

Plant Density and Harvesting Number Effect on Some Agronomic Parameters of Stevia (*Stevia Rebaudiana* Bertoni L.)

erkan boydak

erkanboydak@gmail.com

Bingöl Üniversitesi <https://orcid.org/0000-0002-3466-5356>

irfan omay

Bingöl Üniversitesi <https://orcid.org/0009-0000-8816-4736>

Research Article

Keywords: stevia, plant density, number of harvesting.

Posted Date: August 2nd, 2024

DOI: <https://doi.org/10.21203/rs.3.rs-4835008/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: The authors declare no competing interests.

Abstract

This study was established in order to determine yield and quality parameters of stevia (*Stevia rebaudiana* Bertoni L.) harvesting numbers at different plant densities (25x50, 30x50, 35x50, 40 x 50 cm) in 2017-18. The experiment was carried out with 4 replications according to the "split plots trial pattern". Results; In 2017, plant height was obtained 82.31 and 57.31 cm, Fresh Herb Weight per Plant was 62.79 and 24.38 g plant⁻¹, Fresh Branch Weight per Plant was 38.17 and 8.71 g plant⁻¹, Number of Branches per Plant was 13.88 and 1.71 pcs/plant, Dry Herb Weight per Plant was 18.79 and 6.96 g plant⁻¹, Dry Branch Weight per Plant was 11, 38 to 2.38 g plant⁻¹, fresh branch yield 219.98 to 46.44 kg/ha, fresh leaf weight per plant 24.09 to 15.59 g plant⁻¹, fresh leaf yield 192.68 to 83.12 kg/ha, dry branch yield 74.85 to 12.68 kg/ha, dry leaf weight per plant 7.17 to 4.42 g plant⁻¹, dry leaf yield 57.34 to 23.56 kg/ha. In 2018, plant height was obtained 86.00 to 67.75 cm, Fresh Herb Weight per Plant 52.24 to 34.44 g plant⁻¹, Fresh Branch Weight per Plant 29.24 to 17.27 g plant⁻¹, Number of Branches per Plant 4.25 to 2.75 pcs/plant, Dry Herb Weight per Plant 20.56 to 13.12 g plant⁻¹, Dry Branch Weight per Plant 10, 57 to 4.11 g plant⁻¹, Fresh Branch yield 233.93 to 92.09 kgha-1, Fresh Leaf weight per plant 28.28 to 15.56 g plant⁻¹, Fresh leaf yield 226.20 to 124.50 kgha-1, Dry Branch yield 84.55 to 21.94 kgha-1, Dry Leaf weight per plant 11.79 to 7.94 g plant⁻¹, Dry leaf yield 94.30 to 47.03 kgha⁻¹. When the averages of plant densities are examined, higher values were obtained from the densest plant density (25 x 50 cm) in almost all parameters, while a few parameters were obtained from a lower plant density. When the first and second harvest mean values were compared, the second harvest data had higher values in all parameters except for Number of Branches per Plant, Fresh Leaf Weight per Plant and Fresh Leaf Yield.

1. INTRODUCTION

It is estimated that there are approximately 500,000 plant species in the world, about 100,000 of these plants are used as medicinal and aromatic plants, of which approximately 10,000 are used as food. Medicinal and aromatic plants have an important flora on the earth and are distributed over a very wide region. Turkey is one of the richest countries in the world in terms of plant species and varieties because it has different climatic zones at the meeting point of Asia, Europe and Africa continents. There are approximately 10.000 plant species in Turkey (Baytop 1999). According to the World Health Organization report, it is estimated that approximately 21,000 plants are used in the pharmaceutical industry. Only 500 of the species in our country are used for medicinal purposes (Anonymous 2018a).

Medicinal and Aromatic Plant (MAP) Market in the World: \$60 billion in 2000, \$95 billion in 2015, \$110 billion in 2017, and the market in Turkey is approximately \$2.5 billion (Anonymous 2018b). The sweet compounds, steviol glycosides, found in Stevia make it safe for those who want to control blood sugar levels (Strauss 1995). Stevia leaves are thought to have positive effects against diabetes, high blood pressure, constipation, depression and nervous disorders, and to protect stomach and intestinal flora and acid-alkaline balance (Azarpour et al. 2013).

Stevia (*Stevia rebaudiana* Bertoni) is used as a natural sweetener. It can be easily grown in semi-arid conditions and at least two harvests can be obtained. In this case, the values of fresh grass, dry grass and leaf ratio in the first harvest may be higher in the first harvest. (Büyük et al. 2022). *Stevia* is a potential alternative and health-safe product for those who want to produce calorie-free sugar. While denser plant populations increase plant height, dry leaf weight may not be affected (Iestari et al. 2021).

Solar radiation can be stressful for *stevia* when it can reach very high levels. The positive effect of biospace, which is based on the reduction of ultraviolet radiation, on the net assimilation rate (NAR), harvest index (HI), biomass distribution and root/canopy ratio of *stevia* plants suggests that this system can be used as a strategy against high temperatures and high radiation levels caused by climate change (Alfredo et al. 2020). It has been reported that environment, environmental interactions (GEI) (5.20%) and genotype effects (2.43%) are important in the total variation on *stevia* yield, thus increasing *stevia* leaf yield is highly influenced by genotypes and environment and their interactions, with environmental effects contributing 92.38% of the total variation (Amien et al. 2022).

In one study, the tallest plants were obtained from the narrowest plant population (15 cm × 10 cm). Pinching the apical bud caused a decrease in plant height and increased the number of branches. The pinched plants recorded higher fresh and dry leaf weights than the uncompressed plants. Larger (15 cm × 15 cm) plant populations recorded higher leaf number than smaller populations. Compaction favoured lateral bud formation and produced a significant number of branches and more leaves per plant. In terms of above-ground fresh mass (10925 kg ha⁻¹), dense plantings yielded higher results than sparse plantings (7330 kg ha⁻¹) (Junaidath et al. 2022). *Stevia* cultivation technology is still not sufficiently researched. Studies have been carried out mostly based on plant density and NPK fertiliser rates and yield predictions have been attempted with mathematical models. Mathematical models developed using polynomial and multiple linear regression analyses provided reasonable accuracy in yield prediction. It was found that the best yields of *stevia* were obtained under a plant density of 80–120 thousand plants/ha and mineral nutrition with phosphorus and potassium fertilisers, while nitrogen was less important. Mineral fertilisation of the plant with a focus on phosphorus fertilisers is important (Raisa et al. 2021). In a study of *Stevia rebaudiana* under saline soil conditions and at different plant densities, it was reported that the use of salicylic acid and salinity remover increased the yield as the plant density increased (Mahmoud et al. 2022).

Stevia is effective against antihypertension, antihyperglycemic and viruses (Klongpanichpak et al. 1997) and has strong antioxidant properties (Tadhani et al. 2007), it has the potential to be used in diet programs due to its zero calories, it is used in the treatment of cardiovascular diseases, in mouthwashes, in the composition of toothpastes in the treatment of eczema and acne due to its plaque removal, caries prevention, pain relief and antibacterial effect, it is a calcium antagonist (pushing and pulling muscles, reverse synergistic effect) and has a positive effect on the nervous system (Chalapathi and Thimmegowda 1997; Anonymous 2007; Chatsudhipong and Muanprasat 2009).

So far, there have been no negative reports on the use of Stevia (Brandle and Rosa 1992). In Turkey, the leaves of the sweetgrass plant have been evaluated as “positive” in the Medicinal Plant List published by the Ministry of Food, Agriculture and Livestock. It has been reported that Stevia leaves are in compliance with the Turkish Food Codex Regulation on Food Additives and that the plant is suitable for use as a sweetener (Saltan 2013).

Stevia is a perennial, herbaceous and shrubby plant from the Chrysanthemum (Chrysanthemum) family of the Asteraceae (Compositae) family of the Daisy family, yielding 5–6 years, with a chromosome number $n = 11$, with approximately 230 varieties (Yadav et al. 2011). The Swiss botanist Moises Santiago Bertoni reported the sweet taste of Stevia (Bertoni 1899). The Stevia plant was named *Stevia rebaudiana* Bertoni in 1887 (Bertoni, 1905). Stevia has been used by the Guarani Indians since 1500 BC (Misra et al. 2011). The Stevia plant has 11 chromosomes ($2n = 22$) and different Stevia plants with different chromosome numbers have been found (Oliveira et al. 2004). Stevia Cav. is one of the most prominent genera in the Eupatorieae tribe, consisting of about 150–200 species of herbaceous, shrubby plants, distributed in Mexico, Argentina and Central America in the American Southwest (King and Robinson 1987). Originally *Eupatorium rebaudianum*, it has more than 240 natural species (Landazuri and Tigrero, 2009). A short-day plant (Maheshwar 2005), Stevia dry leaves are 15–20 times sweeter than sucrose obtained from beet and cane and its extract is on average 300 times sweeter than sucrose and has zero calories (Singh and Rao 2005). Stevia leaf extracts contain flavonoids, alkaloids, water-soluble chlorophyll, xanthophyll, hydroxycinnamic acid, neutral water-soluble oligosaccharides, free sugars, amino acids, lipids, essential oils and trace elements (aluminum, iron, zinc, etc.) (Komissarenko et al. 1994; Markovic et al. 2008). The main producers of Stevia are Japan, China, Taiwan, Thailand, Korea, Brazil, Malaysia and Paraguay. Stevia is consumed in Japan, Brazil, Korea, Israel, USA, Argentina, China, Canada, Paraguay and Indonesia (Crammer and Ikan 1986; Singh and Rao 2005). In our country, the term sugar is used for beet sugar and Starch Based Sugar (SBS), and the term sweetener is used for alternative sweeteners that have no caloric value. In the world, when we think of sweeteners, we think of all kinds of substances that give sweetness, and when we think of sugar, we think of white sugar obtained from beet and cane. Sweeteners are divided into two main groups as caloric and alternative sweeteners according to their chemical structure (Anonymous 2015).

(Taleie et al. 2012), fresh twig weight, fresh herb yield, dry twig weight, dry herb yield and fresh twig yield were obtained at 50×20 cm plant density at different dates as the plants were more oriented to the sun with the increase in the number of plants in the plant density per unit area. 2012, the number of plants increased with the increase in plant density per unit area, fresh herb yield increased and more dry herb yield was obtained in the first year (Aladakatti 2011), and in terms of the number of cuttings, the yield increased until a certain time after the harvest started and then the yield decreased (Serfaty et al. 2013).

The aim of this study was to investigate the growth potential of Stevia especially in the Eastern Black Sea Region, the effects of planting frequency on yield and quality of the plant, and it was seen that the plant has the potential to grow in the Eastern Black Sea Region. It is thought that the results of the study will help in the planning of similar researches and future studies on Stevia plant by determining the most

suitable planting frequency, yield and quality characteristics in the conditions of the Eastern Black Sea Region by determining the most suitable planting frequency, yield and quality by using a single variety of *Stevia* (*Stevia rebaudiana* Bertoni L.) variety in the experiment.

2. MATERIALS AND METHODS

Stevia (*Stevia rebaudiana* Bertoni L.) seedlings used as material were obtained commercially. The experiment was established in Hayrat district of Trabzon, which has an average altitude of 180 m, warm and rainy summers and cool and rainy winters.

According to the results of the soil analysis taken from 0–30 cm soil depth; pH was slightly acidic, salt-free in terms of salt content, organic matter content was good, P₂O₅ was very high, lime content was absent, K₂O content was high (Anonymous 2013).

The experiment was established and conducted on May 19, 2017 according to the “Split Plots Experimental Design” with four replications. Each plot consisted of 4 rows. The row length was 3m and the row spacing was 50 cm, and the size of the plots was 6 m². In 25x50 cm plot; 52 plants (13 x 4) in total (52 x 4) 208 plants (8000 plants/da) were planted. In 30x50 cm plot; 44 plants (11 x 4) in total (44 x 4) 176 plants (6666 plants/da) were planted. In the 35x50 cm plot; 40 plants (10 x 4) in total (40 x 4) 160 plants, (6000 plants/da) were planted. In 40x50 cm plot; 36 plants (9 x 4) in total (52 x 4) 144 plants, (5333 plants/da) were planted.

Pure 0.6 kg ha⁻¹ nitrogen, 0.66 kg ha⁻¹ phosphorus and 0.6 kg ha⁻¹ potassium (20-20-20) NPK compound fertilizer was mixed into the soil by sprinkling method. After planting, the plants were given life water.

Urea was applied as top fertilizer at a rate of 4 kg of pure nitrogen. The first harvest was done on August 9, 2017, when the plants reached approximately 5–10% flowering level, 1 plant each at the beginning and end of the plants in the middle 2 rows were discarded and all the plants were harvested. The remaining half of the urea fertilizer was applied by sprinkling method after harvest. On October 25, 2017, when the *Stevia* plants reached approximately 5–10% flowering level, the second harvest was made from a height of 10–12 cm above the ground and the plants spent the winter season in this way. In 2018, weed controls were carried out and no top dressing fertilizer was applied. The first harvest was made on July 21, 2018 and the second harvest was made on November 31, 2018.

Table 1
Climatic data of Trabzon province in 2017–2018

	Average Temp. (°C)		Relative Humidity (%)		Total Precipitation (mm)	
Months	2017	2018	2017	2018	2017	2018
May	14.8	19.6	81.3	84.4	116.9	143.1
June	18.8	23.8	83.4	80.4	69.5	58.1
July	21.5	25.2	85.5	81.3	63.2	116.6
August	22.6	25.2	90.2	80.1	107.1	119.3
September	19.8	22.4	83.1	82.1	67.7	175.4
October	14.2	18.8	83.2	85.5	133.9	167.0
Averages	18.6	22.5	84.5	82.3	-	-
Total	-	-	-	-	558.3	779.5

Source: Republic of Turkey Ministry of Agriculture and Forestry General Directorate of Meteorology

In 2017, the average temperature during the 6-month (May-October) growing season was 18.6 °C, the average relative humidity was 84.5%, and the total precipitation was 558.3 mm. In 2018, the average temperature was 22.5 °C, the average relative humidity was 82.3% and the total precipitation was 779.5 mm. Since there was sufficient rainfall during the vegetation period, there was no need for irrigation. The parameters analyzed and the methods of obtaining them are given below.

Plant Height (cm): Randomly 4 plants were taken from each plot and measured from the soil level to the top of the main stem, the averages were taken and expressed in cm. **Number of Branches per Plant (pcs/plant):** The number of branches on the main stem of 4 plants taken randomly from each plot was determined and averaged and expressed as “number/plant”. **Fresh Herb Weight per Plant (g plant^{-1}):** Fresh herb weight per plant (g plant^{-1}) was calculated by taking the averages of 4 plants taken randomly from each plot, cut 10–15 cm above the soil surface and weighed. **Dry Herb Weight per Plant (g plant^{-1}):** The above-ground part of 4 plants taken randomly from each plot was dried in an oven at 38°C for 72 hours, weighed on a precision balance and the average was calculated. **Fresh Branch Weight per Plant (g plant^{-1}):** The branches of 4 plants taken randomly from each plot were separated from the leaves and weighed and the average was calculated and fresh branch weight per plant (g plant^{-1}) was calculated. **Dry twig weight per plant (g plant^{-1}):** The branches of 4 plants randomly taken from each plot were dried in an oven at 38°C for 72 hours, the weight of the branches were weighed separately and the average was calculated and the dry branch weight per plant (g plant^{-1}) was calculated. **Fresh Branch Yield (kgha^{-1}):** Fresh branch weight per plant was calculated and multiplied by the number of plants per decare and fresh branch yield (kgha^{-1}) was calculated. **Dry Branch Yield (kgha^{-1}):** Dry branch weight per

plant was calculated and multiplied by the number of plants per decare and dry branch yield (kg ha^{-1}) was calculated. Fresh Leaf Weight per Plant (g plant^{-1}): Leaves of 4 plants taken randomly from each plot were separated, weighed and the average was calculated and fresh leaf weight per plant (g plant^{-1}) was calculated. Dry leaf weight per plant (g plant^{-1}): The leaves of 4 plants taken randomly from each plot were dried in an oven at 38°C for 72 hours, the weight of the leaves were weighed separately and the average was calculated and the dry leaf weight per plant was determined. Fresh Leaf Yield (kg/ha): Fresh leaf weight per plant was calculated and multiplied by the number of plants per decare to obtain fresh leaf yield. Dry Leaf Yield (kg ha^{-1}): Dry leaf weight per plant was calculated and multiplied by the number of plants per decare and dry leaf yield was found. The findings obtained from the research were statistically analyzed and evaluated using JMP statistical package program.

3. RESULTS AND DISCUSSION

Plant Height (cm)

According to 2017 data, the highest average plant height was 79.70 cm at the second harvest time and the lowest average plant height was 59.70 cm at the first harvest time. There was no statistical difference between plant densities on plant height. The difference was found to be statistically insignificant in terms of harvest time x plant density interaction and plant height values ranged between 57.31 cm and 82.31 cm. When the second year data were analysed, except for the harvest time averages, other treatments were found to be statistically significant and formed different groups. The highest values of 86.00 and 82.50 cm were obtained from 25 x 50 cm frequency (Table 1).

Table 1
Mean Values of Plant Height of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Plant Density (cm)						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	60.63	82.31	71.47	82.50 ab	86.00 a	84.25 A
30x50 cm	57.31	76.81	67.06	79.00 abc	78.00 abc	78.50 AB
35x50 cm	61.13	79.88	70.50	75.50 abc	73.25 bc	74.38 BC
40x50 cm	59.75	79.81	69.78	67.75 c	71.25 bc	69.50 C
Averages	59.70 B	79.70 A		76.19	77.13	
LSD (0,05)	Harvest time* (5.076), Plant density (NS), Interaction (NS)			Harvest time (NS), Plant density* (8.25), Interaction (NS)		

As a result of the research, although the plant height values were not found to be statistically significant in the first year, it was observed that it tended to increase with increasing plant density in general. The reason for this is thought to be due to the fact that the plants are in competition to reach sunlight. The fact that the plant height in the second harvest is longer than the first harvest is thought to be due to the slow development of the seedlings at the time of the first planting, the plant height of the plants growing in shady environments is longer than the plants growing in the sun, the plant height increases in parallel with the number of days as the plant moves away from the first planting time, and after the first harvest, the plant begins to utilise nutrients and water more regularly. The findings obtained were lower than those of Klienle (1993), Casaccia and Alvarez (2006), in parallel with the findings of Burling (2007), Lankes and Pude (2008), Taleie et al. (2012), Samadpourrigani (2014), Yıldırım (2017) and higher than those of Shyu (1994), Valois (2002), Megeji et al. (2005).

Fresh herb weight per plant (g plant⁻¹)

According to 2017 data, the highest average fresh herb weight per plant was determined at the second harvest time with 60.31 g plant⁻¹ and the lowest average fresh herb weight per plant was determined at the first harvest time with 33.38 g plant⁻¹. The average fresh herb weight per plant between plant densities varied between 51.31 g plant⁻¹ and 42.44 g plant⁻¹. Accordingly, the highest average fresh herb weight per plant was 51.31 g plant⁻¹ at 25x50 cm plant density and the lowest average fresh herb weight per plant was 42.44 g plant⁻¹ at 40x50 cm plant density.

Table 2

Mean Values of Fresh Herb Weight Per Plant of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Fresh Herb Weight Per Plant (g plant ⁻¹)						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	39.83 c	62.79 a	51.31 A	50.84 a	52.24 a	51.54 A
30x50 cm	37.16 c	62.75 a	49.96 A	47.62 b	41.93 c	44.77 B
35x50 cm	32.17 d	55.21 b	43.69 B	42.94 c	36.06 d	39.50 C
40x50 cm	24.38 e	60.50 a	42.44 B	41.96 c	34.44 d	38.20 D
Averages	33.38 B	60.31 A		45.84 A	41.17 B	
LSD (0,05)	Harvest time* (4.322), Plant density* (2.342), Interaction* (3.312)			Harvest time* (0.98), Plant density* (1.19), Interaction* (1.68)		

According to the harvest time x plant density interaction, the highest fresh herb weight per plant was 62.79 g plant⁻¹ at 25x50 cm plant density in the second harvest period and the lowest fresh herb weight

per plant was $24.38 \text{ g plant}^{-1}$ at $40 \times 50 \text{ cm}$ plant density in the first harvest. When the second year data were analysed, it was observed that the first harvest value was higher than the second harvest value averages. This is thought to be due to the fact that the plants which were in the young seedling stage in the first harvest in the first year, developed and became robust in the second year and closed the difference between the harvest periods. The second year plant density averages were higher in the treatments with dense plant density as in the first year (Table 2). As a result of the research, the values of fresh herb weight per plant were found to be statistically significant, and it was observed that as the plant density increased and the harvest time was delayed, plant height increased and leaf yield tended to increase (Midmore and Rank 2002). The fact that the increase in fresh herb weight per plant in the second harvest was higher than the first harvest is thought to be due to the slow growth of the seedlings at the first planting time. The reason for this is that leaf yield, plant height, number of branches, number of leaves per plant and dry matter accumulation are related to each other (Chalapathi et al. 1998) and the differences between the values obtained related to the delay of harvest time are thought to be due to the amount of organic matter in the soil where the plant is grown, the amount of nutrients available from the soil and the water balance. The findings obtained in this study are lower than the findings of Samadpourrigani (2014) and in parallel with the findings of Sözmen (2015), Gedik and Tansı (2017) for three and four year old plants.

Fresh branch weight per plant (g plant^{-1})

According to 2017 data, it was determined that the average fresh branch weight per plant varied between $12.35 \text{ g plant}^{-1}$ and $32.81 \text{ g plant}^{-1}$ between harvest times. The highest average fresh branch weight per plant was determined at the second harvest time with $32.81 \text{ g plant}^{-1}$ and the lowest was determined at the first harvest time with $12.35 \text{ g plant}^{-1}$. Among the plant densities, the highest mean fresh branch weight per plant was obtained at $30 \times 50 \text{ cm}$ plant density with $23.71 \text{ g plant}^{-1}$ and the lowest mean fresh branch weight per plant was obtained at $25 \times 50 \text{ cm}$ plant density with $20.10 \text{ g plant}^{-1}$.

Table 3
Mean Values and Resulting Groups of Fresh Branch Weight Per Plant of Stevia at Different Plant
Densities and Different Harvest Times

Fresh Branch Weight Per Plant (g plant ⁻¹)						
2017				2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	14.88 d	25.33 c	20.10 B	20.55 bc	29.24 a	24.90 A
30x50 cm	14.42 d	33.00 b	23.71 A	19.20 cde	22.01 b	20.61 B
35x50 cm	11.42 e	34.75 b	23.08 A	17.69 de	19.75 bcd	18.72 C
40x50 cm	8.71 f	38.17 a	23.44 A	17.27 e	18.75 cde	18.01 C
Averages	12.35 B	32.81 A		18.68 B	22.44 A	
LSD (0,05)	Harvest time** (1.6962), Plant density* (1.6897), Interaction** (2.3896)			Harvest time* (1.68), Plant density* (1.74), Interaction* (2.46)		

According to the harvest time x plant density interaction, the highest fresh branch weight per plant was 38.17 g plant⁻¹ at 40x50 cm plant density in the second harvest period and the lowest fresh branch weight per plant was 8.71 g plant⁻¹ at 40x50 cm plant density in the first harvest period. In the first harvest period, it was determined that as the plant density increased and the harvest time delayed, the fresh branch weight per plant increased. In the second harvest period, the highest fresh branch weight per plant was obtained at 40x50 cm plant density and the lowest fresh branch weight per plant was obtained at 25x50 cm plant density. When the second year data were analysed, it was seen that the highest value was obtained from 25 x 50 cm plant density in both the first and second harvests and in the average values of both harvests. In addition, the average of the second harvest was higher than the first harvest. The findings obtained from the number of branches per plant support the results. Under normal conditions, the number of branches is expected to decrease as the plant density increases, but due to the effect of genetic characteristics and environment, the highest number of branches and therefore the highest number of branches per plant weight was obtained from 25 x 50 cm plant density (Table 3). As a result of the research, the values of fresh branch weight per plant in the first year were found to be statistically significant. At 25x50 cm plant density, fresh branch weight per plant was found to be low, and as the plant density increased, fresh branch weight per plant decreased. The reason for this is thought to be the decrease in the number of branches with the increase in plant height. The increase in fresh branch weight at the second harvest time is due to the development of the stem of the plant and hardening of the stem as the vegetation period of the plant increases. The findings of this study are higher than those of Khan et al. (2012), lower than those of Taleie et al. (2012) and Samadpourrigani (2014).

Number of Branches per Plant (pcs/plant)

When the second year data were analysed, it was observed that the number of branches decreased as the plant population decreased in both harvest times and harvest time averages, and the second harvest time averages were higher. The results are in parallel with the fresh branch weight per plant (Table 4). According to 2017 data, it was determined that the average number of branches per plant varied between 1.94 pieces/plant and 11.31 pieces/plant between harvest times. The highest average number of branches per plant was determined at 25x50 cm plant density with 7.79 pieces/plant and the lowest average number of branches per plant was determined at 40x50 cm plant density with 5.67 pieces/plant.

Table 4
Mean Values of Number of Branches per Plant of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Number of Branches per Plant (pcs/plant)						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	1.71	13.88	7.79	4.12 ab	4.25 a	4.19 A
30x50 cm	2.13	12.00	7.06	2.75 e	3.25 cde	3.00 B
35x50 cm	1.88	10.08	5.98	2.81 e	3.63 bc	3.22 B
40x50 cm	2.04	9.29	5.67	2.94 e	3.51 cd	3.23 B
Averages	1.94 B	11.31 A		3.16 B	3.66 A	
LSD (0,05)	Harvest time** (1.41), Plant density* (0.94), Interaction* (1.33)			Harvest time* (0.48), Plant density* (0.43), Interaction (ns)		

In terms of harvest time x plant density interaction, the number of branches per plant varied between 13.88 pieces/plant and 1.71 pieces/plant. Accordingly, the highest average number of branches per plant was 13.88 pieces/plant at 25x50 cm plant density in the second harvest period and the lowest average number of branches per plant was 1.71 pieces/plant at 25x50 plant density in the first harvest. As a result of the research, it is thought that the increase in the number of branches per plant in the second harvest is higher than the first harvest is due to the slow development of the seedlings at the first planting time. The reason for this is thought to be the awakening of the sleeping eyes in the leaf axils after mowing and the increase in the number of branches per plant as the harvest time is delayed. The findings obtained are in parallel with the findings of Samadpourrigani (2014), Sözmen (2015), Yıldırım (2017).

Dry herb weight per plant (g plant⁻¹)

According to 2017 data, the difference between plant densities in terms of dry herb weight per plant in both years was found statistically significant and two different groups were formed. Accordingly, the

average dry herb weight per plant between plant densities varied between $14.75 \text{ g plant}^{-1}$ and $11.42 \text{ g plant}^{-1}$ in the first year and between $18.75 \text{ g plant}^{-1}$ and $13.68 \text{ g plant}^{-1}$ in the second year (Table 5).

Table 5
Mean Values of Dry Herb Weight Per Plant of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Dry Herb Weight Per Plant (g plant^{-1})						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	10.71 d	18.79 a	14.75 A	16.93 b	20.56 a	18.75 A
30x50 cm	10.25 d	18.46 ab	14.35 A	15.18 d	17.40 b	16.29 B
35x50 cm	8.96 e	16.79 c	13.88 B	13.38 f	16.15 c	14.76 C
40x50 cm	6.96 f	16.88 b	11.42 B	13.12 f	14.25 e	13.68 D
Averages	9.22 B	17.98 A		14.65 B	17.09 A	
LSD (0,05)	Harvest time* (0.88), Plant density* (0.62), Interaction* (0.87)			Harvest time* (0.71), Plant density* (0.51), Interaction* (0.72)		

According to different plant densities, the highest average dry herb weight per plant was $14.75 \text{ g plant}^{-1}$ at 25x50 cm plant density and the lowest average dry herb weight per plant was $11.42 \text{ g plant}^{-1}$ at 40x50 cm plant density. According to the first year harvest time x plant density interaction, the highest dry herb weight per plant was obtained $18.79 \text{ g plant}^{-1}$ at 25x50 cm plant density in the second harvest period and the lowest dry herb weight per plant was obtained $6.96 \text{ g plant}^{-1}$ at 40x50 cm plant density in the first harvest period. As a result of the research, dry herb weight per plant values were found to be statistically significant in both years, as the plant density increased, fresh herb weight per plant values increased, and it was observed that dry herb values increased in parallel with the increase in fresh herb weight values. It is thought that the reason why the increase in dry herb weight per plant in the second harvest is higher than the first harvest is that as the harvest time is delayed, the leaves of the plant provide more nutrients in the plant and more dry herb is obtained in the second harvest due to hardening and carding of the leaves. The reason for this is thought to be the increase in dry herb weight depending on the fresh herb weight per plant as the harvest time is delayed. The findings obtained are lower than the findings of Samadpourrigani (2014) and parallel to the findings of Sözmen (2015), Gedik and Tansı (2017) in three and four year old plants.

Dry branch weight per plant (g plant^{-1})

According to 2017 data, the highest average dry branch weight per plant was determined at the second harvest time with $10.27 \text{ g plant}^{-1}$ and the lowest average dry herb yield was determined at the first

harvest time with $3.08 \text{ g plant}^{-1}$. The highest average of dry branch weight per plant was $7.24 \text{ g plant}^{-1}$ at $30 \times 50 \text{ cm}$ plant density and the lowest average of dry branch weight per plant was $5.65 \text{ g plant}^{-1}$ at $25 \times 50 \text{ cm}$ plant density.

Table 6

Mean Values of Dry Branch Weight per Plant of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Dry Branch Weight per Plant (g plant^{-1})						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	3.29 d	8.00 c	5.65 C	5.76 bc	10.57 a	8.16 A
30x50 cm	3.25 d	11.23 a	7.24 A	5.29 cd	7.03 b	6.02 B
35x50 cm	3.42 d	10.46 b	6.94 AB	4.63 cd	6.75 b	5.83 BC
40x50 cm	2.38 e	11.38 a	6.88 B	4.11 d	5.93 bc	5.02 C
Averages	3.08 B	10.27 A		4.95 B	7.57 A	
LSD (0,05)	Harvest time** (0.46), Plant density** (0.35), Interaction** (0.50)			Harvest time* (0.58), Plant density* (0.98), Interaction* (1.39)		

According to the harvest time x plant density interaction, the highest dry branch weight per plant was obtained $11.38 \text{ g plant}^{-1}$ at $40 \times 50 \text{ cm}$ plant density in the second harvest period and the lowest dry branch weight per plant was obtained $2.38 \text{ g plant}^{-1}$ at $40 \times 50 \text{ cm}$ plant density in the first harvest period. In 2017, as a result of the research, dry branch weight per plant values were found to be statistically significant, and as the plant density increased, dry branch weight per plant decreased in relation to fresh branch weight per plant. This is thought to be due to the decrease in the number of branches in the plant with the increase in plant height. The increase in dry branch weight at the second harvest time is thought to be due to the higher dry branch weight per plant obtained due to the development, hardening and carding of the stem of the plant as the vegetation period of the plant extends. In 2018, in both harvest time and plant density averages, the values were higher as the plant density increased. When we look at the harvest time averages, the second harvest time was found to be higher as in the first year. Normally, as time passed, the plants developed and the branches developed in parallel (Table 6). The findings of the study were lower than the findings of Taleie et al. (2012), Samadpourrigani (2014), Gedik and Tansı (2017) obtained from three and four year old plants, and parallel to the findings of Kumar et al. (2013).

Fresh Branch Yield (kgha^{-1})

According to 2017 data, the highest average fresh branch yield per plant was determined at the second harvest time with $208.67 \text{ kg ha}^{-1}$ and the lowest fresh branch yield average was determined at the first harvest time with 825.1 kg ha^{-1} . The lowest fresh branch yield average was determined at the first harvest time. The highest fresh branch yield average among plant densities was obtained with $1608.3 \text{ kg ha}^{-1}$ at $25 \times 50 \text{ cm}$ plant density, while the lowest fresh branch yield average was obtained with $1249.9 \text{ kg ha}^{-1}$ at $40 \times 50 \text{ cm}$ plant density. According to the interactions of harvest time x plant density, the highest fresh branch yield was obtained $2199.8 \text{ kg ha}^{-1}$ at $30 \times 50 \text{ cm}$ plant density in the second harvest period and the lowest fresh branch yield was obtained 464.4 kg ha^{-1} at $40 \times 50 \text{ cm}$ plant density in the first harvest period. In the first harvest period, the highest fresh branch yield was obtained at $25 \times 50 \text{ cm}$ plant density, while the lowest fresh branch yield was obtained at $40 \times 50 \text{ cm}$ plant density.

Table 7

Mean Values of Fresh Branch Yield of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Fresh Branch Yield (kg ha^{-1})						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
$25 \times 50 \text{ cm}$	1190.0 c	2026.6 b	1608.3 A	1644.3 bc	2339.3 a	1991.8 A
$30 \times 50 \text{ cm}$	961.1 d	2199.8 a	1580.4 A	1279.7 d	1761.0 b	1520.3 B
$35 \times 50 \text{ cm}$	685.1 e	2085.0 ab	1385.0 B	1061.3 e	1580.0 bc	1320.6 C
$40 \times 50 \text{ cm}$	464.4 f	2035.5 b	1249.9 C	920.9 e	1500.0 bc	1210.5 C
Averages	825.1 B	2086.7 A		1226.5 B	1795.1 A	
LSD (0,05)	Harvest time** (101.5), Plant density** (111.5), Interaction** (157.7)			Harvest time* (134.6), Plant density* (133.4), Interaction (ns)		

In the first harvest period, it was determined that fresh branch yield increased as the plant density increased and the harvest time was delayed. In the second harvest period, the highest fresh branch yield was recorded at $30 \times 50 \text{ cm}$ plant density, while the lowest fresh branch yield was recorded at $25 \times 50 \text{ cm}$ plant density. When the second year yields were analysed, it was found that as the plant density increased, the fresh branch yield increased in both harvest periods and plant density averages, and the harvest time averages showed higher results in the second harvest period as in the first year (Table 7). As a result of the research, fresh branch yield values were found to be statistically significant, fresh branch yield increased with the increase in the number of plants per unit area (Taleie et al. 2012), and as the plant density increased and the harvest time was delayed, fresh branch yield also increased. The increase in fresh branch yield at the second harvest time is due to the fact that as the vegetation period of the plant is prolonged, more nutrients are formed in the stem of the plant, and more fresh branch yield

was obtained in the second harvest due to hardening and carding in the stem. This is thought to be due to the increase in plant density and the number of plants per decare. The findings obtained in this study are lower than the findings of Taleie et al. (2012), Samadpourrigani (2014).

Fresh leaf weight per plant (g plant⁻¹)

According to 2017 data, the highest average fresh leaf weight per plant was determined at the second harvest time with 21.51 g plant⁻¹ and the lowest average fresh leaf weight per plant was determined at the first harvest time with 20.46 g plant⁻¹. The highest mean fresh leaf weight per plant was 22.83 g plant⁻¹ at 25x50 cm plant density and the lowest mean fresh leaf weight per plant was 18.56 g plant⁻¹ at 40x50 cm plant density.

Table 8

Mean Values of Fresh Leaf Weight Per Plant of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Fresh Leaf Weight Per Plant (g plant ⁻¹)						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	24.09 a	21.58 bc	22.83 A	28.28 a	24.25 c	26.26 A
30x50 cm	21.96 b	21.59 bc	21.77 AB	26.77 b	19.06 d	22.92 B
35x50 cm	20.21 c	21.33 bc	20.77 B	25.56 bc	15.56 e	20.56 C
40x50 cm	15.59 d	21.54 bc	18.56 C	25.80 b	15.69 e	20.74 C
Averages	20.46	21.51		26.60 A	18.64 B	
LSD (0,05)	Harvest time (ns), Plant density** (1.13), Interaction** (1.60)			Harvest time* (0.81), Plant density* (0.98), Interaction* (1.38)		

According to the interactions of harvest time x plant density, the highest fresh leaf weight per plant was 24.09 g plant⁻¹ at 25x50 cm plant density in the first harvest period and the lowest fresh leaf weight per plant was 15.59 g plant⁻¹ at 40x50 cm plant density in the first harvest period. The highest fresh leaf weight per plant was obtained at 25x50 cm plant density, while the lowest fresh leaf weight per plant was obtained at 40x50 cm plant density in the first harvest period. It was determined that as the plant density increased, fresh leaf weight per plant increased as the harvest time was delayed. In the second harvest period, the highest fresh leaf weight per plant occurred at 40x50 cm plant density, while the lowest fresh leaf weight per plant occurred at 25x50 cm plant density. When the data obtained in the second year are analysed, it will be seen that, as in the first year, fresh leaf weight per plant increased as the plant density increased and decreased as the population decreased in the first harvest time, second harvest time results and average results. When the averages of harvesting times were analysed, although

there was no statistical difference in the first year, the data of the first harvesting time in the second year were higher than the data of the second harvesting time (Table 8). It can be concluded that as the number of plants per unit area increased, the number of fresh leaves also increased. As a result of the research, the values of fresh leaf weight per plant were found to be statistically significant and higher values were obtained at 25x50 cm plant density. Fresh leaf weight per plant increased with the increase in the number of plants per unit area. The reason for this was that the number of plants per decare increased with plant density and the plants competed for access to sunlight, and the increase in plant height indirectly increased the fresh leaf weight per plant. This situation was observed in the first form and form averages. There was no statistical difference in the second form. The findings of the study were lower than the findings of Samadpourrigani (2014), Gedik and Tansı (2017) obtained from three and four year old plants.

Fresh leaf yield (kg ha^{-1})

According to 2017 data, the highest fresh leaf yield average was determined at the second harvest time with $1398.6 \text{ kg ha}^{-1}$ and the lowest fresh leaf yield average was determined at the first harvest time with $1358.6 \text{ kg ha}^{-1}$.

Table 9

Mean Values and Resulting Groups of Fresh Leaf Yield of Stevia at Different Plant Densities and Different Harvest Times

Fresh Leaf Yield (kg ha^{-1})						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	1926.8 a	1726.6 b	1826.7 A	2262.0 a	1940.0 b	2101.0 A
30x50 cm	1463.7 c	1438.9 c	1451.3 B	1784.4 c	1525.0 d	1654.7 B
35x50 cm	1212.8 de	1280.0 d	1246.4 C	1533.4 d	1245.0 f	1389.4 C
40x50 cm	831.2 f	1148.9 e	990.0 D	1375.9 e	1255.0 f	1315.5 D
Averages	1358.6	1398.6		1739.0 A	1491.3 B	
LSD (0,05)	Harvest time (ns), Plant density** (757), Interaction** (1070)			Harvest time* (60.3), Plant density* (73.1), Interaction* (103.3)		

The highest fresh leaf yield average was $1826.7 \text{ kg ha}^{-1}$ at 25x50 cm plant density and the lowest fresh leaf yield average was 990.0 kg ha^{-1} at 40x50 cm plant density. According to harvest time x plant density interaction, the highest fresh leaf yield was obtained $1926.8 \text{ kg ha}^{-1}$ at 25x50 cm plant density in the first harvest period and the lowest fresh leaf yield was obtained 831.2 kg ha^{-1} at 40x50 cm plant density in the first harvest period. As a result of the research, the highest fresh leaf yield was obtained at 25x50 cm

plant density in the first harvest period, while the lowest fresh leaf yield was obtained at 40x50 cm plant density. As the plant density increased in the first harvest period, it was determined that fresh leaf yield increased. In the second harvest period, the highest fresh leaf yield was recorded at 25x50 cm plant density, while the lowest fresh leaf yield was recorded at 40x50 cm plant density. When the second year data are analysed, it is seen that similar results were obtained with the first year data even if the figures changed. As a result of the research, fresh leaf yield values were found to be statistically significant and it was observed that fresh leaf yield values increased as the plant density increased. Although the difference between harvest times in the first year was found insignificant, the first harvest time in the second year was statistically higher (Table 9). The data obtained are in harmony with the fresh leaf weight per plant. It is thought that this situation is due to the fact that the second harvest period coincides with short days and the plant encourages the generative parts rather than the vegetative parts. The findings obtained in this study are lower than the findings of Ruta et al. (1999), Taleie et al. (2012), Samadpourrigani (2014), Tadesse et al. (2016) Gedik and Tansı (2017) obtained from 3 and 4 old plants.

Dry Branch Yield (kg ha⁻¹)

According to 2017 data, the highest fresh branch yield average per plant was determined at the second harvest time with 655.6 kg ha⁻¹ and the lowest fresh branch yield average was determined at the first harvest time with 202.9 kg ha⁻¹. The highest average dry branch yield was 482.5 kg ha⁻¹ at 30x50 cm plant density and the lowest average dry branch yield was 366.7 kg ha⁻¹ at 40x50 cm plant density. According to harvest time x plant density interaction, the highest dry branch yield was obtained 748.5 kg ha⁻¹ at 30x50 cm plant density in the second harvest period and the lowest dry branch yield was obtained 126.8 kg ha⁻¹ at 40x50 cm plant density in the first harvest period.

Table 10
Mean Values of Dry Branch Yield of Stevia at Different Plant Density and Different Harvest Times and Resulting Groups

Dry Branch Yield (kg ha ⁻¹)						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	263.4 c	640.0 b	451.7 B	460.5 b	845.5 a	653.0 A
30x50 cm	216.5 d	748.5 a	482.5 A	352.3 c	562.0 b	446.1 B
35x50 cm	204.9 d	627.5 b	416.2 C	277.5 cd	540.0 b	419.8 BC
40x50 cm	126.8 e	606.7 b	366.7 D	219.4 d	474.0 b	346.7 C
Averages	202.9 B	655.6 A		327.4 B	605.4 A	
LSD (0,05)	Harvest time** (30.0), Plant density** (24.3), Interaction** (34.4)			Harvest time* (52.3), Plant density* (75.8), Interaction (ns)		

In the first harvest period, it was determined that dry branch yield increased as the plant density increased and the harvest time was delayed. In the second harvest period, the highest dry branch yield was recorded at 30x50 cm plant density, while the lowest dry branch yield was recorded at 40x50 cm plant density. When the second year data were analysed, it was observed that there was a positive relationship between plant density and dry twig yield increase, which was similar to the first year data. The highest values were obtained from 25 x 50 cm row spacing application in terms of both first harvest time, second harvest time and harvest time averages (Table 10). As a result of the research, dry branch yield values were found to be statistically significant and dry branch yield increased with the increase in the number of plants per unit area. This is thought to be due to the increase in plant density and number of plants per decare. The increase in fresh branch yield at the second harvest time is due to the fact that as the vegetation period of the plant is prolonged, more nutrients are formed in the stem of the plant, hardening and carding of the stem, and fresh branch yield per plant was obtained more in the second harvest. As a result of the study, as the plant density increased, the number of plants per unit area increased and fresh branch yield increased, and more dry branch yield was obtained in the second harvest due to stem hardening and carding. The findings of the study were lower than the findings of Valois (2002), Tulasi (2006), Samadpourrigani (2014), Gedik and Tansı (2017) for three and four year old plants, and parallel to the findings of Kumar et al. (2013).

Dry leaf weight per plant (g plant⁻¹)

According to 2017 data, the highest average dry leaf weight per plant was determined at the second harvest time with 6.33 g plant⁻¹ and the lowest average dry leaf weight per plant was determined at the first harvest time with 5.93 g plant⁻¹. The highest average dry leaf weight per plant was 6.85 g plant⁻¹ at

25x50 cm plant density and the lowest average dry leaf weight per plant was 5.17 g plant⁻¹ at 40x50 cm plant density.

Table 11
Mean Values of Dry Leaf Weight Per Plant of Stevia at Different Plant Densities and Different Harvest Times and Resulting Groups

Dry Leaf Weight Per Plant (g plant ⁻¹)						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	7.17 a	6.34 cd	6.75 A	10.37 b	11.79 a	11.08 A
30x50 cm	6.63 bc	7.08 ab	6.85 A	9.40 bc	9.81 bc	9.61 B
35x50 cm	5.50 e	5.97 de	5.73 B	8.94 cd	8.63 cd	8.78 BC
40x50 cm	4.42 f	5.92 de	5.17 C	8.82 cd	7.94 d	8.38 C
Averages	5.93 B	6.33 A		9.38	9.54	
LSD (0,05)	Harvest time** (0.28), Plant density** (0.37), Interaction** (0.52)			Harvest time (ns), Plant density* (0.85), Interaction (ns)		

According to harvest time x plant density interaction, the highest dry leaf weight per plant was obtained at 25x50 cm plant density in the first harvest period and the lowest dry leaf weight per plant was obtained at 40x50 cm plant density in the first harvest period and 4.42 g plant⁻¹. As a result of the research, the highest dry leaf weight per plant was obtained at 25x50 cm plant frequency in the first harvest period, while the lowest dry leaf weight per plant was obtained at 40x50 cm plant frequency. In the second harvest period, the highest dry leaf weight per plant occurred at 30x50 cm plant density and the lowest dry leaf weight per plant occurred at 40x50 cm plant density. When the results obtained in the second year were analysed, it increased regularly as the plant population increased, just like the results obtained in the first year. In the first year, the mean harvest average was statistically significant, while it was insignificant in the second year (Table 11). As a result of the research, it is thought that the high plant density is due to the competition of plants for access to sunlight. The findings are in parallel with the fresh leaf weight per plant. It is thought that more dry leaf weight per plant was obtained in the second harvest. This is thought to be due to the increase in dry leaf weight per plant due to the increase in plant height and number of branches as the harvest time is delayed. The findings of the study were lower than the findings of Samadpourrigani (2014), Gedik and Tansı (2017) obtained from 3 and 4 year old plants.

Dry leaf yield (kg ha⁻¹)

According to 2017 data, the highest average dry leaf yield was determined at the second harvest time with 413.1 kg ha^{-1} and the lowest average dry leaf yield was determined at the first harvest time with 395.2 kg ha^{-1} . The highest average dry leaf yield was 540.1 kg ha^{-1} at $25 \times 50 \text{ cm}$ plant density and the lowest average dry leaf yield was 275.6 kg ha^{-1} at $40 \times 50 \text{ cm}$ plant density. According to harvest time x plant density interactions, the highest dry leaf yield was 573.4 kg ha^{-1} at $25 \times 50 \text{ cm}$ plant density in the first harvest period and the lowest dry leaf yield was 235.6 kg ha^{-1} at $40 \times 50 \text{ cm}$ plant density in the first harvest period.

Table 12
Mean Values of Dry Leaf Yield of Stevia at Different Plant Density and Different Harvest Times and Resulting Groups

Dry Leaf Yield (kg ha^{-1})						
	2017			2018		
Plant density	Harvest 1	Harvest 2	Averages	Harvest 1	Harvest 2	Averages
25x50 cm	573.4 a	506.8 b	540.1 A	829.5 b	943.0 a	886.3 A
30x50 cm	441.6 c	472.1 bc	456.9 B	626.6 cd	785.0 b	705.8 B
35x50 cm	330.0 de	358.1 d	344.0 C	536.3 de	690.0 c	613.1 C
40x50 cm	235.6 f	315.6 e	275.6 D	470.3 e	635.0 c	552.7 C
Averages	395.2 B	413.1 A		615.7 B	763.3 A	
LSD (0,05)	Harvest time** (14.8), Plant density** (24.8), Interaction** (35.0)			Harvest time* (77.1), Plant density* (65.4), Interaction (ns)		

In the first harvest period, the highest dry leaf yield was recorded at $25 \times 50 \text{ cm}$ plant density, while the lowest dry leaf yield was recorded at $40 \times 50 \text{ cm}$ plant density. In the first harvest period, as the plant density increased, dry leaf yield increased. In the second harvest period, the highest dry leaf yield was recorded at $25 \times 50 \text{ cm}$ plant density, while the lowest dry leaf yield was recorded at $40 \times 50 \text{ cm}$ plant density. When the data obtained in the second year of the research were analysed, it was found that the values obtained decreased as the plant population decreased and increased as the dry leaf yield values increased, showing a very close parallelism with the data obtained in the first year. The same situation was similar for the first and second harvest averages and the second harvest averages were higher than the first year averages (Table 12). As a result of the research, dry leaf yield values were found to be statistically significant and it was observed that dry leaf yield values increased as the plant density increased. It is thought that the reason why the increase in dry leaf yield in the second harvest is higher than the first harvest is that more nutrients are formed in the leaves and branches of the plant, and more dry leaf yield is obtained in the second harvest due to hardening and carding in the leaves and stems. It is thought that this situation is due to the fact that more nutrients are formed in the plant as the plant

density and harvest time is delayed, especially fresh leaf yield is related to the number of branches and plant height (Midmore and Rank 2002), and the increase in fresh leaf yield causes an increase in dry leaf yield. The findings of this study are lower than the dry leaf yield findings of Brandle and Rosa (1992), Klienle (1993), Shyu (1994), Kornienko (1995), Megeji et al. (2005), Tulasi (2006), Burling (2007), Lankes and Pude (2008), Taleie et al. (2012), Samadpourrigani (2014), Tadesse et al. (2016) and in parallel with the findings of Kumar et al. (2013).

Declarations

ACKNOWLEDGEMENT

In the first year of this study, the data obtained from İrfan OMAV's Master's thesis were used.

AUTHOR CONTRIBUTION STATEMENT

In this study, the authors contributed equally.

CONFLICT OF INTEREST

There is no conflict of interest between the authors

References

1. Aladakatti YR (2011) Response of Stevia (stevia rebaudiana Bertoni.) to Irrigation Schedule, Planting Geometry and Nutrient Levels. Department of Agronomy College of Agriculture, Dharwad University of Agricultural Sciences, Dharwad. Ph.d. thesis. p. 214
2. Alfredo Jarma-Orozco, Enrique Combatt-Caballero, Juan Jaraba-Navas, (2020) Growth and development of Stevia rebaudiana Bert., in high and low levels of radiation. Current Plant Biology, Volume 22, <https://doi.org/10.1016/j.cpb.2020.100144>.
3. Amien S, Maulana H, Ruswandi D, Nurjanah S (2022) Stevia (*Stevia rebaudiana* B.) Genotypes assessment for leaf yield stability through genotype by environment interactions, AMMI, and GGE biplot analyses. *SABRAO J. Breed. Genet.* 54 (4) 767-779. <http://doi.org/10.54910/sabao2022.54.4.8>
4. Anonymous (2007) Medicinal and Aromatic Plant Cultivation Strategy. Uttaranchal Decentralized Watershed Development Project, p. 34
5. Anonymous (2013) T.C. Trabzon İl Özel İdaresi Tarımsal Hizmetler Müdürlüğü Toprak Analiz Raporu ve Gübre Tavsiyeleri
6. Anonymous(2015)[https://www.tarimorman.gov.tr/SDB/Belgeler/faaliyet_raporlari/2015_Şeker %20Kurumu _Faaliyet%20Raporu.pdf](https://www.tarimorman.gov.tr/SDB/Belgeler/faaliyet_raporlari/2015_Şeker%20Kurumu_Faaliyet%20Raporu.pdf) (erişim tarihi 22.06.2019)
7. Anonymous (2018a) view-source:<http://www.fitoterapihaber.com/tibbi-ve-aromatik-bitkiler-uzerine-arastirmalar-yapildi/> (erişim tarihi 28.06.2019)

8. Anonymous (2018b) <http://www.fitoterapihaber.com/tibbi-aromatik-bitkilerin-durumu/> (erişim tarihi 28.06.2019)
9. Azarpour E, Moraditochaee M, Bozorgi HR (2013) Effects of vermicompost application under methanol foliar spraying on dry leaf yield and biomass yield of *Stevia rebaudiana* (bert.) in north of Iran. *ARPN J. Agri. Bio. Sci.* 8(5): 419-422
10. Baytop T (1999) Türkiye’de Bitkiler ile Tedavi, Geçmişte ve Bugün. Nobel Tıp Kitabevleri, II. Baskı ISBN: 975-420-021- 1. İstanbul, s. 480
11. Bertoni MS (1899) *Revista de Agronomia de 11. l'Assomption* 1: 35
12. Bertoni MS (1905) La Kaa Hee- Sa nature et ses proprietes. *Anales Cientificos Paraguayos*, 5: 1-14
13. Brandle JE, Rosa N (1992) Heritability for Yield, Leaf: Stem Ratio and Stevioside Content Estimated from a Landrace Cultivar of *Stevia rebaudiana*. *Can. J. Plant Sci.*, 72: 1263-1266
14. Burling K (2007) Entwicklung Von *Stevia rebaudiana* (Bertoni) unter dem Einfluss von verschiedenen Anzucht- und Standortbedingungen. Diplomarbeit der Landwirtschaftlichen Fakultät der Rheinischen Friedrich- Wilhelms-Universität zu Bonn. s. 158
15. **Büyük G, Bayram CA, Kırpık M, İnan M (2022) Agronomic Performance and Nutrient Content of *Stevia* (*Stevia rebaudiana* Bertoni) in Different Semi-Arid Locations. *Communications in Soil Science and Plant Analysis*, 53(7), 848–861. <https://doi.org/10.1080/00103624.2022.2028819>**
16. Casaccia JY, Alvarez E (2006) Recomendaciones Técnicas Para Una Producción Sustentable
17. Chalapathi MV, Thimmegowda S (1997) Natural Non-Calorie Sweetener *Stevia* (*Stevia rebaudiana* Bertoni) A future Crop of India. *Crop Res. Hisar* 14(2): 347-350
18. Chatsudthipong V, Muanprasat C (2009) Stevioside and Related Compounds: Therapeutic Benefits Beyond Sweetness. *Pharmacol Ther* 121(1): 41–54
19. Crammer B, Ikan R (1986) Sweet glycosides from the stevia plant. *Chem. Britain* 22: 915-916
20. Gedik S, Tansı LS (2017) Çukurova Koşullarında Bitki Yoğunluğu ve Bitki Yaşının Şeker Otu (*Stevia rebaudiana* Bertoni)’nın Verimine Etkisi Araştırma Makalesi / Research Article Iğdır Üni. Fen Bilimleri Enst. Der. / Iğdır Univ. J. Inst. Sci. & Tech. 7(3): 285-292
21. Khan AR, Chowdhury SH, Karim MM (2012) Effect of Date of Planting on the Growth and Leaf Yield of *Stevia* (*Stevia rebaudiana*). *J. Bangladesh Agril. Univ.* 10(2): 205–210
22. King RM, Robinson H (1987) The genera of the Eupatorieae (Asteraceae) Monographs in systematic botany, Missouri Botanical Garden St. Louis, MO

23. Klienle U (1993) Einfluß Von Bewässerung und Schnittfolge auf den Ertrag Von *Stevia rebaudiana* in Südsanien. Göttinger Beiträge zur Land- und Forstwirtschaft in den Tropen und Subtropen, Heft. p. 144
24. Klongpanichpak S, Temcharoen P, Toskulkao C, Apibal S, Glinsukon T (1997) Lack of mutagenicity of stevioside and steviol in salmonella typhimurium TA98 and TA100. J Med Assoc Thai, 80(1): 121 – 128
25. Komissarenko NF, Derkach AI, Kovalyov IP, Bublik NP (1994) Diterpene glycosides and phenylpropanoids of *stevia rebaudiana bertonii*, Rast Res. 1(2): 53-64
26. Kornienko AV (1995) *Stevia* Cultivation (Russian). Sakharnaya Svekla 10: 22- 24
27. Kumar R, Sharma S, Prasad R (2013) Yield, Nutrient Uptake, and Quality of *Stevia* as Affected by Organic Sources of Nutrient. Communications in Soil Science and Plant Analysis 44: 3137–3149
28. Landazuri AP, Tigrero SJ (2009) *Stevia rebaudiana* Bertuna Planta Medicinal. Escuela Politecnica del Ejercito. Departamento de Ciencias de la Vida, Carrera de Ingeniería en Ciencias Agropecuarias, p. 33
29. Lankes C, Pude R (2008) Possibilities for Growth of *Stevia* in European Temperate Zones. In *Steviol Glycosides: Technical and Pharmacological Aspects*. 2 *Stevia* Symposium Organized by Eustas. Kuleuven 7: 103-
30. Lestari A, Herwati A, Supriyono, Yulaikah S, (2021) The Effect of Clones and Plant Spacing on The Growth and Yields of *Stevia (Stevia Rebaudiana Bertonii L.)*. **Russian Journal of Agricultural and Socio-Economic Sciences**, 2 (110), DOI <https://doi.org/10.18551/rjoas.2021-02.03>
31. Maheshwar HM (2005) Effect of Different Levels of Nitrogen and Dates of Planting on Growth and Yield of *Stevia (Stevia rebaudiana Bert.)*. Department of Horticulture College of Agriculture, Dharwad University of Agricultural Sciences, Dharwad, M. Sc. Thesis s. 66
32. Mahmoud A, Gomaa1, Mohamed A Nassar, Adel M, Abd El-Aal, Mostafa M, Eladon, (2022) Response of *Stevia* to Salicylic Acid, Salinity Remediator and Plant Density under Soil as Affected by Salinity. Journal of the Advances in Agricultural Researches (JAAR) Volume: 28 (4). DOI:10.21608/JALEXU.2023.245608.1163
33. Markovic IS, Dartmati ZA, Abramovic BF (2008) Chemical Composition of Leaf Extracts of *Stevia rebaudiana Bertonii* Grown Experimentally in Vojvodina. Journal of the Serbian Chemical Society 73(3): 283-297
34. Megeji NW, Kumar JK, Singh V, Kaul VK, Ahuja PS (2005) Introducing *Stevia rebaudiana* a Natural Zero-Calorie Sweetener. Curr. Sci. 88(5): 31-35
35. Midmore DJ, Rank AH (2002) A new rural industry- *Stevia*- to replace imported chemical sweeteners: A report for the Rural Industries Research and Development Corporation, Australia. u: RIRDC Project No UCQ-16A, <http://owndoc.com/pdf/Stevia%20new%20rural%20industry.pdf> (Erişim tarihi: 05.08.2019)
36. Misra H, Soni M, Silawat N, Mehta D, Mehta BK, Jain DC (2011) Antidiabetic Activity of Medium-Polar Extract from the Leaves of *Stevia rebaudiana Bert. (Bertonii)* on Alloxan-Induced Diabetic Rats. J.

37. Oliveira VM, Forni-Martins ER, Magalhaes PM, Alves MN (2004) Chromosomal and morphological studies of diploid and polyploid cytotypes of *Stevia rebaudiana* (Bertoni) Bertoni (Eupatorieae, Asteraceae) Genet. Mol. Biol. 27: 215-222 Crossref
38. Junaidath P, Sindhu PV, Prameela P, Beena C and Syama, S Menon (2022) Growth and Yield of *Stevia (Stevia rebaudiana Bertoni)* as Influenced by Plant Density and Pinching. International Journal of Plant & Soil Science. Volume 34, Issue 24, Page 447-45. DOI: 10.9734/IJPSS/2022/v34i242661.
39. Raisa V, Lykhovyd P, Biliaieva I, Shebanova V, Rudik O, Sinhaievskyi A (2021)
40. Modeling stevia yields depending on plant density and mineral fertilizers rates. Modern Phytomorphology 15: 91–94, 2021. DOI: 10.5281/zenodo.5801191
41. Ruta C, De Mastro G, Fortunato IM, Mazzi V (1999) Modalita di propagazione e tecniche di coltivazione di *Stevia rebaudiana* Bertoni. 33th Congress SIA Agripolis. Padova (Italy)
42. Saltan G (2013) Türkiye'nin Geleceği ve Ekonomisi "Stevia G7" ile Şekillenecek. Medikal Teknik Online Dergi. Medikal bilgi formu. <http://www.medikalteknik.com.tr/turkiyenin-gelecegi-ve-ekonomisi-stevia-g7-ile-sekillenecek/>
43. Samadpourrigani E (2014) Çukurova koşullarında şeker otu (*Stevia rebaudiana* B.)'nda farklı ekim sıklıkları, biçim zamanları ve biçim sayılarının verim ve kaliteye etkisi tez çalışması
44. Serfaty M, Ibdah M, Fisher R, Chaimovitsh D, Saranga Y, Dudai N (2013) Dynamics of yield components and stevioside production in *Steviarebaudiana* grown under different planting times, plant stands and harvest regime. Industrial Crops and Products 50: 731–736
45. Shyu YT (1994) Effects of harvesting dates on the characteristics, yield, and sweet. J. Agric. Res. China 43: 29-39
46. Singh SD, RAO GP (2005) *Stevia*: the Herbal Sugar of 21st Century. Sugar Tech, 7(1): 17-24
47. Sözmen UE (2015) Şeker Otu (*Stevia rebaudiana bertoni*) Bitkisinin Bazı Verim ve Kalite Özellikleri Üzerine Farklı Azot Dozlarının Etkisi. Akdeniz Üniversitesi Fen Bilimleri Enstitüsü Tarla Bitkileri Anabilim Dalı Doktora Tezi, Antalya
48. Strauss S (1995) The perfect sweetener. Technol. Rev. 98: 18-20
49. Tadesse N, Gebere A, Lulie B, Hordofa M (2016) Influence of plant population density on growth and yield of *Stevia (Stevia rebaudiana Bertoni L.)* at Wondo Genet South Ethiopia. Acad. Res. J. Agri. Sci. Res. 4(6): 321-329
50. Tadhani MB, Patel VH, Subhash R (2007) In vitro antioxidant activities of *stevia rebaudiana* leaves and callus. J Food Compos Anal, 20:323-329
51. Taleie N, Hamidoghli Y, Rabiei B, Hamidoghli S (2012) Effects of Plant Density and Transplanting Date on Herbage, Stevioside, Phenol and Flavonoid Yield of *Stevia rebaudiana Bertoni*. International Journal of Agriculture and Crop Sciences. 4(6): 298-302
52. Tulasi M (2006) *Stevia (Stevia rebaudiana Bertoni) Hemsl.)* Family- Asteraceae. Hand Book On Medicinal & Aromatic Plants p. 79-83

53. Valois ACC (2002) *Stevia rebaudiana* Bert: Uma Alternativa Econômica. Comunicado Técnico, Cenargen 13: 1-13
54. Yadav AK, Singh S, Dhyani D, Ahuja PS (2011). A Review On The Improvement Of *Stevia* [*Stevia Rebaudiana* (Bertoni)]. Can. J. Plant Sci. 91:1-27
55. Yıldırım K (2017) *Stevia rebaudiana* Bertoni Bitkisinin İn vitro Üretim Potansiyeli ve Tokat Şartlarına Adaptasyonu, Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi Journal of Agricultural Faculty of Gaziosmanpasa University <http://ziraatdergi.gop.edu.tr/>