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Yield Performance of Cowpea (*Vigna unguiculata* L. Walp.) Cultivars Under Rainfed and Irrigated Conditions

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Abstract: The object of this study was to compare seed yield and yield related characters of cowpea cvs. Karagoz-86 and Akkiz-86 under both rainfed (non-irrigated) and irrigated (well-watered) conditions in Samsun, Turkey in the years of 2005 and 2006 and also to determinate reduction in seed yield under rainfed condition. The field experiments were arranged in Completely Randomized Design with ten replications. Significant differences ($p<0.01$) were found among study years for plant height, 100 seed weight, the number of seeds per plant, seed yield and biological yield. Cultivars differed for ($p<0.01$) 100 seeds weight, the number of seeds per plant, seed yield, biological yield and harvest index. Karagoz-86 gave higher seed yield (116.36 g m^{-2}) than Akkiz-86 (53.51 g m^{-2}) due to it has larger seeds and more seeds per plant. Except for the number of branches per plant, 100 seed weight and harvest index, plants grown in irrigated conditions gave higher means regarding all characters when compared with plants grown in rainfed conditions. Seed yield reductions of 64.01 and 43.11% were determined in Karagoz-86 under rainfed conditions when compared with irrigated conditions in 2005 and 2006, respectively. Yields of Akkiz-86 under rainfed conditions were lower 58.02 and 31.50% than that in irrigated conditions for the same years.

Key words: *Vigna unguiculata*, cowpea, irrigated, rainfed, seed yield

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is a leguminous, annual, herbaceous legume and an important source of proteins, present in tropical and subtropical areas (Ehlers and Hall, 1997). It is primarily grown in drier regions of the world where it is one of the most drought-resistant food legumes (Dadson *et al*., 2005). It tolerates heat and dry conditions, but is intolerant of frost. Cowpea is usually better adapted to drought, high temperatures and other biotic stresses compared with other crop plant species (Ehlers and Hall, 1997; Kuykendall *et al*., 2000; Martins *et al*., 2003). Drought resistance is one reason that cowpea is such an important crop in many underdeveloped parts of the world. Cowpeas are grown under both irrigated and non-irrigated regimes. The crop responds positively to irrigation, but will also produce well under dry land conditions. If irrigation is used, more vegetative growth and some delay in maturity may result. The most critical moisture requiring period is just prior to and during bloom (Davis *et al*., 1991).

In Turkey, cowpea is generally cultivated in Aegean and Mediterranean regions. However, in the middle Black Sea region, it is grown to supply for only family requirements. Some agricultural researches on the cultivation of cowpea under Samsun conditions (Gulumser *et al*., 1989), determination of seed characteristics of cowpea genotypes (Peksen *et al*., 2000), the effects of sowing dates on fresh yield and quality of cowpea genotypes grown in greenhouse (Peksen *et al*., 2002), the effects of different row spacing and nitrogen fertilization on yield and yield components of cowpea (Ozturan, 2003), determination of fresh pod yield and some pod characteristics of cowpea genotypes

from Turkey (Peksen, 2004), comparison of some cowpea genotypes from Turkey for seed yield and yield related characters (Peksen and Artik, 2004) and determination of genotypic differences for leaf characteristics in cowpea genotypes (Peksen *et al.*, 2005) have been carried out in Samsun conditions.

The effects of water deficit on plant development and seed yield show differences depending on plant development stages and some other factors. It has been reported that the most sensitive stages for cowpea to water deficit or water stress were seed filling stage (Cordeiro *et al.*, 1998) and vegetative stage, followed by the flowering and fruiting stages (Carvalho *et al.*, 2000). Santos *et al.* (2000) informed that it is necessary to develop specific cowpea genotypes for different environments and social conditions, with special focus on irrigated conditions. It has been determined that shoot growth was more sensitive to increasing water stress than root growth. Seed yields of cowpea cv. MI 35 were higher in the rainy than dry seasons and were decreased by delaying sowing (Sangakkara, 1998). There is a need for cowpea cultivars, which are more tolerant to water deficit or more efficient in their water use (Anyia and Herzog, 2004).

There are only two registered cowpea cultivars, namely Karagoz-86 and Akkiz-86, in Turkey. The object of this study was to compare seed yield and yield-related characters of cowpea cvs. Karagoz-86 and Akkiz-86 under both rainfed (non-irrigated) and irrigated (well-watered) conditions and also to determinate reduction in seed yield under rainfed condition.

MATERIALS AND METHODS

This study was conducted in the experimental area of Faculty of Agriculture, Ondokuz Mayis University of Samsun (41.3°N longitude, 36.3°E altitude, 150 m above sea level), Turkey, in 2005 and 2006 years. Cowpea (*Vigna unguiculata* L. Walp.) cvs. Akkiz-86 and Karagoz-86 were used in the study.

Field Trials

Field trials were carried out in both rainfed (non-irrigated) and irrigated (well-watered) conditions. To avoid from drought stress, plants were watered when they required. Field experiments were arranged in Completely Randomized Design (CRD) with 10 replications. Seed sowing was performed by hand on May 16, 2005 and May 24, 2006. Distance between two alternate rows and two plants on the same row were 0.6 and 0.1 m, respectively.

Climatically Conditions

The average air temperatures were 20.4 and 20.6°C during the field experiments in 2005 and 2006, respectively. Total rainfall was 338.2 and 229.2 mm for the same periods. Long-term average air temperatures were very similar to that of research years. However, monthly total rainfall for the study years showed significant differences when compared with the long-term period (Table 1).

Soil Properties

The soil of the experimental area was heavy clay, slightly acidic, limeless and saltless, low in phosphorus, rich in potassium and high in organic matter in both years.

Investigated Plant Characters

Plant height (cm), first pod height (cm), the number of pods per plant (pods plant^{-1}), the number of branches per plant (branches plant^{-1}), 100 seed weight (g), the number of seeds per plant (seeds plant^{-1}), seed yield (g m^{-2}), biological yield (g m^{-2}) and harvest index (%) were determined in the study.

Table 1: Monthly average temperature (°C) and monthly total rainfall (mm) in both years (2005 and 2006) and over the long term (1974-2003)

	Monthly average air temperatures (°C)						
Years	May	June	July	August	September	October	Mean (°C)
2005	15.8	20.2	24.2	25.4	21.3	15.7	20.4
2006	14.6	21.3	23.0	26.5	20.9	17.2	20.6
1974-2003	15.3	20.0	23.1	23.2	19.8	15.8	19.5
	Monthly total rainfall (mm)						
Years	May	June	July	August	September	October	Total (mm)
2005	34.7	51.1	5.9	114.2	69.4	62.9	338.2
2006	69.0	36.3	9.0	-	66.2	48.7	229.2
1974-2003	50.6	47.9	31.3	31.5	50.9	83.7	295.9

Statistical Analysis

Data were subjected an analysis of variance according to Completely Randomized Design using MSTATC statistical program. Means showing statistically significance were compared by Duncan's Multiple Comparison Method.

RESULTS AND DISCUSSION

Effects of Years

Significant differences ($p<0.01$) were found among years for plant height, 100 seed weight, the number of seeds per plant, seed yield and biological yield (Table 2). Means for these traits in 2006 were higher than that in 2005. Seed and biological yield were high in 2006, as plants were longer and produced more vegetative parts, larger seeds and more seeds per plants.

Significant interactions were found between Y×GC for first pod height, pods number per plant and 100 seed weight. Y×C interactions were significant for seeds number per plant, seed yield, biological yield and harvest index. Y×G×GC interaction was significant for only 100 seed weight (Table 2).

Effects of Cultivars

Cowpea cultivars didn't show significant difference for plant height, first pod height, the number of pods and branches per plant. Highly significant differences ($p<0.01$) were found among cowpea cultivars in terms of 100 seed weight, seeds number per plant, seed and biological yield and harvest index. Karagoz-86 gave higher seed yield (116.36 g m^{-2}) than Akkiz-86 (53.51 g m^{-2}) due to it has larger seeds and more seeds per plant. In the present study, 100 seeds weight were 20.33 and 12.76 g for Karagoz-86 and Akkiz-86, respectively. This result was in agreement with finding of Peksen and Artik (2004) stated that 100 seeds weight were 21.84 and 12.86 g for Karagoz-86 and Akkiz-86 and Karagoz-86 was found to be more productive (751.2 kg ha^{-1}) than Akkiz-86 (680.2 kg ha^{-1}) under irrigated conditions in Samsun. In addition, Karagoz-86 had higher biological yield (214.33 g m^{-2}) than that of Akkiz-86 (117.51 g m^{-2}) (Table 2).

Effects of Growth Conditions

Plants grown under irrigated conditions gave higher means regarding all of characters when compared with grown under rainfed conditions, except for the number of branches per plant, 100 seed weight and harvest index. Under irrigated conditions, 100 seed weight were reduced depending on the increases in the number of pods and seeds per plant. Plants were longer, showed better vegetative growth and had more seeds per plant under irrigated conditions. Therefore, harvest index was lower due to increasing vegetative growth and also decreasing 100 seed weight (Table 2).

Table 2: Means of cowpea cvs. Karagoz-86 and Akkiz-86 for investigated characters under rainfed and irrigated conditions in 2005 and 2006 years

		2005			2006					
Characters	Cultivars	Irrigated	Rainfed	Y×C int.	Irrigated	Rainfed	Y×C int.	Means of cultivars (C)	Means of growth conditions (GC)	
Plant height (cm)	Karagoz-86	57.80	29.10	43.45	78.50	49.60	64.05	53.75	Irrigated	64.25a**
	Akkiz-86	53.20	33.60	43.40	67.50	44.33	55.92	49.66	Rainfed	39.16b
	Y×GC int.	55.50	31.35		73.00	46.97				
	Year (Y)			43.43b**			59.98a			
First pod height (cm)	Karagoz-86	28.30	24.90	26.60	30.40	22.30	26.35	26.48	Irrigated	27.65a**
	Akkiz-86	21.10	21.50	21.30	30.80	18.30	24.55	22.93	Rainfed	21.75b
	Y×GC int.	24.70b*	23.20b		30.60a	20.30b				
	Year (Y)			23.95			25.45			
Pods number per plant	Karagoz-86	7.90	3.20	5.55	8.00	5.10	6.55	6.05	Irrigated	7.03a**
	Akkiz-86	6.80	4.10	5.45	5.40	5.20	5.30	5.38	Rainfed	4.40b
	Y×GC int.	7.35a*	3.65c		6.70a	5.15b				
	Year (Y)			5.50			5.93			
Branches number per plant	Karagoz-86	1.30	1.30	1.30	1.50	1.20	1.35	1.33	Irrigated	1.30
	Akkiz-86	1.10	1.10	1.10	1.30	1.20	1.25	1.18	Rainfed	1.20
	Y×GC int.	1.20	1.20		1.40	1.20				
	Year (Y)			1.20			1.30			
100 seed weight (g)	Karagoz-86	16.33b*	20.99a	18.66	22.24a	21.75a	22.00	20.33a**	Irrigated	15.96b*
	Akkiz-86	11.53c	11.78c	11.66	13.73bc	13.98bc	13.86	12.76b	Rainfed	17.13a
	Y×GC int.	13.93b*	16.39a		17.98a	17.87a				
	Year (Y)			15.16b**			17.93a			
Seeds number per plant	Karagoz-86	38.10	10.60	24.35b**	55.30	29.90	42.60a	33.48a**	Irrigated	39.43a**
	Akkiz-86	35.00	14.60	24.80b	29.30	20.10	24.70b	24.75b	Rainfed	18.80b
	Y×GC int.	36.55	12.60		42.30	25.00				
	Year (Y)			24.58b**			33.65a			
Seed yield (g m^{-2})	Karagoz-86	105.69	38.04	71.85b**	205.12	116.69	160.90a	116.36a**	Irrigated	112.14a**
	Akkiz-86	69.13	29.02	49.06b	68.66	47.03	57.84b	53.51b	Rainfed	57.69b
	Y×GC int.	87.38	33.52		136.89	81.87				
	Year (Y)			60.51b**			109.36a			
Biological yield (g m^{-2})	Karagoz-86	235.26	64.10	149.68b*	354.82	203.16	278.99a	214.33a**	Irrigated	223.81a**
	Akkiz-86	142.18	59.18	100.29b	162.97	106.49	134.73b	117.51b	Rainfed	108.02b
	Y×GC int.	188.72	61.23		258.90	154.83				
	Year (Y)			124.97b**			206.86a			
Harvest index (%)	Karagoz-86	46.24	58.21	52.23ab**	57.00	57.74	57.37a	54.80a**	Irrigated	48.16b*
	Akkiz-86	48.56	49.60	49.08bc	40.83	43.58	42.20c	45.64b	Rainfed	52.28a
	Y×GC int.	47.40	53.91		48.91	50.66				
	Year (Y)			50.66			49.79			

*Significant at 0.05 level, **Significant at 0.01 level, Y: Year, C: Cultivar, GC: Growth Conditions

Lower yields of 64.01 and 43.11% obtained from Karagoz-86 under rainfed conditions when compared with irrigated conditions in 2005 and 2006, respectively. Seed yields of Akkiz-86 under rainfed conditions were lower 58.02 and 31.50% than that in irrigated conditions for the same years (Table 3).

Table 3: Reductions in seed yields of cowpea cvs. Karagoz-86 and Akkiz-86 under rainfed conditions in 2005 and 2006 years

	2005			2006		
	Seed yield (g m^{-2})		Reduction in seed yield	Seed yield (g m^{-2})		Reduction in seed yield
Cultivars	Irrigated	Rainfed	(%)	Irrigated	Rainfed	(%)
Karagoz-86	105.69	38.04	64.01	205.12	116.69	43.11
Akkiz-86	69.13	29.02	58.02	68.66	47.03	31.50
Means	87.38	33.52	61.64	136.89	81.87	40.19

It was found that seed yield of cowpea was decreased by 50% due to water deficit occurring at the flowering and pod filling stages by Shouse (1979). Shouse *et al.* (1981) determined that the most

sensitive growth stages to drought were flowering and pod filling and also yield reduction ranged from 35 to 69% depending on the timing and length of the drought treatment in cowpea. Bezerra *et al.* (2003) informed that water deficit during the whole growth period of cowpea reduced the yield by 59%. The effect of water stress on flower production, pod retention and the number of seeds per pod strongly reflected in reduction of seed yield per plant by 24, 56, 75 and 89%, respectively, under mild, moderate, strong and severe stresses (Jamadagni *et al.*, 2003). Our results for the reduction in seed yields under rainfed conditions were in agreement with those study results.

Bezerra *et al.* (2003) found that water deficit significantly affected the number of pods per plant and the number of grains per pod in cowpea. However, pod size and 100 seed weight were not significantly affected. On the contrary, the number of pods per plant was not affected by growth conditions while 100 seed weight was significantly affected in the present study (Table 2).

CONCLUSION

Very high seed yield loses due to water deficit or drought stress in the summer time may occur in cowpea cultivation under rainfed conditions. Study results revealed that additional water supply at the critical growth stages such as flowering, pod setting and seed filling can be compensate seed yield losses on a large scale. For this reason, watering should be performed at drought periods that plants need more water. Nevertheless, the effects of irrigation methods, irrigation interval and levels and duration of irrigation should be investigated in more detail to increase cowpea seed yield.

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