Original scientific paper
10.7251/AGSY1404340A

COMPARISON OF YIELD PARAMETERS FOR KABULI CHICKPEA (*Cicer Arietinum* L.) GENOTYPES WITH THE FERN AND UNIFOLIATE LEAF TYPES

Abdulkadir AYDOĞAN*, Cemalettin Yaşar ÇİFTÇİ

Central Research Institute for Field Crops Ankara/Turkey
*Corresponding author : akadir602000@yahoo.com

Abstract

This research was conducted to determine the yield parameters of ten unifoliate- and ten fern-leafed Kabuli chickpea (*Cicer arietinum* L.) cultivars and lines, during the years of 2010 and 2011, in Ankara (Turkey) conditions. The experiment was planned in a randomized, complete-block design with split-plot and three replications.

In the study, unifoliate- and fern- leafed cultivars and lines were evaluated for pod and seed number per plant, seed and biological yield per plant, seed and biological yield per hectare, and harvest index. Results showed that pod and seed number per plant, seed and biological yield per plant, and harvest index were not found to be significantly different between the unifoliate, and fern- leafed types. On the other hand, seed and biological yield between leaf types of chickpea were significantly different at the 0.01 level.

The seed yields of fern- and unifoliate- leafed chickpea cultivars and lines were 2030 kg ha $^{-1}$ and 1560 kg ha $^{-1}$, respectively. The yield of the fern- leafed cultivar Inci was the highest with 2370 kg ha $^{-1}$. Biological yields of fern-and unifoliate- leafed cultivars were 5750 kg ha $^{-1}$, and 4580 kg ha $^{-1}$, respectively. The highest performance in biological yield was 6710 kg ha $^{-1}$, and was obtained with Canıtez cultivar in fern leaf.

Keywords: *Chickpea, fern leaf, unifoliate leaf, cultivars, traits*

Introduction

Chickpea (*Cicer arietinum* L.) is a self-pollinated, diploid, annual grain legume. It is one of the oldest annual grain legumes in the World. Chickpea seed is a major source of high-quality protein and carbohydrates in human diets. Chickpea maintains soil fertility through biological nitrogen fixation (Gan et al., 2003), and contributes to the agricultural sustainability of cropping systems in cereal-legume rotations (Miller et al., 2002).

Several morphological characters are used for classification of chickpea into two main market classes. The desi type, grown mainly in the Indian subcontinent, Iran and Ethiopia, is characterized by pink flowers and small (180-300 mg), usually angular, yellow-brown colored seeds. Desi cultivars account for about 85% of chickpea production, worldwide. The kabuli type is grown in countries of the Mediterranean region, West Asia, North Africa, Mexico, and more recently in Australia, and North America (FAO, 2004). It possesses white flowers, and large (200-680 mg), smooth, or wrinkled, light-colored seeds.

Kabuli chickpea has several leaf types including narrow leaflets, tiny leaflets, and bipinnate leaf, two of which are fern leaf and unifoliate leaf. The fern leaf is the most common leaf type, worldwide. The unifoliate leaf trait is controlled by a single gene (Muehlbauer and Singh, 1987). Multiple leaflets attached to a petiole characterize the fern leaf, while the unifoliate leaf is a single, large leaf attached to the petiole. The unifoliate leaf-type is associated with reduced resistance to ascochyta blight, a fungal disease caused by *Ascochyta rabiei* (Pass.) Labrousse (Gan et al., 2003). In some production areas, the fern leaf-trait may increase the green leaf area duration, compared to the unifoliate leaf trait (Anwar et al.,

2003). The distribution of genetic diversity in the kabuli is much narrower than in the more predominant, desi chickpea-type (Moreno and Cubero, 1978).
Evaluation of canopy architecture, and morphology, as selection criteria for chickpea, might increase yield. Leaf size in the upper canopy may affect yield response to plant population. Larger leaf size causing canopy closure was reported by Wells et al.(1993). Soltani et al. (2006) quantified the effects of temperature, photoperiod, and plant population, on plant leaf-area in chickpea, and developed a two-phase segmental model for leaf production per plant: Phase 1 when plant leaf number increases at a lower rate, and Phase 2, with a higher rate of leaf production per plant.

In this study, the following key questions were addressed:

Do fern and unifoliate leaf traits in kabuli chickpea differ in yield and associated traits?
Which leaf type, fern or unifoliate, is superior for seed production?

Materials and methods

Field experiments were conducted in 2010 and 2011, at Haymana Experimental Farm in Ankara (Turkey). In field trials, each plot consisted of four rows spaced 0.3 m apart. Each row was 5 m in length. The experiments were performed using a randomized complete block-design with split-plot and three replicates. Forty-five seeds were used per plot. Mean air temperature, rainfall, and relative humidity, were recorded on an automatic weather station near the plots at Haymana (Table 1). Types of soil in the experimental areas in 2010 and 2011 were clay-loam and clay, respectively.

Table 1. Rainfall (mm), mean temperature (^{o}C), and relative humidity (%): Haymana, Turkey, 2010 and 2011

	2010			2011		
Months	Rainfall (mm)	Mean temperature (^{o}C)	Mean relative humidity (%)	Rainfall (mm)	Mean temperature (^{o}C)	Mean relative humidity (%)
April	37	12	55	49	10	67
May	31	18	46	73	15	64
June	58	21	56	44	19	58
July	26	25	46	11	25	48
August	0	28	32	19	23	48
Total	152			196		
Mean		20.8	47		18.4	57

In this research, ten unifoliate-leafed (AkN 501, AkN 485, AkN 892, AkN 897, AkN 899, AkN 680, AkN 896, AkN 491, AkN 804 Küsmen 99), and ten fern-leafed (Gökçe, İnci, Akçin, Sarı 98, Uzunlu 99, Er 99, Yaşa 05, Damla 89, Canıtez 87 ve Dikbaş) kabuli chickpea cultivars and lines, were used as materials.
In the study, unifoliate- and fern-leafed cultivars and lines were evaluated for pod and seed number per plant, seed and biological yield per plant, seed and biological yields (kg ha^{-1}), and harvest index (%). Data were analyzed using analysis of variance in MSTAT-C software.

Results and discussion

Informative results indicated that significant differences ($P < 0.01$) were observed on the biological and seed yield between leaf type and genotypes. However, there were no

statistical differences determined between genotypes, and leaf type for pod number per plant, seed number per plant, seed yield per plant, and harvest index (Table 2).

Two-year results showed that pod-number per plant, seed-number per plant, seed-yield per plant, seed-yield, biological-yield, and harvest-index in fern leaf type were better than unifoliate leaf type, while biological yield per plant in unifoliate leaf, was higher than fern leaf type.

Table 2. Range, mean, general mean, maximum of observations in unifoliate and fern-leaf types in Haymana, Turkey, 2010 and 2011.

Traits		Types of leaf			
		Unifoliate		Fern	
		2010	2011	2010	2011
Pod numbers per plant (pods/ plant)	Range	17.7-51.3	20.0-37.0	23.0-68.7	20.7-49.0
	Mean	33.5	28.2	42.1	36.3
	General mean	30.9		39.2	
	$F_{(TL)}$	ns			
	$F_{(G)}$	ns			
	$F_{(TLXG)}$	*			
Seed numbers per plant (seeds/plant)	Range	16.3-46.3	17.0-36.3	20.0-72.7	21.7-40.7
	Mean	29.5	26.2	43.4	33.4
	General mean	27.9		38.4	
	$F_{(TL)}$	ns			
	$F_{(G)}$	ns			
	$F_{(TLXG)}$	**			
Seed yield per plant (g/plant)	Range	9.3-21.9	10.8-19.8	10.4-26.7	9.4-20.1
	Mean	14.8	13.3	19.5	17.8
	General mean	14.1		17.7	
	$F_{(TL)}$	ns			
	$F_{(G)}$	ns			
	$F_{(TLXG)}$	*			
Biological yield per plant (g/plant)	Range	31.7-57.7	47.3-70.0	25.3-61.0	49.1-60.1
	Mean	41.9	56.1	41.9	54.3
	General mean	49.0		48.1	
	$F_{(TL)}$	ns			
	$F_{(G)}$	ns			
	$F_{(TLXG)}$	ns			
Seed yield (kg ha $^{-1}$)	Range	1150-1650	1470-2210	1500-2630	1620-2700
	Mean	1410	1710	2110	1950
	General mean	1560		2030	
	$F_{(TL)}$	**			
	$F_{(G)}$	**			
	$F_{(TLXG)}$	*			
Biological yield (kg ha $^{-1}$)	Range	3620-5170	3980-5880	3860-6980	5310-7220
	Mean	4430	4730	5580	5920
	General mean	4580		5750	
	$F_{(TL)}$	**			
	$F_{(G)}$	**			
	$F_{(TLXG)}$	*			
(%) Harvest index	Range	27.5-42.5	30.2-57.6	35.0-43.2	26.6-38.8
	Mean	32.7	37.2	38.8	33.0
	General mean	34.9		35.9	
	$F_{(TL)}$	ns			
	$F_{(G)}$	ns			
	$F_{(TLXG)}$	*			

ns : Not significant; **: significant at 0.01,*: Significant at 0.05, TL: Type of Leaf, G: Genotype

Genotype × types of leaf interactions were significant (P< 0.05) for harvest-index, biological-yield, seed-yield, seed-yield per plant, and pod-number per plant, while genotype × types of leaf interaction for seed number per plant were all highly significant (P< 0.01).
Mean pod-number per plant in fern- and unifoliate-leafed chickpea were 39.2 and 30.9, respectively.In our study, pod number in fern-leafed types was greater than unifoliate-leafed types. Our results are in general agreement with reports by Poniedzialek et al. (2005), and Srinivasan et al. (2006) In the study, mean seed-number per plant ranged between 13.3-72.7. Kara (2003), Bağcı (2003), and Karaköy (2008) found 34.3-37.9, 22.5-28.9, and 18.0-31.4 seed-numbers per plant, respectively. Seed-yield per plant in fern chickpea was 17.7 g, while it was 14.1 g in unifoliate-leafed chickpea. Results from this research for seed-yield per plant confirm the results of the studies completed by Bağcı (2003), Kara (2003), Biçer ve Anlarsal (2004), and Çakır (2006). Mean seed yield was 1795 kg ha $^{-1}$. The yields were 1560 kg ha $^{-1}$ in unifoliate-leafed, and 2030 kg ha $^{-1}$ in fern-leafed chickpea. The yield of fern-leafed cultivars and lines in both years was more than unifoliate-leafed ones. Similar results in the yield of fern and unifoliate-leafed types were reported as 1900 kg ha $^{-1}$, and 930 kg ha $^{-1}$ by Wichman et al. (2001), and as 1559 kg ha $^{-1}$, and 1002 kg ha $^{-1}$, by Short et al. (2002). And also Gan et al. (2006), reported similar results, indicating that yield of fern-leafed chickpea was 3 times more than unifoliate-leafed chickpea. In addition to this, mean biological yields were 4580 kg ha $^{-1}$ in unifoliate- leaf type, and 5750 kg ha $^{-1}$ in fern-leafed type (Table 2). Fern-leafed chickpea has greater mean biological-yield than unifoliate-leafed chickpea. Similarly, biological yield in fern-leafed chickpea was 306-818 g/m^2, and 300-771 g/m^2 in unifoliate-leafed ones, as reported by Vanderpuye (2010). Percentages of harvest index ranged from 32.7 % to 37.2% in unifoliate-leafed, and 33.3% to 38.8 % in fern-leafed types. Li et al. (2010) reported 33-51% of fern-leafed, and 20-35% of unifoliate-leafed chickpea for harvest index.

Correlation coefficients for yield components

Biological yield per plant had high and positive correlations with pod-number per plant (r= 0.738), seed-number per plant (r= 0.713), and seed-yield per plant (r= 0.760). Pod-number significantly correlated with seed-number per plant (r= 0.966), and seed yield per plant (r= 0.915). Seed number per plant had high positive influence (r= 0.923) on seed yield per plant. Seed yield was highly correlated with biological yield (r= 0.600), and percent harvest index (r= 0. 398). Biological yield was high and negatively correlated with harvest index (r= -0.478) (Table 3).

Table 3. Correlation coefficients for yield components

	BYP	PNP	SNP	SYP	SY	BY	HI %
BYP	1.000	0.783**	0.713**	0.760**	0.038 ns	0.022 ns	-0.013 ns
PNP		1.000	0.966**	0.915**	0.196 ns	0.012 ns	0.184 ns
SNP			1.000	0.923**	0.281 ns	0.062 ns	0.235 ns
SYP				1.000	0.242*	0.016 ns	0.237 ns
SY					1.000	0.600**	0.398**
BY						1.000	-0.478**
HI %							1.000

BYP: Biological-yield per plant (g/plant), PNP: Pod-number per plant (pods/plant); SNP: Seed-number per plant (seeds/plant); SYP: Seed yield per plant (g/plant); SY: Seed yield (kg da^{-1}); BY: Biological yield (kg ha^{-1}); HI %: Harvest index, ns : not significant; **: significant at 0.01,*: Significant at 0.05

Conclusion

The genetic base of chickpea is very narrow. For this reason, many studies are focused on expanding the genetic-base. Mutation is one of the breeding methods used to broaden the

genetic base. Changes of the morphological traits for plant structure are sometimes applied as a method in plant breeding. Unifoliate-leafed chickpea developed by mutation, and fern-leafed chickpea (normal), were compared for yield and associated traits in this study.
Different plant types influence agronomical practices and yield compound. The fern-leafed chickpea is commonly grown for chickpea production, worldwide.
We conclude that the fern-leafed chickpea produced 30% more seed and 25% more biological yield compared to unifoliate-leafed chickpea. Unifoliate-leafed chickpeas can be used for increasing variation in Chickpea material.

References

Anwar, M.R., Mckenzıe, B.A. and Hıll, G. D. 2003.The effect of irrigation and sowing date on crop yield and yield components of Kabuli chickpea (Cicer arietinum L.) in a cool-emperate subhumid climate. Journal of Agricultural Science (2003), 141, 259–271.

Biçer, B.T., Anlarsal, A.E. 2004. Determination of Botanical and Agronomical Characteristics of Some Chickpea (Cicer arietinum L.) Landraces. Ankara University. Journal of Agricultural Sciences, 10(4): 389-396. Ankara.

Bağcı, İ. 2003.Effect on yield and yield components of some chickpea (Cicer arietinum L.) varieties in some different planting time. Ankara Üniversity. MSc. Thesis.Ankara.

Çakır, A. 2006. Effects of seed placement of chickpea (Cicer arietinum L.) in seed bed on the emergence and yield components Ankara Üniversity. MSc Thesis. Ankara.

FAO (2004) FAOSTAT Database faostat.fao.org

Gan, Y., Liu, P. and McDonald,C. 2003. Severity of ascochyta blight in relation to leaf type in chickpea. Published in Crop Science Societyof America. 43:2291-2294 (2003).

Gan, Y.T., Siddique,K.H.M., MacLeod, w.j., Jayakumar, P. 2006. Management options for minimizing the damage by ascochyta blight (Ascochyta rabiei) in chickpea (Cicer arietinum L.). Volume 97, Issues 2–3, 1 June 2006, Pages 121–134. Field Crops Research. ELSEVIER.

Karaköy, T. 2008. A Study On Determining Yield And Yield Components On Some Local Genotypes Of Chickpea (Cicer Arietinum L.) Collected From Çukurova And Central Anatolian Regions. PhD Thesis. Çukurova University. Adana

Li, L., Gan, Y. T., Bueckert, R. and Warkentin, T. D. 2010. Shading, defoliation and light enrichment effects on chickpea in northern latitudes. Journal of Agronomy and Crop Science 2010 Vol. 196 No. 3 pp. 220-230

Miller, P., McKay, K., Jenks, B., Riesselman, J.,Neill, K., Buschena, D. and Bussan, A.J.(2002) Growing chickpea in the Northern Great Plains. Montana State University Extension Service Bulletin 2002, Bozeman, Montana.

Moreno, M. and Cubero, J.I. (1978) Variation in Cicer arietinum L. Euphytica 27, 465–485.

Muehlbauer, F.J. Singh.K.B.1987. Genetics of Chickpea. The Chickpea. Pp. 99-125. Ed. M.C. Saxena and K.B. Singh. C.A.B. International. U.K.

Poniedziałek, M., Jędrszczyk, E.,Sękara, A., Skowera, B. and Dziamb.S. 2005. The effect of locality and sowing term on chosen morphological features of two chickpea (Cicer arietinum L.) cultivars . Folıa. Hortıculturae. Ann. 17/1, 2005, 37-46

Short, R. W., Stratton, R.G., Muehlbauer, F. J., McPhee, K. E., and Chen, W. 2002.Web sitesi: www http://pwa.ars.usda.gov/pullman/glgp/. Erişim: 12.10.2011

Srinivasan, S., Gaur, P.M. and Rao, B.V. 2006. Relationships of Pinnate (Fern) and Simple (Unifoliate) Leaf Traits with Seed Yield and Seed Size in Kabuli Chickpea. Pp. 6. International Chickpea and Pigeonpea Newsletter. ICPN Editor. ICRISAT. Patancheru 502 324. Andhra Pradesh, India.

Soltani, A., M.J. Robertson, Y. Mohammad-Nejad, and A. Rahemi-Karizaki. 2006. Modeling chickpea growth and development: Leaf production and senescence. Field Crops Res. 99:14-23.

Vanderpuye, A.W. 2010. Canopy Archıtecture and Plant Densıty Effect in Short-Season Chıckpea (Cıcer arıetınum L.). A Thesis submitted to the College of Graduate Studies and Research in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in the Department of Plant Sciences University of Saskatchewan.

Wells, R., J.W. Burton, and T.C. Kilen. 1993. Soybean growth and light interception: response to differing leaf and stem morphology. Crop Sci. 33:520-524.

Wichman, D.M. and Neil,K.E.2001.Wepsitesi(http://ag.montana.edu/carc/2001/annual reort/ speccrops/ar01statechickpea.pdf,Eriş,m 06.10.2010)