Growth and thermal unit of chickpea(*Cicer arietinum* L.) genotypes under variable weather conditions of Eastern Uttar Pradesh

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SUMMARY

A field experiment was conducted during winter season of 2004-05 and 2005-06 at Faizabad to study the growth and thermal unit requirement of chickpea (*Cicer arietinum* L.) genotype under variable weather conditions. Results revealed that November 5 produced significantly higher growth due to fulfillment of optimum thermal requirement for various plant processes. Delay in sowing (November 20) with temperature 20.7^{0}C. reduced the crop duration by 20 days over sowing done on October 20 and 10 days over sowing done on November 5 with 23.1^{0}C.temperature. "K850" was found more conducive for growth and higher thermal unit. Heliothermal unit 16751 (degree days hr) and photothermal unit 22267 from sowing to maturity produced the higher yield of chickpea under agroclimatic conditions of eastern Uttar Pradesh.

Key words : Growing degree days, Thermal unit, Chickpea, *Cicer arietinum*, Genotypes, Yield.

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Chickpea (*Cicer arietinum* L.) is grown in India during post-monsoon and winter season as it requires cool and dry weather conditions for optimum growth. In India, it is grown in area of 6.76 million hectare with annual production of 5.56 million tones and average productivity 8.41 q/ha. Crop is predominantly grown under rain fed conditions and is raised mainly on conserved soil moisture. Sowing dates/sowing temperature has been proved to be one of the most non-monetary inputs affecting the yield of chickpea. Sub-optimal photo thermal requirement during crop growing season are known to have profound effect on productivity. Selection of sowing time is important to exploit the environmental conditions during the growth of chickpea for maximum production. Higher temperature about 30-35^{0}C has a detrimental effect on growth of chickpea.

Solar radiation is the ultimate source of energy that sustains the crop productivity and governs the distribution of photosynthates among different organs of plants. The dry matter accumulation and distribution during different growth stages ultimately affect the yield of crop. Delay in sowing causes early maturity resulting drastic reduction in yield. The yield of chickpea fluctuates as it responds differently due to the variation in the environment and thermal requirements of a given genotypes in a particular agro-climatic condition. The productivity of chickpea in eastern U.P. is quite below which needs to be improved by climatic and resource management (Shendge *et al.*, 2002). Keeping this in view, attempts have been made to assess growth, development and thermal indices under varying sowing dates.

MATERIALS AND METHODS

The field experiment was conducted during winter season of 2004-05 and 2005-06 in sandy loam soil at the experimental farm of N.D.University of Agricultural Technology, Kumarganj, Faizabad (U.P.) India. To study the growth and thermal unit of chickpea genotypes under variable weather conditions. Geographically the experimental site was situated at 26^0 47' N latitude, 82^0 12'E longitude and at an elevation of 113 m in the north indo-gangetic plain. The experiment was laid out in factorial RBD design, consisting 12 treatment combinations comprised of three sowing dates (sowing on October 20 with temperature 25.7^{0}C, November 5 with temperature 23.1^{0}C and November 20 with temperature 20.7^{0}C) and four genotypes of chickpea (K-850, Awarodhi, Uday and Radhey) with three replications. Soil of the site was medium in fertility and saline in reaction having pH 8.38, Electrical conductivity-0.51, organic carbon(0.45%) with available N, 132.5 kg/ha, available P_2O_5, 16.4 kg/ha and available K_2O,

340.37 kg/ha. Sowing of seeds was done in rows, 30 cm apart. An amount of 20 kg N+40 kg P_2O_5 were applied through urea and single SSP and given as basal just below the seed. Leaf area of each plant was measured by automatic leaf area meter(model no. LI-251) and Leaf area index(LAI), Growing degree day(GDD), Photothermal unit(PU) and Heliothermal unit (HU) were calculated as per following formula:-

$$\text{LAI} \quad \frac{\text{Leaf area (cm}^2\text{)}}{\text{Ground area (cm}^2\text{)}}$$

$$\text{GDD } (^0\text{C days}) = \frac{\text{Tmax. + Tmin.}}{2} - \text{Base temperature}$$

Base temperature for chickpea= 5^0C

$$\text{PU}(^0\text{C day hrs.}) = \text{p GDD } (^0\text{C days}) \text{ x day length}$$

$$\text{HU}(^0\text{C day hrs.}) = \text{p GDD } (^0\text{C days}) \text{ x actual BSS}$$

RESULTS AND DISCUSSION

Effect of sowing dates:

Thermal indices during different phenophases:

Days taken to vegetative stage was recorded maximum (112 days) and minimum (96 days) when crop was sown on 20th October and 20th November, respectively. Delay in sowing by one month reduced the vegetative phase by 19 days over 20th October sowing and 10 days over 5th November sowing (Table 1). The maximum GDD to reach maturity (2318.20 days) was recorded at 20th October followed by 2042.90 days on 5th November while minimum GDD 1864.10 days was observed on 20th November which indicated that the crop exposed sub-optimal thermal regime with delay in sowing (Agrawal *et al.*, 2002). The requirement of Heliothermal

Table 1: Thermal indices during different phenophases of chickpea as affected by various treatments

Treatments	Thermal indices	Emergence	Vegetative	50% flowering	Podding	Maturity
Sowing dates	Days taken	6	112	125	149	166
	GDD	106.4	1351.3	1614.1	1917.1	2318.2
D_1	PTU	1159.8	14731.9	17601.3	20896.4	25386.3
October 20	HTU	872.5	11082.7	13234.8	15720.2	19179.9
D_2	Days taken	7	102	120	138	157
November 5	GDD	116.9	1216.5	1464.8	1734.7	2042.9
	PTU	1289.0	132.60.2	15966.3	18908.5	22267.8
	HTU	967.6	10057.5	12011.3	14224.8	16751.9
D_3	Days taken	8	96	111	126	146
November 20	GDD	118.20	1012.9	1303.5	1495.64	1864.1
	PTU	1296.2	12125.7	14208.5	16302.7	20551.2
	HTU	969.2	9122.1	10688.9	12264.2	15460.7
Genotypes	Days taken	7	103	119	138	158
	GDD	117.3	1236.8	1452.3	1738.7	2100.0
K 850	PTU	1278.6	13481.5	15829.7	18952.4	22944.5
	HTU	961.9	10142.1	11908.6	14457.7	17861.0
	Days taken	6	101	117	135	154
	GDD	114.2	12152.2	1452.3	1693.5	2080.0
Awarodhi	PTU	1245.2	13246.0	15829.6	18459.9	22673.3
	HTU	936.7	996.1	11808.5	13887.0	17261.1
	Days taken	5	85	108	134	153
	GDD	116.2	1216.2	1453.3	1683.5	2010.2
Uday	PTU	1266.2	13257.	15840.6	18350.5	22619.2
	HTU	953.1	9731.6	11916.8	13804.9	17056.3
	Days taken	6	102	118	137	157
	GDD	116.4	1236.8	14402	1738.6	2085.0
Radhey	PTU	1268.5	13372.2	15807.3	18950.4	22844.0
	HTU					

and photothermal unit to attain different phenophases could be seen in Table 1. Heliothermal unit from sowing to maturity ranged between 15460.70 to 19179.90^{0}days hr. and photothermal unit ranged from 20551.20 to 25386.30^0 days hrs. Heliothermal and photothermal unit was recorded highest in 20th October followed by 5th November due to higher growing degree days(Hundal *et al.*, 2005) while lowest value was recorded at 20th November.

Leaf area index and drymatter:

LAI and dry matter yields were significantly influenced by sowing dates. Significantly higher LAI and dry matter accumulation was obtained when sown on 5th November over 20th October and 20th November. However lowest LAI and drymatter were recorded in when sown on 20th November at all the stages.(Table 2) Higher LAI and drymatter accumulation in 20th October sowing might have due to increased number of green leaves and higher number of branches per unit area.

Relationship developed between GDD and LAI of chickpea sown on 5th November was found cyclic. Highest (2.8) LAI was recorded with GDD between 1300 to 1500^{0}C. Relationship between GDD and dry matter of

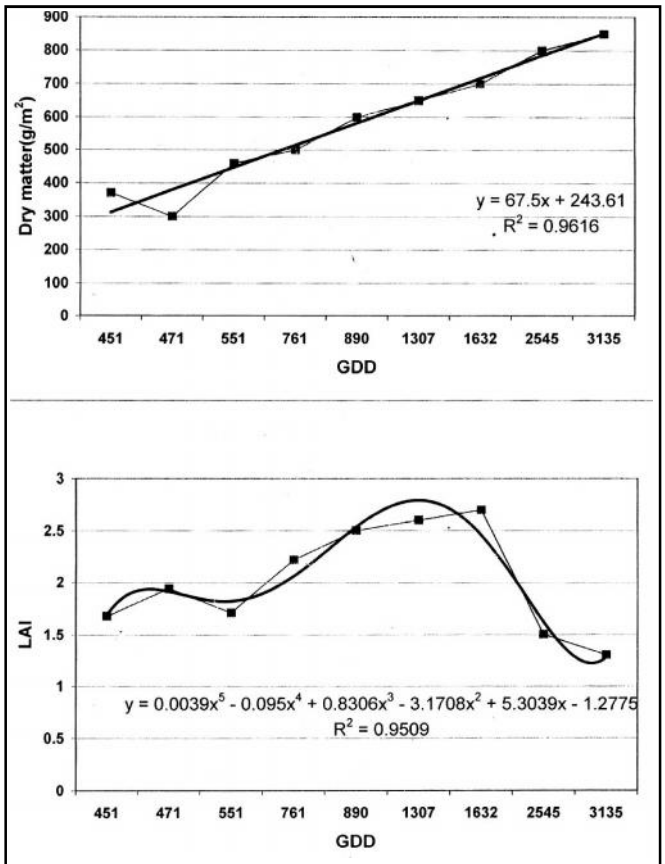

Fig. 1 : Relationship between dry matter and leaf area index and GDD of chickpea sown on November 05

Table 2 : Leaf area index and dry matter (g/m^2) of chickpea as affected by different treatment

Treatments	Days after sowing								
	15	30	45	60	75	90	105	120	135	AH
Sowing dates										
October 20	0.12(36.14)	0.17(125.06)	0.54(233.71)	1.59(302.42)	1.94((374.98)	2.37(492.92)	2.56(575.68)	2.66(634.45)	1.38(690.56)	0.59(752.32)
November 5	0.14(38.16)	0.21(134.18)	0.58(247.25)	1.71(321.05)	2.12(497.01)	2.54(627.52)	2.70(694.09)	2.80(774.05)	1.52(834.12)	0.62(878.87)
November 20	0.11(31.35)	0.14(107.01)	0.50(204.91)	1.49(267.92)	1.58(330.11)	2.09(438.87)	2.32(482.39)	2.43(547.80)	1.24(624.28)	0.52(665.85)
S.E.±	0.01	0.01	0.01	0.03	0.03	0.05	0.05	0.05	0.02	0.01
C.D. (P=0.05)	0.01	0.01	0.03	0.09	0.10	0.16	0.16	0.15	0.08	0.03
Genotypes										
K 850	0.13(37.51)	0.19(130.10)	0.58(244.29)	1.68(316.69)	2.05(425.79)	2.53(543.45)	2.76(585.62)	2.88(683.37)	1.48(748.55)	0.62(795.50)
Awarodhi	0.12(35.51)	0.16(116.60)	0.52(215.48)	1.53(280.10)	1.73(378.62)	2.16(498.62)	2.30(528.58)	2.40(623.85)	1.32(687.11)	0.55(738.89)
Uday	0.11(31.56)	0.15(112.58)	0.50(211.44)	1.50(276.06)	1.70(374.60)	2.12(494.58)	2.28(524.59)	2.38(619.81)	1.28(683.07)	0.51(735.85)
Radhey	0.13(36.25)	0.18(129.05)	0.56(243.28)	1.65(315.67)	2.04(423.79)	2.51(542.43)	2.73(584.61)	2.86(681.37)	1.44(746.55)	0.60(792.48)
S.E.±	0.01	0.04	0.01	0.03	0.04	0.06	0.64	0.06	0.03	0.01
C.D. (P=0.05)	0.09	0.01	0.06	0.11	0.11	0.18	0.18	0.05	0.09	0.03

Dry matter is given in bracket

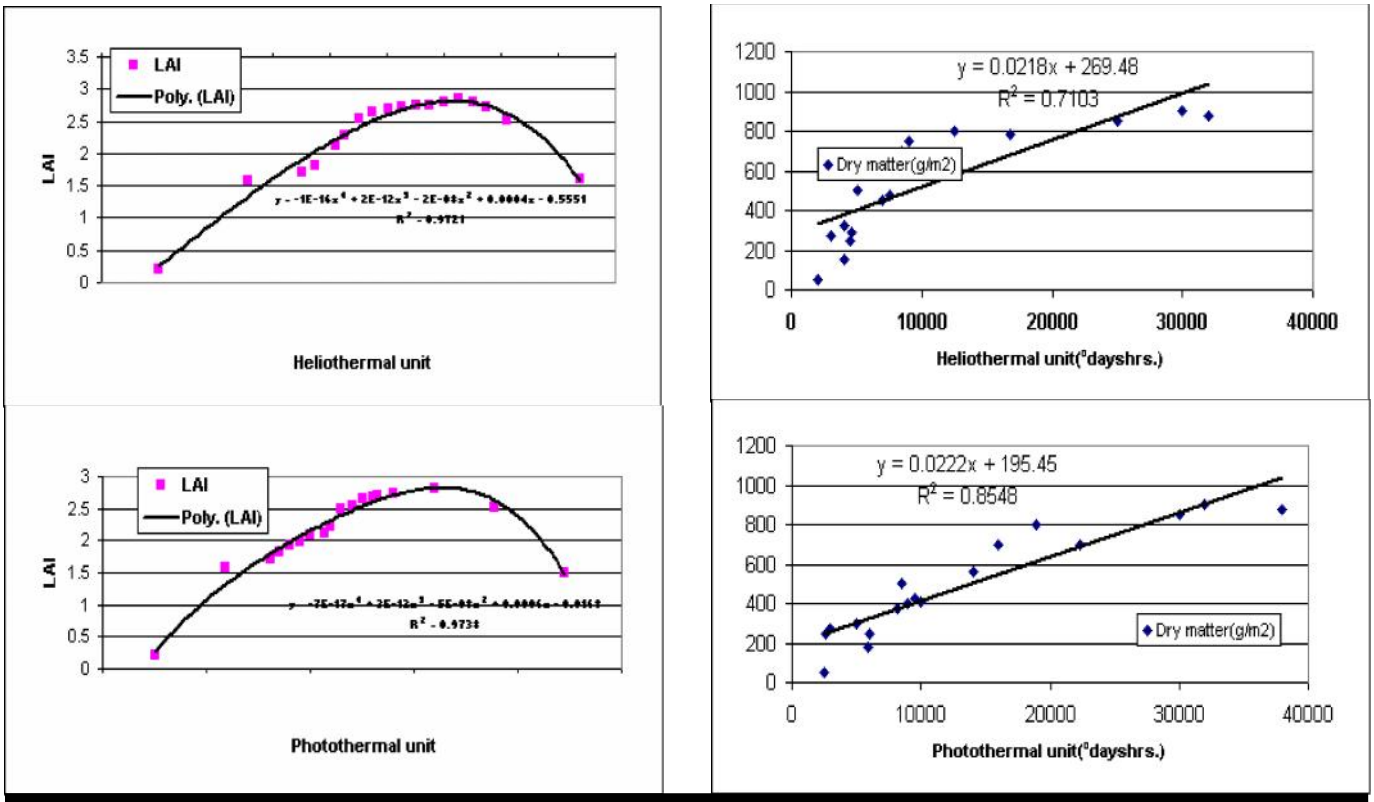

Fig. 2 : Variation of LAI and dry matter with heliothermal and photothermal unit (°days hr.) of chickpea sown on November 05

chickpea sown on 5th November was linearly correlated with R^2=0.96.(Fig. 1).

LAI was non linearly related with heliothermal and photothermal units of chickpea. Highest LAI was recorded with heliothermal unit of 12000°days hr and photothermal unit of 15000°days hr. while beyond which LAI was progressively decreased. Variation of heliothermal unit and photothermal unit with total dry matter of chickpea sown on 5th November was linearly correlated (Fig. 2). Every increase in heliothermal and photothermal unit by 1000°C days hrs., increased the dry matter to the extent of 90 g/m^2.

Yield and yield attributes:

Different sowing dates brought significant influence on seed yield. Highest seed yield of 24.4 q/ha was recorded, when sowing done on 5th November due to more number of branches, LAI, dry matter accumulation and higher test weight which was at par with crop sown on 20th October, while significant over sowing done on 20 November (Table 3). Crop sown on 5th November increased the seed yield by 14.5% and 17.7% over sowing done on 20th October and 20th November, respectively (Table 3). The lowest yield was obtained in 20th November due to poor partitioning of photosynthates from source to sink. Early sown crops (20th October) experienced high thermal regime(1351.6°C day)during vegetative phase, hence reduced the yield over crop sown on 5th November. Lower temperature, during reproductive phase were found more favourable for crop growth in 5th November sowing.

Effect of genotypes:

Thermal requirement under different environment:

K-850 genotype recorded comparatively higher days to attain different phenophases followed by Radhey, Uday. Different varieties had marked impact on GDD of chickpea. Maximum (2100°days) heat unit requirement from sowing to maturity was obtained in K-850, while minimum(2010° days) in Uday variety. Heliothermal unit and photothermal unit from sowing to maturity ranges between 17056°days to 17861°days hr and 22619°days to 22944°days hrs., respectively. Highest heliothermal and photothermal unit at all phenophases were obtained in K-850 followed by Radhey due to maximum days taken from sowing to maturity and lowest in Uday variety of chickpea.

Leaf area index and dry matter:

Higher LAI and dry matter was obtained in K-850 followed by Radhey due to higher number of branches and leaf area. These were significantly superior over Awarodhi and Uday in all the phenophases which

Table 3: Yield and yield attributes as affected by various treatments

Treatments	No. of pod/ plant	No. of seed/ plant	No. of seed/ pod	1000 seed weight (g)	Volume of 100 seed (cc)	Seed yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Sowing dates								
October 20	64.61	104.20	1.62	285.72	182.81	23.52	53.80	44.71
November 5	70.78	135.90	1.92	289.54	207.28	24.45	55.25	44.27
November 20	58.68	86.84	1.48	276.50	276.42	20.10	51.43	39.07
S.E.±	1.56	2.71	0.031	6.602	4.52	0.51	1.21	0.76
C.D. (P=0.05)	4.58	7.96	0.09	NS	13.27	1.50	3.6	2.25
Genotypes								
K 850	69.69	129.13	1.82	323.38	264.71	24.04	55.50	43.49
Awarodhi	61.89	99.00	1.62	252.39	190.34	22.60	52.90	42.28
Uday	58.39	80.72	1.49	238.45	170.67	20.79	51.08	40.60
Radhey	68.79	127.07	1.75	321.46	262.96	23.33	54.48	43.03
S.E.±	1.80	3.13	0.03	7.62	5.22	0.59	1.39	0.88
C.D. (P=0.05)	5.29	9.19	0.11	22.36	15.32	1.73	2.91	2.24

recorded lowest LAI and dry matter.

Yield and yield attributes:

Seed yield of chickpea was affected significantly due to different varieties. Significantly higher seed yield (24.04 q/ha) was recorded in K-850 variety followed by Radhey (23.33 q/ha) due to better growth and development particularly higher number of branches, dry matter accumulation, better utilization of heat and radiation which ultimately increased the seed yield by 12-15% over Awarodhi and Uday variety.

Conclusively, sowing temp. 23.1^{0}C which occurred on 5 November gave significantly higher growth and yields due to fulfillment of optimum thermal requirement for various plant processes. Delay in sowing on 20th November with temperature 20.7^{0}C reduced the crop duration by 20th days over sowing done on 20th October at 25.7^{0}C and 10 days over sowing done on 5th November with temperature 23.1^{0}C. K 850 genotype was found more conducive for growth and development. Heliothermal unit 16751 degree days hr. and photothermal unit 22267 degree days hr. from sowing to maturity produced the higher yield of chickpea in agroclimatic conditions of Eastern Uttar Pradesh.

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