering	Pod formation	Pod maturity
Growing environment					
Oct. 25/24.2 ^{0}C	130.7	1145.0	1331.5	1510.0	1784.4
Nov. 4/22.5 ^{0}C	147.7	1011.7	1225.0	1354.3	1728.5
Nov. 14/ 22.2 ^{0}C	106.7	977.0	1228.0	1330.3	1690.0
Cultivars					

Radhey	131.7	1132.0	1255.3	1510.0	1767.3
Pusa-372	165.0	1001.8	1209.3	1371.4	1721.6
BG-256	193.3	945.0	1120.8	1264.8	1512.3

Table 1.2: Dry matter accumulation of chickpea cultivars as influenced by growing environment.

Treatments	Dry matter accumulation (gm^{-2})							
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS	A.H
Growing environment								
Oct.25/24.2 ^{0}C	129.2	241.9	318.8	388.9	514.7	592.9	671.8	772.1
Nov.4/22.5 ^{0}C	124.2	226.0	297.7	363.2	480.7	553.7	627.4	721.1
Nov.14/22.2 ^{0}C	119.2	216.8	285.7	348.5	461.3	531.3	602.1	692.0
SEm±	3.04	5.32	7.06	10.97	10.64	13.22	14.34	17.2
CD at 5%	NS	16.7	22.2	NS	33.5	41.6	41.6	54.4
Cultivars								
Radhey	127.9	239.7	315.8	385.2	509.8	587.3	665.4	764.8
Pusa-372	123.0	223.7	294.7	359.5	475.8	548.1	621.1	713.8
BG-256	121.7	221.4	291.7	355.8	471.0	542.5	614.7	706.5
SEm±	2.4	4.7	6.0	7.4	9.8	11.7	11.9	14.0
CD at 5%	NS	13.7	17.5	NS	28.8	34.4	34.7	41.0

Table 1.3: HUE of chickpea cultivars as affected by growing environment.

Treatments	HUE ($g/m^{-2}/^0days^{-1}$)							
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS	A.H
Growing environment								
Oct.25/24.2 ^{0}C	0.35	0.49	0.52	0.54	0.62	0.59	0.58	0.56
Nov.4/22.5 ^{0}C	0.30	0.46	0.52	0.53	0.53	0.52	0.51	0.51
Nov.14/22.2 ^{0}C	0.27	0.43	0.41	0.44	0.51	0.52	0.49	0.46
Cultivars								
Radhey	0.37	0.51	0.53	0.54	0.61	0.59	0.58	0.55
Pusa-372	0.30	0.46	0.52	0.50	0.58	0.53	0.50	0.50
BG-256	0.27	0.36	0.41	0.43	0.52	0.52	0.49	0.46

Table 1.4: RUE of chickpea cultivars as affected by growing environment.

Treatments	RUE (g/MJ)						
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
Growing environment							
Oct.25/24.2 ^{0}C	0.96	1.15	1.25	1.32	1.60	1.55	1.44
Nov.4/22.5 ^{0}C	0.95	1.12	1.12	1.28	1.50	1.45	1.30
Nov.14/22.2 ^{0}C	0.85	1.10	1.05	1.18	1.53	1.35	1.28
Cultivars							
Radhey	0.96	1.15	1.25	1.30	1.51	1.35	1.30
Pusa-372	0.95	1.12	1.22	1.25	1.45	1.32	1.28
BG-256	0.93	1.10	1.20	1.20	1.50	1.28	1.26

Conclusion

It is concluded that study in Heat use efficiency (0.62 $gm^{-2}\,^0C\ day^{-1}$) and radiation use efficiency (1.6 g/MJ) was recorded when sowing was done sown Oct.25th with temperature 24.2 ^{0}C followed by sowing done on Nov.4th while lowest heat use efficiency and radiation use efficiency was recorded when sowing was done on Nov.14th with sowing temperature 22.2 ^{0}C. Radhey cultivar was found more conducive and remunerative for growth development seed yield radiation use efficiency and heat use efficiency.

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