

Performance of Local Cowpea Genotypes Grown Under Deficit Irrigation Conditions

Author Details: Feride ÖNCAN SÜMER

Aydın Adnan Menderes University, Agriculture Faculty, Department of Field Crops

Received Date: 28-Sep-2022

Accepted Date: 29-Oct-2022

Published Date: 31-Oct-2022

Abstract

Drought reduces the yield of many plants. The cowpea is the most drought-resistant legume. Due to its high protein content, it should also be included in a person's daily diet. Cowpea is one of the best-adapted legumes to poor field conditions. The objective of this research was to determine the yield and quality losses caused by drought in certain genotypes. The study utilized local genotypes grown in the region under deficit irrigation conditions. To accomplish this, local cowpea genotypes (genotype 1 and genotype 2) were grown under normal irrigation (100%) and deficit irrigation (50%). The study was conducted during the 2019 and 2020 cowpea production seasons on the trial fields of the Faculty of Agriculture at Aydın Adnan Menderes University. The grain yield, some components of the yield, the grain's protein content, and its zinc content were measured. As a result, higher grain yield and grain yield components were observed under conditions of complete irrigation. It was discovered that grain protein ratios were greater under deficit irrigation conditions. Among the genotypes, genotype 2 produced the highest grain yield and yield components.

Keywords: Cowpea, drought, grain protein content.

ÖZET

Kuraklık pek çok bitkide verim kaybına neden olmaktadır. Baklagiller içerisinde kuraklığa en toleranslı olanı börülcedir. Ayrıca yüksek protein oranı ile insanların günlük beslenmesinde yer almalıdır. Börülce baklagiller içerisinde kötü tarla şartlarına en iyi uyum gösterenlerden biridir. Bu çalışmada kuraklığın yol açtığı verim ve kalite kayıpların bazı genotiplerde belirlenmesi amaçlanmıştır. Araştırmada kısıtlı sulama koşullarında bölgede ekilen yerel genotipler kullanılmıştır. Bu amaçla normal sulama (% 100) ve kısıtlı sulama (% 50) koşullarında, yerel börülce genotipleri (genotip 1 ve genotip 2) yetiştirilmiştir. Çalışma, 2019 ve 2020 yılları börülce üretim sezonunda, Aydın Adnan Menderes Üniversitesi Ziraat Fakültesi Deneme alanlarında yürütülmüştür. Çalışmada tane verim, bazı verim komponentleri, tane protein oranı ve tane çinko içeriği ölçümlenmiştir. Sonuçta tane verim ve verim komponentlerinin tam sulama koşullarında daha yüksek değerler verdiği gözlenmiştir. Tane protein oranlarının kısıtlı sulama koşullarında daha yüksek bulunduğu belirlenmiştir. Genotipler arasında genotip 2 tane verimi ve bazı verim komponentleri bakımından daha iyi değerler vermiştir.

Anahtar kelimeler: Börülce, kuraklık, tane protein içeriği.

INTRODUCTION

Protein is derived from edible legumes for more than 2 billion people worldwide. They are nutritious, low in fat, and high in carbohydrates. 70% of the protein consumed worldwide comes from plant sources, while 30% comes from animal sources. In human nutrition, edible grain legumes provide 22% of vegetable proteins and 7% of carbohydrates; in animal nutrition, 38% of proteins and 5% of carbohydrates are derived from edible grain legumes. In addition, the significance of legumes in crop production increases due to their ability to bind the free nitrogen of the air to the soil and to serve multiple purposes, such as increasing soil fertility through crop rotation and contributing to the improvement of soil structure in saline soils and fallow areas. Despite the rapidly expanding global population, the daily demand for plant and animal foods necessary for human nutrition is rising. Therefore, studies conducted to increase agricultural production remain current (Dhanda et al. 2004).

It is observed that the cultivation areas of edible grain legumes are decreasing in our country. Due to the importance of edible grain legumes in human nutrition and in ensuring the sustainability of agricultural systems, it is necessary to conduct more research in this area and increase the cultivation area and production of these crops. In many parts of the world, cowpea is cultivated under arid and semiarid

October 31, 2022

conditions (Şehirali, 1988). Cowpea, which is widely cultivated in our country, particularly in the Aegean and Mediterranean regions, is a product that farmers consume rather than sell. There are a number of reasons why cultivation areas have not spread to other regions, but the most significant is that producers prefer high-return products (Ceylan and Sepetoğlu, 1980). As a result of global warming, it is necessary to identify prominent crop groups or varieties for future drought conditions.

The purpose of this study was to determine the cowpea plant's performance under deficit irrigation conditions in order to incorporate cowpea and other legumes with high grain protein content into the crop pattern.

METHODS AND MATERIALS

In 2019 and 2020, the study was conducted at the Aydın Adnan Menderes University Faculty of Agriculture Research and Application Farm. The experiment employed a split-plot experimental design with three replicates in random blocks. The length of the plot was 5 meters, and the row spacing was 70 centimeters across six rows (5 m long). In the first year, planting occurred on April 30, 2019, and in the second year, on May 8, 2020. Two distinct genotypes of cowpea were utilized in the experiment. Farmers have been producing these genotypes for decades. Therefore, they were designated genotypes 1 and 2. Planting was carried out by targeting 25 plants per square meter. Before planting, fertilization was made with 15-15-15 fertilizer as 40 kg ha⁻¹ nitrogen, phosphorus and potassium. When the plants reached a height of 15 cm, hoeing was done to remove weeds.

Water meters were used to measure the amount of irrigation water to be applied to the plots. The irrigation water to be applied to the plots was calculated based on the cumulative evaporation amount from the class A evaporation container multiplied by different coefficients. In the study, 2 irrigation subjects, TS (100%) and KS (50%), where different levels of cumulative evaporation amount were applied, were taken into consideration.

These are; Full Irrigation (FI): Irrigation water was applied as much as the entire 7-day cumulative evaporation from the class A evaporation container.

Restricted Irrigation (RI): It was formed in the form that 50% of the irrigation water was applied to the TS subject.

$I = Kpc \cdot Ep \cdot P \cdot A$; I = Amount of irrigation water to be applied to the plot (L); Kpc = Evaporation container coefficient 100%; Ep = Cumulative evaporation amount (mm); P = Percent cover (%); A = Plot area (m²) and drip irrigation method was used (Efetha et al., 2011).

Table 1. Soil properties of the experimental area

Soil Texture			pH	Organic Matter	Phosphorus	Potassium	Calcium	Sodium
Sand	Silt	Clay						
72	16.7	11.3	8.4	% 1.2	ppm 21	ppm 176	ppm 2978	ppm 101
Sandy Soil			High	Low	High	Low	High	Low

According to the analysis results in Table 1, it is observed that the soil texture is sandy loamy. It was determined that the pH value (8.4) was high, and the organic matter content was low. In addition, phosphorus and calcium content was high, while sodium and potassium content was low.

October 31, 2022

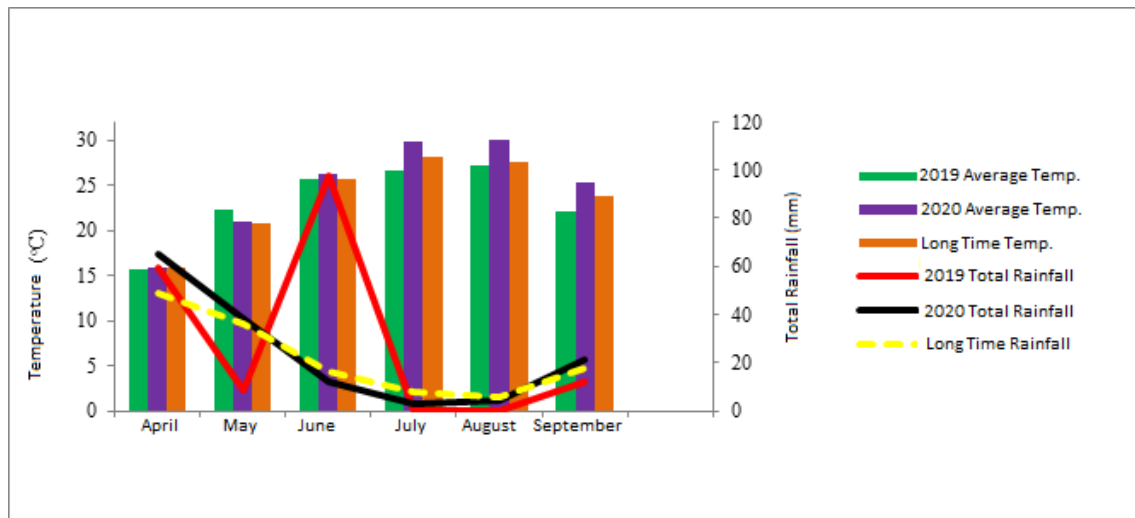


Table 1. Meteorological data for the experimental years

Aydın Meteorological Station, 2020.

Climatic data for the experimental years are given in Table 1. The table shows average temperatures and total rainfall data. In the first year, total rainfall in June was realized in a remarkable amount. In addition, it is observed that the average temperatures in July, August and September in the second year of the experiment were higher than in the long years and the other experimental year.

Characteristics analyzed

Plant height, first pod height, number of pods per plant, number of grains per pod, grain yield, grain protein content, and grain zinc content were measured.

Harvesting was done in 11.4 m² (4 rows x 4 m x 0.7 m) in each plot for the seed yield (kg da⁻¹).

Seed protein content (%) was measured by NIRS-FT (Bruker MPA) at Adnan Menderes University Agricultural Biotechnology and Food Safety Application and Research Center (ADÜ-TARBIYOMER) (Gislum et al., 2004).

The seed grain's content (mg kg⁻¹) was determined by atomic absorption spectrometry after ashing samples at 550°C and dissolving ash in 3.3% HCl (Cakmak et al., 1996).

Statistical evaluations were carried out in the JMP (pro 13 version) analysis program in a randomized block split-plot experimental design.

RESULTS AND DISCUSSION

The year factor was found to be significant in the data obtained from the study, and for this reason, the years were evaluated separately and summarized in the table.

Table 1. Analysis of variance (mean squares) for the analyzed characters

Sources of Variation	SD	Plant Height (cm)		First Pod Height (cm)		Number of Pods per Plant (pcs)		Number of Grain in Pod	
		2019	2020	2019	2020	2019	2020	2019	2020
Irrigation	1	22.963*	19.635*	10.429*	12.751	29.297*	107.88*	4.429*	19.995*
Error 1	2	0.460	0.285	0.931	0.869	0.512	0.892	0.166	0.217
Genotypes	1	97.47*	121.285*	1.833*	2.108*	2.0419	4.060	1.086	0.858
Error 2	4	0.710	1.980	0.458	0.107	2.895	0.926	0.192	0.117
S*G	1	0.120	1.650	0.285	0.002	8.927	0.974	0.357	2.679*
CV (%)		3.099	5.05	5.76	2.57	18.31	10.18	5.18	4.55
Sources of Variation	SD	Grain Yield (kg da ⁻¹)		Grain Protein Content (%)		Grain Zinc Content (mg kg ⁻¹)			
		2019	2020	2019	2020	2019	2020		
Irrigation	1	3834.19*	2820.72*	42.827*	14.763*	821.21*	470.176*		

October 31, 2022

Error 1	2	7.668	75.05	1.857	0.032	61.120	11.752
Genotypes	1	0.908	653.278	4.165	0.969	20.460	37.256*
Error 2	4	37.142	39.931	0.613	1.160	17.438	4.816
S*G	1	442.87*	12.120	0.018	0.138	4.480	3.752
CV (%)		13.79	3.073	3.38	4.78	8.28	4.42

The mean square values of the traits analyzed in the first and second years are displayed in Table 1. In the first year, the genotype factor in plant height, the irrigation and genotype factors in first pod height, the number of pods per plant, the number of grains per pod, the irrigation factor in grain zinc content, the irrigation*genotype interaction and the irrigation factor in grain yield, and the irrigation factor in grain protein content were found to be significant. In the second year, the irrigation and genotype factors in plant height, the genotype factor in first pod height, the irrigation factor in the number of pods per plant, the irrigation factor and irrigation*genotype interaction in the number of grains per pod, the irrigation and genotype factors in grain yield, the irrigation factor in grain protein content, and the irrigation and genotype factors in grain zinc content were found to be significant. Groupings based on factors with statistically significant effects are presented in Table 2.

Table 2. Grain yield and average values of some yield components of the trial years

Types	Plant Height (cm)					
	2019			2020		
	Full irrigation (100%)	Deficit Irrigation (50%)	Mean	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean
Genotype 1	25.5	23.0	24.3 b	25.5	23.7	24.6 b
Genotype 2	30.8	28.5	29.7 a	32.6	29.3	31.0 a
Mean	28.2 A	25.7 B	27.0	29.1 A	26.5 B	27.8
LSDIrrigation		1.68			1.29	
LSDGenotype		1.33			2.24	
LSDIrrigation*Genotype		ns			ns	
Çeşitler	First Pod Height (cm)					
	2019			2020		
	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean
Genotype 1	12.3	10.2	11.2	13.1	11.02	12.0 b
Genotype 2	12.8	11.3	12.0	13.9	11.8	12.9 a
Mean	12.6 A	10.7 B	11.6	13.5	11.4	12.5
LSDIrrigation		1.68			ns	
LSDGenotype		ns			0.510	
LSDIrrigation*Genotype		ns			ns	
Çeşitler	Number of Pods per Plant (pcs)					
	2019			2020		
	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean
Genotype 1	10.4	9.0	9.7	12.1	5.6	8.9
Genotype 2	11.3	6.5	8.9	12.7	7.3	10.0
Mean	10.9 A	7.7 B	9.3	12.4 A	6.4 B	9.4
LSDIrrigation		1.76			2.34	

October 31, 2022

LSDGenotype	ns	ns
LSDIrrigation*Genotype	ns	ns

Number of Grain in Pods (pcs)

Çeşitler	2019			2020		
	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean
	Genotype 1	9.4	7.8	8.6	9.5	6.0
Genotype 2	8.4	7.6	8.0	8.0	6.4	7.2
Mean	8.9 A	7.7 B	8.3	8.8 A	6.2 B	7.5
LSDIrrigation	1.01			2.34		
LSDGenotype	ns			ns		
LSDIrrigation*Genotype	ns			ns		

Grain Yield (kg/da)

Çeşitler	2019			2020		
	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean
	Genotype 1	216.7 A	175.1 B	195.9 b	214.3	181.7
Genotype 2	223.0 A	196.7 B	209.8 a	227.1	198.4	212.8 a
Mean	219.9	185.9	202.9	220.7 A	190.1 B	205.4
LSDIrrigation	13.76			21.5		
LSDGenotype	ns			10.08		
LSDIrrigation*Genotype	6.83			ns		

Grain Protein Rate (%)

Çeşitler	2019			2020		
	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean
	Genotype 1	20.6	24.3	22.5 b	21.1	23.1
Genotype 2	21.7	25.6	23.7 a	21.4	23.9	22.7
Mean	21.2	25.0	23.1	21.3 B	23.5 A	22.4
LSDIrrigation	3.35			0.43		
LSDGenotype	ns			ns		
LSDIrrigation*Genotype	ns			ns		

Grain Zinc Content (mg kg⁻¹)

Çeşitler	2019			2020		
	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean	Full Irrigation (100%)	Deficit Irrigation (50%)	Mean
	Genotype 1	57.9	40.2	49.1	53.4	42.0
Genotype 2	59.3	42.3	50.8	58.1	44.4	51.2 a
Mean	58.6 A	41.3 B	49.9	55.7 A	43.2 B	49.5
LSDIrrigation	13.71			8.47		
LSDGenotype	ns			1.49		
LSDIrrigation*Genotype	ns			ns		

ns:nonsignificant

October 31, 2022

According to the data in Table 2, both irrigation and genotype factors were found to be significant in plant height values in the first year (2019) and second year (2020) of the experiment. Higher values were obtained from full irrigation conditions and genotype 2 in both years of the experiment. Under full irrigation conditions where the plant can obtain the water it needs, plants are taller than under deficit irrigation conditions because they can fully complete vegetative growth (Ogbonnaya et al., 2003). Santos et al. (2020) reported that the plant height of plants exposed to drought stress decreased in cowpea.

In the first year (2019), the irrigation factor was found to be significant in the first pod height values, and a longer first pod height (12.6 cm) was measured in fully irrigated plants. In the second year (2020), the genotype factor was found to be significant, and a longer (12.9 cm) first pod height value was obtained in genotype 2. In previous studies, average first pod height values of 9.00-28.40 cm and 9-16.6 cm were observed (Stoilova and Pereira, 2013; Pal et al., 2014).

In both years of the experiment, the irrigation factor was found to be significant, while the genotype factor was found to be insignificant. In both years, the number of pods per plant was greater under total irrigation than under deficit irrigation (10.9 -12.4). Under drought conditions, the plants lost their flowers, and consequently, the number of pods per plant decreased. Similar to this study, Çulha and Bozoğlu (2016) determined the average number of pods to be between 8.83 and 15.45. Under conditions of adequate soil moisture, the flowering period lasts longer, and the plant produces more pods than under drought conditions. Under drought conditions, the flowering period concludes early, grains mature rapidly, and the formation of new flower nodes or flowers is delayed (Turk et al., 1980).

The number of grains in pods was found to be significantly affected by the irrigation factor but not by the genotype factor. In the experiment, the highest grain number values were recorded in the first year (8.9) and the second year (8.8) under conditions of complete irrigation. The number of grains decreased as a result of deficit irrigation. Genotype 2 produced more pods and grains than genotype 1 under conditions of complete irrigation. Under conditions of deficit irrigation, both genotypes produced fewer pods and grains. These variations also impacted grain yield. Under conditions of deficit irrigation, water use efficiency and photosynthesis rate become crucial. A low photosynthesis rate may cause the plant to produce fewer pods and grains, resulting in yield loss (Condon et al., 20002).

In grain yield values, irrigation*genotype interaction was found to be significant in the first year of the experiment. The highest value was obtained from genotype 2 (223.0 kg/ha) under full irrigation conditions in the first year. In the second year, similarly, a high yield (227.1 kg/da) was obtained from full irrigation conditions. It is observed that the plant was negatively affected under drought conditions. The first drought escape mechanism of cowpea is to reduce leaf growth, thus reducing the amount of water lost by evaporation. The sensitivity of water use in the root zone increases, and the plant can provide partial sustainability of the water in its body (Turk and Hall, 1980). Sert and Ceyhan (2012) measured the highest grain yield of 101.26 kg/ha in the cowpea varieties they examined. When soil water content decreases, leaf water potential and carbon dioxide uptake also decrease, and photosynthetic activity is deficit, resulting in slower plant growth and yield losses (Kramar 1983). However, in some studies, no decrease in plant water potential was observed despite the decrease in soil water content (Ismail and Hall, 1992). It was revealed that these differences might be due to the different responses of the genotypes used in the trials (Tomas et al., 2012). Plant water use efficiency may vary within species according to cultivars (Martin and Ruiz-Torres, 1992; Condon et al., 2002).

Genotype factor was found to be significant on grain protein ratio in the first year. Among the genotypes, genotype 2 (23.7%) gave the highest value. In the second year, the irrigation factor was found to be significant, and higher protein content was measured with deficit irrigation (23.5%) compared to full irrigation. Cowpea is known to be a legume with high-quality protein content. Protein content may vary according to cultivars or genotypes (Vasconcelos et al., 2010). Kanda et al. (2020) obtained higher protein content under full irrigation conditions in their study, but in some studies on legumes, higher protein content was obtained under stress conditions (Kahraman et al., 2015).

Grain zinc content has been measured because of its importance in human nutrition. It can be determined how much zinc we can get from the food we consume. Zinc, which is one of the absolutely necessary microelements, is the building block of various enzyme systems formed in the plant and some hormones that provide the formation of shoots. Zinc is a very common micronutrient problem in Turkey, and this problem

occurs especially in areas cultivated in arid-semi-arid regions (Graham and Welch 1996; Cakmak et al. 2010). In the first year, the irrigation factor was found to be significant, and the highest value was measured under full irrigation conditions (58.6 mg kg⁻¹). In the second year, the effect of the genotype factor on grain zinc content was found to be significant, and the highest value was obtained from genotype 2 (59.4 mg kg⁻¹).

Conclusion

Cowpea grain yield and some yield components were negatively affected by deficit irrigation conditions, according to the results of the experiment. Under conditions of deficit irrigation, it was observed that the plants in the experiment had smaller leaves, shed their leaves earlier, and thus completed their vegetation period earlier. Under deficit irrigation conditions, grain protein content was found to be higher, and grain zinc content was found to be lower. While the genotypes responded similarly to deficit irrigation conditions, genotype 2 performed better.

References

- Ceylan, A., Sepetoğlu H. 1980. Farklı kökenli börülcelerin (*Vigna sinensis* Endi) Bornova ekolojik koşullarında bazı agronomik özelliklerinin saptanması üzerine araştırma. Ege Üniv. Ziraat Fak. Yayınları. No:387. Bornova/İzmir
- Condon, A.G., Richards, R.A., Rebetzke, G.J., Arquhar, G.D., 2002. Improving intrinsic water-use efficiency and crop yield, *Crop Sci.* 42, 122–131.
- Cakmak, I., Yilmaz, A., Kalayci, M., Ekiz, H., Torun, B., Braun, H. J. 1996. Zinc deficiency as a critical problem in wheat production in Central Anatolia. *Plant and soil*, 180(2), 165-172.
- Cakmak, I., Pfeiffer, W. H., McClafferty, B. 2010. Biofortification of durum wheat with zinc and iron. *Cereal chemistry*, 87(1), 10-20.
- Efetha A, Harms T, Bandara M. 2011. Irrigation management practices for maximizing seed yield and water use efficiency of Othello dry bean (*Phaseolus vulgaris* L.) in southern Alberta, Canada. *Irrig. Sci.* 29, 103–113.
- Çulha, G., Bozoğlu, H. 2016. Farklı kültürel uygulamalarla yetiştirilen amazon ve sırma börülce çeşitlerinin verim ve verim özellikleri. *Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi*, 25(ÖZEL SAYI-1), 177-183.
- Gislum, R., Micklander, E., Nielsen, J. P. 2004. Quantification of nitrogen concentration in perennial ryegrass and red fescue using near-infrared reflectance spectroscopy (NIRS) and chemometrics. *Field Crops Research*, 88(2-3), 269-277.
- Graham, R. D., Welch, R. M. 1996. Breeding for staple food crops with high micronutrient density (Vol. 3). *Intl Food Policy Res Inst.*
- Ismail, A.M., Hall, A.E. 1992. Correlation between water-use efficiency and carbon isotope discrimination in diverse cowpea genotypes and isogenic lines. *Crop Sci.*, 32, 7–12.
- Kahraman, A., Ceyhan, E., Harmanakaya, M. 2015. Nutritional variation and drought tolerance in chickpeas (*Cicer arietinum* L.). *Journal of Elementology*, 20(2).
- Kanda, E. K., Senzanje, A., Mabhaudhi, T., & Mubanga, S. C. 2020. Nutritional yield and nutritional water productivity of cowpea (*Vigna unguiculata* L. Walp) under varying irrigation water regimes. *Water SA*, 46(3), 410-418.
- Kramer, P.J. 1983. *Water relations of plants*. Academic Press, New York.
- Martin, B. Ruiz-Torres, N.A. 1992. Effects of water-deficit stress on photosynthesis, its components and component limitations, and on water use efficiency in wheat (*Triticum aestivum* L.), *Plant Physiol.* 100; 733–739.
- Pal, R., Nautiyal, M.K., Singh, Y.V., Sharma, C.L. 2014. Evaluation of Genetic Variability for Some of Quantitative Traits in Grain Cowpea [*Vigna unguiculata* (L.) Walp.]. *International Journal of Basic and Applied Agricultural Research*, Vol. 12 (2).
- Sert H., Ceylan, E. 2012. Hatay ili ekolojik şartlarında börülce (*Vigna sinensis* L.) çeşitlerinin tane verimi ve bazı tarımsal özellikleri üzerine farklı bitki sıklıklarının etkileri. *Selcuk Journal of Agriculture and Food Sciences*, 26(1), 34-43.

October 31, 2022

Stoilova, T., Pereira, G. 2013. Assessment of The Genetic Diversity in a Germplasm Collection of Cowpea (*Vigna unguiculata* (L.) Walp.) Using Morphological Traits. African Journal of Agricultural Research Vol. 8(2), pp. 208- 215.

Şehirli S., 1988. Yemelik Tane Baklagiller. IV.Börölce. Gıda-Tarım ve Hayvancılık Bakanlığı, Ziraat İşleri Genel Müdürlüğü Yayınları, Ankara

Tomás, M.; Medrano, H.; Pou, A.; Escalona, J.M.; Martorell, S.; Ribas-Carbó, M.; Flexas, J. Water-use efficiency in grapevine cultivars grown under controlled conditions: Effects of water stress at the leaf and whole-plant level. Aust. J. Grape Wine Res. 2012, 18, 164–172

Turk, K.J., A.E. Hall, and C.W. Asbell. 1980. Drought adaptation of cowpea. I. Influence of drought on seed yield. Agron. J. 72:413–420.

Vasconcelos, I. M., Maia, F. M. M., Farias, D. F., Campello, C. C., Carvalho, A. F. U., de Azevedo Moreira, R., Oliveira, J. T. A. 2010. Protein fractions, amino acid composition and antinutritional constituents of high-yielding cowpea cultivars. Journal of food composition and analysis, 23(1), 54-60.