Original Research Article

Effect of Different Temperature Regime on growth and Yield of Chickpea Under Irrigated Condition

ABSTRACT

A field experiment conducted to study the effect to find out optimum time of sowing and suitable cultivar for sustainable production in the region. Therefore, this study was undertaken to found yield reduction with further extension in the sowing date.In this field experimentation different sowingdates viz., 30^{th} October (44 MW), 15^{th} November (46 MW), 30^{th} November (48 MW), 15^{th} December (50 MW) and 30^{th} December (52 MW) in relation with two chickpea cultivars viz., JAKI 9218 and Vijay were studied. The varieties selected are dominated under cultivation.The results revealed that crop sown on 30^{th}October produced higher but statistically equivalent number of pods/plant, number of seeds/plant and grain yield as compared to 15^{th}November dates of sowing. Crop sown on 30^{th}October utilized comparable accumulated Growing Degree Days (GDD: 2012 day^{0}C) andHeliothermal Units (HTU: 13515 ^{0}C day hr)with15^{th}November sown crop (GDD; 1975-day^{0}C, HTU: 13130 ^{0}C day hr) during cropping period from vegetative to pod-seed development phase. The number of pods/plant, weight of seed/plant and test weight was higher in cultivar JAKI 9218 than Vijay. Maximum accumulated GDD(1888 ^{0}C day) and HTU (12706 ^{0}C day hr) were utilized by cultivar JAKI 9218 over Vijay (GDD: 1856 ^{0}C day; HTU: 12449 ^{0}C day hr). Amid different date of sowing 15^{th}November sown chickpea exhibited maximum Heat Use Efficiency (HUE) of 0.96 grain kg/ha/ ^{0}C.day.

Key words*:*Chickpea, Date of sowing, GDD, HTU, HUE.

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1. INTRODUCTION

Chickpea is the dominant crop of *rabi* season grown on receding soil moisture possibly in mungbean/urdbean based crop sequencesown during first fortnight of October. On the contrary, chickpea which is largely grown in soybean based crop sequence cannot seeded during first fortnight of October and also loose the getting advantage of stored soil moisture under rainfed cultivation resulting in failure to keep the optimal initial plant stand. Therefore, sowing time plays an important role in optimal utilization of residual soil profile moisture (Rathore and Patel 1991). In addition to this sowing executed after first fortnight of October requires pre sowing irrigation for maintaining optimal initial plant stand. Variations in the agricultural production are mostly attributed to the effect of seasonal weather conditions on plant growth (Sastry *et al.* 2000).

Chickpea can thrive under good moisture conditions with day time temperature between 21 to 29^{0}C and night time temperature near 20^{0}C. Chickpea is sensitive to chilling temperatures (<10 ^{0}C), especially at its reproductive phase leading to floral abortion. The exact causes of reproductive failures are not fully understood (Sanjeev Kumar *et al*, 2010). According to Wery *et al.* (l993), critical temperature during the reproductive phase, which includes flowering, filling and enlargement of seeds of chickpea, plays an important role in productivity. Length of crop maturity depends on available heat units and moisture, but is usually in the range of 95-1l0 days depending upon type of chickpea genotypes (Croser*et al.,* 2003).Intergovernmental Panel on Climate Change has projected 1.6 to 3.8 ^{0}C increase in global average air temperature at the critical stage may cause considerable yield losses (Anonymous 2007).Keeping this in view, an investigation was undertaken to study the response of different dates of sowing in relation to different cultivars so as to provide wider sowing period to the farmer for the sowing of chickpea.

2. MATERIALS AND METHODS

A field experiment was conducted at AICRP on Chickpea, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola ($22^{0}42'$ N latitude, $72^{0}02'$ E longitude and at an altitude of 307.42 m above MSL) in Vidarbha region of Maharashtra, in factorial randomized block design with 10 treatments comprising of 5 date of sowing *viz.*, 30thOctober (44 MW) sowing was considered as normal growing condition, 15thNovember(46 MW) and 30thNovember (48 MW) and 15thDecember (50 MW) and 30thDecember(52 MW) and two cultivar *viz.*, Vijay and JAKI9218, replicated three times. The soil of experimental field was Inceptisol, almost neutral in reaction (pH 8.07), low in organic carbon (0.45%), medium in available phosphorus (18.89 $kgha^{-1}$) and medium in available potassium (344 $kgha^{-1}$). The chickpea was sown at row spacing of 30 cm. Recommended basal dose of nitrogen (25 kg N ha^{-1}),phosphorus (50 kg $P_2O_5ha^{-1}$)and potassium (30 K_2O $kgha^{-1}$) was applied through urea,di-ammonium phosphateand muriate of potash. Meteorological data *viz,* rainfall, relative humidity, maximum and minimum temperature, bright sunshine hrs and day length were recorded from Agro-meteorological observatory of Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola, India.

The Agro-meteorological indices growing degree days (GDD), photothermal units (PTU), heliothermal units (HTU), heat use efficiency (HUE) were calculated using following formula:

$$GDD = \frac{\text{Max. temperature}+\text{Min. temperature}}{2} - \text{Threshhold temperature}$$

Threshold temperature of 5°C was considered for chickpea crop (Nuttonson, 1955).

PTU = GDD × maximum sunshine hours (Rajput, 1980; Pandey *et al*., 2010)

Heat unit concept has been applied to correlate phenological development in crop. The summation of daily mean temperature for days required to a phenophase namely, emergence, vegetative, flowering, pod to seed development were considered for growing degree days with base temperature (T_b) of 5^0C. It is based on the concept that real time to attain a phenological stage is linearly related to temperature in the range between base temperature (T_b) and optimum temperature (Montieth 1981). The accumulated Heliothermal Unit (HTU) for each phenophase was determined by the following formula:

$$\text{Accumulated HTU } (°\text{C day hr}) = \sum_{i=1}^{n} [(T\text{ Mean} - T\text{ bi}) \times \text{No. of bright sunshine hours})]$$

Where,

T Daily mean air temperature in ^{o}C = (T max + Tmin)/ 2 T_{max} and T_{min} are maximum and minimum air temperatures, respectively; T_b is the base temperature (Sastry and Chakravarthy 1982).

Heat Use Efficiency (HUE) for grain yield was computed by using the formula described below:

$$\text{HUE } [(\text{kg/ha})/^0\text{C day}] = \frac{\text{Grain yield (kg/ha)}}{\text{Accumulated GDD } (^0\text{C day})}$$

The relative temperature disparity (RTD) and relative humidity disparity (RHD) were calculated by using the formula given below.

$$\text{RTD} = \frac{T_{max} + T_{min}}{T_{max}} \times 100$$

$$\text{RTD} = \frac{RH_{morn} + RH_{even}}{RH_{morn}} \times 100$$

After maturity ten complete plants were harvested from each plot to measure harvest index, number of pods and grain weight/plant, 100-grains weight (GW), plant height and number of branches/ plant.

3. RESULTS AND DISCUSSION

3.1 Seed Yield

The results indicated that the significantly higher ancillary parameters like number of pods/plant, grain weight/plant and seed yield (1913 kg/ha) were obtained with the crop sown on 30thOctober which was statistically on par with 15thNovember sowing, but significantly higher than recorded in the late sowing dates (Table 1). It might be due to higher GDD, HTU, PTU, day taken to attain physiological maturity phase in these sowing dates (Tables 3 &4). This may be due to the favourable weather conditions for growth and development of the 30thOctober and 15thNovember sown crop which resulted in higher dry matter accumulation. Thereduction in seed yield continues with further delayed sowing (30thNovember, 15thDecember and 30thDecember)was due to the shorter reproductive period and the reduction in seed yield perhaps due to unfavourable temperature conditions during reproductive period. The detrimental effect of heat at a later stage of crop development and earning in delayed sowing had an adverse effect on grain yield. Wardlaw and Wringley (1994) reported 3 to 4% decrease in grain yield for each 1°C rise in ambient temperature above 15°C during grain filling. The interaction effect between date of sowing and cultivars was found to be significant (Table 1a) and both the cultivars sown at different dates significantly improved the seed yield of chickpea. Cultivar sown at 30thOctober showed clear superiority over remaining sowing dates excluding sowing at 15thNovember with respect to seed yield of chickpea. This indicated that sowing of chickpea can be extended up to 15thNovember without any significant loss in seed yield. In terms of economics significantly higher gross, net return and BCR were recorded with 30thOctober and 15thNovember sown chickpea over further delayed in sowing.

3.2 Crop Phenology

The calendar for different phenophases of chickpeaobserved during the experimentation period revealed(Table 1) that the crop took maximum number of days for vegetative phase compared to the completion of other phases in all dates of sowing. The number of days required to attain different phenological stages decreased with delay in sowing from 30thOctober (44 MW) to 30thDecember (52 MW). The crop sown early (44 MW) took 101 days from sowing to maturity, while late sown crop (52MW) took 85 days for maturity. With delay in sowing (30thNovember, 15thDecember and 30thDecember) took lesser number of days as compared to early sowing for vegetative, flowering and pod-seed development phases. The number of days taken from sowing to pod-seed development was highest in early sown crop and decreased consistentlywith subsequent sowing. During late sowing, the duration of crop growth decreased because of forced maturity due to high temperatures. The calendar for different phenophases observed during the crop seasons showed little variations in the number of days taken by the crop for the completion of each phenophase. The cropduration reduced with delay in sowing on account of shorter vegetative and reproductive phases. It is wellknown that shorter days and lower temperature under delayed sowing in the initial stages of crop growth reduces photosynthesis and other physiological activities of the plant. The cultivar JAKI 9218 recorded longest vegetative period (37) over Vijay (35). The cultivar Vijay flowered earlier (44) in comparison to JAKI 9218 (46) cultivars. The number of days required to complete each phenophase with cultivars did not vary much, the cultivar JAKI 9218 taken more days for pod to seed development (95) over Vijay (93). The length of phenophasic duration differed in cultivars due to change in sowing time.

3.3 Effect of temperature

Temperatures during vegetative and reproductive stage are presented in (Table 3). Data shows that chickpea crop sown under different sowing dates had exposed to various thermal regimes during vegetative and reproductive phase of the crop. It was noted that 30thOctober and 15thNovember sown crop experienced higher mean temperature during vegetative phase and further delayed sowing decreases the T_{max} and T_{min}. However, during reproductive phase, later sowing dates i.e., 30thNovember and15thDecember recorded higher T_{max} and however no change with T_{min} was observed excepting at 30thDecember where both T_{max} and T_{min} increased as compared to early sowing dates (30thOctober and 15thNovember). The result confirms the earlier findings that yield reduction would be more with T_{max} than T_{min} on fine textured soils (Jalota and Prabhjot-Kaur 2013). During pod to seed development phaseT_{max} of 29.3^{0}C and 30.3^{0}C and, T_{min} of 13.3^{0}C and 14.3^{0}C recorded with October 30th(44 MW) and November 15th(46 MW) sown chickpea, respectively, and took higher number of days for pod to seed development phase *i.e.*, greater growing period. Sowing on 15thNovember onwards decreases the days for pod to seed development, however, T_{max} increases. Devasirvatham (2011) reported that sowing time may vary in different locations depending on the temperature experienced at different crop developmental stages. Temperature, therefore the most important for growth that governs yield and high temperature during reproductive phase of chickpea is a major cause of yield loss. Suneeta Patra *et al.* (2011) observed that the performance of high yielding chickpea under different temperature condition revealed that 25 to 30^{0}C temperature was optimum for better seed yield in chickpea. Similar results are obtained from the present study also.

3.4 Growing degree days (GDD)

The number of accumulated growing degree days required for attaining different phenophases under different sowing dates and chickpea cultivars are presented (Table 4). The heat unit or GDD was proposed to explain the relationship between growth duration and temperature. This concept assumes a direct and linear relationship between growth and temperature (Nuttonson, 1955).The accumulated heat units (GDD) to reach various growth stages varied among the sowing dates. Heat units requirement for various phonological stages from vegetative to pod-seed development decreased with successive delay in sowing. The early sown crop on 30^{th}October (44 MW) and 15^{th}November (46 MW) utilized maximum heat units for attaining various phonological stages and hence total maximum heat units (GDD: 2012 and 1975 ^{0}C day) for pod to seed development phase. With progressive decrease in the number of days for reaching maturity, last sowing on 30^{th}December (52 MW) availed1725^{0}C day. This describes clearly the effect of temperature on phenological stage. Every crop needs a specific amount of GDD to enter its reproductive phase from vegetative phase. Early sowing resulted in absorbing sufficient GDD in relatively more time. While late sown crop experienced higher temperature during later stage in less time. The shortened crop growth period (85-94 days) under late sown condition was due to the sudden drop in temperature during early vegetative phase and sharp rise in temperature during pod-seed development phase which hastened reproductive phase and maturity (Table 3).Pandey *et al*. (2010) also reported lower consumption of heat units under delayed sowing.Amid the cultivarsJAKI-9218 utilized maximumheat units (GDD: 1888^{0}Cdays) as compared to cultivar Vijay (GDD: 1856 days ^{0}C) to attain various phonological phases and growing degree days. The differential behaviors to heat unit requirements and days required to reach the various phenological phases could be ascribed solely to their genetic makeup.

3.5 Heliothermal Units (HTU)

Heliothermal units (HTU) required to attain different phonological stages of chickpea are shown in Table 4. Early sown crop on 30^{th}October (44 MW) and 15^{th}November (46 MW) accumulated 13515 and 13130 °C days hour thermal units, respectively, from sowing to pod-seed development phase while for late sowingon 30^{th}November (12856 ^{0}C day hr), 15^{th}December (11649 ^{0}C day) and 30^{th}December (11737 ^{0}C day). HTU decreased with delay in sowing as the late sown crop suffer from high temperature later in the growing season. Late sowing compelled the plants to complete their life cycle with a short period of time resulting in decreased HTU.It was reported that HTU for different phenological stages decreased with delay in sowing as reported by Masoni *et al*. (1990).Among cultivars JAKI 9218 recorded more HTU (12706^{0}C day hr) over Vijay (12449^{0}C day hr). Sowing on 30^{th}October and 15^{th}November was found to be most suitable in harnessing the prevailing weather conditions in the region.

3.6 Heat use efficiency (HUE)

Heat use efficiency with respect to seed yield (Table 3) under different dates of sowing showed maximum with 15thNovember (0.96grain kg ha^{-10}C day^{-1}) sown chickpea and then 30thOctober(0.95 grain kg ha^{-10}C day^{-1}), further delayed in the sowing showed slips in the heat use efficiency of chickpea. Among cultivars heat use efficiency was higher with cultivar JAKI 9218 (0.69 kg ha^{-10}C day^{-1}) over Vijay (0.65 kg ha^{-10}C day^{-1}).

3.7 Correlation between agro-climatic indices and yield

The performance of high yielding chickpea under different temperature condition revealed that 25 to 30^{0}C temperature was optimum for better seed yield in chickpea. Though there was no perfect association between T_{max} and T_{min} at 50% flowering with yield, but strong linear regression was obtained between yield, and T_{max} at vegetative stage (R^2=0.761), T_{min} at pod to seed development phase (R^2=0.472), GDD and HTU values at vegetative phase (R^2=0.544; 0.496), 50% flowering (R^2=0.603; 0.643) and pod to seed development phase (R^2=0.762;0.519).

4.**Conclusion:**

Under irrigated condition sowing of *desi* chickpea cultivar (Vijay and JAKI 9218) can beextend up to 15thNovember without significant loss in grain yield.

Table 1: Effect of sowing dates and cultivars of chickpea on yield and economics

Treatment	Seed yield (kg/ha)				% decrease in yield	COC	GMR (Rs/ha)	NMR (Rs/ha)	BCR
	2011-12	2012-13	2013-14	Pooled					
Factor A. Sowing date									
30 Oct	2315	1846	1579	1913	--	24307	60748	36423	2.50
15 Nov	2267	1810	1586	1887	1.36	24322	59923	35606	2.46
30 Nov	1428	1097	905	1143	40.25	23947	36301	12346	1.52
15 Dec	837	667	1180	895	53.21	24777	28406	3630	1.15
30 Dec	520	415	847	594	68.95	24117	18860	-5254	0.78
CD at 5%	163.3	170	190	80.2	--	--	1990	1990	--
Factor B. Cultivar									
Vijay	1400	1100	1211	1237	--	24252	39275	15013	1.62

JAKI-9218	1547	1234	1227	1336	--	24335	42418	18087	1.74
CD at 5%	120.68	NS	NS	NS	--	--	NS	NS	--
Interaction	251.1	228.4	225.1	113.4	--	--	--	--	--

Table 1 a: Interaction effect of date of sowing and cultivar on seed yield of chickpea (Pooled of 3 years)

Date of sowing / **Cultivars**	30 October	15 November	30 November	15 December	30 December	Mean
Vijay	1771	1744	1060	864	745	1237
JAKI-9218	2055	2031	1226	925	444	1336
Mean	1913	1887	1143	895	594	
CD at 5%	113.4					

Table 2: Effect of sowing dates and cultivars of chickpea on yield attributes(Mean of 3 years)

Treatment	Plant height (cm)	No. of branches /plant	No. of pods/ plant	Weight of seed /plant (g)	100-seed weight (g)	Harvest Index (%)
Factor A. Sowing date						
30 Oct	44.26	12.17	51.63	6.93	19.72	42.64
15 Nov	43.03	12.20	51.43	6.80	19.52	41.91
30 Nov	39.28	10.12	40.73	4.47	19.11	38.86
15 Dec	34.33	8.07	37.43	3.70	18.51	33.16
30 Dec	31.68	7.19	22.10	2.73	17.24	32.46
CD at 5%	1.87	0.36	1.83	0.32	0.47	4.73
Factor B. Cultivar						
Vijay	37.77	19.30	29.30	16.67	11.00	37.77
JAKI-9218	39.10	6.99	30.90	17.93	17.00	39.10
CD at 5%						

Table 3: Heat use efficiency (HUE; kg ha^{-1}°C day^{-1}), relative temperature disparity (RTD) and relative humidity disparity (RHD)of chickpea varieties in terms of seed yield at different date of sowing.

Treatment	HUE	RTD (%)	RHD (%)
Factor A. Sowing dates			
D_1-30 October	0.95	55.86	63.82
D_2-15 November	0.96	55.87	63.26
D_3-30 November	0.59	55.34	63.24
D_4-15 December	0.52	55.05	62.77
D_5-30 December	0.35	52.85	64.22
Factor B. Cultivars			
V_1-Vijay	0.65	55.05	63.00

V_2-JAKI 9218	0.69	54.94	63.92

Table 4: Effect of accumulated T_{max}, T_{min}, GDD (^{0}C day) and HTU (^{0}C day hr) for days to vegetative, days to 50% flowering, days to pod-seed development phase (Mean of 3 years).

Treatment	Emergence					Days to vegetative phase					Days to 50% flowering phase					Days for pod to seed development phase				
	Days	T_{max}	T_{min}	GDD	HTU	Days	T_{max}	T_{min}	GDD	HTU	Days	T_{max}	T_{min}	GDD	HTU	Days	T_{max}	T_{min}	GDD	HTU
Factor A. Sowing dates																				
D_1-30 October	7	32.3	16.3	165	1068	40.5	31.3	14.3	866	6122	49.5	30.1	11.5	1105	7961	101.7	29.3	13.3	2012	13515
D_2-15 November	7	28.1	11.9	155	1132	40.5	30.4	13.2	826	6068	48.3	29.0	12.1	1040	7230	100.7	30.3	14.3	1975	13130
D_3-30 November	8	28.3	14.7	146	1197	36.0	29.6	12.2	749	5127	46.0	27.8	10.7	959	6427	94.7	31.5	14.3	1923	12856
D_4-15 December	8	26.2	11.0	157	1136	32.5	28.8	12.1	606	4046	42.5	29.2	14.0	889	5599	89.7	32.2	14.7	1727	11649
D_5-30 December	8	26.9	14.7	168	1075	32.5	28.7	12.8	622	3610	42.5	30.7	13.5	899	5318	85.8	34.0	16.5	1725	11737
Factor B. Cultivars																				
V_1-Vijay	8	30.6	13.7	162	1074	35.6	29.7	12.9	719	4893	44.8	29.4	12.4	958	6360	93.3	31.3	14.6	1856	12449
V_2-JAKI 9218	7	26.1	13.7	162	1074	37.2	29.8	12.9	749	5096	46.7	29.3	12.4	999	6654	95.7	31.6	14.6	1888	12706

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