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INFLUENCE OF DIFFERENT PLANTING DATES ON GROWTH RATE OF CHICKPEA *(CICER ARIETINUM* L.) GENOTYPES

MANISH KUMAR SINGH, P.S. DESHMUKH* and SUDHIR KUMAR**
Arid Forest Research Institute, Jodhpur, India.
*Division of Plant Physiology, I.A.R.I., New Delhi-110 012, India.
**Department of Botany, Kisan (P.G.) College, Simbhaoli, Ghaziabad, India.
Email: mksingh@icfre.org

About 90% of chickpea *(Cicer arietinum* L.) in the world is grown under rainfed conditions where it is subjected to heat stress. A field experiment was, therefore conducted to know the effect of high temperature on growth rate of twenty chickpea genotypes and thence to screen tolerant and susceptible genotypes grown under different planting dates. Pusa-1103 from north zone, KWR108 from east, RSG-963 form west zone and BDG-72 from south zones showed higher leaf area index (LAI), crop growth rates (CGR). Among the zones north zone genotypes comparatively required less accumulated heat units as compare to other zonal varieties. It means genotypes from this zone are early maturing and have higher yield because of better utilization of accumulated heat units.

Keywords : Accumulated heat units; Chickpea; Crop growth rate; GDD; Leaf area index.

Introduction

Chickpea *(Cicer arietinum* L.) is the third most important pulse crop in the world after dry beans and dry pea in the global farming community and is widely cultivated in West and South Asia and North African countries. It has been grown in semiarid regions of the world for hundreds of years. The major chickpea producers India, Pakistan and Turkey contribute 67.0, 9.5 and 6.7%, respectively to the world harvest. Latest estimate for 2007-08 indicate that the production of pulses in the country is 16.64 million tonnes from an area of 26.15 million hectares. Inspite of having largest area under chickpea in the world India's position in average productivity is yet to see major breakthrough to meet the per capita availability of 50 g pulses/day to alleviate proteins energy malnutrition, whereas the situation is quite different and there was a decreasing per capita availability of pulses from 69 g in 1961 to 37 g in 2004.

In northern India, however, late planting of chickpea is done after harvest of rice, early potato or cotton. Under such situations the crop has to be sown up to the end of November to mid-December. Such late sown chickpea crop experiences low temperature during seedling establishment time and high temperature at the end of the cropping season. Low temperature at initial stage of crop growth results in poor and slow vegetative growth, whereas high temperature at the end of cropping season lead to problem of poor biomass and forced maturity[1]. Strand[2] reported that early sowing in wheat increased the heat sum requirement by the cultivars because of longer duration. Bishnoi and Taneja[3] showed that with the increase of average temperature in the crop season, phonological stages are advanced rapidly due to availability of higher thermal units over a short period of time. this may result in forced maturity. One, thus, needs a variety, which take less GDD for physiological maturity. Ghadekar *et al.*[4] reported that early sowing resulted in highest accumulation of heat sum and photothermal units causing better growth and yield. Therefore, it was aimed to study the relative variation in leaf area development, crop growth rate of chickpea in twenty chickpea genotypes grown under different planting dates.

Material and Method

A field experiment was conducted at research field of the Indian Agriculture Research Institute; New Delhi during 2009-10. The experiment was laid out in RBD design, twenty chickpea genotypes were grown under three dates of sowing, *i.e.* 23rd October, 21st November and 18th December 2009. Total 180 plots of 3 × 1.8 m^{-2} area were made and plants were grown at a distance of 30 cm between rows and 10 cm within a row. The plant samples were collected for the study of leaf area index at 30, 60, 90 and 105 and for crop growth rate between 30-60, 60-90 and 90-105 days after sowing (DAS). The growing

Table 1. Leaf area index of chikpea genotypes as influenced by the time of planting.

	Genotypes	30DAS				60DAS				90DAS				105DAS			
		I	II	III	Mean	I	II	III	Mean	I	II	III	Mean	I	II	III	Mean
Check North Zone	Pusa-256	0.183	0.063	0.047	0.097	0.197	0.141	0.072	0.137	1.205	1.201	1.093	1.166	1.218	1.214	1.081	1.171
	C-235	0.175	0.041	0.038	0.085	0.235	0.059	0.058	0.117	1.298	1.087	1.073	1.152	1.311	1.090	1.062	1.154
	Pusa-362	0.216	0.077	0.049	0.114	0.271	0.055	0.109	0.145	1.327	1.093	1.137	1.186	1.340	1.106	1.125	1.190
	Pusa-372	0.215	0.041	0.096	0.117	0.264	0.085	0.121	0.156	1.332	1.122	1.140	1.198	1.345	1.135	1.280	1.253
	Pusa-1103	0.271	0.096	0.076	0.148	0.369	0.163	0.103	0.212	1.439	1.210	1.158	1.269	1.452	1.240	1.380	1.357
	BG-3004	0.134	0.049	0.028	0.070	0.166	0.048	0.056	0.090	1.197	1.074	1.121	1.131	1.210	1.087	1.106	1.134
	ZM	0.202	0.061	0.057	0.107	0.261	0.082	0.089	0.144	1.319	1.117	1.126	1.187	1.332	1.132	1.191	1.218
East Zone	KWR-108	0.271	0.072	0.028	0.124	0.286	0.143	0.043	0.157	1.339	1.205	1.194	1.246	1.352	1.218	1.180	1.250
	Radhey	0.180	0.073	0.105	0.119	0.207	0.207	0.151	0.188	1.243	1.292	1.176	1.237	1.256	1.305	1.163	1.241
	Pant G-186	0.166	0.036	0.027	0.076	0.268	0.082	0.070	0.140	1.301	1.116	1.084	1.167	1.314	1.129	1.072	1.172
	ZM	0.205	0.060	0.053	0.106	0.254	0.144	0.088	0.162	1.294	1.204	1.151	1.217	1.307	1.217	1.138	1.221
West Zone	RSG-143-1	0.311	0.044	0.044	0.133	0.445	0.112	0.057	0.204	1.551	1.158	1.106	1.272	1.564	1.171	1.092	1.276
	RSG-888	0.234	0.045	0.058	0.113	0.314	0.048	0.063	0.142	1.381	1.074	1.112	1.189	1.394	1.087	1.098	1.193
	RSG-963	0.253	0.066	0.047	0.122	0.483	0.154	0.093	0.243	1.512	1.122	1.036	1.223	1.625	1.235	1.126	1.329
	Pusa-261	0.301	0.032	0.086	0.139	0.325	0.124	0.083	0.177	1.416	1.170	1.067	1.218	1.429	1.183	1.153	1.255
	GNG-459	0.231	0.057	0.046	0.111	0.297	0.077	0.051	0.142	1.364	1.117	1.146	1.209	1.377	1.130	1.135	1.214
	ZM	0.266	0.049	0.056	0.124	0.373	0.103	0.069	0.182	1.445	1.128	1.093	1.222	1.478	1.161	1.121	1.253
South Zone	ICCV-10	0.178	0.045	0.040	0.088	0.204	0.066	0.041	0.104	1.221	1.096	1.167	1.161	1.234	1.109	1.156	1.166
	Chaffa	0.165	0.044	0.073	0.094	0.202	0.085	0.077	0.121	1.247	1.123	1.113	1.161	1.260	1.136	1.102	1.166
	BGD-72	0.269	0.094	0.057	0.140	0.319	0.171	0.077	0.189	1.489	1.215	1.120	1.275	1.502	1.228	1.109	1.280
	JG-11	0.136	0.073	0.056	0.089	0.204	0.181	0.066	0.150	1.226	1.255	1.160	1.214	1.239	1.268	1.148	1.218
	Vijay	0.367	0.059	0.066	0.164	0.530	0.037	0.069	0.212	1.664	1.060	1.088	1.271	1.677	1.073	1.077	1.276
	Phule-G 96006	0.215	0.047	0.030	0.097	0.261	0.079	0.061	0.133	1.323	1.117	1.099	1.180	1.336	1.130	1.087	1.184
	ZM	0.221	0.060	0.054	0.112	0.286	0.103	0.065	0.152	1.362	1.145	1.124	1.210	1.375	1.158	1.113	1.215
	Mean	0.232	0.056	0.055		0.300	0.099	0.075		1.359	1.150	1.129		1.342	1.164	1.137	
CD at 5%	Planting time (P)		0.009				0.013				0.052				0.039		
	Genotypes (G)		0.007				0.010				0.053				0.047		
	P × G		0.0127				0.021				0.091				0.083		

I=Oct.23,II=Nov.21,III=Dec.18, planting date

Table 2. Crop growth rate (g m^{-2} day^{-1}) of chickpea genotypes as influenced by the time of planting.

	Genotypes	Time of planting: 30-60 DAS				60-90 DAS				90-105 DAS			
		I	II	III	Mean	I	II	III	Mean	I	II	III	Mean
Check North Zone	Pusa-256	1.35	0.34	0.24	0.65	2.74	3.25	5.03	3.67	4.34	6.87	5.61	5.60
	C-235	1.09	0.49	0.17	0.59	3.02	4.10	4.12	3.74	4.57	5.37	4.24	4.73
	Pusa-362	2.11	0.49	0.35	0.98	4.15	4.52	4.40	4.36	6.03	3.48	4.29	4.60
	Pusa-372	1.29	0.57	0.14	0.67	3.26	3.91	4.28	3.81	5.90	4.58	3.73	4.74
	Pusa-1103	1.60	0.73	0.40	0.91	12.26	4.12	3.92	6.77	7.19	6.83	3.96	5.99
	BG-3004	1.26	0.51	0.20	0.66	2.75	4.26	4.36	3.79	5.34	4.87	4.31	4.84
	ZM	1.47	0.56	0.25	0.76	5.09	4.18	4.21	4.49	5.81	5.02	4.11	4.98
East Zone	KWR-108	3.04	0.50	0.28	1.27	4.95	5.55	5.08	5.19	4.52	3.51	4.07	4.03
	Radhey	1.90	0.35	0.18	0.81	3.11	5.07	4.86	4.34	5.20	5.15	5.03	5.12
	Pant G-186	2.06	0.41	0.17	0.88	11.32	2.54	4.10	5.98	10.05	3.91	4.21	6.06
	ZM	2.33	0.42	0.21	0.99	6.46	4.39	4.68	5.17	6.59	4.19	4.43	5.07
West Zone	RSG-143-1	1.37	0.64	0.17	0.73	9.00	4.26	4.39	5.89	7.20	4.73	4.28	5.40
	RSG-888	1.59	0.39	0.16	0.72	7.99	3.93	4.59	5.50	8.43	4.58	4.30	5.77
	RSG-963	2.04	1.45	0.26	1.25	7.90	4.22	4.56	5.56	7.17	4.45	4.75	5.46
	Pusa-261	2.16	1.09	0.14	1.13	6.00	4.27	4.92	5.06	5.49	3.85	3.65	4.33
	GNG-459	1.82	0.50	0.20	0.84	5.19	4.41	4.56	4.72	6.77	4.12	3.29	4.73
	ZM	1.80	0.81	0.19	0.93	7.22	4.22	4.60	5.35	7.01	4.35	4.05	5.14
South Zone	ICCV-10	1.86	0.45	0.19	0.83	5.66	4.00	4.62	4.76	6.71	4.59	4.36	5.22
	Chaffa	1.01	0.32	0.11	0.48	3.72	4.26	3.88	3.95	4.32	5.93	3.44	4.56
	BGD-72	2.78	0.70	0.25	1.25	9.78	4.52	4.49	6.26	8.85	4.90	4.26	6.00
	JG-11	2.63	0.31	0.25	1.06	6.73	5.39	4.74	5.79	7.78	3.98	4.49	5.42
	Vijay	2.02	1.33	0.20	1.18	11.42	4.88	4.28	6.86	9.97	4.22	3.41	5.87
	Phule-G 96006	1.20	0.57	0.17	0.65	1.07	4.10	4.14	3.10	9.23	4.21	3.73	5.72
	ZM	1.92	0.61	0.20	0.91	6.40	4.61	4.36	5.12	7.81	4.64	3.95	5.47
	Mean	1.77	0.55	0.22		5.58	4.13	4.58		6.31	5.01	4.43	
CD at 5%	Planting time (P)		0.052				0.187				0.224		
	Genotypes (G)		0.057				0.193				0.189		
	P × G		0.082				0.343				0.33		

I= Oct. 23, II=Nov. 21, III=Dec.18 planting date.

degree days (GDD) and other growth parameters were calculated by the following formulae:-
Tmax and Tmin represents the daily maximum and minimum temperatures and T_b is the base temperature and for chickpea T_b considered as 5° C.

Results and Discussion

Leaf area index (LAI) - A perusal of results revealed that LAI increased with the advancement of the crop age.

Growth parameters	Symbol	Formula for mean value over time interval $(T_2 - T_1)^b$	Unit	Reference
Leaf area index	LAI	$LAI = [(L_{A2} + L_{A1})/2] . (1/G_A)$	Dimensionless	Watson, (1947)
Crop growth rate	CGR	$CGR = (W_2 - W_1)/ [(T_2 - T_1) . G_A)]$	g m^{-2}day^{-1}	Blackman *et al.*, Black (1955)
Growing degree days	GDD	$GDD = \Sigma[(T_{max} + T_{min})/2-T_b]$	Dimensionless	Rajput,(1980)

G_A = ground area. T = time, W = weight, A = area

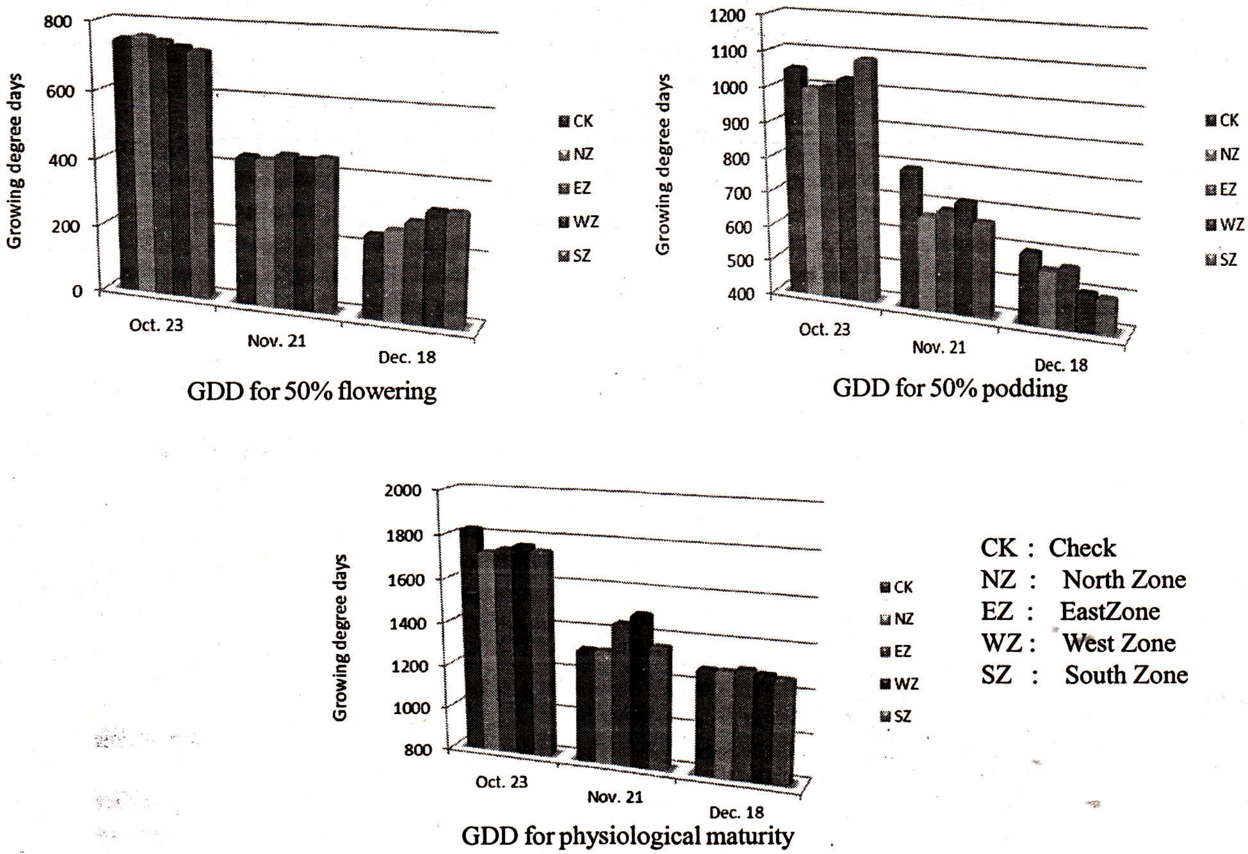

Fig.1. Growing degree days for different phenophages of chickpea genotypes as influenced by date of planting.

Table 3. Crop growth rate (g/m/GDD) of chickpea genotypes as influenced by date of planting.

	Date of planting											
	Oct. 23	Nov. 21	Dec. 18		Oct. 23	Nov. 21	Dec. 18		Oct. 23	Nov. 21	Dec. 18	
	30-60 DAS			Mean	60-90 DAS			Mean	90-105 DAS			Mean
Check	0.180	0.078	0.100	0.119	0.261	0.407	0.835	0.501	0.237	0.521	0.437	0.398
North	0.194	0.129	0.096	0.140	0.509	0.625	0.755	0.630	0.336	0.381	0.320	0.346
East	0.311	0.093	0.070	0.158	0.641	0.635	0.820	0.699	0.378	0.289	0.342	0.336
West	0.244	0.184	0.057	0.162	0.699	0.584	0.909	0.731	0.397	0.290	0.316	0.334
South	0.264	0.137	0.059	0.153	0.587	0.689	0.876	0.717	0.447	0.341	0.311	0.366
Mean	0.239	0.124	0.076		0.539	0.588	0.839		0.359	0.364	0.345	
C.D.(5%)	(P)	(Z)	P×Z		(P)	(Z)	P×Z		(P)	(Z)	P×Z	
	0.016	0.075	0.081		0.021	0.015	0.019		0.008	0.012	0.014	

Where P= Planting time and Z= Zonal mean

Significant differences were recorded in first planting followed by second and third planting at 30 DAS. The overall mean varied from 0.70 to 0.164. Regarding zonal mean west zone genotypes showed highest LAI (0.124) followed by south (0.112), than north (0.107) and least by east zone (0.106). Among the genotypes significantly higher LAI were recorded in genotypes Vijay (0.164), Pusa-1103 (0.148), BGD-72 (0.140), RSG-143-1 (0.133) and KWR-108 (0.124) in comparison to Pusa-256 (0.097). While at 60 DAS, the overall mean value varied from 0.243 to 0.104 and zonal mean from 0.144 to 0.182 respectively. Significant differences were also observed among all the twenty genotypes under study. At 105 DAS, the mean value of leaf area index ranged from 1.357 to 1.134 respectively. However, among three different planting conditions higher LAI was recorded in first planting (1.375) followed by second (1.158) and third planting (1.113). Among the genotypes, Pusa-1103 (1.357) from north zone, KWR-108 (1.250) and Radhey (1.241) from east zone, RSG-963 from west zone and BGD-72 (1.280) and Vijay (1.276) from south zone were having comparatively more leaf are index than their corresponding zonal mean.In general genotypes Pusa-1103, KWR-108, Radhey, RSG-143-1 and BGD-72 recorded high leaf area index and C-235 showed least LAI than national check Pusa-256 at all the growth stages and planting times. The genotypic differences, which expressed more clearly under various planting conditions in the present study are in the line with the observation reported by Hsiao[5], Boyer[6], Aggarwal and Koundal[7], Rangdale *et al.*[8] and Singh *et al.*[9]

Crop growth rate (CGR) - As indicated from the data CGR value increased progressively with the advancement of the crop age under all the three planting conditions. During 30-60 DAS overall mean values indicated wide variations in crop growth rate ranging from 0.48 in Chaffa to 1.27 in KWR-108 whereas, highest CGR was recorded in the first planting (1.81 gm^{-1} day^{-1}), intermediate in second (0.61 gm^{-1} day^{-1}) and least in the third planting (0.21 gm^{-1} day^{-1}). As far as genotypes are concerned significant differences were recorded among all the twenty genotypes studied. Among the zonal mean significant variation was seen between North and East zone however, between west and south zones variability was relatively narrow *i.e.* 0.93 in West and 0.91 in South zone. Between 60-90 DAS, the mean value of CGR ranges from 3.10 to 6.86 gm^{-1} day^{-1}. Whereas among the planting conditions significantly higher CGR was recorded in first (6.10) followed by third planting (4.47) than second planting (4.30). All the genotypes except Phule-G 96006 exhibited significantly higher CGR as compared to national check Pusa-256. Regarding zonal mean it was found maximum in west zone followed by east, then south and lowest in north zone. Regarding genotypes Pusa-362, Pusa-1103 from north, KWR-108 from east, RSG-143-1, RSG-963 from west and Vijay, BGD-72 from south zone were having higher CGR values compare to zonal mean.

With regard to CGR mean, during 90-105 DAS it varies from 4.03 (KWR-108) to 6.06 (Pan-G 186). In different planting conditions it shows similar trends as observed during 30-60 DAS *i.e.* significantly higher CGR was recorded in first planting (6.75) followed by second (4.71) and third planting (4.17) respectively. Whereas, in the genotypes studied, higher CGR was recorded in Pant G-186 (6.06) followed by BGD-72 (6.00) and Pusa-1103 (5.99) whereas least was recorded in KWR-108 (4.03). In general Pusa-1103 from north zone, Pant-G 186 from east zone, RSG-143-1, RSG-888, RSG-963 from west zone and BGD-72, Vijay from south zone, retained comparatively higher CGR values than national check in all successive growth stages in comparison to other varieties. This positive association between leaf area index and crop growth rate was also reported by Summerfield *et al.*[10], Boyer[6], and Singh *et al.*[9].

Accumulated heat units (GDD)- The Accumulated heat units or GDD taken to attain different phenological phase, *i.e.* 50 per cent flowering, 50 per cent pod formation and maturity by chickpea genotypes grown in different zones are presented in Fig. 1. In general the growing degree days (GDD) requirement for 50 per cent flowering, 50 per cent pod formation and maturity were higher in first planting followed by second and third planting. The genotypes from south zone require less GDD during Ist planting whereas in IInd planting north zone varieties and in IIIrd national check (Pusa-256) required less GDD during 50% flowering stage. However, for 50% pod formation and for physiological maturity north zone genotypes relatively required less GDD as compared to other zonal varieties. These low accumulated heat units were associated with early attainment of phenophases and high yield in different crop plants. Similar observations were also recorded by Ghadekar *et al.*[4], Lama *et al.*[11] and Paikaray and Chakravarti[12], Singh *et al.*[9]. In the present investigation all the phenophase in the south and north zone were attain early. This clearly shows that the genotypes from these zones are relatively faster in growth than other zonal varieties.

Crop growth rate per GDD - Growth rate per GDD of twenty chickpea genotypes as influenced by date of planting presented in Table 3. On the basis of the data recorded, it was observed that growth rate per GDD was significantly higher in 23rd October planting (0.239g) followed by 21st November planting (0.124g) and 18th December planting (0.076g) during 30-60 DAS. Between 60-90 DAS significant differences were recorded between all the three dates of planting, while at during 90-105 DAS significant differences were recorded in 21st November planting (0.364g) followed by 23rd October planting (0.359g) and 18th December planting (0.239g). The higher growth rate per GDD was recorded in early maturing and high yielding genotypes. Similar observations were also recorded by Bishnoi and Taneja[3], Sharma and Sonakiya[13], Ghadekar *et al.*[4], Lama *et al.*[11] and Paikaray and Chakravarty[12] in different crops. After national check, north zone genotypes showed significantly lower growth rate per GDD during 30-60 DAS and 60-90 DAS. Between 90-105 DAS west zone genotypes recorded significantly lower growth rate per GDD among all the zones. In general mean values of the growth rate per GDD was significantly higher in west zone between 30-60, 60-90 and south during 90-105 DAS. This clearly indicated that growth rate per GDD of west zone genotypes are faster than genotype from other zones. It means they are early maturing and high yielding because of better utilization of accumulated heat units.

This study indicated that chickpea genotypes Pusa-1103 from north zone, KWR-108 from east zone, RSG-963 from west zone and BGD-72 from south zone showed higher LAI, CGR per day at all the growth stages and planting dates. However, Pusa -261 showed least value of above three traits also need more GDD. It confirms that genotypes which have higher LAI, CGR per day and per GDD are better for increasing the chickpea productivity under stress environment. It means short duration/early maturing genotypes should be developed for such conditions.

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