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Research Article

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The Effects of Different Planting Densities on Lentil (*Lens culinaris* Medic.) Yield and Yield Components in Mardin Conditions

Abstract

In this study, the effects of four different sowing densities (200, 250, 300 and 350 seed m^{-2}) on the yield and yield components for two winter lentil cultivars (Şakar and Fırat-87) in Mardin conditions. The study was laid out in a factorial randomised block design with three replicates at the fields of Mardin Artuklu University, Kızıltepe Vocational High School in 2012-2013 growing season. In the study were investigated the effect of planting densities on the plant height, first pod height, numbers of branche, numbers of pod per plant and numbers of seed per plant, numbers of seed per pod, seed yield per unit area, harvest index, biological yield and 1000 seed weight. While the highest seed yield per area was obtained from second plant density and Şakar variety with 275.23 kg da^{-1}, the lowest seed yield per area was obtained from first plant density and Fırat-87 variety with 208.83 kg da^{-1}.

INTRODUCTION

Of the grain legumes grown for food, lentil comes foremost on the global scale with 4.800 million ha of sowing area and 5.734 million tons of produce, whereas in Turkey, it ranks third with its 281.741 ha of sowing area and 353631 tons of produce; the mean global yield is 1194 kg ha^{-1}, whereas this parameter is 1255 kg ha^{-1} for Turkey (Anonymous, 2019).

Traditionally, lentil is grown in spring in Turkey; however, winter-lentil cultivars are grown in Van conditions (Dogan et al., 2014a). Since some lentil varieties are resistant to drought and cold, they are grown for winter even in harsh winter regions of our country and play an important role in narrowing fallow land (Gungor, 1991). Lentil is an edible legume plant rich in vitamins A, B and D as well as having a high protein content (Dogan et al., 2014b) and Adams et al. (1985). For this reason, lentils are an important resource in meeting the protein needs of people, especially in underdeveloped and developing countries. In addition to being used in human nutrition, lentils are also used in animal nutrition. While there is 137.4 kg of protein in a ton of legume stalks, there is 70.5 kg of protein in a ton of grain stalks. Lentil cultivation is decreasing day by day in the Mardin region. One of the biggest reasons for this is the low yield per unit area. Thus, the manufacturer turns to different products. In order to increase lentil cultivation in the region again, determining the most suitable planting frequency is also important in addition to high-yield variety breeding and other growing methods. In agricultural sustainability, plant growth promoting rhizobacteria (PGPR) are selected considering their efficiency and adaptability to environmental conditions, and are also used as biological fertilizers containing single or multiple species (Coskun and Bengisu, 2021).

In addition to other cultivation techniques, plant density is of great importance in increasing the grain yield per unit area. Today, in order to increase the yield per unit area in lentils, as in all plant varieties, it is becoming increasingly important to determine the most suitable plant number to be grown per unit area, along with high-yield variety breeding and other cultivation methods. As it is known, under certain environmental and growing conditions, the total amount of dry matter produced by certain plant varieties or varieties in a unit area does not vary greatly. The difference between the varieties reveals more of the denominator of the economic yield in biological yield (the total dry matter product that can be produced by the above-ground organs of the plant such as grain, stalk and straw).

In this study, Şakar and Fırat-87 lentil varieties were sown at different plant densities (200, 250, 300 and 350 seeds m^{-2}) and the most suitable variety and planting frequency for Mardin and its surroundings were investigated.

MATERIAL and METHODS

Fırat-87 and Şakar lentil varieties were used in the experiment. Fırat-87 has been improved by the Southeastern Anatolia Agricultural Research Institute and is resistant to winter and cold. The grain shell color is pink and the top is black dotted, the cotyledon color is red, and the grain weight is 35-40 g. Sakar variety is a variety that was improved by Dicle University Faculty of Agriculture and registered in 2005. The stem is 25-45 cm semi-erect, brown orange grain color and 1000 grain weight 39-45 g. It is resistant to wilt disease.

The study was carried out in the trial field of Mardin Artuklu University, Kızıltepe Vocational School for winter in 2012-13 growing season. The province of Mardin, where the research was conducted, is located in the Southeastern Anatolia Region and the altitude of the province is 1150 m, located at 370 18 'north latitude and 400 44' east longitude.

The climate data for the months covering the period in which the experiment was carried out and the average of long years are given in Table 1. In the region where the

research was conducted, the annual precipitation amount related to the average of long years in the growing season is 660.8 mm, the average temperature is 11.9 °C, and the average relative humidity is 50.2%. The amount of rainfall in the 2012-13 growing season is 981.6 mm. Average temperature is 13.2 ^{0}C and average relative humidity is 51.6% (TSMS, 2013).

Table 1. Climatic data of Mardin in 2012-2013 and long term

	Precipitation (mm)		Average temperature (^{O}C)		Relative humidity (%)	
Months	2012-2013	Long term	2012-2013	Long term	2012-2013	Long term
October	65.4	36.2	19.0	18.3	44.6	46
November	93.1	69.7	13.0	10.7	52.1	57
December	192.5	106.9	5.2	5.3	66.4	67
January	152.7	112.3	4.9	3.0	68.0	70
February	105.4	108.2	6.6	4.0	71.0	66
March	53.7	96.8	9.1	8.0	52.1	61
April	62.3	83.6	15.2	13.4	46.0	56
May	154.4	40.4	19.5	19.6	43.0	45
June	4.0	4.9	26.3	25.6	21.7	34
Total	981.6	660.8				
Average			13.2	11.9	51.6	50.2

According to the results of the soil analysis, it was determined that the soil samples taken from the research area have clayey-textured, slightly alkaline reaction, low organic matter content, high calcareous in terms of lime content, salt-free, and sufficient potassium content. Phosphorus content was found to be moderate (Table 2).

Table 2. Some properties of the <2 mm fraction of the top 20 cm of soil used for site

Soil properties	**2011**
Texture	Clay
pH[A]	7.62
Clay (%)[B]	50.30
$CaCO_3$ (%)[C]	31.60
Olsen soil test P (ppm)[D]	6.23
Total Salt (%)[E]	0.062
Organic matter (%)[F]	1.65

[A] 1 : 2.5 soil : water, [B] Bouyoucos (1951), [C] lime by calcimetric methods, [D] Olsen et al. (1954), [E] Richard (1954), [F] Jackson (1962)

The experiment was conducted in the trial field of Mardin Artuklu University Kızıltepe Vocational School in three replications according to the Factorial Trial Pattern in Random Blocks during the 2012-13 growing season. There are a total of 24 parcels in the trial. Each parcel is determined as 5 rows, and the distance between rows in plots is 20 cm. Each parcel is determined as 5 rows, and the distance between rows in plots is 20 cm. Parcel area; it was arranged as 1 m x 5 m = 5 m². There is a gap of 1 m between parcels and 2 m between blocks. In the experiment, 4 different plant densities (200, 250, 300 and 350 seeds m^{-2}) were applied on both cultivars. 15 kg da^{-1} DAP fertilizer was applied to the lentil varieties used in the experiment. The sowing process was done manually on 20 October 2012 by opening lines with a marker. In the experimental area, weed control was carried out twice, before and after earing. The harvesting process was carried out on 02.06.2013 with sickles, leaving the plants 50 cm above and 50 cm below the parcels, and one row on each side of the 5 rows forming the parcel.

The measurement, counting and blending processes of the harvested plants were carried out with great care in the laboratory and the average values were taken. Plot yields were calculated by threshing the plants after drying in bunches. The effect of treatments on bean were analyzed using analysis of variance procedures in Randomized Blocks with the COSTAT statistical package. The means related with yield and yield components in wheat were evaluated with Duncan's Multiple Range Test statistical analysis.

RESULTS and DISCUSSION

When Table 3 is examined, the average plant height of Fırat -87 variety is 44.3 cm, while the average plant height of Şakar variety is 42.0 cm. Although plant height is affected by environmental conditions, it is a feature that is primarily affected by the genetic structure of the plant. The values obtained are similar to the plant height values of Wilson and Teare, (1972). Karadeniz and Togay (2009) reported that the average plant height of lentil varieties ranged from 27.9 to 35.1 cm. Dogan and Dogan (2020) reported that the average plant height of lentil varieties ranged from 26.7 to 49.6 cm. The average plant height obtained in plant density applications varied between 40.3-46.9 cm. The lowest plant height value was determined at a plant density of 40.3 cm and 200 seeds m^{-2}, and the highest plant height value was obtained at a plant density of 46.9 cm and 350 seeds m^{-2}. As the frequency increases, the plants increase their size as they compete to benefit from the light. Similar findings Togay et al. (2005) and Sharma and Sing (1994). The findings obtained in this study are in agreement with the findings of the researchers.

Table 3. Effect of different organic manures on dry bean in inoculation and uninoculation conditions on the yield parameters of bean*

Treatments	Plant height	First pod height	Numbers of branches	Numbers of pod per plant	Numbers of seed per plant	Seed yield	Harvest index	Biological yield	1000 seed weight
Sowing densities									
200 seed m^{-2}	40.33 d	18.60 d	6.88 a	30.48 a	37.81 ab	225.5 b	31.4 a	717.3 c	42.16 a
250 seed m^{-2}	41.68 c	22.26 c	6.75 a	31.23 a	38.38 a	248.5 a	31.75 a	783.2 b	41.31 b
300 seed m^{-2}	43.88 b	24.11 b	6.05 b	30.51 a	36.80 b	255.1 a	31.51 a	808.7 b	42.61 a
350 seed m^{-2}	46.91 a	26.60 a	5.68 b	27.36 b	30.88 c	250.4 a	28.8 b	871.2 a	39.48 c
Varieties									
Şakar	42.03 b	21.40 b	5.65 b	30.23 a	37.75 a	261.6 a	32.59 a	803.7	43.25 a
Fırat-87	44.37 a	24.39 a	7.03 a	29.56 b	34.18 b	228.2 b	29.14 b	786.5	39.54 b

*Means in the same column followed by the same letter are not significantly different at $p<0.05$

Generally, tall plants with large vegetative parts also have high first pod height values. First pod height is a yield criterion depending on genotype and environmental factors. In terms of varieties, the average height of the first pod was 21.4 cm and the lowest value was found in Şakar variety, while the highest value was 24.39 cm in Fırat-87 variety. The average first pod height obtained in plant density applications varied between 18.6-26.6 cm. The lowest initial pod height value was determined at a plant density of 18.6 cm with 200 seeds m^{-2}, while the highest first pod height was obtained at a plant density of 26.6 cm and 350 seeds m^{-2}. As the plant density decreases, the plant will not have a problem such as using the light, so it will not compete and will not increase its height. Accordingly, it can be said that the first pod height distance is long in dense planting and shorter in sparse planting. Erskine et al. (1989) reported in their studies that there is a close relationship between ecological conditions and plant density and first pod height similar to our findings. While the highest number of branches was obtained as 7.03 units $plant^{-1}$ from Fırat-87 variety, the

lowest value was realized as 5.65 units plant^{-1} from Şakar variety. Although the rate of branching in plants is a kind of feature, it is affected by planting frequencies and ecological factors. The varieties used in this study have different genetic structures, causing them to form different numbers of branches depending on the environmental conditions. When the effect of different plant density applications on the number of branches per plant was examined, the lowest value was obtained from a plant density of 5.68 seeds plant^{-1} with 350 seeds m^{-2} and it was included in the same group with a plant density of 300 seeds m^{-2}. Although the highest value was obtained with 6.88 seeds plant^{-1} with 200 seeds m^{-2}, the difference between 250 seeds m^{-2} was found to be insignificant. Plants that compete with each other reduce the number of branches and use more of their power to lengthen the plant. For this reason, the highest branch number value was found in the lowest plant density. The results obtained are similar to the reports of Sing and Ram (1986) and Sharma and Sing (1994).

In terms of the number of pods per plant, the lowest value was found in Fırat-87 variety with 29.56 pieces^{-1}, while the highest value was found in Şakar variety with 30.23 pieces^{-1}. The number of pods produced by the plants is affected by the planting frequency depending on the genotype of the variety. The number of pods obtained in this study were close to the values obtained by researchers such as Tosun and Eser (1978) from similar varieties. When the effect of different plant density applications on the number of pods per plant was examined, it was determined that the average values varied between 27.36-30.51. The lowest value was obtained from a plant density of 27.36 seeds plant^{-1} with 350 seeds m^{-2}, while the highest value was obtained from a plant density of 30.51 seeds plant^{-1} with 200 seeds m^{-2}, and the difference between them was statistically significant with a plant density of 300 seeds m^{-2} and a plant density of 250 seeds m^{-2} is not as important. As the frequency of planting increases, the plants compete and they are more prolonged. The number of pods in undersized plants is expected to be low. The findings obtained are consistent with the findings of Sharma and Sing (1994), Varshney (1992) and Venkateswarlu and Ahlawat (1993). On the other hand, Sing et al. (1990) 's findings. It can be said that such a result is due to the varieties used by researchers and the difference in ecological environment.

Depending on the variety, the number of grain per plant is related to the number of seeds per pod, as well as the soil, climatic conditions and planting frequency are significantly affected. While the highest seed number value was obtained from Şakar variety with 37.75 pieces plant^{-1}, the lowest value was determined from Fırat-87 variety with 34.18 pieces plant^{-1}. In general, coarse grained varieties form less grains in the plant, while small grained varieties create more grains. The average number of grain per plant of different plant density applications varied between 30.88-38.38 pieces plant^{-1}. While the number of grain in the highest plant was obtained from the application of 38.88 seeds plant^{-1} with a plant density of 250 seeds m^{-2}, it was in the same group with a plant density of 200 seeds m^{-2}. The lowest number of grain in the plant was obtained from the application of 30.88 seeds plant^{-1} and 350 seeds m^{-2} plant density. The number of grain in the plant obtained in this study is similar to the findings of Tosun and Eser (1978) in terms of the values of the properties of coarse grained varieties.

While the average grain yield per unit area obtained from Şakar variety was 261.6 kg da^{-1}, the average grain yield per unit area obtained from Fırat-87 variety was 228.2 kg da^{-1}. It is expected that the reaction of different cultivars at different frequencies will be different. The average grain yield per unit area obtained from plant densities varied between 225.5-255.4 kg da^{-1}, while the lowest unit area grain yield was obtained from a plant density of 200 seeds m^{-2}, the

highest unit area grain yield was obtained from a plant density of 250 seeds m^{-2} and 300 and The difference between 350 seeds m^{-2} and the plant density was not statistically significant. As the frequency of sowing increases in plants, competition between them increases especially when they enter the generative phase, the plant cannot grow and develop sufficiently and the grains remain thin and the grain yield per unit area may be low because the plant cannot fully fill. With the results found Silim et al. (1990) reports.

In terms of harvest index, Şakar variety had the highest value with 32.59%. The lowest value was realized in Fırat-87 variety with 29.14%. It is known that generally legumes produce enough vegetative parts but very little grain yield, therefore they have a low harvest index. In general, the vegetative failure rate of the grain in legumes ranges from 2/3 to 1/2. The average harvest index obtained from plant densities varied between 28.8-31.75%, the lowest harvest index was obtained from 350 seeds m^{-2} plant density, the highest harvest index was obtained from 250 seeds m^{-2} plant density and statistically 200 and 300 seeds m^{-2}. The difference between plant density was insignificant. After a certain sowing frequency, it can be said that the harvest index, which is the ratio of grain yield to biological yield, decreases in plants that cannot fill their grains sufficiently due to the high competition between plants in the generative phase.

Biological yield can also be defined as total yield or stem + grain yield. Ecological conditions, breeding techniques and genotype affect biological yield. Any changes that may occur on the vegetative characters that form the yield elements (plant height, grain yield per unit area, number of branches, etc.) also affect biological yield. While the average biological yield obtained from Şakar variety was 803.7 kg da^{-1}, the average biological yield obtained from Fırat-87 variety was 786.5 kg da^{-1}. Biological yield averages obtained from different plant density applications varied between 717.3-871.2 kg da^{-1} and the lowest biological yield was determined from a plant density of 200 seeds m^{-2}, the highest biological yield was determined from a plant density of 200 seeds m^{-2}.

While the average weight of 1000 seeds of Fırat-87 variety was 39.54 g, the average weight of thousand seeds obtained from Şakar variety was 43.25 g. Genetic structures and grain sizes of different varieties are expected to produce grain of different weight.

The thousand grain weight averages obtained in plant density applications varied between 39.48-42.61 g. The lowest thousand kernel weight value was determined at a plant density of 39.48 g with 350 seeds m^{-2}, and the highest thousand kernel weight value was obtained at a plant density of 42.61 g with 300 seeds m^{-2} and shared the same rub with a plant density of 200 seeds m^{-2}. Venkateswarlu and Ahlawat (1993) reported that sowing frequencies did not affect thousand grain weights, which can be said to be due to the differences in the frequencies used by the researchers and the response of the cultivars to the frequencies.

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The study is part of the master's thesis.

CONCLUSION

In this study, the effects of four different sowing densities (200, 250, 300 and 350 seed m^{-2}) on the yield and yield components for two winter lentil cultivars (Şakar and Fırat-87) in Mardin conditions. The study was laid out in a factorial randomised block design with three replicates at the fields of Mardin Artuklu University, Kızıltepe Vocational High School in 2012-2013 growing season. In the study were investigated the effect of planting densities on the plant height, first pod height, numbers of branche, numbers of pod per plant and numbers of seed per plant, numbers of seed per pod, seed yield per unit area, harvest index, biological yield and 1000 seed weight. While the highest seed

yield per area was obtained from second plant density and Şakar variety with 275.23 kg da^{-1}, the lowest seed yield per area was obtained from first plant density and Fırat-87 variety with 208.83 kg da^{-1}.

As a result, it is recommended to apply 250 seeds m^{-2} for the Şakar variety in lentil in Mardin and its surroundings.

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