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Journal of Food Legumes 33(2): 127-132, 2020

Short Communication

Phenology, thermal indices and yield of chickpea (*Cicer arietinum* L.) varieties under different sowing dates in New Alluvial Zone of West Bengal

SHREYASEE SETH*[1], MRITYUNJAY GHOSH[1], R NATH[1], MD HEDYATULLAH[1] and MK NANDA[2]

[1]Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia 741252, West Bengal, India

[2]Department of Agricultural Meteorology and Physics, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia 741252, West Bengal, India

Email: mghoshbckv@rediffmail.com

Received: *26 Feb, 2020*

Acceptance: *10 August, 2020*

Handling Editor:

Dr. Narendra Kumar, ICAR-IIPR, Kanpur

ABSTRACT

A field experiment was conducted at Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal, India to study the effect of four sowing dates and four varieties on phenology and yield of chickpea during *rabi* season of 2017-18. Mean cultivar days of chickpea crop from sowing to emergence, flower initiation, pod initiation and maturity were 6.7, 59.6, 80.5 and 112.6 days, respectively. The duration of chickpea and summed growing degree days (GDD) were reduced successively with delay in sowing from 4 November (119.8 days and 1715) to 19 December (103.9 days and 1604). The average GDD, heliothermal units (HTU) and photothermal units (PTU) for entire life cycle of chickpea were recorded as 1661, 11403 and 18766, respectively. Chickpea sown on 20 November produced the highest seed yield (1084.50 kg/ha), which was 11.4, 16.9 and 34.7% greater over 4 November, 5 December and 19 December, respectively. The correlations between thermal indices and seed yield revealed that GDD (r = 0.483), HTU (r = 0.633**) and PTU (r = 0.379**) during pod initiation to maturity had positive effect (P < 0.01) on economic yield of chickpea. Based on seed yield, chickpea varieties could be arranged as 'Uday' (1058 kg/ha) > 'JG 14' (908 kg/ha) > 'Anuradha' (904 kg/ha) > 'Vaibhav' (787 kg/ha).**

Key words: Chickpea, Phenology, Sowing date, Thermal indices, Variety, Yield

Chickpea, known as bengal gram or *chana*, is one of major pulses cultivated and consumed in the country since long. India is the largest producer of chickpea (9.63 Mt) in the world covering an area of 9.38 Mha with the average productivity of 974 kg/ha during 2016-17 (Government of India, 2019). Chickpea is mainly cultivated in western part of India; where Madhya Pradesh (37.8%), Maharashtra (18.3%) and Rajasthan (15.0%) contribute about 70% production in the country. Large numbers of important high-yielding varieties of chickpea have evolved, but yield of most of such varieties is not stable over environments, which is one of the reasons for poor adaptation (Yogesh *et al*., 2017). The front-line demonstrations in recent times revealed improvement in productivity and profitability of chickpea over farmers' practices in Bhagalpur district of Bihar (Mauriya *et al*., 2017) and Ferozepur district of Punjab (Kaur *et al*., 2019). In West Bengal, chickpea is grown in 0.26 lakh ha land with production of 0.31 lakh tonnes and yield of 1178.3 kg/ha (Government of West Bengal, 2016), which indicate scope of adaptation of the crop with proper technology in different agro-climatic zones of the state. Nitesh *et al*. (2018) observed that selection of high number of pods/plant and 100 seed weight would lead to high seed yield; while number of secondary branches/plant, plant height and number of seeds/pod facilitate selecting genotypes for high number of pods/plant. The commonly cultivated chickpea varieties *viz*. 'Mahamaya 1', 'Mahamaya 2', 'Anuradha', etc. are usually

sown between mid October to mid November in West Bengal; but sowings are often delayed when grown in sequence with *kharif* rice, which leads to drastic reduction (20-50%) in grain yield. As the State Department of Agriculture take initiatives for area expansion of suitable chickpea varieties in recent times, the optimization of sowing time along with selection of promising varieties in particular region needs to be done. Keeping these in view, a comprehensive study was done on the effect of sowing time on phenology, thermal indices like growing degree days (GDD), heliothermal units (HTU) and photothermal units (PTU) and yield of chickpea varieties in new alluvial zone of West Bengal.

A field experiment was conducted for chickpea crop (*Cicer arietinum*) during *rabi* season (November-March) of 2017-2018 on a medium land loamy soil at Instructional Farm (22°-93′ N, 88°53′ E and 9.75 m m.s.l.) of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia, West Bengal, India. Treatments replicated thrice were assigned in a split-plot design with four sowing dates (4 November, 20 November, 5 December and 19 December) in main plots and four varieties ('Anuradha', 'Uday', 'Vaibhav' and 'JG 14') in sub-plots. Seeds of four chickpea varieties collected from AICRP on MULLaRP, BCKV were sown at 30 cm row spacing in the experimental plots (4 m × 3 m) as per sowing time schedule. The standard crop management practices like uniform fertilizer dose of 20:40:40 kg/ha of N:P_2O_5:K_2O, one hand weeding at 30-40 days after sowing (DAS) and one irrigation at 30-40 DAS were adopted.

The phenophases (*viz.* emergence, flower initiation, pod initiation and maturity) of chickpea varieties at different sowing dates were noted by regular field inspection method. The daily meteorological data at Mohanpur for the period of investigation (November, 2018 to March, 2019) were collected from the Department of Agricultural Meteorology and Physics, BCKV, West Bengal. Phenophase-wise growing degree days (GDD) were calculated following Nuttonson (1955) by taking a base temperature of 5ÚC, while Heliothermal units (HTU) and photothermal units (PTU) were determined by the equations proposed by Singh *et. al*. (1990) and Nuttonson (1948), respectively. The correlation studies between thermal and photothermal requirements for each phenological stage and grain yield were made. The plant height, yield components, grain and stover yield of chickpea were recorded at crop maturity stage.

Phenology: The average emergence of seedlings of four chickpea varieties was relatively faster (5.3 days) in 5 December sown plots compared to other three sowings on 4 November (6.58 days), 20 November (7.0 days) and 19 December (7.8 days) in the study (Table 1). This might be due to the fact that early December sown crop received 9.13 mm rainfall just after sowing, which hastened the germination of seeds as well as emergence in the field. Although the variations in length of phenophases among three sowing dates were complex, but the trends during emergence to flower initiation (E-FI) and pod initiation to maturity (PI-M) primarily determined the life cycle of chickpea crop. The phenophasic durations of chickpea crop during above mentioned two stages as well as the life cycle were reduced successively with delay in sowing from 4 November to 19 December. Chickpea sown on 4 November took 119.8 days from sowing to maturity which was decreased by 2.6 days in 20 November, 10.2 days in 5 December and 15.8 days in 19 December sowing in the investigation. Similarly, Sahu *et al*. (2007) reported that the life cycle of four chickpea varieties was reduced by 22 days (103 *vs*. 81 days) due to delay in sowing from 15 October to 15 November at Junagarh, Gujarat.

The phenophase-wise average duration of chickpea was 6.7 days (sowing to emergence), 52.9 days (emergence to flower initiation), 20.9 days (flower initiation to pod initiation) and 32.1 days (pod initiation to maturity). Based on the length of life cycle, chickpea varieties could be arranged as 'Uday' (114.2 days) > 'Anuradha' (113.9 days) > 'JG 14' (112.1 days) > 'Vaibhav' (110.3 days).

Growing degree days (GDD): Mean cultivar GDD for chickpea from sowing to emergence, flower initiation, pod initiation and maturity

Table 1. Effect of sowing date on phenology and thermal indices of chickpea varieties in West Bengal

Treatment	Sowing to Emergence (S - E)	Emergence to Flower Initiation (E - FI)	Flower Initiation to Pod Initiation (FI - PI)	Pod Initiation to Maturity (PI - M)	Sowing to Maturity (S - M)
Phenological duration (days)					
Sowing date					
4 November	6.6	55.9	22.5	34.8	119.8
20 November	7.0	54.2	21.5	34.5	117.2
5 December	5.3	51.2	21.7	31.4	109.6
19 December	7.8	50.4	18.1	27.7	103.9
CD (P=0.05)	0.42	2.37	NS	0.58	1.44
Variety					
'Anuradha'	7.5	52.8	21.1	32.5	113.9
'Uday'	6.3	53.8	21.7	32.3	114.2
'Vaibhav'	6.3	52.8	20.1	31.0	110.3
'JG 14'	6.5	52.2	20.9	32.5	112.1
CD (P=0.05)	0.44	NS	NS	0.81	1.05
Growing degree days					
Sowing date					
4 November	119	796	236	564	1715
20 November	109	661	290	632	1692
5 December	77	603	325	628	1633
19 December	96	608	330	570	1604
CD (P=0.05)	7.1	28.3	43.3	13.4	30.3
Variety					
'Anuradha'	113	663	301	613	1690
'Uday'	95	677	308	612	1693
'Vaibhav'	95	669	282	566	1612
'JG 14'	98	658	291	603	1650
CD (P=0.05)	6.4	NS	NS	14.4	21.3
Helio-thermal units					
Sowing date					
4 November	1142	5091	1633	4037	11903
20 November	982	4129	2089	4651	11850
5 December	268	3981	2329	4432	11011
19 December	501	4299	2405	3644	10850
CD (P=0.05)	61.8	226.9	303.9	63.2	179.8
Variety					
'Anuradha'	807	4360	2143	4246	11556
'Uday'	692	4442	2213	4223	11570
'Vaibhav'	692	4389	2203	4032	11116
'JG 14'	702	4310	2098	4263	11373
CD (P=0.05)	54.3	NS	NS	100.2	115.3
Photo-thermal units					
Sowing date					
4 November	1351	8669	2607	6484	19111
20 November	1203	7152	3267	7388	19009
5 December	833	6547	3711	7420	18511
19 December	1021	6759	3837	6818	18434
CD (P=0.05)	79.3	317.7	489.6	166.8	362.6
Variety					
'Anuradha'	1237	7244	3420	7204	19105
'Uday'	1048	7396	3506	7197	19149
'Vaibhav'	1048	7304	3199	6635	18187
'JG 14'	1074	7181	3295	7074	18624
CD (P=0.05)	70.6	NS	NS	171.7	255.5

were 100, 767, 1062 and 1661, respectively (Table 1). There was successive reduction in summed GDD for entire life cycle with delay in sowing from 4 November (1715) to 19 December (1604). This might be mainly due to reduction in days to maturity for delay in sowing from early November to mid December during *rabi* season. Tyagi (2014) also reported

that total summed GDD was reduced with delay in sowing of 3 chickpea varieties from October 25 to December 4 at Tikamgarh, Madhya Pradesh. Varieties differed significantly for accumulated GDD at different phenophases and life cycle, excluding emergence to flower initiation (E-FI) and flower initiation to pod initiation (F-PI) stage.

Heliothermal unit (HTU): There was a little variation in daily bright sunshine hour averaged over entire life cycle (6.71-6.95 hour) among four sowing dates in the study. The variation in mean daily temperature and bright sunshine hour among four sowing dates resulted in varied accumulated HTU at different phenophases as well as life cycle of chickpea crop. Early sowing (4 November) of chickpea recorded highest summed total HTU (11903), which was successively decreased due to delayed sowings on 20 November (11850), 5 December (11011) and 19 December (10850) in the investigation (Table 1). Mean cultivar summed total HTU for the entire life cycle was 11403 with a range between 11116 ('Vaibhav') and 11570 ('Uday').

Photothermal unit (PTU): Temperature generally governed the onset of different phenophases in chickpea, but day length had also influence on photo-thermal requirements of the crop. The total PTU for entire life cycle was highest (19111) in early sown crop primarily due to greater duration (119.8 days) than three late sowings on 20 November (19009 and 117.2 days), 5 December (18511 and 109.6 days) and 19 December (18434 and 103.9 days) (Table 1). Mean cultivar summed PTU at different phenophases were recorded as 1102 (sowing to emergence), 7282 (emergence to flower initiation), 3355 (flower initiation to pod initiation), 7027 (pod initiation to maturity) and 18766 (sowing to maturity).

Yield attributes and seed yield: Although the plant height of two November sown crops (4 and 20 November) was more or less similar (53.7 cm and 51.3 cm), but it was gradually decreased for delayed sowings on 5 December (43.8 cm) and 19 December (41.4 cm) (Table 2). Perusal of data revealed that three varieties ('Anuradha', 'JG 14' and 'Vaibhav') had <45 cm height, while 'Uday' recorded >65 cm plant height at harvest indicating erect plant type. Sowing time had significant influence on branching habit, number of pods/plant, number of seeds/pod and 100-seed weight of chickpea in the investigation. Chickpea sown on 4 November produced the maximum number of branches (3.97/plant) and number of pods/plant (59.5), these were gradually decreased with delay in sowing to 19 December (2.83/plant and 31.1/plant). Similar number of pods/plant (43.1-49.3) was reported by Rehman *et al.,* (2015), but less number of pods/plant (12.1-18.0) was noted by Chaitanya and Chandrika (2006). Among four varieties, 'Vaibhav' recorded the highest number of primary branches (3.46/plant) and 100 seed weight (20.6g), but lowest number of seeds/pod(1.15).

Chickpea sown on 20 November recorded the highest seed yield (1084.5 kg/ha), stover

Table 2. Effect of sowing date and variety on growth, yield attributes and yield of chickpea

Treatment	Plant height (cm)	No. of plants/m²	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100 seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Heat use efficiency (kg/°C/day)
Sowing date									
4 November	53.7	28.7	3.97	59.5	1.33	15.3	960.9	1256.0	0.56
20 November	51.3	30.5	3.32	55.7	1.52	15.7	1084.5	1345.1	0.64
5 December	43.6	29.9	2.82	39.5	1.58	14.7	903.0	1235.1	0.55
19 December	41.4	29.2	2.63	31.1	1.43	14.6	708.0	1085.2	0.44
CD (P=0.05)	2.22	NS	0.31	3.65	0.15	0.55	128.36	127.32	0.08
Variety									
'Anuradha'	39.5	30.0	3.33	50.8	1.82	10.2	903.9	1206.2	0.53
'Uday'	65.1	32.3	2.83	42.8	1.36	17.2	1057.9	1427.6	0.62
'Vaibhav'	44.1	25.4	3.46	48.1	1.15	20.6	786.8	1079.5	0.49
'JG 14'	41.3	30.6	3.13	44.2	1.53	12.4	908.0	1208.1	0.55
CD (P=0.05)	3.74	2.69	0.35	4.67	0.14	0.82	105.20	87.54	0.06

yield (1345.1 kg/ha) and heat use efficiency (0.64 Kg $^0C^{-1}$ day^{-1}) in the study. Perusal of data revealed that 20 November sowing resulted in 11.4%, 16.9% and 34.7% greater seed yield over 4 November, 6 December and 19 December sowings, respectively. Based on seed yield, four varieties could be arranged as 'Uday' (1057.9 kg/ha) > 'JG 14' (908.0 kg/ha) > 'Anuradha' (904.0 kg/ha) > 'Vaibhav' (786.8 kg/ha). Thus, 'Uday' produced 149.9, 154.0, 271.1 kg/ha greater yield over JG 14, 'Anuradha' and 'Vaibhav', respectively. Kumar *et al*. (2017) identified 'Birsa Chana 3' as a promising variety among ten cultivars/genotypes in Jharkhand. The interaction between sowing date and variety shows that 'Anuradha' performed equally better at two November sowings (1006.5 and 1025.8 kg/ha); while 'Uday' could be sown upto first week of December for sustained yield, and 'Vaibhav' and 'JG 14' gave maximum yield in third week of November (Table 3).

Table 3. Interaction between sowing time and variety on seed yield of chickpea

Variety	Seed yield (kg/ha)			
	Sowing date			
	4 November	20 November	5 December	19 December
'Anuradha'	1006.5	1025.8	897.0	686.2
'Uday'	1071.5	1246.2	1099.7	814.2
'Vaibhav'	810.3	936.6	741.5	658.7
'JG 14'	955.5	1129.5	874.0	673.0

Correlations between thermal indices and seed yield: The correlation studies between thermal indices and seed yield revealed that GDD (r = 0.483**), HTU (r = 0.635**) and PTU (r = 0.379**) during pod initiation to maturity (PI-M) showed positive effect (P < 0.01) on economic yield of chickpea in the investigation (Table 4). Thus, it could be concluded that temperature, bright sunshine hour and day length during late growth phase favoured the pod and seed development *i.e.* seed yield of chickpea. Sahu *et al*. (2007) also reported similar positive correlation for grain yield of four chickpea varieties with GDD, HTU and PTU at Junagarh, Gujarat.

Thus, it could be concluded that the duration of chickpea was reduced by 15.8 days with delay in sowing from 4 November to 19 December. Mean summed GDD, HTU and PTU for entire life cycle were 1661, 11403 and 18766, respectively. Chickpea sown on 20 November recorded highest seed yield (1084.1 kg/ha). Among the four varieties, 'Vaibhav' took minimum days (110.3) to maturity, but 'Uday' produced the highest seed yield (1057.9 kg/ha) in the study.

Table 4. Correlations between thermal indices at different growth stages and yield of chickpea varieties

Thermal indices	Growth stage	Correlation co-efficient (r)
GDD	S-E	0.172
	E-FI	0.348*
	FI-PI	-0.314*
	PI-M	0.483**
HTU	S-E	0.370**
	E-FI	0.125
	FI-PI	-0.315*
	PI-M	0.635**
PTU	S-E	0.216
	E-FI	0.302*
	FI-PI	-0.345*
	PI-M	0.379**

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