IJPAS | INTERNATIONAL JOURNAL PURE AND APPLIED SCIENCES
ISSN: 2149-0910

Vol. 10(2); 342-351 (2024)
DOI: 10.29132/ijpas. 1408326

Research Article

Effect of Cultivar and Sowing Density on Yield and Yield Components of Chickpea (*Cicer arietinum* L.)

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Received: 23.12.2023

Accepted: 15.08.2024

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Abstract: The goal of this study was to determine the effects of cultivars in different sowing densities on yield, yield components and some morphological traits of chickpea (*Cicer arietinum* L.). Field experiment was carried out in experimental area at the Agriculture Faculty of Bingöl (Turkiye) in 2016 spring season. A complete blocks design in two cultivar Güneysarısı and Arda were in main plots, whereas five sowing densities (20, 30, 40, 50 and 60 seed m^{-2}) were in sub plots. The results showed that sowing densities significantly affected emergence rate, days to flowering, biological and grain yield, while plant height, number of pods, first pod height, number of brunches per plant, harvest index and thousand grain weights were not affected significantly. The cultivar x sowing density interaction was found to be in-significant except for grain yield. The highest grain yield, 86.26 kg da^{-1}, was obtained from the 60 seeds m^{-2} sowing density of the Güneysarısı cultivar, and the regression equation was determined as linear. Moreover, 9 mm^{-1} sieve analysis was found to be significant in terms of both sowing density and cultivar.

Keywords: Chickpea; cultivar; sieve; sowing density; yield and yield component.

Çeşit ve Ekim Sıklığının Nohutta (*Cicer arietinum* L.) Verim ve Verim Unsurlarına Etkisi

Özet: Bu çalışma Arda ve Güneysarısı nohut çeşitlerinde farklı ekim sıklıklarının verim ve verim unsurlarına etkisini tespit etmek amacıyla 2016 bahar döneminde Bingöl Üniversitesi uygulama araştırma merkezi arazisinde yürütülmüştür. Tarla çalışması, tesadüf bloklarında bölünmüş parseller deneme desenine göre üç tekerrürlü olarak kurulmuştur. Denemede çeşitler ana parseli ekim sıklıkları ise (20, 30, 40, 50 ve 60 tohum/m^2) alt parselleri oluşturmuştur. Çalışmada çıkış oranı, çiçeklenme gün sayısı, bitki boyu, bitkide anadal ve bakla adedi, ilk baklanın yerden yüksekliği, biyolojik verim, hasat indeksi, tane verimi ve elek analiz test değerleri incelenmiştir. Çalışmada ekim sıklığı uygulamalarının çıkış oranı, çiçeklenme gün sayısı, biyolojik verim ve tane verimi dışında geri kalan diğer özellikler üzerinde istatistiki olarak önemli bir etkisi görülmemiştir. Çeşit x ekim sıklığı interaksiyonu ise tane verimi dışında önemli bulunmamıştır. Tane verimi bakımından en yüksek değer 86.26 kg/da ile Güneysarısı çeşidinin 60 tohum/m^2 ekim sıklığından elde edilmiş olup, regresyon eşitliği de linear olarak önemli bulunmuştur. Elek analizi testlerinde de çeşitler arasında önemli farklılıklar bulunmuştur.

Anahtar Kelimeler: Ekim sıklığı; elek analizi; nohut; tane verimi, verim unsurları.

1. Introduction

Unbalanced and one-sided nutrition can cause many diseases in human health. The importance of legumes cannot be ignored, especially in Asian societies where a grain-based diet prevails. Due to its importance in terms of nutrition, developing and introducing chickpea varieties that can adapt to the climate and soil characteristics of the regions where they are grown, have high yields and are better in terms of technological features, is of great importance for the nutrition of our country's people.

Consumption of protein foods, which play an important role in human body and intelligence development, is insufficient [1]. Chickpea, one of the edible legumes, is rich in protein and minerals required by humans. Edible legumes are a healthy food group and contain proteins similar to animal proteins [2, 3]. The adaptation and healthy development of human beings, who are created in different geographies, can be achieved by consuming local products of the region in a balanced way and by lifestyle appropriate to nature. It is accepted as a place with a radius of 160-400 km in defining local or local agricultural products. The benefits of local geographical agricultural products to human and environmental health have been confirmed by research. In this context, the demand for local foods has increased rapidly recently [4]. Because they contain rich dietary fiber, they have recently been recommended by nutritionists as a protector against diabetes, cardiovascular diseases, colon cancer, obesity and some other diseases [5].

Two types of chickpea are cultivated in the world, Desi and Kabuli types [6] . In our country, the white-flowered macrosperm called Kabuli type is grown [7,8]. Türkiye is among the leading countries in the world in terms of chickpea covered area and production. According to 2020 data, with 511.000 ha. it ranks 4th after India, Pakistan and Australia in terms of covered area, and 2nd in production with 630.000 tons [9]. After the recent increase in the use of chickpeas as raw material in roasted chickpea, the cultivation areas have increased rapidly. The fact that it is the most drought-resistant species among the edible legumes has increased its preference. Chickpea, which is generally preferred by producers in places where irrigation is not possible, requires adaptation based on the selection of appropriate varieties and determination of planting frequency and timing for high yields. In addition to this, technological properties of chickpea and chemical composition depends on the genotype, the ecological variability depending on conditions and cultivation technique shows [(10]. For this purpose, it was tried to determine the effect of different cultivar and sowing densities on the yield and yield components of chickpea in the Bingöl ecological conditions.

2. Materials and Methods

The research was carried out 2016 at the Agricultural application and research centre area of Bingöl university, Bingöl, Türkiye (38° 48' N; 40° 32' E, 1090 m above sea level) (Figure 1.).

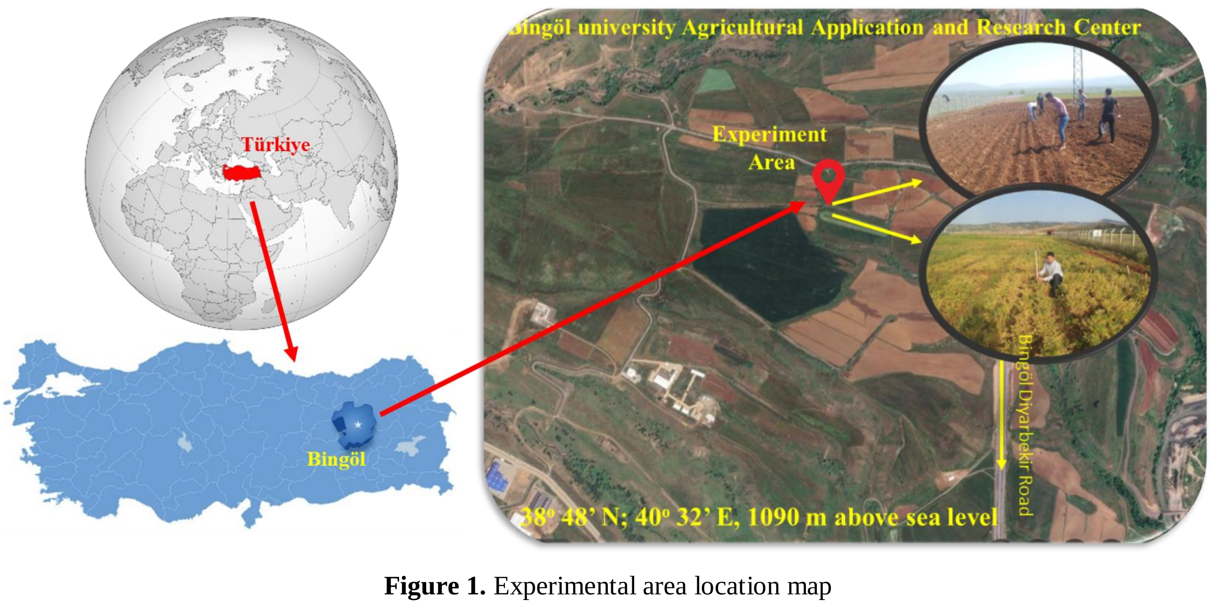

Figure 1. Experimental area location map

Climatic conditions for Bingöl were given Table 1. Long term annual total precipitation was 918 mm^{-1} and it was 800 mm^{-1} in the 2015-2016 growing season. However, Total of rainfall during the chickpea growing period is 96 mm. The soil of experimental area is loamy, with low in organic matter (1.9%), salt content (0.032 %), pH 6.57, P_2O_5 (7.91 kg da^{-1}) and K_2O (24.51 kg da^{-1}). Average Fe, Zn and Na microelement concentrations in the experiment soil are 14.15 ppm^{-1}, 0.33 ppm^{-1} and 0.78 ppm^{-1}, respectively [11].

The experiment was designed in randomized complete block design as split plot with three replications. Two registered cultivars (Arda and Güneysarısı) were in main plots, while sowing densities (20, 30, 40, 50, 60 seed m^{-2}) were sub plots. The plots were planted in 4 rows with 30 cm row spacing and 5 m length. The seeds were drilled by hand in opened lines on 05 April 2016.

Table 1. *Long-term and monthly averages of some climate data of Bingöl central district.*

Bingöl	Mean max. temperature (^0C)		Mean min. temperature (^0C)		Precipitation mm^{-1}	
Months	Long term	2015-2016	Long term	2015-2016	Long term	2015-2016
September 2015	30.0	32.6	14.0	15.7	17.0	0.8
October 2015	22	20.6	8.6	10	65.8	220.9
November 2015	13.1	14.5	2.1	2.2	88.4	18.9
December	5.5	7.9	-3.0	-3.3	134.2	45.1
January 2016	2.1	3.2	-6.1	-5.7	133.7	148.2
February 2016	3.5	6.5	-5.3	-1.6	132.0	115.8
March 2016	9.2	11.0	-0.4	1.1	125.9	154.4
Total					697	704.1
Climate data for the chickpea growing season 2016						
April 2016	16.4	16.6	5.7	5.6	119.6	66.7
May 2016	22.8	23.9	10.1	9.8	75.0	21.2
June 2016	29.3	30.4	14.6	14.6	20.7	8.1
July 2016	34.5	35.8	18.9	19.4	5.7	0.0-
Average/Total	25.6	26.7	12.3	12.4	221	96

In this study, half of dose of nitrogen (5 kg N da^{-1}) with whole dose of P (6 kg P da^{-1}) were broadcasted at planting time. The remaining nitrogen (5 kg N da^{-1}) was top-dressed as Ammonium Nitrate (%33) with flowering time on 26 July 2016 due to the absence of Rhizobium bacteria. Weeds were kept under control by plucking them by hand.

Harvest was done by hand on 7 July 2016. All plants forming two rows from each plot were harvested to measure the emergence rate (ER), days to flowering (DF), number of brunches per plant (NB), number of pods per plant (NP), plant height (PH) first pod height (FPH), biological yield (BY), harvest index (HI), thousand grain weight (TGW), grain yield (GY) and sieve test.

2.1 Statistical Data Analysis

The statistical analysis for all variables were carried out using the JMP 7 statistical package program and the LSD at $P \leq 0.05$ multiple comparison test was applied [12]. Data from sieve test (9 mm) was not distributed normally, therefore transformed as square root ($\sqrt{}+1$) before data analysis.

3. Results and Discussion

In this study, significant differences were detected among the cultivar in terms of emergence percentage, days to flowering, number of pods, first pod height, harvest index, grain yield and grain sieve test (9 mm^{-1}, 8 mm^{-1}, 7 mm^{-1} and 6 mm^{-1}).

Table 2. *Values of variance of emergence rate (ER: number of plants emerged per hundred viable seeds planted), days to flowering (DF), plant height (PH), number of brunches per plant (NBP), number of pods per plant (NP), first pod height (FPH), biological yield (BY), harvest index (HI), thousand grain weight (TGW) and grain yield (GY) of different chickpea cultivars and densities.*

Sources	DF	Mean Squares									
		ER	DF	PH	NB	NP	FPH	HI	BY	TGW	GY
Replication	2	196.26	2.63	1.73	0.32	0.421	5.75	48. 69	418.519	1373.3	15.26
Cultivar	1	1344.1*	396.03*	3.89ns	2.52ns	90.13*	163.8*	1752.5*	7634.13ns	1763.3ns	8768 *
Error 1	2	26.46	4.63	10.19	0.33	3.40	4.190	50.35	1780.46	813.3	90.04
Density	4	133.93*	2.22**	9.49ns	0.29ns	11.19ns	1.244ns	18.36ns	5608.57*	1146.7ns	958.6**
Cultivar*density	4	46.31ns	0.62ns	2.57ns	0.12ns	4.17ns	0.857ns	152.3ns	733.86ns	1246.7ns	407.1**
Error-2	16	43.11	0.22	8.39	0.17	4.50	1.962	299.49	840.91	676.7	61.24

*: Significance at ≤5 % probability, **Significance at ≤1 % probability, ns = non-significant

Among the sowing densities, differences were found to be significant in terms of three factors: emergence rate, days to flowering and grain yield (Table 2 and Table 3).

Table 3. *Analysis of rate of sieve 9 mm>, sieve> 6 mm, sieve 7 mm>, sieve 6 mm> of different chickpea cultivars and sowing densities*

Sources	DF	Mean Squares			
		Sieve 9 mm^{-1}	Sive 8 mm^{-1}	Sieve 7 mm^{-1}	Sieve 6 mm^{-1}
Replication	2	0.264	44.82	74.89	7.89
Cultivar	1	7.104 *	3783.39 **	1723.69 *	813.28 *
Error 1	2	0.264	0.259	21.25	7.49
Density	4	0.327 *	27.81 ns	25.82ns	15.41 ns
Cultivar*density	4	3.336 ns	19.36 ns	18.35ns	9.81 ns
Error-2	16	0.083	47.62	15.07	15.48

*: Significance at ≤5 % probability, **Significance at ≤1 % probability, ns = non-significant

3.1. Emergency rate

Table 2 revealed that different seeding densities and cultivar significantly affected emergency rate, while cultivar x density interaction did not significantly affect the emergence rate. Although 30 seed m^{-2} produced the maximum emergence rate. Emergence rate depends on germination rate, rate of pre-emergent shoot elongation and sowing depth [13]. Emergence rates decreased substantially as seeding densities increased (Table 2). For example, the mean field emergence rate of chickpea decreased from 64.8% at a density of 30 seed m^{-2} to 58.6% at a density of 60 seed m^{-2}. The reasons further lower emergence rates with increasing seeding rate are unknown. In our study, the mean emergence rates were lower than those obtained by [14].

3.2. Days to Flowering.

Seed density had a significant influence on days to flowering. The negative relation-ship between seed density and days to flowering was observed at this study. The earliest flowering was observed at 43 days at density of 60 seed m^{-2}. [15] reported that kabuli genotypes had highly variable flowering responses ranging from similar photoperiod responses to the desi genotypes, to probable photoperiod neutral responses. Arda cultivar (47.20 days) was found earlier than Güneysarısı (39.9 days).

3.3. Plant Height

There was no significant difference between both varieties and seed density in terms of plant height. As the Table 2 and Table 3 suggests, the highest plant height has been obtained from Arda cultivar (37.23 cm^{-1}) by 20 seed m^{-2} . While [16] reported that there was a significant difference in plant height, [17] reported that they could not detect a difference in terms of planting density. In a study on soybeans, plant height increased slightly with increase in sowing density [18].

3.4. Number of Brunches per Plant

No significant difference was found between the varieties and sowing density in terms of number of brunches per plant. However, high sowing densities can result in reduced branching and a decline in the number of lateral stems per plant [19]. According to [20], the number of branches per plant decreases relatively as sowing density increase.

3.5. Number of Pods per Plant

While the difference between varieties in terms of number of pods per plant was found to be significant, the difference between sowing density and cultivar x density interaction was not found to be significant. Although not significant, the number of pods decreased as the sowing density increased (Table 4). [21] reported that they found a difference between sowing densities in terms of the number of pods and that the number of pods decreased as the sowing densities increased. As expected, fewer pods per plant were noted for all cultivars when the sowing density was increased [22].

3.6. First Pod Height

While the difference between the varieties in terms of first pod height was found to be significant, no significant difference was found between sowing density. The first pod height of the Arda cultivar (20.0 cm) was found to be longer than that of the Güneysarısı cultivar (15.32 cm) (Table 4). [16] also reported that the difference between varieties in terms of first pod height is significant, sowing density and the sowing density x cultivar interaction is insignificant. On the other hand, [23] reported in a similar study with 55-c and İnci varieties that there was a significant difference between sowing densities in terms of first pod height.

3.7. Biological Yield

In our study, while sowing density was found to be important in terms of biological yield, the sowing density and cultivar x density interaction were found to be insignificant (Table 3). Biological yield also increased in parallel with the increase in sowing density (Table 4). While the highest biological yield was obtained from 60 seed m^{-2} (182.32 kg da^{-1}), the lowest value was obtained from 20 seed m^{-2} (116.7 seed m^{-2}). While [16] stated that similar results were obtained, [24] reported that biological yield increased up to the density of 60 seed m^{-2} and decreased at the density thereafter (70 seed m^{-2}).

3.8. Harvest Index

Sowing density did not affect harvest index. In contrast, the effect of cultivar on harvest index was significant (Table 2). Arda cultivar had a higher rate of 35.12% than Güneysarısı (19.83%) (Table 5). [16] was found to be compatible with our study by reporting that the difference between varieties in terms of harvest index was significant, but they did not find a significant difference between planting densities, while [20] reported that the harvest index increased as the sowing density increased, but there was a slight decrease in the harvest index after the application of 60 seeds m^{-2}.

3.9. Thousand grain weight

In terms of thousand grain weight, the difference between both sowing density and varieties was found to be insignificant (Table 2). An similar studies, [17, 21, 25-26] report that there is no significant difference in terms of thousand grain weight between seed densities, but the difference between varieties is significant.

3.10. Grain yield

In this study, it has been determined that the effects of both cultivar and sowing density are important ($P<0.01$) in terms of grain yield. The cultivar x sowing density interaction was, however, significant (Table 2). While the highest grain yield (86.3 kg da^{-1}) was obtained from the 60 seed m^{-2} density of the Arda cultivar, the lowest yield (19.8 kg da^{-1}) was obtained from the 30 seed m^{-2} density of the Güneysarısı cultivar (Table 4).

In line with this result, [27] reported that high rate density gave higher grain yield as compared to low rate density in chickpea, also noticed that high plant density (50 seed m^{-2}) gave higher seed yield as compare to low plant density (26 seed m^{-2}) in chickpea. [28] reported that higher seeding density increased grain yield in chickpea when moisture was not limiting. [14] reported that increasing yield of chickpea at high rate density and they detected strong positive relationship between grain yield and sowing densities.

Table 4. *Effect of sowing density and cultivar on the grain yield and yield components of chickpea*

Traits	Cultivars	Densities (Seeds m^{-2})					Means
		20	30	40	50	60	
Emergence rate %	Arda	52.7	54.5	46.8	58.5	52.0	52.9 B
	Güneysarısı	68.8	75.3	57.5	64.5	65.2	66.3 A
	Means	60.8A	64.9 A	52.2 B	61.5 A	58.6 AB	59.6
Days to flowering	Arda	47.7	47.3	47.3	47.0	46.7	47.2 a
	Güneysarısı	41.3	40.3	39.3	39.3	39.3	39.9 b
	Means	44.5 A	43.8 B	43.3 BC	43.2 C	43.0 C	43.6
Plant height cm	Arda	37.23	33.40	35.20	36.10	34.93	35.37
	Güneysarısı	35.60	33.33	32.93	35.40	36.00	34.65
	Means	36.41	33.36	34.06	35.75	35.46	35.01
Number of brunches per plant	Arda	3.26	2.93	2.60	2.40	2.73	2.78
	Güneysarısı	3.40	3.60	3.40	3.20	3.23	3.36
	Means	3.33	3.26	3.00	2.80	2.98	3.08
Number of pods	Arda	11.86	8.26	8.53	8.06	6.46	8.64 B
	Güneysarısı	12.73	12.66	11.40	13.2	10.53	12.10 A
	Means	12.300	10.46	9.96	10.63	8.50	10.37
First pod height cm	Arda	19.20	19.20	20.93	20.400	20.26	20.00 A
	Güneysarısı	15.43	15.13	15.66	14.86	15.53	15.32 B
	Means	17.31	17.16	18.30	17.63	17.90	17.66
Biological yield kg/da	Arda	105.98	84.54	134.54	143.85	157.20	125.22
	Güneysarısı	127.42	136.34	133.46	180.97	207.45	157.13
	Means	116.70 C	110.44 C	134.00 BC	162.41AB	182.32 A	141.175
Harvest in-dex %	Arda	22.69	20.64	19.54	19.18	17.14	19.83 B
	Güneysarısı	30.16	33.81	37.95	36.56	37.10	35.12 A
	Means	26.42	27.22	28.87	27.87	27.12	27.47
Thousand grain weight g	Arda	250.00	273.33	260.00	300.00	316.66	280.00
	Güneysarısı	266.66	256.66	270.00	263.33	266.66	264.66
	Means	258.33	265.00	265.00	281.66	291.66	272.33
Grain yield kg/da	Arda	22.48 de	19,80 e	24,43 de	25,69 de	33,41cd	25,16 B
	Güneysarısı	32.71 cde	46,02 c	62,86 b	68,93 b	86,26 a	59,36 A
	Means	27.59 C	32.91 C	43.64 B	47.31 B	47,31 B	59,84 A

Grain yield increased in parallel with the increase in sowing density and the relevant regression equation is given in Figure 2 and Figure 3. Thus, In the regression analysis, a linear relationship was observed in parallel with the increase in sowing density. In the regression analysis of both two cultivar, a linear relationship was observed in parallel with the increase in planting frequency.

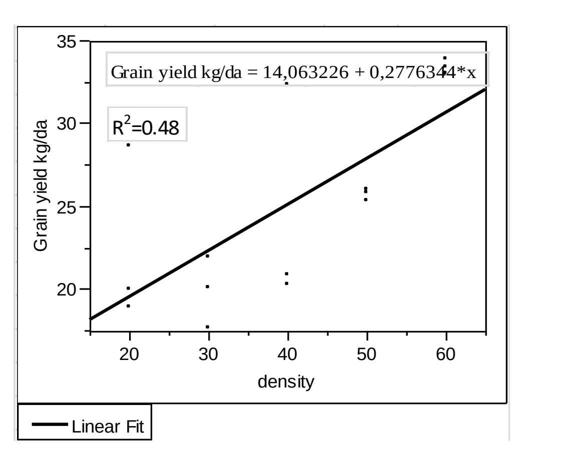

Figure 2. Regression curve of grain yield of cultivar Arda with different sowing densities

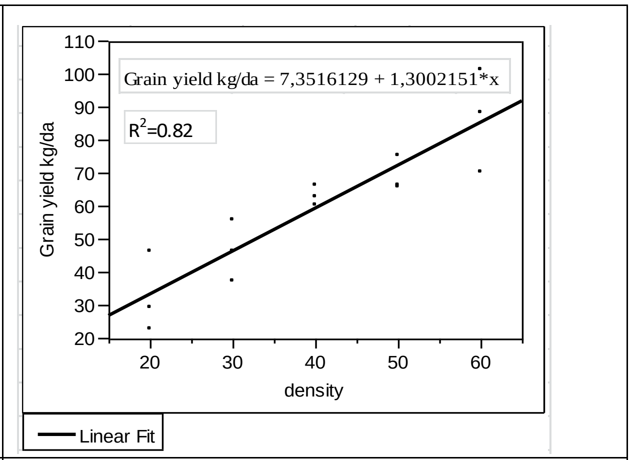

Figure 3. Regression curve of grain yield of cultivar Güneysarısı with different sowing densities

3.11. Grain Size Fractions (Sieve test)

Grain size is an important trait for trade**.** At the same time, grain size is considered an important quality criterion in terms of strong germination and vigour emergence. For this reason, two Kabuli commercial chickpea varieties were selected as materials in the experiment. Cultivar Güneysarısı has small seeds, while Arda has large seed. In the experiment divided seeds size of chickpea to 4 types contained of 6 mm, 7 mm, 8 mm and 9 mm. Sieve test analysis (6 mm, 7 mm and 8 mm) was found to be insignificant in terms of sowing density, but significant in terms of cultivar.

Table 5. *Effect of sowing density and cultivar on the sieve test of chickpea*

grain sieve %	Cultivars	Densities (Seeds m^{-2})					Means
		20	30	40	50	60	
>6 mm	Arda	11.56	12.06	12.96	11.60	8.56	11.35 B
	Güneysarısı	20.23	24.36	19.80	24.36	20.06	21.76 A
	Means	15.90	18.21	16.38	17.98	14.31	16.56
>7 mm	Arda	46.16	40.90	45.33	44.00	39.40	43.16 B
	Güneysarısı	55.26	58.86	61.43	59.70	56.33	58.32 A
	Means	50.71	49.88	53.38	51.85	47.86	50.74
>8 mm	Arda	41.43	42.86	41.53	41.63	44.36	42.36 A
	Güneysarısı	24.13	16.73	18.70	16.30	23.66	19.90 B
	Means	32.78	29.80	30.11	28.96	34.01	31.13
>9 mm	Arda	0.73	4.46	4.06	3.30	3.90	3.29 A
	Güneysarısı	0.00	0.00	0.00	0.00	0.00	0.00 B
	Means	0.37 B	2,23 A	2.03 A	1.65A	1.95 A	1.64

*:Means within columns or rows with the same letters are not significantly different at 5% level.

While the Arda variety had a higher rate than Güneysarısı in terms of 8 mm^{-1} and 9 mm^{-1} sieve values, Güneysarısı had a higher rate in terms of 6 mm and 7 mm sieve values. [29] reported that in terms of sieve analysis, significant differences were detected in all sieve diameters (6 mm, 7 mm, 8 mm and 9 mm) of 27 chickpea varieties. However, 9 mm sieve analysis was found to be significant in terms of both sowing density and cultivar (Table 5). Genotype, ecology, planting time and distance between rows are important in revealing the differences in varieties in sieve analysis [30- 31].

4. Conclusion and Suggestions

As a result of this study, it was seen that chickpea yield was related to variety and sowing density. According to the variance analysis, the highest grain yield was detected from the 60 seed m^{-2} sowing density of the Güneysarısı cultivar. However, the linearity of the regression equation led to the conclusion that higher seed densities should be considered in future studies under Bingöl ecological conditions.

Conflict of Interest

The authors report no conflict of interest relevant to this article

Research and Publication Ethics Statement

The authors declare that this study complies with research and publication ethics.

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