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Agronomic and Morphological Characters of Chickpea Under Irrigated Conditions in Turkey

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ABSTRACT

This research was conducted to determine the effects of irrigation on chickpea (*Cicer arietinum* L.) at Agriculture Management Office in Bismil-Diyarbakir, Turkey, in 2001 spring season. Four chickpea varieties were used as material. The experiment was set up as split block design with four replications under irrigated and rainfed conditions. Observations were recorded on 33 morphological and agronomic characters. Days to maturity, pod length, pod width, pod roughness, seed length, seed width, seed roughness, number of secondary branches plant^{-1}, biological yield plant^{-1}, number of filled pods plant^{-1}, number of seeds plant^{-1}, seed yield plant^{-1}, 100 seed weight, grain yield unit area^{-1}, total biological yield, hay yield unit area^{-1} and harvest index increased by irrigation.

Key Words: Chickpea (*Cicer arietinum* L.); Irrigation; Rainfed; Agronomic Characters; Morphological Characters

INTRODUCTION

Chickpea is the most important pulse crop in Turkey after lentil. In Southeastern Anatolia of Turkey, it is only sown during spring. However, in most part of the Turkey, it is generally grown throughout the winter and spring as a rainfed crop, and suffers from water shortage during seed development in spring. Although there has been also little development of specifically adapted varieties to all environments, these varieties may not been seen in farmer's field. The basis of the wide adaptation in chickpea is important as new cultivars are developed. The possibility that higher yields could be achieved if chickpea cultivars were more specifically adapted to a particular environment needs to be explored. In our study, it is aimed to adapt both the new varieties to Southeastern Anatolia and introduced cultural practice as irrigation. This region has possibility irrigation, due to South East Anatolia Project (the largest irrigation project in Turkey). In southeastern Anatolia, chickpea is a spring crop, sown early in March and harvested in middle of July, covering non-irrigated areas. Chickpea sown early in March are usually subjected to moisture stress particularly during flowering and pod filling stages, at the middle of May and during June. This situation reduces yields, especially in the case of late spring sowing. A good solution to this situation is through the adjustment of sowing time or supply irrigation water. Irrigation is frequently used to supplement rainfall to increase crop productivity in chickpea (Bicer *et al*., 2004).

This study was aimed to determine the effect of irrigation on botanical characters as well as seed yield of spring sown chickpea.

MATERIALS AND METHODS

Four chickpea varieties, developed at obtained from National Research Program of Turkey were grown during spring season 2001 under rainfed and irrigated conditions. The experiment was carried out in split block design with four replications at Bismil (37°30'N, 40°37'E), near Diyarbakir, Turkey. The soil of experiment area is deep sandy soil with mild alkaline reaction, and low in organic matter, so it is quickly dried after rainfalls. The experimental area was no fertilized due to general practice in this the region. The sowing was done on moist soil, and irrigation water applied after emergence. The seedbed preparation was achieved by moldboard plow in 30 cm deep in December and furrow cultivator followed this before spring.

Each variety was sown in eight-row plots of 6 m length with between- and within-row spacing of 45 cm and 7.5 cm, respectively. Sowing was done on 12 Feb. 2001 by hand. After emergence, each plot was randomly separated

Table I. Monthly min., max. and mean temperatures, rainfall and mean moisture during cropping season at Diyarbakir, Turkey

Months	Mean Monthly Temperature (°C)			Rainfall	Mean moisture
	Min	Max	Mean	(mm)	(%)
January	-1.2	10.2	4.0	14.9	68
February	-0.7	11.3	5.0	72.4	66
March	5.4	18.0	11.4	126.1	69
April	7.3	20.9	14.3	54.0	64
May	9.8	23.5	16.7	86.9	60
June	16.3	34.7	26.7	0	26
July	21.3	39.2	31.6	0	22

into two parts, and each variety was separately grown, one under rainfed conditions and the other under irrigation, in the same field but at a reasonable distance. Meteorological data for cropping season is presented in Table I Rainfalls during cropping season was high, except June.

The observations recorded were: days to 50% flowering, pod filling stage, time taken from flowering to maturity, days to maturity and lodging were recorded on per plot basis. Natural plant height and natural first pod height were measured while the plants were in plot randomly in ten points within the plot average was taken calculated. Plant height and first pod height of the ten plants were measured after harvested by laying them on the ruler. Ten leaf for leaf length and width, leaflet length and width were taken from various plants, and length and width were measured by compass, and average were taken. Number of leaflet and flower length was recorded on ten plants of each plot. Twenty pods and its seeds for pod length, width and depth, seed length, width and depth were taken from various plants within the plot, and these traits were measured by compass, and average were taken. Observations on number of primary and secondary branches plant^{-1}, biological yield plant^{-1}, number of pods plant^{-1}, filled pods plant^{-1}, seeds plant^{-1} and seed yield plant^{-1} recorded on ten plants selected randomly from two central rows of each plot. Harvest area for grain yield, biological yield unit area^{-1}, and hay yield unit area^{-1} was 4.5 m^2 in each plot. Also, 100 seed weight and harvest index were evaluated for each plot. Data were subjected to analysis of variance using MSTATC program.

Irrigation water was calculated with model of Penman-Monteith, and Cropwat Ver.7.0 Computer Program. According to this computer program, min and max temperatures monthly, moisture percentage (*%/monthly*), wind speed (*km/day*), radiation (*mj/m²/day*), total rainfall (*mm/month*) for experimental area, and altitude for experiment site were determined, and potential water consumption was calculated for this experiment. Irrigation water was applied using gated pipes in furrows. Irrigation water was applied by one at twice day, and irrigation time calculated following by model of (Kamber *et al.,* 1986). The results showed that the total amount of water and working time were 112.0 mm and 14 h for this experiment.

$$T = I \times A \times 60/qe \times n$$

(*T*: working time, sec; *I*: irrigation water, mm; *A*: irrigation area m^2; *qe*: gate flow, L/h; *n*: number of emitter plot^{-1}).

RESULTS AND DISCUSSION

Differences in days to 50% flowering, pod filling stage, time taken from flowering to maturity and days to maturity among cultivars were significant, but the interaction effect was non significant (Table II). These characters, except days to maturity, showed low response to irrigation, since rainfalls was high during the vegetative period (March, April & May). However, rainfalls was low at the beginnings of generative period, the end of May and the beginning of June, in this the region where the experiment were carried out. Although irrigation effect was not significant for time taken from flowering to maturity, differences between irrigated and rainfed were ranged from 30.8 to 46.31 days. Therefore, almost all varieties favorably zresponded to irrigation, and mean days to maturity under irrigation were higher than that under rainfed. Malhotra *et al.* (1997), Bicer *et al.* (2004) and Palled *et al.* (1985) reported that days to flowering and maturity due to irrigation were increased. The latest flowering and maturity were determined from Diyar 95 among varieties.

The effects of cultivars and irrigation were non significant for natural plant height, natural first pod height, plant height and first pod height (Table III). In this study, it was observed that plant height was permanently increased during flowering and pod filling stage. Also, every irrigation made in this period increased plant height.

The analysis for irrigated and rainfed conditions of leaf length, leaf width, number of leaflet, leaflet length and leaflet width revealed that cultivars varied significantly, but irrigation and irrigation x cultivars interaction were not significant (Table IV). This might be due to the fact that these characters stabile characteristic, and were not affected by environmental conditions (Cubero, 1987), this response to irrigation was low too. Moreover, leaf characters are of the property of a variety. However, some researchers reported that leaf characters affected by irrigation (Bicer *et al*., 2004). Diyar 95 and Sari 98 among varieties gave the highest leaf characteristic. Varieties had leaves about 8 cm long with 13 to 15 leaflets.

The flower length was not affected by irrigation. The irrigation effect was significant for pod length, pod width and pod depth, but cultivars and irrigation x cultivar interaction was not (Table V). The mean pod length, pod width and pod depth under irrigation condition were higher than that under rainfed condition. The effect of irrigation on seed length, seed width and seed depth were significant (Table VI). The irrigation water had positive effect on these characters. Seed length, width and depth due to irrigation increased by 14.92, 13.76 and 12.75%, respectively over rainfed crop. Differences among cultivars for seed length and seed width were significant (Table VI).

Effect of irrigation on number of primary branches plant^{-1} and lodging was not significant (Table VII). Malhotra *et al.* (1997) in their studies on irrigation of chickpea in winter sown reported that number of primary branches and secondary branches was not affected by irrigation. The irrigation water was affecting the number of secondary branches plant^{-1} and biological yield plant^{-1}. These results agree with those of Bicer *et al.* (2004) and Palled (1985) who also found substantial increases due to irrigation in number of secondary branches plant^{-1} and biological yield plant^{-1}. The highest responding to irrigation among varieties gave Aziziye 94 for number of secondary branches plant^{-1} and biological yield plant^{-1}. The lodging among plants was

Table II. Means of days to 50% flowering, pod filling stage, duration between time taken from flowering to maturity and days to maturity in four chickpea varieties under rainfed (R) and irrigated (I) conditions, at Diyarbakir, Turkey

Cultivars	Days to 50% flowering			Pod filling stage			Time taken from flowering to maturity			Days to maturity			
	R	I	Mean	R	I	Mean	R	I	Mean	R	I	Mean	In %
Gökçe	71.00	71.00	71.00 d	79.75	80.00	79.88 d	38.75	53.75	46.25 a	117.0	132.0	124.50 c	12.8
Aziziye 94	77.25	77.25	77.25 c	93.50	93.50	93.50 c	32.00	47.00	39.50 b	118.0	133.0	125.50 b	12.7
Sari 98	80.00	80.00	80.00 b	96.50	96.50	96.50 b	26.50	42.50	34.50 c	118.0	134.0	126.00 b	13.6
Diyar 95	83.00	83.00	83.00 a	98.00	98.25	98.13 a	26.00	42.00	34.00 c	119.0	135.0	127.00 a	13.5
Means	77.81	77.81		91.94	92.06		30.81	46.31		118.0 b	133.5 a		
LSD		*C:0.40***			*C:1.033***			*C:1.075***			*C:0.566***		*I:0.385***

Table III. Means of various traits in four chickpea varieties under rainfed (R) and irrigated (I) conditions at Diyarbakir, Turkey

Cultivars	Natural plant height(cm)			Natural lowest pod height (cm)			Plant height(cm)			First pod height(cm)		
	R	I	Mean	R	I	Mean	R	I	Mean	R	I	Mean
Gökçe	49.13	49.28	49.20	20.45	21.70	21.08	51.60	50.98	51.29	21.13	22.23	21.68 b
Aziziye 94	50.28	44.20	47.24	31.40	30.30	30.85	52.78	52.93	52.85	33.08	31.53	32.30 a
Sari 98	46.43	44.85	45.64	30.90	27.23	29.06	54.83	57.53	56.18	35.35	33.68	34.51 a
Diyar 95	55.68	53.80	54.74	35.33	35.30	35.31	57.30	59.83	58.56	35.88	36.85	36.36 a
Means	50.38	48.03		29.52	28.63		54.13	55.31		31.36	31.07	
LSD												*C:7.945***

Table IV. Means of leaf length and width number of leaflet, leaflet length and width in four chickpea varieties under rainfed (R) and irrigated (I) conditions at Diyarbakır, Turkey

	Leaf length (cm)			Leaf width(cm)			Number of leaflet			Leaflet length (cm)			Leaflet Width(cm)		
Cultivars	R	I	Mean	R	I	Mean	R	I	Mean	R	I	Mean	R	I	Mean
Gökçe	6.98	7.03	7.00 c	3.70	3.73	3.71 b	12.88	12.88	12.88 b	1.70	1.70	1.70 c	0.90	0.90	0.90 c
Aziziye 94	7.45	7.48	7.46 b	4.00	4.08	4.04 b	12.88	12.98	12.93 b	1.75	1.80	1.78 b	0.90	0.90	0.90 c
Sari 98	8.35	8.50	8.42 a	4.38	4.55	4.46 a	14.73	14.98	14.85 a	1.95	2.00	1.98 a	0.95	1.03	0.99 b
Diyar 95	8.28	8.30	8.29 a	4.60	4.60	4.60 a	14.80	14.90	14.85 a	2.03	2.00	2.01 a	1.05	1.00	1.03 a
Means	7.76	7.83		4.17	4.24		13.82	13.93		1.86	1.88		0.95	0.96	
LSD		C:0.164**			C:0.384**			C:0.341**			C:0.060**			C:0.033**	

Table V. Means of flower length, pod length, width and roughness in four chickpea varieties under rainfed (R) and irrigated (I) conditions at Diyarbakır, Turkey

Cultivars	Flower length (mm)			Pod length (cm)				Pod width (cm)				Pod depth (cm)			
	R	I	Mean	R	I	Mean	In %	R	I	Mean	In %	R	I	Mean	In%
Gökçe	11.95	12.00	11.98	2.50	2.68	2.59	7	1.23	1.33	1.28	9.0	1.33	1.43	1.38	8
Aziziye94	12.10	11.93	12.01	2.35	2.40	2.38	2.2	1.18	1.28	1.23	9.0	1.28	1.38	1.33	8
Sari 98	11.93	11.85	11.89	2.13	2.40	2.27	13	1.18	1.33	1.25	13.0	1.28	1.43	1.35	12
Diyar 95	12.08	11.98	12.03	2.33	2.60	2.47	11.8	1.18	1.30	1.24	10.7	1.30	1.40	1.35	8
Means	12.01	11.94		2.33 b	2.52a		8.5	1.19 b	1.31 a		10.43	1.29 b	1.41 a		9.0
LSD							I:0.113			I:0.077				I:0.079**	

Table VI. Means of seed length, width and roughness in four chickpea varieties under rainfed (R) and irrigated (I) conditions, and increase from irrigated (%) at Diyarbakir, Turkey

Cultivars	Seed length (mm)				Seed width (mm)				Seed depth (mm)			
	R	I	Mean	In %	R	I	Mean	In %	R	I	Mean	In %
Gökçe	8.63	10.08	9.35 a	16.8	7.00	7.93	7.46 a	13.2	7.00	8.05	7.53	15.0
Aziziye 94	8.98	9.50	9.24 a	5.9	7.15	7.50	7.33 a	5.0	7.13	7.68	7.40	7.8
Sari 98	8.28	9.98	9.13 a	20.6	6.75	8.00	7.38 a	18.5	6.80	7.80	7.30	14.8
Diyar 95	7.53	8.80	8.16 b	16.4	6.13	7.13	6.63 b	16.4	6.38	7.23	6.80	13.4
Means	8.35 b	9.59 a		14.92	6.76 b	7.64 a		13.7	6.83 b	7.69 a		12.75
LSD	C:0.649**		I:0.608**		C:0.574*		I:0.623**				I:0.606*	

not occurring, since the plants examined in this research had not high the plant height.

The effect irrigation was significant for number of pods plant^{-1}, filled pods plant^{-1} and seeds plant^{-1} (Table VIII). Since irrigation was increased duration between flowering and maturity, days to maturity and number of secondary branches plant^{-1}, it was founded that these characters were increase. As rainfall and moisture content (%) were decreased after flowering, the plants need more water, and almost all cultivars responded favorably to irrigation. All varieties gave higher values with respect to these characters under irrigation than under rainfed. Aziziye 94 had the highest increase in these characters due to irrigation.

Differences between under rainfed and irrigated conditions for seed yield plant^{-1}, 100 seed weight and grain yield were significant (Table IX). Almost all varieties for these characters responded high to irrigation. Variety of Diyar 95 under irrigated conditions variety had the highest increase in these characters. Compared under rainfed conditions, the percentage increase in yield of these genotypes due to irrigation was 232%. Malhotra *et al.* (1997) and Silim and Saxena (1986) reported that seed yield was increased under irrigated conditions. Asghar and Tahir

Table VII. Means of primary and secondary branches plant^{-1}, lodging and biological yield plant^{-1} in four chickpea varieties under rainfed (R) and irrigated (I) conditions at Diyarbakir, Turkey

	Primary branches			Secondary branches				Lodging			Biological yield plant^{-1}			
Cultivars	R	I	Mean	R	I	Mean	In (%)	R	I	Mean	R	I	Mean	In (%)
Gökçe	2.58	3.05	2.81 b	11.73	13.33	12.53	13.7	1.250	1.000	1.125	17.23	23.63	20.43	37
Aziziye94	3.68	3.35	3.51 a	10.70	16.43	13.56	53.5	1.250	1.750	1.500	10.90	28.98	19.94	165
Sari 98	3.30	3.38	3.34 ab	11.90	14.30	13.10	20	1.750	2.000	1.875	11.23	33.78	22.50	201
Diyar 95	3.58	3.78	3.68 a	14.00	14.33	14.16	2.4	1.250	1.500	1.375	18.43	29.08	23.75	58
Means	3.28	3.39		12.08 b	14.59 a		22.4	1.375	1.563		14.44 b	28.86 a		115
LSD		C:0.607*			I:1.908							I:5.325**		

Table VIII. Means of pods, filled pods and seeds plant^{-1} in four chickpea varieties under rainfed (R) and irrigated (I) conditions, and increase from irrigated (In %) at Diyarbakir, Turkey

Cultivars	Pods plant^{-1}				Filled pods plant^{1}				Seeds plant^{1}			
	R	I	Mean	In (%)	R	I	Mean	In (%)	R	I	Mean	In (%)
Gökçe	16.20	20.63	18.41	27.3	10.38	17.23	13.80	66	11.53	18.85	15.19	63.6
Aziziye 94	9.05	20.10	14.58	122.0	8.00	18.48	13.24	131	9.30	20.25	14.78	117.6
Sari 98	6.63	13.20	9.91	99.2	5.33	12.25	8.79	130	5.85	12.45	9.15	113.0
Diyar 95	10.45	18.13	14.29	73.5	7.43	16.18	11.80	118	7.90	18.10	13.00	129.0
Means	10.58 b	18.01 a			7.78 b	16.03 a			8.64 b	17.41 a		
LSD			I:3.110**				I:2.221**					I:1.936

Table IX. Means of seed yield plant^{-1} (g), 100 seed weight (g) , seed yield (kg/ha) in four chickpea varieties under rainfed (R) and irrigated (I) conditions, and increase from irrigated (In%) at Diyarbakir, Turkey

Cultivars	Seed yield plant^{-1} (g)				100 seed weight (g)				Seed yield(kg/ha)			
	R	I	Mean	In(%)	R	I	Mean	In(%)	R	I	Mean	In(%)
Gökçe	3.88	8.13	6.00	109	33.10	42.48	37.79 a	28.4	658.8	1560.0	1109.4 a	137
Aziziye 94	3.00	8.43	5.72	181	30.25	41.58	35.91 a	37.5	559.5	1529.4	1044.4 a	173
Sari 98	1.88	5.16	3.52	174	29.31	41.28	35.29 a	40.9	270.1	848.9	559.5 b	214
Diyar 95	2.12	6.58	4.35	211	24.66	36.10	30.38 b	46.4	390.1	1296.1	843.1 ab	232
Means	2.72 b	7.07 a			29.33 b	40.36 a			469.6 b	1308.6 a		
LSD			I:0.993**		C:3.895**		I:3.366**		C:298.92**		I:168.24**	

Table X. Means of biological yield (kg/da), hay yield (kg/da) and harvest index (%) in four chickpea varieties under rainfed (R) and irrigated (I) conditions, and increase from irrigated (In%) at Diyarbakır, Turkey

Cultivars	Biological yield (kg/da)				Hay yield (kg/da)				Harvest index(%)			
	R	I	M	In (%)	R	I	M	In(%)	R	I	M	In (%)
Gökçe	313.73	463.16	388.40	47.7	247.85	307.15	277.50	24	24.64 a	36.56 a	30.60 a	48.4
Aziziye 94	203.81	524.32	364.07	157.3	147.86	281.09	214.48	90	27.64 a	29.85 b	28.75 ab	8.0
Sari 98	190.15	641.65	415.90	237.5	163.14	556.76	359.95	242	11.86 b	16.48 d	14.17 c	39.0
Diyar 95	371.67	596.11	483.89	60.4	332.66	466.50	399.58	40	10.63 b	23.59 c	17.11 bc	121.8
Means	269.84 b	556.31 a			222.88b	402.88 a			18.70 b	26.62 a		
LSD			I:110.264**				I:112.960**		IxC: *	C:11.874*		I:3.092**

(1997) reported that maximum seed yield in all the varieties, their used, was found with one irrigation at pre-flowering stage. Whereas yield response was poor where crop was sown only by soaked seed without rauni and no irrigation was given from sowing to maturity.

The effect of irrigation was significant for biological yield unit area^{-1}, hay yield unit area^{-1} and harvest index, and the cultivar x irrigation interaction were significant for harvest index (Table X). The indicated the differential response of some of the cultivars under rainfed and irrigated conditions. The irrigation had positive effects on these characters. This finding was paralleled with Palled (1985).

CONCLUSIONS

It was concluded that seed yield plant^{-1}, 100 seed weight, grain yield, biological yield per unit area, hay yield per unit area and harvest index responded high to irrigation.

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