Turkish Journal of Field Crops, 2010, 15(1): 79-83

RELATIONSHIP BETWEEN SOME PLANT GROWTH PARAMETERS AND GRAIN YIELD OF CHICKPEA (*Cicer arietinum* L.) DURING DIFFERENT GROWTH STAGES

Çağlar ÖZALKAN[1] Hasan T. SEPETOĞLU*[1] Ihsanullah DAUR[1] Oğuz F. ŞEN[1]

[1]*Ege University, Faculty of Agriculture, Department of Field Crops, 35100 Bornova-Izmir, Turkey*
**Corresponding Author: caglaroz@gmail.com*

ABSTRACT

Relation between some plant growth parameters (Leaf Area Index (LAI), Net Assimilation Rate (NAR), Relative Growth Rate (RGR), Leaf Area Ratio (LAR), Leaf Area Duration (LAD) and Crop Growth Rate (CGR)) with biomass and grain yield of chickpea (*Cicer arietinum* L.) during four growth stages (slow vegetative growth stage, linear vegetative growth stage, flowering stage and grain filling stage) were studied in the field experiments conducted at Bornova, Izmir. There was a wide variation among genotypes for all the growth parameters during the growth stages. Highest values of LAI and LAD were recorded for the period of linear vegetative growth stage; RGR and LAR through slow vegetative growth stage; NAR and CGR during flowering stage. Significant correlations among most of the growth parameters were found during all the growth stages. Most of the growth parameters except NAR also showed significant correlation with biomass. Mean grain yield was 1.86 t ha^{-1} that varied between 1.41 and 2.27 t ha^{-1} for different varieties.

Key words*:* Chickpea, growth parameters, growth stages, grain yield

INTRODUCTION

Plant growth analysis is considered to be a standard approach to study of plant growth and productivity (Wilson, 1981). Growth and yield are functions of a large number of metabolic processes, which are affected by environmental and genetic factors. Studies of growth pattern and its understanding not only tell us how plant accumulates dry matter, but also reveals the events which can make a plant more or less productive singly or in population (Ahad, 1986). In a crop the growth parameters like optimum LAI and CGR at flowering have been identified as the major determinants of yield (Sun et al., 1999). A combination of these growth parameters explain different yields better than any individual growth variable (Ghosh and Singh, 1998). Srivastava and Singh (1980) reported that growth process i.e. CGR, RGR and NAR directly influenced the economic yield of lentil. Similarly, Thakur and Patel (1998) reported that dry matter production, LAI, LAD, CGR, NAR and RGR are ultimately reflected in higher grain yield. Tesfaye et al. (2006) reported that attainment of high LAI that reduces soil water evaporation intercepts and converts radiation into dry matter efficiently and partitioning of the dry matter efficiently and partitioning of the dry matter to the seed is the major requirement of a high seed yield in grain legumes in semi-arid environments. Meadley and Milbourn (1971) stated that the major source of dry matter for pea yield was the photosynthate produced during the post flowering period. Srivastava and Singh (1980) revealed comparatively higher CGR in podding stage than in early growth stage in different varieties. Khan et al., (2004) studied twenty-two genetically diverse chickpea genotypes for their physiological efficiency to select the most desirable genotype/genotypes. Significant difference was found in grain and biological yield of different genotypes. Harvest index and economic yield showed significant positive correlation value of (r = +0.595), while negative correlation value of (r = -0.435) was observed between harvest index and biological yield. Karim and Fattah (2007) reported that LAI, NAR and CGR were increased to pod filling period, LAD was decreased to first pod setting and biomass was increased all vegetation period in chickpea. LAD was found to be highly correlated with biomass and seed yield of chickpea in Southern Spain conditions. (Lopez-Bellido et al., 2008)

Like other plants, chickpea that need much attention for increased yield because it is an important grain legume crop having high protein content (about 20%) (Liener, 1975) and high protein efficiency rate (PER) (Sepetoğlu, 2002). Unfortunately, literature about yield increase related to growth parameters formed during different growth stages of chickpea has not been found. That is why based on other crops the present study was conducted to determine the interrelation of different growth parameters and their relation with grain yield.

MATERIALS AND METHODS

Fifteen Kabuli chickpea genotypes were grown during three consecutive seasons at the agriculture research fields of Ege University, Bornova, Izmir, Turkey. Thirteen genotypes were taken from ICARDA, Syria as F4 generation that were selected as single plant from CIF4N-MR-94 population while two were local cultivars Izmir 92 and Ispanyol. The experiment was laid out in randomized complete block design. Net subplot size was 8.4 m^2. Sowing was done in mid November for the first year, mid January for the second and mid November for the third year as 35x5 cm row spacing. 20 kg/ha N and 60 kg/ha P_2O_5 were applied at the sowing.

The soil of the experimental site was clay loam. The chemical and physical properties of soil based on at 0-40 cm soil depth before the starting of the experiment are presented in Table1.

Table 1. Chemical and physical soil properties of the experimental area.

Soil property	Value	Interpretation
pH	7.83	Slightly alkaline
Organic matter (%)	2.76	Sufficient
Total N (%)	0.117	Sufficient
Available P (ppm)	2.02	Medium
Available K (ppm)	450	High
Available Ca (ppm)	6080	High
Available Mg (ppm)	278	High
Available Na (ppm)	25	Low
Available Fe (ppm)	3.72	Medium
Available Cu (ppm)	2.00	Sufficient
Available Zn (ppm)	2.28	Sufficient
Available Mn (ppm)	12.0	Sufficient
Clay (%)	37.28	
Silt (%)	14.68	
Sand (%)	30.16	

Plant samples were taken with 10 plants from each plot at the end of slow vegetative growth stage (76 days after sowing), beginning (123 days after sowing) and end (178 days after sowing) of flowering stage and 20 days after end of flowering stage (198 days after sowing). The duration between sowing and first sampling was indicated as slow vegetative growth stage (SG), duration between first sampling and second sampling as linear growth stage (LG), duration between beginning and end of flowering as flowering stage (FS) and 20 days later after end of flowering stage was called grain filling stage (GF).

Statistical analysis was done with standard ANOVA technique using TARIST program (Açıkgöz et al., 2004). Leaf area was determined by Flaeche program (A-Kraft, 1995). The following equations were used to calculate the different growth indices (Roderick, 1990; Sepetoğlu and Budak, 1994):

LAI = L / P, RGR = 1 / W * dw / dt, NAR = 1 / L*dw / dt, LAR = L / W, LAD = LAI * number of days from beginning of flowering to maturity, CGR = 1 / P * dw / dt

Where LAI = Leaf Area Index, RGR = Relative Growth Rate, NAR = Net Assimilation Rate, LAR = Leaf Area Ratio, LAD = Leaf Area Duration, CGR = Crop Growth Rate. W = Initial Dry Weight, dw = Dry Weight Production in t Days, dt = Number of Days, P = Ground Area, L = Initial Leaf Area.

RESULTS AND DISCUSSION

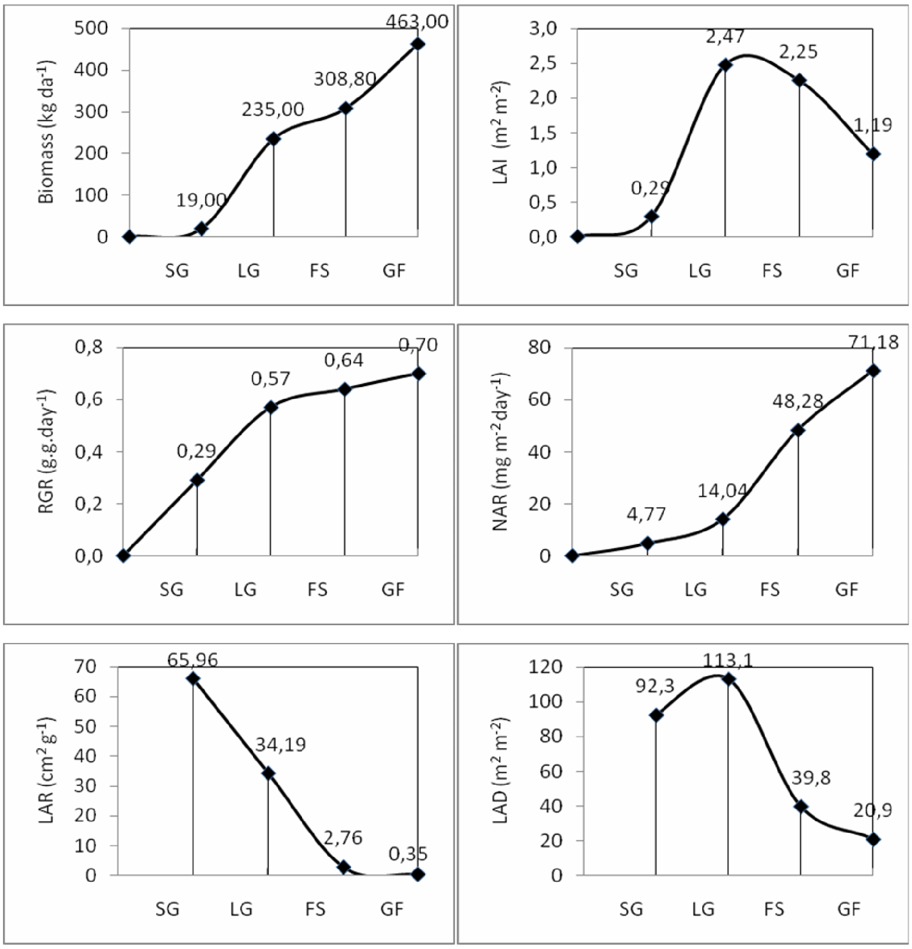
Three years field trial average values for biomass and some growth parameters are shown as dynamics (Figure-1) and in the form of maximum, minimum and mean during slow vegetative growth stage, linear vegetative growth stage, flowering stage and grain filling stage are given in Table-2.

Slow vegetative growth stage (SG), linear vegetative growth stage (LG), flowering stage (FS) and grain filling stage (GF).

Table 2. Average values of three years and 15 chickpea genotypes for biomass and some growth parameters in the form of maximum, minimum and mean during different growth stages.

Growth parameters	SG Min-max (mean)	LG Min-max (mean)	FS Min-max (mean)	GF Min-max (mean)
Biomass	167 - 211	1564 - 2629	(-526) - 2198	(-499) - 3517
(kg ha^{-1})	190	2160	738	1542
LAI	0.24 - 0.36	1.54 – 2.76	(-0.93) - (-0.61)	(-1.63) - (-0.64)
(m^2 m^{-2})	0.29	2.18	(-0.22)	(-1.06)
RGR	0.25 - 0.33	0.23 – 0.37	0.05 - 0.11	0.04 - 0.10
(g.g.day^{-1})	0.29	0.28	0.07	0.06
NAR	3.89 - 8.78	7.56 - 11.33	24.89 - 44.56	9.56 - 46.90
(mg m^{-2} day^{-1})	4.77	9.27	34.24	22.9
LAR	54.56 - 80.95	26.21 - 43.85	2.11 - 5.04	0.15 - 0.53
(cm^2 g^{-1})	65.96	34.19	2.76	0.35
LAD	72.3 - 111.3	97.1 - 129.3	27.9 - 47.2	7.0 - 28.3
(m^2 m^{-2})	92.3	113.1	39.8	20.9
CGR	0.26 - 0.34	3.43 – 6.08	9.74 - 17.18	18.21 - 39.32
(mg m^{-2} day^{-1})	0.29	4.86	13.67	28.39
Grain Yield	1.411 - 2.266			
(t ha^{-1})	1.862			

Slow vegetative growth stage (SG), linear vegetative growth stage (LG), flowering stage (FS) and grain filling stage (GF).



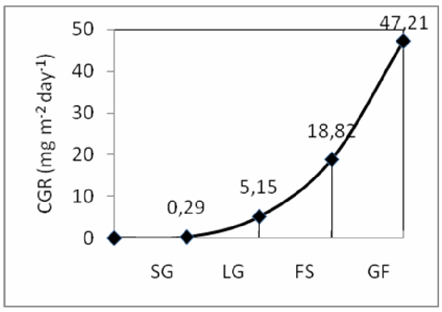


Figure 1. Dynamics of biomass and some growth parameters in chickpea as average of 15 genotypes and three years. Slow vegetative growth stage (SG), linear vegetative growth stage (LG), flowering stage (FS) and grain filling stage (GF).

During the different growth stages, growth parameters mean values variation were recorded as: biomass between 190 and 2160 kg ha^{-1}; LAI between -1.06 and 2.18 m^2 m^{-2}, RGR between 0.06 and 0.29 g g^{-1} day^{-1}; NAR between 4.77 and 34.24 mg m^2 day^{-1}; LAR between 0.35 and 65.96 cm^2 mg^{-1}; LAD between 20.9 and 113.1 m^2 m^{-2}; CGR between 0.29 and 28.39 mg m^{-2} day^{-1}. These results are in par with those of Srivastava and Singh, 1980; Ghosh and Singh, 1998. The maximum and minimum values of Table-2 indicate variation for growth parameters and biomass between genotype that could consequence in variation of yield parameters. These findings are in agreement with that of Ahad, 1986; Ghosh and Singh, 1998; Sun et al., 1999. LAI was recorded more during linear growth stage and during flower stage. During grain filling stage, there was decrease in leaf area and consequently in LAI. This finding is confirmed by Sun et al., (1999), Tesfaye et al. (2006), Karim and Fattah (2007). This shows that leaf area during flowering stage of plant is important factor for consideration of high yield. Mean values of the above ground weight showed higher increase during linear vegetative growth stage. Similar results was reported by Meadley and Milbourn (1971). Mean values of the fifteen genotype for grain yield varied between 1.41 t ha^{-1} (Ispanyol) and 2.26 t ha^{-1} (Genotype 11) which are supported by Khan et al., (2004).

The correlation between different growth parameters during different growth stages are shown in Table-3. In the experiment grain yield was significantly positive correlated with biomass, LAI and CGR at linear vegetative stage and with LAI, LAD at flowering stage. Also among the growth parameters there were found positive correlations. These outcomes are supported by the finding of Lopez-Bellido et al., (2008).

Table 3. Correlation among grain yield, biomass and some growth parameters during different growth stages.

Growth Parameters	Growth Stages	Grain yield	Biomass	LAI	RGR	NAR	LAR	LAD
Biomass	SG	0.030						
	LG	0.596*						
	FS	0.047						
	GF	0.091						
LAI	SG	0.148	0.742**					
	LG	0.642*	0.591*					
	FS	0.571*	0.136					
	GF	0.146	0.651**					
RGR	SG	-0.028	0.992**	0.736**				
	LG	0.030	0.470	0.127				
	FS	-0.060	0.424	0.526*				
	GF	-0.242	0.775**	0.267				
NAR	SG	-0.195	-0.323	-0.423	-0.284			
	LG	0.067	0.584*	0.107	0.286			
	FS	-0.040	0.774**	-0.120	0.311			
	GF	-0.273	0.461	-0.118	0.655*			
LAR	SG	0.174	0.820**	0.971**	0.797**	-0.513*		
	LG	0.023	-0.077	-0.070	0.735**	-0.283		
	FS	-0.420	-0.080	0.754**	0.517*	-0.334		
	GF	0.391	0.364	0.583*	0.155	0.188		
LAD	SG	0.405	0.433	0.621*	0.409	-0.415	0.632*	
	LG	-0.071	-0.476	-0.634*	-0.112	0.185	-0.049	
	FS	0.628*	0.028*	0.777**	0.399	-0.012	0.673**	
	GF	0.007	0.520**	0.706**	0.201	-0.153	0.586*	
CGR	SG	-0.083	0.953**	0.576*	0.965**	-0.247	0.656**	0.307
	LG	0.514*	0.972	0.707**	0.467	0.501	-0.067	-0.542*
	FS	-0.082	0.953**	0.354	0.638*	0.740**	0.104	0.171
	GF	-0.138	0.886**	0.347	0.946**	0.642*	0.235	0.285

Slow vegetative growth stage (SG), linear vegetative growth stage (LG), flowering stage (FS) and grain filling stage (GF).

CONCLUSION

The study revealed that growth was continue during all growth stages but grain yield is rather more related to growth in linear growth stage and flowering stage. LAI and LAD revealed most effective to final grain yield than dry weight. It is further concluded that for higher yield those varieties should be selected which has high LAI and LAD especially during linear growth and flowering stage. Beside this cultural practices that contribute to higher LAI and increase LAD should be managed in such a way that keep optimum LAI and LAD during flowering stage.

ACKNOWLEDGEMENTS

This work was supported by TÜBİTAK (The Scientific and Technical Research Council of Turkey) as TARP – 2174 project. The authors heartedly thank and appreciate TÜBİTAK for their support. No doubt TÜBİTAK encourage scientists in developing technology and have facility to disseminate the technology in their scientific journals. The present work was not possible without their support.

LITERATURE CITED

Açıkgöz, N., M.E. Akkaş, A.F. Moghaddam, K. Özcan, 1994. PC'ler için Veritabanlı Esaslı Türkçe İstatistik Paketi: TARİST, Tarla Bitkileri Kongresi Bitki Islahı Bildirileri. 25-29 Nisan 1994, İzmir. 264-267.

Ahad, M.A. 1986 Growth analysis of Rice bean (*Vigna umbellata* Thunb.) under different management practices and their agronomic appraisal. Ph.D. Dissertation in Agron.. 21-22.

A-Kraft, 1995. Flächen berchunung einer sw-Grafik. Justus Liebig Üni., Giessen, Deutschland.

Ghosh D.C., B.P. Singh. 1998 Crop growth modeling for wetland rice management. Environ. and Ecol. 16(2): 446-449.

H., Roderick, 1990. Basic growth analysis. Unwin Hyman Ltd., London. 112 pp.

Karim, M. F., Q. A. Fattah, 2007. Growth analysis of chickpea cv. Bari Chhola-6 as affected by folar sprey of growth regulators. Bangladesh J. of Bot., 36(2):105-110.

Khan A., M. Rahim, F. Ahmad and A. Ali, 2004. Performance of chickpea genotypes under Swat Valley conditions. J. of Res. (Sci), 15 (1): 91-95.

Liener, I., 1975. Antitryptic and other antinutritional factors in legumes. Pages 239-258. In Nutritional Improvement of Food Legumes by Breeding (Milner, M., ed.). John Wiley and Sons, New York.

Lopez-Bellido, F.C., R. J. Lopez-Bellido, S. K. Khalil, L. Lopez-Bellido, 2008. Effect of planting date on winter kabuli Chichpea growth and yield under rainfed Mediterranean conditions. Agron, J. 100(4):957-964.

Meadley, J.T. and G.M. Milbourn, 1971. The growth of vining peas III. The effect of shading on abscission of flowers and pods. *J. Agric. Sci.* 77(1): 103-108.

Sepetoğlu, H., N. Budak, 1994. Bitki Büyüme Analizi: Ege Üni. Ziraat Fak. Dergisi. 31(2-3): 297-301.

Sepetoğlu H., 2002. Yemeklik Dane Baklagiller. Ege Üni. Ziraat Fak. Yayınları Ders Notları: 24(4): 262 pp.

Srivastava, B.K., R.P. Singh. 1980. Morpho-physiological response of garden pea (*Pisum sativum* L.) to sowing dates. II- Growth analysis. *Indian J. of Hort.* 382-389.

Sun Y.F., J.M. Liang, J. Ye, W.Y. Zhu., 1999. Cultivation of super-high yielding rice plants. China Rice. 5:38-39.

Tesfaye, K., S. Walkerb and M. Tsubob, 2006. Radiation interception and radiation use efficiency of three grain legumes under water deficit conditions in a semi-arid environment. European J. of Agron. 25: 60-70

Thakur D.S., S.R. Patel., 1998 Growth and sink potential of rice as influenced by the split application of potassium with FYM in inceptisols of eastern central India. J. Potassium Res. 14(1/4):73-77.

Watson. D.J. 1952. The physiological basis of variation in yield. In “Advances in Agron. Academic Press Inc, New York Vol.4.101-144.

Wilson, W.J., 1981. Analysis of growth, photosynthesis and light interception for single plant stand. Ann. of Bot. 48:507-512.