

ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
<http://ansijournals.com/ja>

JOURNAL OF
AGRONOMY



ANSI*net*

Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

The Effect of Irrigation on Spring-sown Chickpea

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Abstract: This study was aimed to determine agronomic and morphological characters of 12 chickpea (*Cicer arietinum* L.) cultivars under irrigated conditions in Diyarbakır in 2000 spring season. The cultivars were sown in a Randomised Complete Block Design with four replications. Natural plant height, seed yield/plant, number of pods/plant, leaf size, number of leaflets per leaf, seed size and pod size were increased with irrigation application. However, protein content in grain decreased with irrigation.

Key words: Chickpea (*Cicer arietinum* L.), irrigation, agronomic characters, morphological characters

INTRODUCTION

The chickpea (*Cicer arietinum* L.) production in the world was 8.8 million tones in 1998 and 70% of this was produced by India. In Turkey, it was grown in 625.000 ha with an annual production of 595.000 tones. The 16% of Turkey's chickpeas was produced by the Southeast Anatolia. However, chickpea cultivation was considered to be 7.4% of the total 1.7 million ha irrigated land in the region after the completion of Southeast Anatolia project. Malhotra *et al.*^[1] reported that in dry areas of West Asia and North Africa (WANA), chickpea is usually grown as a spring-sown crop and inadequate soil water is a major constraint to crop productivity. The chickpea yields in these regions have indicated complete crop failure of chickpea in certain years due to improper distribution or reduced rainfall. Irrigation is necessary used to supplement rainfall to increase crop productivity. Similarly, chickpea, an important pulse crop of the South East Anatolia of Turkey, often suffers from drought and can benefit from such a practice. After the completion Southeast Anatolia Project, chickpea likely is grown with supplemental irrigation water in this region. Palled *et al.*^[2] reported that number of secondary branches/plant and biological yield/plant due to irrigation were increased. Malhotra *et al.*^[1] and Silim and Saxena^[3] reported that seed yield was increased under irrigated conditions. Asghar and Tahir^[4] reported that maximum seed yield in all the varieties, their used, was found only-one irrigation at pre-flowering stage. Zhang *et al.*^[5] reported that supplemental irrigation can significantly increase grain yield of chickpea. However, there was less increase in grain yield in the wet seasons than in the dry seasons. Although there are numerous studies on seed yield in chickpea under irrigated conditions, there is no published

report about botanical characters of chickpea under irrigated conditions. This study on irrigation applied to spring-sown chickpea was designed to: (I) determine the effect of irrigation on botanical characters as well as seed yield and (ii) identify irrigation responsive genotypes.

MATERIALS AND METHODS

The present study was carried out on Experimental Farm in Faculty of Agriculture at Dicle University in Diyarbakır-Turkey during 2000 spring season. 12 different chickpea (*Cicer arietinum* L.) cultivars: Sarı 98, Diyar 95, Gökçe, Aziziye 94, Uzunlu 99, Küsmen 99, Damla 89, Aydın 92, Akçin 91, Er 99, Menemen 92 and İzmir 92 developed from National Research Program of Turkey, were used as material.

According to meteorological data, rainfalls of January and February were higher than other months, but mean monthly temperatures with decreased moisture were increased at April, May and June (Table 1).

The experiment was carried out in a Randomized Complete Block Design with four replications in 2000 at Diyarbakır, Turkey. Each cultivar was sown in eight-row plots of 6 m length with between-and within row spacing

Table 1: Rainfall, mean monthly maximum, minimum and mean temperatures and mean moisture during 2000 cropping season at Diyarbakır

Months	Mean monthly temperature (°C)			Rainfall (mm)	Mean moisture (%)
	Mean	Max.	Min.		
January	1.3	5.7	-3.0	70.9	74
February	2.5	8.6	-2.5	58.2	65
March	7.0	14.0	-0.5	30.7	64
April	15.3	22.5	7.6	33.0	57
May	21.3	28.4	10.8	6.1	37
June	28.1	34.8	18.1	0.3	21

of 0.45 m and 0.10 m, respectively. After emergence, each plot was randomizedly separated two parts, one part was under rainfed conditions and the other under irrigation in the same field.

Irrigation water was calculated with a computer program model of Penman-Monteith and Cropwat Ver. 7.0. According to this computer program, monthly min and max temperatures, moisture percentages (%/monthly), wind speed km/day, radiation (mj/m²/day), total rainfall (mm/month) for Diyarbakır and altitude for experiment site, were given as inputs and potential water consumption was calculated. Potential water was determined consumption for this experiment. Irrigation water was applied using with drip irrigation system. Irrigation water was applied every other days and this irrigation time was calculated from a model^[6]. The finally, the total amount of water and working time were 141.0 mm and 33.08 h for this experiment.

RESULTS

The statistical analysis revealed that effect of cultivars and irrigation were significant for natural plant height, number of leaflet, leaflet width, flower length, biological yield/plant, number of pods/plant, pods with seed/plant, seed yield/plant, pod length, seed width, seed depth and 100 seed weight. But, the analysis for natural lowest pod height, leaf length, leaflet length, pod width and depth revealed that effects of cultivars, irrigation and cultivars x irrigation interaction effect were significant.

Natural plant height was affected by irrigation water and mean natural plant height under irrigation (39.53 cm) was significantly higher than that of under rainfed (32.62 cm). The highest increase (31%) in plant height due to irrigation was achieved by Diyar 95. Almost all cultivars also gave higher natural lowest height pod under

irrigation than rainfed. The highest increase (46%) in natural lowest height pod due to irrigation was achieved by Diyar 95 (Table 2).

The mean leaf length under irrigation (8.91 mm) was higher than that under rainfed (7.79 mm). But the order of the cultivars has changed to some extent in irrigated and rainfed environment. The most responsive cultivars to irrigation were Küsmen 99 and Damla 89, with an increase of 40.4-35.5%, respectively (Table 2). For leaf width, cultivars were affected differentially with irrigation was different affected by irrigation. While some cultivars strongly and positively responsive to irrigation, responding to irrigation of some cultivars was small and negatively (Table 3). İzmir 92 and Damla 89 were the most responsive cultivars.

Mean number of leaflets ranged from 13.13 to 15.58 among cultivars. Due to the fact that this character had a stabile characteristic, responding to irrigation was low and the mean number of leaflets was varied from 14.21 to 14.60 mm, from rainfed to irrigation, respectively. Leaflet length affected by irrigation water and mean leaflet length under irrigation was 1.85 mm, compared with 1.60 mm under rainfed conditions, giving an overall increase of 15.62% in leaflet length due to irrigation. The highest increased in leaflet length (77.3%) was achieved by İzmir 92. Cubero^[7] reported that leave characters were affected by environmental conditions.

Leaflet width ranged from 0.63 to 2.64 mm among cultivars. Respond to irrigation of Er 99 was negative (-10.9%), but other cultivars were positively affected from irrigation. Akçin 91 had the highest positive response. Flower length varied from 1.58 to 2.24 mm among cultivars. The mean flower length under irrigation (2.12 mm) was higher than that under rainfed conditions (1.96 mm). Flower length due to irrigation for Er 99 had maximum positive response (32.4%) (Table 4).

Table 2: The means of some of characteristics in twelve chickpea cultivars under rainfed (R) and irrigated (I) conditions and increase from irrigated (%) at 2002

Cultivars	Natural plant height				Natural lowest pod height				Leaf length			
	R	I	M	In.	R	I	M	In.	R	I	M	In.
Sarı 98	32.53	39.23	35.88c-e	20.5	23.08b	25.28b	24.18	9.50	7.36c-e	7.48g	7.42	1.6
Diyar 95	29.30	38.40	33.85ef	31.1	15.45d	22.55c	19.00	46.00	7.76c	8.35de	8.05	7.5
Gökçe	30.20	35.30	32.75e-g	16.9	17.46d	18.00e	17.73	3.10	6.97e	7.88e-g	7.42	13.1
Aziziy 94	33.49	37.91	35.70d-f	13.1	23.65b	22.30cd	22.98	-5.90	7.78c	8.25d-f	8.01	6.0
Uzunlu 99	41.15	48.70	44.93a	18.5	29.33a	31.45a	30.39	7.20	9.83a	10.98b	10.40	11.7
Küsmen 99	30.85	36.90	33.88ef	19.8	20.18c	19.75de	19.96	2.00	9.66a	13.56a	11.61	40.4
Damla 89	28.45	36.40	32.43fg	28.1	15.45d	22.25cd	18.85	44.00	6.17f	8.36de	7.23	35.5
Aydın 92	35.20	42.98	39.09bc	22.2	23.70b	26.28b	24.99	10.90	7.58cd	9.17c	8.37	21.1
Akçin 91	29.75	38.20	33.98ef	28.6	20.25c	21.45cd	20.85	5.90	7.19de	7.79fg	7.49	8.3
Er 99	27.45	33.50	30.48g	22.2	15.15d	17.55e	16.35	15.80	7.35c-e	7.83fg	7.59	6.5
Menemen 92	38.45	44.75	41.26b	16.4	24.75b	25.30b	25.03	2.40	8.55b	8.56d	8.56	0.1
İzmir 92	34.58	42.83	38.70b-d	24.0	22.55bc	26.87b	24.71	19.10	7.30c-e	8.66d	7.98	18.6
Means	32.62b	39.53a			20.92b	23.25a			7.79b	8.91a		
LSD %	Cult.: 3.360		I.: 1.217		Int. Cult.: 3.048		Int. I.: 2.62		Int. Cult.: 0.149		Int. I.: 0.48	

Table 3: The means of some of characteristics in twelve chickpea cultivars under rainfed (R) and irrigated (I) conditions and increase from irrigated (%) at 2002

Cultivars	Rachis width				Number of leaflet				Leaflet length			
	R	I	M	In.	R	I	M	In.	R	I	M	In.
Sarı 98	2.85d	3.02	2.93	6.0	14.18	14.25	14.21c-e	0.5	0.97g	1.21g	1.09	24.70
Diyar 95	2.79de	2.91f	2.85	4.3	14.56	14.98	14.78b-d	2.9	1.24gh	1.43f	1.33	15.30
Gökçe	2.88d	3.00ef	2.94	4.2	13.95	14.38	14.16de	3.1	1.51e	1.64e	1.57	8.60
Aziziye 94	2.40f	2.47h	2.43	2.9	14.28	14.45	14.36c-e	1.2	1.33fg	1.49f	1.41	12.00
Uzunlu 99	3.95a	4.07ab	4.01	3.0	15.48	15.68	15.58a	1.3	2.26b	2.45b	2.35	8.40
Küsmen 99	3.85a	4.16a	4.01	8.1	13.80	13.70	13.75ef	-0.7	2.75a	3.09a	2.92	12.40
Damla 89	2.67e	3.22d	2.95	20.5	12.78	13.48	13.13f	5.5	1.89c	2.17c	2.03	12.20
Aydın 92	3.61b	3.42c	3.51	-5.3	14.75	14.95	14.85bc	1.4	1.61e	1.70e	1.65	5.60
Akçin 91	2.35f	2.68g	2.52	11.6	15.03	15.68	15.35ab	4.3	1.38f	1.53f	1.45	10.90
Er 99	2.32f	2.44h	2.38	5.2	14.65	14.90	14.78b-d	1.7	1.32fg	1.49f	1.40	12.90
Menemen 92	3.05c	3.13de	3.09	2.6	14.40	15.08	14.74b-d	4.7	1.73d	1.93d	1.83	11.60
İzmir 92	3.12c	3.99b	3.55	27.9	12.63	13.75	13.19f	8.9	1.19h	2.11c	1.65	77.30
Means	2.99b	3.21a			14.21b	14.60a			1.60b	1.85a		15.62
LSD %	Cult.: 3.360			I: 1.217	Int. Cult.: 3.048		Int. I: 2.62		Int. Cult.: 0.149		Int. I: 0.48	

Table 4: The means of some of characteristics in twelve chickpea cultivars under rainfed (R) and irrigated (I) conditions and increase from irrigated (%) at 2002

Cultivars	Leaflet width				Flower length				Biological yield/plant			
	R	I	M	In.	R	I	M	In.	R	I	M	In.
Sarı 98	0.84	1.07	0.96ef	27.4	1.51	1.65	1.58d	9.3	10.56	15.94	13.25ab	50.9
Diyar 95	0.94	1.13	1.03ef	20.2	2.00	2.30	2.15ab	15.0	8.99	19.73	14.36a	119.0
Gökçe	0.92	1.13	1.02ef	22.8	2.03	2.13	2.08ab	4.9	10.31	14.98	12.36ab	44.3
Aziziye 94	0.80	0.94	0.87f	17.5	2.07	2.12	2.09ab	2.4	9.32	14.63	11.98b	57.0
Uzunlu 99	1.35	1.56	1.46b	15.5	1.91	2.06	1.98bc	7.9	8.57	15.07	11.82bc	75.8
Küsmen 99	2.56	2.73	2.64a	6.6	2.01	2.15	2.08ab	7.1	7.40	15.46	11.43bc	108.9
Damla 89	0.86	0.92	0.89e f	11.6	2.07	2.21	2.14ab	6.8	8.86	16.80	12.83ab	89.6
Aydın 92	1.06	1.09	1.07c-e	2.8	2.10	2.22	2.16ab	5.7	10.14	15.52	12.83ab	53.0
Akçin 91	0.52	0.73	0.63g	40.4	1.95	2.19	2.07ab	12.3	8.02	12.10	10.06c	50.9
Er 99	1.10	0.98	1.04d-f	-10.9	1.52	2.02	1.77cd	32.9	8.95	15.07	12.01b	68.4
Menemen 92	1.13	1.38	1.25c	22.1	2.18	2.29	2.24a	5.0	9.55	15.92	12.74ab	66.7
İzmir 92	1.12	1.34	1.23cd	19.6	2.13	2.11	2.12ab	-0.9	9.30	16.72	13.01ab	79.8
Means	1.10b	1.25a			1.96b	2.12a			9.16b	15.66a		
LSD %	Cult.: 0.192		I: 0.064		Cult.: 0.250		I: 0.065		Cult.: 1.892		I: 0.763	

Table 5: The means of some of characteristics in twelve chickpea cultivars under rainfed (R) and irrigated (I) conditions and increase from irrigated (%) at 2002

Cultivars	Number of pods/plant				Number of fully pods/plant				Seed yield/plant			
	R	I	M	In.	R	I	M	In.	R	I	M	In.
Sarı 98	10.66	15.15	12.90cd	42.1	9.66	14.58	12.12c-e	50.9	3.93	6.73	5.33bc	2.8
Diyar 95	9.66	19.63	14.64bc	103.2	8.78	17.97	13.37cd	104.7	3.12	7.53	5.32bc	8.7
Gökçe	13.75	20.10	16.92ab	46.1	13.10	20.19	16.64ab	54.1	4.42	8.60	6.51a	1.2
Aziziye 94	10.35	17.06	13.71c	64.8	9.88	16.66	13.27c-e	68.6	4.12	6.98	5.55a-c	3.3
Uzunlu 99	8.50	13.03	10.77d	53.3	7.87	13.00	10.44de	65.2	2.82	5.37	4.09d	4.2
Küsmen 99	7.07	14.35	10.71d	103.1	6.72	13.94	10.33e	107.4	2.52	5.55	4.03d	6.5
Damla 89	13.41	21.72	17.56a	62.1	12.44	21.38	16.91a	71.9	3.81	8.13	5.97ab	5.4
Aydın 92	10.56	19.78	15.17c	87.3	9.00	18.69	13.85bc	107.7	3.04	6.76	4.90cd	8.7
Akçin 91	10.38	15.19	12.78cd	46.3	9.82	14.22	12.02c-e	44.8	3.57	7.01	5.29bc	4.8
Er 99	10.88	18.28	14.58d	68.0	10.41	17.14	13.77bc	64.6	3.82	7.19	5.51a-c	4.8
Menemen 92	10.81	19.19	15.00a-c	77.5	9.97	18.69	14.33a-c	87.5	4.07	6.89	5.48a-c	12.9
İzmir 92	9.03	18.78	13.91c	108.0	8.38	18.25	13.32cd	117.8	3.45	7.76	5.60a-c	3.1
Means	10.42b	17.68a			9.67b	17.06a			3.56b	7.04a		
LSD %	Cult.: 2.834		I: 0.870		Cult.: 2.975		I: 0.933		Cult.: 1.065		I: 0.383	

Biological yield/plant ranged from 10.06 to 14.36 g/plant among cultivars, the mean biological yield under irrigation (15.66 g/plant) was higher than that under rainfed conditions (9.16 g/plant). All cultivars gave higher biological yields under irrigation than under rainfed. Palled *et al.*^[2] reported that biological yield/plant due to irrigation were increased.

The mean number of pods/plant was higher under irrigation (17.68) than rainfed (10.42). Almost all cultivars

responded favorably to irrigation and all cultivars gave higher pods under irrigation than under rainfed. The highest increase in number of pods/plant due to irrigation was 108% for İzmir 92. Number seeded pods/plant varied from 10.33 to 16.91 among cultivars. The mean number of seeded pods/plant was higher than that under rainfed conditions. The top four responsive cultivars to irrigated conditions were Diyar 95 (104.7%), Küsmen 99 (107.4%), Aydın 92 (107.7%) and İzmir 92 (117.8%) (Table 5).

Table 6: The means of some of characteristics in twelve chickpea cultivars under rainfed (R) and irrigated (I) conditions and increase from irrigated (%) at 2002

Cultivars	Pod length				Pod width				Pod roughness											
	R	I	M	In.	R	I	M	In.	R	I	M	In.								
Sarı 98	21.93	22.55	22.24de	2.8	11.81a	11.20c-e	11.50	-5.1	11.59bc	11.75bc	11.07	1.4								
Diyar 95	22.41	24.36	23.39cd	8.7	10.89bc	11.22c-e	11.06	3.0	10.85de	11.32b-e	11.08	4.3								
Gökçe	24.65	24.95	24.80ab	1.2	11.44ab	11.63b-d	11.53	1.7	11.07b-d	11.28b-e	11.07	1.9								
Aziziye 94	22.74	23.48	23.11cd	3.3	10.81c	11.09de	10.95	2.6	11.27b-d	10.96e	11.12	2.8								
Uzunlu 99	23.65	24.65	24.15a-c	4.2	11.93a	13.00a	12.46	9.1	12.45a	13.06a	12.76	4.9								
Küsmen 99	22.83	24.32	23.57b-d	6.5	11.77a	13.00a	12.89	10.5	11.72b	13.05a	12.38	11.0								
Damla 89	22.55	23.77	25.16cd	5.4	10.90bc	11.06de	10.98	1.5	10.34e	11.24c-e	10.79	8.7								
Aydın 92	20.63	22.43	21.53e	8.7	10.76c	11.10de	10.93	3.2	11.03cd	11.02de	11.03	-0.1								
Akçin 91	22.05	23.11	22.58de	4.8	10.81c	11.07de	10.94	2.4	10.80de	11.37b-e	11.09	5.3								
Er 99	24.46	25.64	25.05a	4.8	10.92bc	11.70bc	11.31	7.1	10.89de	11.15c-e	11.02	2.4								
Menemen 92	18.79	21.22	20.01f	12.9	10.55c	11.92b	11.24	13.0	10.62de	11.90b	11.26	12.0								
İzmir 92	21.18	21.81	21.49e	3.1	10.49c	10.74e	10.62	2.4	10.86de	11.64b-d	11.25	7.2								
Means	22.32b	23.52a			11.09b	11.56a			11.13b	11.64a										
LSD %	Cult.: 1.421				Int. Cult.: 0.768				Int. I.: 0.593				Int. Cult.: 0.832				Int. I.: 0.656			

Table 7: The means of some of characteristics in twelve chickpea cultivars under rainfed (R) and irrigated (I) conditions and increase from irrigated (%) at 2002

Cultivars	Seed length				Seed width				Seed roughness							
	R	I	M	In.	R	I	M	In.	R	I	M	In.				
Sarı 98	9.55	9.75	9.65	2.1	7.96	7.90	7.93a	-0.8	7.91	8.02	7.97a	1.4				
Diyar 95	8.80	9.48	9.14	7.7	7.35	7.84	7.59b	6.7	7.61	7.94	7.77ab	4.3				
Gökçe	9.32	9.56	9.44	2.6	7.34	7.56	7.45bc	3.1	6.96	7.07	7.01d	1.6				
Aziziye 94	9.05	9.57	9.31	5.7	7.36	7.54	7.45bc	2.4	7.64	7.58	7.61ab	-0.8				
Uzunlu 99	9.89	10.29	10.09	4.0	7.48	7.79	7.63ab	4.1	7.27	7.54	7.41b-d	3.7				
Küsmen 99	9.63	10.13	9.88	5.2	7.14	7.37	7.25cd	3.2	6.95	7.08	7.01d	1.9				
Damla 89	8.69	8.39	8.54	3.5	6.92	6.93	6.92d	0.1	6.89	7.07	6.98d	2.6				
Aydın 92	8.95	8.96	8.95	0.1	7.53	7.48	7.50bc	-0.7	7.49	7.30	7.39b-d	2.5				
Akçin 91	8.94	9.12	9.03	2.0	7.25	7.53	7.39bc	3.9	7.31	7.59	7.45bc	3.8				
Er 99	9.68	9.09	9.38	-6.1	7.48	7.43	7.46bc	0.7	7.53	7.64	7.58ab	1.5				
Menemen 92	9.23	9.34	9.28	1.2	7.37	7.51	7.44bc	1.9	6.72	7.51	7.12cd	11.8				
İzmir 92	9.30	7.69	8.36	-17.3	7.28	7.51	7.39bc	3.2	7.30	7.74	7.52a-c	6.0				
Means	9.23	9.28			7.37b	7.53a			7.30b	7.50a						
LSD %	Cult.: 0.329				I.: 0.104				Cult.: 0.094				I.: 0.127			

Table 8: The means of some of characteristics in twelve chickpea cultivars under rainfed (R) and irrigated (I) conditions and increase from irrigated (%) at 2002

Cultivars	100 seed weight				Protein percentage	
	R	I	M	In.	R	I
Sarı 98	40.76	49.21	44.98a	20.7	20.37	18.64
Diyar 95	35.21	41.87	38.54b	18.9	22.43	19.42
Gökçe	32.19	37.75	34.97de	17.3	17.05	16.17
Aziziye 94	36.32	38.32	37.32bc	5.5	21.51	18.05
Uzunlu 99	34.98	39.76	37.37bc	13.7	22.39	18.58
Küsmen 99	34.21	38.35	36.28b-d	12.1	24.96	20.72
Damla 89	31.10	34.49	32.80e	10.9	20.42	18.88
Aydın 92	31.09	34.43	32.76e	10.7	22.80	17.14
Akçin 91	32.83	37.02	34.93de	12.8	22.66	19.53
Er 99	31.97	41.41	36.69b-d	29.5	16.28	15.94
Menemen 92	34.57	35.92	35.24cd	3.9	21.32	19.71
İzmir 92	34.67	37.90	36.32b-d	9.3	21.48	19.79
Means	34.16b	38.87a				
LSD %	Cultivars: 2.313		Irrigation: 1.075			

Almost all cultivars for seed yield/plant responded positively low to irrigation. The highest increase in seed yield/plant due to irrigation was 12.9% for Menemen 92 (Table 5). The mean seed yield/plant under irrigation was 7.04 g, compared with 3.56 g under rainfed conditions, giving an all overall increase of 51% or 3.48 g in seed yield/plant due to irrigation. Malhotra *et al.*^[1] and Saxena *et al.*^[8] reported that seed yield was increasing under irrigated conditions (Table 5).

Pod length ranged from 21.53 to 25.05 mm among cultivars. Pod length increased with irrigation. The highest increase in pod length due to irrigation was 12.9% for Menemen 92 (Table 6). Irrigation x cultivars interaction was significant for pod width and pod depth. This revealed the different response of some of the cultivars under rainfed and irrigated conditions. All cultivars, except Sarı 98, were positively affected by irrigation for pod width.

Seed length varied from 8.36 to 10.09 mm among cultivars, although it did not differ significantly by irrigation. Seed width varied from 6.92 to 7.93 mm among cultivars and mean seed width under irrigation (7.53 mm) was higher than under rainfed (7.37 mm). Increasing of seed width with irrigation among cultivars was small (Table 7).

Seed depth affected by irrigation. Menemen 92 had the highest seed depth. While some of the cultivars of seed depth under irrigation condition, but there was no increase for Aziziye 94.

100 seed weight affected by irrigated condition. The highest increase in 100 seed weight due to irrigation was 29.5% for Er 99. This character ranged from 32.76 to 44.98 g among cultivars. Mean 100 seed weight with irrigation was 38.87 g, compared with 34.16 g under rainfed

conditions, giving an overall increase of 87% in 100 seed weight due to irrigation. Protein percentage decreased under irrigation conditions (Table 8). However, Kűsmeu 99 had the highest protein content in irrigated and rainfed conditions.

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