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Influence of Thermal Time Requirement And Heat Use Efficiency in Yield Related Parameters in Chickpea Crop in Gujarat

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ABSTRACT

Investigate the effects of early and late sowing dates on yield and yield components of chickpea varieties. Results showed that the longer growing period of chickpea affected by the growing degree days, heat use efficiency and radiation use efficiency and positively characters contributing to yield such as plant height, pods per plant. 100-seeds weight and quality parameter as a protein content which in turn contributed to increased seed yield. Dahod yellow variety gave higher GDD, HUE and RUE and higher seed yield in October 15th sowing date. The degree of superiority of seed yield in early sowing date as compared to late was strongly affected by the environmental conditions and tolerance of varieties. The maximum GDD, HUE and RUE (1867 °C day^{-1}, 1.003 kg ha^{-1} °C day^{-1} and 0.090 g MJ^{-1}) and seed and fodder yield (1874 kg ha^{-1} and 2116 kg ha^{-1}) was recorded with Dahod yellow variety sown on October 30th.

KEYWORDS GDD, HUE, RUE, varieties, yield parameters, chickpea.

INTRODUCTION

Sowing time and variety are two important factors which influence crop performance including chickpea. The sowing time of chickpea is one of the most important factor that governs the crop phonological development and economic yield. The most important step towards maximizing yield of chickpea is to ensure that the phenology of the crop or cultivar is well matched to resources and constraints of the production environment (Summerfield ***et al***., 1990). Flowering time is important because environmental conditions during the reproductive phase have a major impact on grain yield. The onset of flowering often determines the entire crop duration (Egli., 1998). Normal sowing has longer growth duration which consequently provides an opportunity to accumulate more grain yield as compared to late sowing and hence forth manifested in higher grain and biological yield (Singh and Pal., 2003).

The total heat and radiant energy available to any crop is never completely converted to dry matted and grain yield depend upon genetic factors, sowing time and crop type (Rao ***et al***., 1999). The concept of heat growing degree days are based on the concept that real time to attain a phenological stages is linearly related to optimum temperature (Monteith, 1981). Influence of temperature on phenology and yield parameter of crop plants can be studied under field condition through accumulated heat units system. The efficiency of conversion of absorbed light into carbon varies with time, light intensity, temperature and water availability (Schapendonk ***et al***., 1998). Extensive experimentation (Monteith, 1990) has shown that biomass formed per unit intercepted light, HUE (heat Use Efficiency, ε, g dry matter MJ^{-1}) is constant. Therefore, we adopted a constant crop specific value of heat use efficiency. Keeping this in view, an attempts made to know the phenology and heat unit requirement of promising chickpea variety under different date of sowing condition under different crop environment in Gujarat.

MATERIALS AND METHODS

The field requirement were conducted during ***rabi*** 2010-11, 2011-12 and 2012-13 at the Pulse Research Station of Junagadh Agricultural University, Junagadh, Gujarat, India (21° 31' N and 70° 33' E and altitude 83 mls.) with chickpea (***Cicer arietmum***) cultivar Dahod Yellow, GG-1, JG 16 (SAKI 9516), GJG 0619. The climate is subtropical humid with warm summer and dry winter. The experiment was laid out in strip plot design with date of sowing as the main plot and varieties levels as sub plot factors, replicated three times. The experiment was sown for four date of sowing, 30th October, 15th November, 30th November and 15th December. 15th December. All the cultural operation and plant protection measures were followed as per recommendation. At physiological maturity,10 plants from each plot were selected randomly from the rows, sun dried and then plant height, numbers of pods per plant and 100-seeds weight were determined. To determine seed yield and fodder yield harvested in rows of each plot.

GDD determining the mean daily temperature and subtracting it from the base temperature needed for additional growth rate are considered. GDD are calculated by taking the average of the daily maximum and minimum temperatures compared to a base temperature, T_{base} (5°C). As an equation:

$$GDD = \frac{T_{\max} + T_{\min}}{2} - T_{\text{base}}.$$

(If the mean daily temperature is lower than the base temperature then GDD=0)

Daily value of maximum and minimum temperature were used to calculate the accumulated heat unit/GDD and heat use efficiency (HUE, Wilsie, 1962) for different stages of crop growth using base temperature as 5°C (Iwata, 1975).

$$\text{HUE (kg ha}^{-1}\text{ day}^{-1}\text{ °C)} = \frac{\textit{Biomass yield}}{\textit{Accumulated Heat Units}}$$

Radiation Use Efficiency (RUE) was calculated as the ratio of the biological yield (BY) to intercept Photosynthetically Active Radiation by the crop canopy. Growth in biomass is calculated as proposed by Monteith (1977) from intercepted radiation and the efficiency with which energy is converted into dry matter.

$$\text{RUE (g/MJ)}: \frac{dW}{dt} = \varepsilon Q$$

Where, dW/dt the daily biomass growth rate (g m^{-2} d^{-1}), ε the light use efficiency (g. MJ^{-1}) and Q the intercepted Photosynthetically Active Radiation (MJ m^{-2} d^{-1}).

The phenological stages like initiation of flowering (IF). The period from sowing (S) to initiation of flowering was termed as vegetative phase while initiation of flowering to end of flowering (EF) is termed as reproductive phase and end of flowering to harvest is termed as maturity phase (PM), Stover and grain yield was recorded.

Cumulative heat units/GDDs
Higher accumulated heat units for 30th October sowing date and 15th December in the early growth phases which due to initial higher temperatures experienced. Further, 30th October and 15th November sown chickpea crop with 1867 to 1741 accumulated heat units proved to be the best range to attaining the maturity for better yields, indicated best sowing time from 1st to 2nd week of November for sowing of chickpea in the region.

Heat use efficiency
Different sowing environments had influenced the heat use efficiency of chickpea (Table 1). The higher heat use efficiency during early growth phases viz., sowing to 45 DAS (vegetative phase) and 45-90 DAS (reproductive phase) reflect congenial temperatures experienced during duration. Further, at later stages increased temperature 90 DAS in 30th November and 15th December sowing treatments lowered the heat use efficiency as compared to 30th October and 15th November sowings. Higher heat use efficiency (Table 1) and higher chickpea yield (Table 2) was recorded when crop was sown on 30th October and 15th November. Late sown crop was less efficient than the earlier sown crop. This was due to higher temperature experienced during reproductive phase by the late sown crops, which causes more losses in photosynthesis by increasing photo-respiration (Zelitch, 1967) noticed that photo-respiration was greater with increasing temperature. Maturity days had pronounced effect of date of sowing and drastically reduced from 120 days for 30th October to 100 days for 15th November sown crop. The decrease in maturity days in wheat crop due late sowing have also been reported by Singh ***et al.***, 2001.

RESULTS AND DISCUSSION
Variability in chickpea varieties for yield and yield components had been reported by (Yucel and Anlarsal. 2008, Chaitanya and Chandrika., and 2006). We also found that all characteristics were affected by sowing dates. The highest plant height (44.3 cm), pods per plant (60.1 kg ha^{-1}), 100-seeds weight (16.20 g), Protein content (24.2 %), seed yield (1874 kg ha^{-1}) and fodder yield (2116 kg ha^{-1}) were recorded on October 15th sowing date (Table 2).

Growing degree days (GDD), heat use efficiency (HUE) and radiation use efficiency were computed. The base temperature of 5.0 °C was used for computation of GDD on daily basis (Leong and Ong, 1983). The agro-meteorological indices were computed using the daily meteorological data. The days to complete different phenological stages and growth parameters were recorded. Heat use efficiency (HUE), which is a measure of amount of dry matter or grain yield produced per unit of GDD, was worked out as per procedures reported by Sahu ***et al***., (2007).

The grain yields were differed significantly within different dates of sowing. The crop sown on 30th October recorded the highest grain yield which was due to higher yield attributes. The significant reduction in grain yield was recorded when sowing was delayed beyond December 15th. It was significantly higher than other sowing dates. The higher value of yield in case of early sowing over delayed ones could be attributed to availability of optimum environmental conditions for growth and development of crop which might enhance accumulation of photosynthates from source to sink. The greater reduction in yield of chickpea crop under delayed sowing situation was attributed to decrease in season length might have an effect by reduction in its potential yield and hastened the crop phenological development, thereby causing significant reduction in chickpea yields. (Iliadis., 2001)

In case of varieties, the highest seed (1874 kg ha^{-1}) and fodder (2116 kg ha^{-1}) yield was recorded by Dahod yellow variety. The grain yield was the lowest for JG 16 (SAKI 9516), GG-1 and GJG at different date of sowing. Grain yield was significantly influenced by different varieties at different sowing date at different growth stages. (Omid and Parviz, 2012)

Data indicated that plant height was significantly affected by varieties. The increase plant height (44.3 cm) were achieved in Dahod yellow at October 30th date of sowing which was statistically at par with November 15th and November 30th at GJG 0619 variety. Non- significant interaction was found between sowing dates and varieties with regard to pods per plant. 100-seed weight and quality parameter as a protein content. (Table 2).

The growing degree days (GDD) ranged from 1579 °C day^{-1} to 1867 °C day^{-1} across the sowing date and 1681 °C day^{-1} to 1762 °C day^{-1} across different varieties at different growth stages. The growing degree days were found to be higher at different dates of sowing (Table 1). Higher growing degree days from sowing to maturity were recorded in October 30th date of sowing and GDD reduced with delayed sowing. The requirement of GDD was higher for normal growing condition than late growing condition. This was due to longer period for all phenological stages in the normal growing condition. The late sowing decreased the duration of phenological stages as compared to normal sowing due to fluctuated unfavourable high temperature.

Crop sown on October 15th showed significantly higher heat use efficiency of 1.003 kg ha^{-1} °C day^{-1} (Table 1). The heat use efficiency was decreased with delay in sowing. The higher heat use efficiency in timely sowing could be attributed to the highest grain yield. As the temperature was optimum throughout the growing period crop utilized heat more efficiently and increased biological activity that confirms higher yield. Similar relationship was also expressed by Rajput ***et al***., (1987) in different dates of sowing. The heat use efficiency found more in case of Dahod yellow variety (0.887 kg ha^{-1} °C day^{-1}) compared to other varieties under investigation.

The radiation use efficiency (RUE) was observed in the first date of sowing (30th October) and the lowest RUE found in case of the last date of sowing (15th December). The requirement of RUE was higher for early growing condition than late sowing of chickpea varieties.

CONCLUSION
To present study, the first date of sowing (30th October) recorded the significantly seed and fodder yield as compared to the other date of sowing. All varieties except Dahod yellow variety gave higher seed and fodder yield obtained with October 30th sowing date. The crop sown on October 30th required maximum growing degree days which was reduced at subsequent delay in sowing time and recorded highest for October 30th and lowest for December 15 sown crop. It also took maximum growing degree days, and showed higher heat use efficiency and radiation use efficiency than chickpea varieties.

Table 1: Effect of different date of sowing and varieties on GDD, HUE and RUE of chickpea.

Treatment 2010-11		GDD (°C day^{-1})				HUE (kg ha^{-1} °C day^{-1})				RUE (g MJ^{-1})			
		2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
Date of sowing (D)													
D_1	30th October	1779	1963	1858	1867	1.144	1.154	0.712	1.003	0.103	0.104	0.064	0.090
D_2	15th November	1642	1734	1846	1741	1.222	1.110	0.646	0.993	0.110	0.100	0.058	0.089
D_3	30th November	1644	1679	1770	1698	0.695	0.986	0.617	0.766	0.062	0.088	0.055	0.068
D_4	15th December	1560	1493	1684	1579	0.729	0.798	0.615	0.714	0.064	0.070	0.054	0.063
Varieties (V)													
V_1	Dahod Yellow	1691	1825	1771	1762	0.895	1.090	0.677	0.887	0.081	0.098	0.061	0.080
V_2	GG-1	1642	1695	1825	1721	0.959	1.006	0.664	0.876	0.086	0.091	0.060	0.079
V_3	JG 16 (SAKI 9516)	1688	1751	1818	1752	1.029	0.976	0.623	0.876	0.092	0.088	0.056	0.079
V_4	GJG 0619	1607	1654	1783	1681	0.031	0.987	0.616	0.545	0.082	0.086	0.054	0.074

Table 2: Effect of different date of sowing and varieties on growth and quality parameters & seed and fodder yield of chickpea.

Treatments		Plant height (cm)	Pods / plant (kg/ha)	Test weight(g)	Protein %	Seed yield (kg/ha)	Fodder yield (kg/ha)
Date of sowing (D)							
D_1	30th October	44.3	60.1	16.2	24.2	1874	2116
D_2	15th November	42.1	56.1	15.6	24.0	1707	1992
D_3	30th November	43.3	53.1	14.9	23.8	1297	1778
D_4	15th December	39.7	60.1	14.9	23.5	1121	1618
LSD (p=0.05)		3.6	NS	NS	NS	236.8	246
Varieties (V)							
V_1	Dahod Yellow	43.2	53.9	14.7	23.9	1567	1921
V_2	GG-1	41.6	52.1	14.5	23.8	1497	1874
V_3	JG 16 (SAKI 9516)	41.2	56.2	15.1	23.9	1226	1875
V_4	GJG 0619	43.1	51.6	17.3	24.1	1409	1833
LSD (p=0.05)		1.47	10.3	0.56	NS	NS	NS

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