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Araştırma Makalesi

Farklı Dikim Sistemlerinin 'Azman' Muz Çeşidinin Büyüme ve Verim Parametreleri Üzerine Etkileri

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ÖZ

Bu çalışmanın amacı, farklı dikim sıklıklarında yetiştirilen Azman (AAA, Cavendish alt grubu) muz çeşidinin büyüme ve verim parametrelerini değerlendirmektir. Deneme tek (1.8 x 2.0 m), çift (1.2 x 1.2 x 2.0 m) ve üçgen (1.5 x 1.8 m) sıra dikim sistemleri kullanılarak hazırlanmıştır. Farklı dikim sistemlerine göre bitkiler arasında yalancı gövde uzunluğu, yalancı gövde çevresi, yaprak uzunluğu ve yaprak genişliği bakımından önemli bir farklılık belirlenmiştir. En fazla yalancı gövde uzunluğu tek sıralı sistemde (216.00 cm), en fazla yalancı gövde çevresi ise üçgen sıralı sistemde (64.00 cm) gözlenmiştir. Bitki sıklığının verim ve verime atfedilen karakterler üzerindeki etkisi belirgin bir şekilde gözlenmiştir. Dikim sistemlerine göre tek sıra dikim 34.66 kg ile en yüksek hevenk ağırlığa sahip olurken, çift sıra ve üçgen sıra dikimlerde istatistiksel olarak bir fark belirlenememiştir. Meyve ile ilgili parametreler incelendiğinde tarak ve parmak sayıları bakımından dikim sistemleri arasında istatistiksel olarak fark bulunmazken, parmak uzunluğu ve çapı arasında anlamlı bir fark bulunmuştur. Çalışma sonunda 1.2 x 1.2 x 2.0 m aralığının, 1.5 x 1.8 m aralığına göre daha yüksek toplam muz verimi ve ekonomik kazanç sağladığı sonucuna varılmıştır. Ancak 1.8 x 2.0 m bitki aralığında daha uzun ve daha geniş meyveler elde edilmiştir. Bu nedenle, dekara dikilen bitki ve hevenk ağırlığı olarak hesaplandığında, muz yetiştiricileri için çift sıra dikim önerilebileceği sonucuna varılmıştır.

Anahtar kelimeler: muz, hevenk uzunluğu, dikim mesafesi, verim.

Effects of Different Planting Systems on Growth and Yield Parameters of 'Azman' Banana Variety

ABSTRACT

The objective of this work was to evaluate the growth and yield of the Azman banana (AAA, Cavendish subgroup) variety subjected to increasing planting densities. The trial was prepared using single (1.8 x 2.0 m), pair (1.2 x 1.2 x 2.0 m), and triangle (1.5 x 1.8 m) row planting systems. There was a significant difference in pseudostem length, pseudostem circumstance, leaf length, and leaf width with regard to different planting systems. Maximum pseudostem length was observed in the single row system (216.00 cm), but maximum pseudostem circumstance was observed in the triangular row system (64.00 cm). The influence of plant population on yield and characters expressed by yield was clearly observed. According to the planting systems, single row planting had the highest bunch weight of 34.66 kg, while no statistical difference could be determined in pair and triangular row planting. When the parameters related to the fruit were examined, there was no statistical difference between planting systems in terms of hand and finger numbers, but a significant difference was found between finger length and diameter. At the end of the study, it is concluded that spacing of 1.2 x 1.2 x 2.0 m (pair row) gave higher total banana yield and economic profit than the spacing of 1.5 x 1.8 m (triangular row). However, longer and wider fruits were obtained in plant spacing 1.8 x 2.0 m (single row). Therefore, when calculated as the plant planted per decare and bunch weight, it was concluded that pair row planting can be recommended for banana growers.

Key words: banana, bunch length**,** planting distance, yield.

INTRODUCTION

Banana is one of the most consumed fruits in the world. Türkiye produced 883.455 tons in 122.864 decares area in 2021. While Türkiye was an importer country in the banana trade until 2020, its self-sufficiency level has increased to 85.2% with the increase in production in recent years (TUIK, 2022).

The global banana trade in 2021 has been heavily influenced by several factors, both supply and demand. These include the COVID-19 pandemic, shocks caused by very high and low temperatures in plants, the rapid spread of diseases (*Fusarium oxysporum* f. sp. *cubense* tropical race (TR4)), restrictions based on high residues in fruits by large markets, low demand from import markets (FAO, 2022). With the increase in the aforementioned production inputs, it has become necessary to find alternative ways to reduce the cost of banana cultivation in Türkiye.

Banana cultivation in Türkiye is carried out on the Mediterranean coastline and almost 98% of it is done in modern greenhouses. In Türkiye, banana cultivation is common in single row planting. The spacings frequently used in banana planting are 1.8 x 2.0 or 2.0 x 2.5 cm. Compared to other planting systems, the spacing between rows is close and the spacing between rows is wider in single row planting. This system ensures good ventilation of the vegetation and reduces the severity of fungal disease by allowing wet leaves to dry faster. In this way, there are fewer plants in the field and the yield decreases accordingly.

The planting distance adopted for bananas varies throughout the world. They are paired row system, square system, and triangular system. It is important to determine the appropriate planting density for the purpose. Because the difference between the yield obtained from the unit area and the potential yield can be determined in this way.

The recommended planting spacings for the cultivation of plant trees are in 3.0 x 2.5 m single rows, with 1.333 plants ha^{-1}. Spacings at 4.0 x 2.5 x 2.5 m (1.231 plants ha^{-1}) and 2.0 x 3.0 m (1.666 plants ha^{-1}) have been used for 'Farta Velhaco' banana variety (Marcilio et al., 2014; Martins et al., 2016). Badway et al. (2010) reported that spacing at 3 x 2 m and 2 plants per hole gave the highest yield (23.8 and 32.34 ton/fed) during the main plants and first fresh shoot, respectively. Four different planting distances were used in a study to evaluate yield performance of Grand Nain banana variety. Planting distance of 1.2 x 1.2 x 2.0 m pair row showed markedly higher yield (t/ha) compared to other planting distances (Patel et al., 2018). Salmazo et al. (2021) reported that when 3,333 plants per hectare (4.0 x 2.0 x1.0 m) are planted, higher economic income will be obtained. They also reported that this number is the most suitable number of plants when considering morphological characteristics, yield and fruit quality in a production period.

In this study, the effects of paired row and triangular planting systems, which can be an alternative to single planting, which is common in our country, on plant growth and yield of the Azman banana variety were investigated.

MATERIAL and METHOD

Plant Material

The present study was carried out during two consecutive seasons of 2021/2022 on Azman banana plants in a greenhouse located at Alata Horticultural Research Institute, Erdemli, Mersin. Three months old uniform sword suckers were selected for planting. Throughout the year in the greenhouse, irrigation and fertilization were carried out with an average of 45 kg of nitrogen, 150 kg of potassium and 60 kg of phosphate per plant.

Establishment and maintenance of greenhouse trials

The side height of the greenhouse where the plants are planted is 4 m and the roof height is 6.5 m, and a 350 micron thick UV+IR reinforced plastic cover system is used.

-While the distances between rows are close in single row planting, the spacing between rows is quite wide. This system ensures a great ventilation of the vegetation and reduces fungal diseases by allowing wet leaves to dry faster.

-In pair row planting, the distance between the two lines is 1.20 m and plant to plant distance is 2 m. In this way, cultural practices can be carried out easily and drip irrigation costs are reduced.

-In triangular row planting system, the distance between rows was 1.5 m and plant to plant was 1.8 m in the row. The distance between any two adjoining trees in a row is equal to the vertical distance between any two adjoining rows in triangular row system.

As can be seen in Table 1, the planting of the plants in the greenhouse was done as follows:

Table 1. Planting systems and spacings applied in plants.

System of planting	Planting distance	Estimated plant population of per decare
Single row	1.8 x 2.0 m	278
Pair row	1.2 x 1.2 x 2.0 m	520
Triangular row	1.5 x 1.8 m	363

Plant growth and yield parameters

-The pseudostem length (cm), and circumstance (cm): The area was measured from the root throatof plant to the shoot tip by meters as cm (± 0.5). Pseudostem circumstance was evaluated as cm (± 0.1) with the help of a meter.
-Leaf length (cm): It is the value in cm of the part from the tip of the leaf to the beginning of the petiole, taken from the middle part of the plant.
-Leaf width (cm): It is the length of the plant from the midpoint of the leaf to both sides.
-Stalk length (cm): It is the total length of the pseudostem on which the flowers are located.
-Number of hands (n): It is the total number of fruit clusters on the bunch.
-Number of fingers (n): It is the total number of fruits in the middle hand.
-Bunch weight (kg): It is the weight of the total fruit on the stalk.
-Finger length (mm): It is the distance between the pedicel and the tip of the fruit.
-Finger diameter (mm): It is the measure of the radius of the exact midpoint of the fruit.

Data analysis

In the experiment, each application was designed with three replications and three plants in each replication. Plant growth and yield data were presented as mean ± SD and subjected to one-way ANOVA with a randomized plot design for each parameter using JPM 5.0.1. software (SAS Institute, Cary, NC, 1989) followed by the LSD test ($p < 0.05$).

RESULTS and DISCUSSION

The study was carried out for two consecutive years. The study was made to identify growth and yield parameters related to three different planting systems, the data present in Table 2 indicated that there was a significant difference in pseudostem length, pseudostem circumtance, leaf length, and leaf width with regard to different planting systems. The spacing had a significant effect on plant height. Maximum pseudostem length was observed in single row system (216.00 cm) and maximum pseudostem circumstance was observed in the triangular row system (64.00 cm). In the pair and triangular row systems, it was observed that while the plants were farther from each other in the first year, they came near each other as time passed. This situation is related to the growth of the rhizome under the ground over time. While Patel et al. (2018) reported that pseudostem height and circumference increased significantly with a planting distance of 2.0 x 2.0 m for two plants per hill, Salmazo et al. (2021) reported that the spacing between plants had no significant effect on the pseudostem circumference. Prata et al. (2018) and Gasparotto et al. (2019), reported that plant height tends to increase as plant density increases. In this study, pseudostem length was highest in single row planting (1.8 x 2.0 m), while pseudostem circumference was highest in triangular row planting (1.5 x 1.8 m). As the plants got closer, it was understood that there was an expansion in the pseudostem and a shortening of the plant height. Similarly, Kumar et al. (2008) reported that pseudostem circumference also increased due to increased plant density but the effects were nonsignificant. The reason why the results are different from other studies compatible with Patel et al. (2018) and Kumar et al. (2008) is thought to be due to the differences in the cultivars used and the cultural process.

Table 2. Influence of planting systems on plant growth parameters of banana.

Treatments	Pseudostem height (cm)	Pseudostem circumtance (cm)	Leaf length (cm)	Leaf width (cm)
Single row	216.00±28.79 ^{a}	54.33±4.16 ^{ab}	160.00±2.65 ^{a}	60.67±2.52 ^{a}
Paired row	171.00±6.92 ^{b}	45.00±5.29 ^{b}	128.70±21.34 ^{b}	55.00±3.61 ^{ab}
Triangular row	167.67±15.57 ^{b}	64.00±2.65 ^{a}	117.17±6.45 ^{b}	49.00±2.00 ^{b}

*Mean ± SD; Mean of three replications and three plants in each replication; the values within the same column followed by different letters are significantly different ($p \leq 0.05$) according to one-way variance analysis (ANOVA) (student *t*-test).

During the experiment, leaf decreasing was done between cultural treatments. While the number of leafs was 12 during the flowering period on the plants, it was 6 during the harvest period. Measurements were made on the middle leaf to represent the plant. The longest leave length and width were measured in single row plants with 160.00 cm and 60.67 cm, respectively. According to Salmazo et al. (2021) evaluated the number of leaves in the harvest period and reported that the number of leaves increased as the planting space expanded. In this study, leaf size was evaluated and similarly, leaf length and width were found to be greater in single row planting.

The effect of plant population on yield and yield-forming characters was clearly observed. According to the planting systems, single row planting had the highest weight of 34.66 kg, while no statistical difference could be determined in pair and triangular row planting (Table 3). This is thought to be due to competition for nutrient intake between plants.

Table 3. Influence of planting systems on yield parameters of banana.

Treatments	**Stalk length (cm)**	**Bunch length (cm)**	**Bunch circumtance (cm)**	**Bunch weight (kg)**
Single row	173.00±24.58	93.67±6.43 [a]	106.67±10.07 [a]	24.77±2.16 [a]
Paired row	172.33±16.44	80.67±12.66 [ab]	89.83±2.47 [b]	18.90±0.85 [b]
Triangular row	163.67±8.72	77.67±4.16 [b]	83.20±2.71 [b]	16.80±1.56 [b]

*Mean ± SD; Mean of 3 replications and three plants in each replication; the values within the same column followed by different letters are significantly different ($p \leq 0.05$) according to one-way variance analysis (ANOVA) (student *t*-test).

Stalk size may affect fruit distribution in the bunch and, consequently, the fruit quality because of possible wounds at harvest (Cavatte et al., 2012). While there was no significant difference between the treatments in terms of stalk length, single row planting had the highest length and circumstance of the bunch. Although bunch length was higher in paired row planting than in triangular row planting, the circumference of the bunch was statistically in the same group. Patel et al. (2018) reported that plants grown under planting distance 1.2 x 1.2 x 2.0 m pair row showed significantly higher yields (t/ha). Chaudhuri and Baruah (2010) also observed the highest bunch weight (18.50 kg) in the planting density with one sucker per pit. Nalina et al. (2003) also reported similar results on the Robusta' banana cultivar. Significantly higher yields were obtained in the lower plant population compared to the higher plant population.

When the parameters related to the fruit were examined, there was no statistical difference between planting systems in terms of hand and finger numbers, but a significant difference was found between finger length and diameter (Table 4).

Table 4. Influence of planting systems on fruit parameters of banana.

Treatments	**Hand number (n)**	**Finger number (n)**	**Finger length (mm)**	**Finger diameter (mm)**
Single row	11.00±1.00	19.33±1.53	148.00±3.61[a]	44.85±0.79 [a]
Paired row	10.70±0.76	19.10±0.46	137.67±2.08 [b]	37.85±1.62 [b]
Triangular row	10.00±0.45	19.10±0.46	126.73±3.16 [c]	34.16±1.91 [c]

*Mean ± SD; Mean of 3 replications and three plants in each replication; the values within the same column followed by different letters are significantly different ($p \leq 0.05$) according to one-way variance analysis (ANOVA) (student *t*-test).

It was concluded that planting systems had a significant effect on fruit size. Although lower spacings reduce fruit lengths, these lengths are within the values established for the Plantain bananas to be classified as superior, that is, fruit with lengths higher than 23 cm, show higher commercial value (Ceagesp, 2021). Chaudhuri and Baruah (2010) reported that as the number of plants increased, the number of hands and fingers per bunch decreased, and there was a decrease in finger length/diameter with increasing plant number. They added that this may be due to excessive darkening by the canopy developed under high-density planting.

In single-row planting, the intervals between the rows were wide and the rows were narrow. In this way, better ventilation of the plants is ensured and the entry of diseases is prevented. While yield per plant increased, total yield decreased because of plant number. Due to pair row planting, intercultural operations were carried out easily and the cost of drip irrigation was decreased. When the average yield per decare was calculated, the highest value was obtained from pair row planting with 9828 kg, while the lowest yield was obtained from triangular (6098.4 kg) and single (6886.06 kg) row planting, respectively. While Khalequzzaman et al. (2009) found economically profitable due to high density of banana plants, Gasparotto et al. (2019) found that decreases in spacings and, consequently, increases in planting densities cause significant increases in the production costs of bananas. In this study, if the initial investment cost in banana cultivation is not taken into account, the increase in the number of plants increases the production and therefore the profit rate.

CONCLUSION

Commercial banana cultivation is generally done at 2 x 2 m spacing which is a large spacing. However, for economic reasons many growers cultivate bananas at closer spacing. Accordingly, with closer distance, the overall yield is higher. Besides, banana is a botanically taller crop and the duration is also longer (10-14 months). Closer spacing may help prevent natural hazards, especially speedy wind and storms. It is to be estimated whether wider or closer spacing gives a higher yield of bananas.

At the end of the study, it is concluded that spacing of 1.2 x 1.2 x 2.0 m gave higher total banana yield and economic profit than the spacing of 1.5 x 1.8 m. However, longer and wider fruits were obtained in plant spacing 1.8 x 2.0 m. So, pair row planting can be recommended for banana farmers. Banana production in Türkiye is carried out only in the Mediterranean Region and only 85% of domestic consumption is met. Pair row planting can be one of the steps toward solving this problem.

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