Black Sea Journal of Agriculture
doi: 10.47115/bsagriculture.1289320

Open Access Journal
e-ISSN: 2618 – 6578

Research Article
Volume 6 - Issue 4: 366-372 / July 2023

DETERMINATION OF YIELD AND YIELD COMPONENTS OF SOME SWEET FENNEL POPULATIONS

Seyhan GÜNDOGMUŞ ÇETİNKAYA[1], Hülya DOĞAN[2]*

[1]*Yozgat Bozok University, Faculty of Agriculture, Department of Field Crops, 66100, Yozgat, Türkiye*
[2]*Yozgat Bozok University, Hemp Research Institute, Department of Agriculture and Food, 66100, Yozgat, Türkiye*

Abstract: This research was carried out to determine the yield and yield characteristics of some sweet fennel (*Foeniculum vulgare* Mill. var. *dulce*) populations obtained from different regions in Yozgat ecological conditions. The experiment was established in Yozgat Bozok University, Faculty of Agriculture, Research and Application Area in the vegetation period of 2019, according to the random blocks trial pattern with 3 replications. In the study, the emergence of four different sweet fennel populations, biological yield (kg/da), plant height (cm), number of branches per plant (pieces/plant), number of umbellets per plant (pieces/plant), number of small umbellets per plant (pieces/plant), number of seed per plant (pieces) /plant), seed yield per plant (g/plant), seed yield (kg/da), 1000 seed weight (g), essential oil content (%), essential oil yield (L/da) were investigated. According to the results, the plant height of sweet fennel is 48.33-59.56 cm, the number of branches in the plant is 5.00-5.96, seed yield is 8.52-13.60 g per plant; one thousand seed weight is 3.82-7.435 g biological yield 708.70-1972.00 kg/da seed yield, 67.96-198.43 kg/da essential oil ratio 3- 4.20% essential oil yield 5.35-15.06 L/da was observed. Consequently, it has been concluded that the population of Tokat was found to have outstanding characteristics in terms of seed yield and essential oil yield.

Keywords: Sweet fennel, Populations, Essential oil, Seed yield

***Corresponding author:** Yozgat Bozok University, Hemp Research Institute, Department of Agriculture and Food, 66100, Yozgat, Türkiye
E mail: hulya.dogan@bozok.edu.tr (H. DOĞAN)
Seyhan GÜNDOGMUŞ ÇETİNKAYA https://orcid.org/0000-0003-2092-6794
Hülya DOĞAN https://orcid.org/0000-0003-1970-4123

Received: April 30, 2023
Accepted: June 06, 2023
Published: July 01, 2023

Cite as: Gündogmuş Çetinkaya S, Doğan H. 2023. Determination of yield and yield components of some sweet fennel populations. BSJ Agri, 6(4): 366-372.

1. Introduction

Medicinal and aromatic plants are used in fields such as herbal tea, essential oil, especially medicine, due to their pleasant smell, spices and flavors (Baydar, 2005). *Foeniculum vulgare* L. (fennel), belonging to the Umbelliferae (Apiaceae) family, is a medicinal and aromatic plant of Mediterranean origin that has been used by humans since ancient times. Although Fennel (*Foeniculum vulgare* Mill.) is natural plant of the Mediterranean climate zone, it has emerged and has been cultivated in many regions (Damjanovic et al., 2005). *F. vulgare* Mill. is one of 300 genera in the Apiaceae family (Davis, 1984). There are two subspecies and three varieties of the fennel plant. Of these, sweet fennel (*Foeniculum vulgare* Mill. var. *dulce*) is cultivated and *Foeniculum vulgare* var. *vulgare* generally spreads naturally in natüre (Ceylan, 1997; Baydar, 2013). Today, fennel, which is cultivated in some countries such as Egypt, China, India, Italy, Germany, Bulgaria and Romania, is cultivated in the northern, southern and western regions of Türkiye in the provinces of Istanbul, Zonguldak, Kastamonu, Artvin, Bursa, Çanakkale, Kırklareli, Kocaeli, Samsun, Sinop, Trabzon and Hatay province in the south Anatolia (Davis, 1984; Koru, 2019). All parts of fennel are used. Especially the leaves and fruits are used in the production of essential oil (Erberk et al., 2019). Fennel has a rich content of essential oil components. It has been reported that anethole and other compounds in the fennel essential oil contain galactagogue, which causes the secretion of breast milk (Rosti et al., 1998). Fennel is used as an antiseptic in medicine. Compared to other plants in the Umbelliferae family, fennel is known to have a more relaxing and stimulating effect. Its use as a carminative is increasing in low-level digestive system disorders (Erberk et al., 2019). The genetic variability of medicinal plants with natural evolution increases the importance of these plants as a gene source in breeding studies, as well as the diversity of their usage areas. Fennel production in Türkiye is mostly sweet fennel (*Foeniculum vulgare* var. *dulce*). However, in some regions, it is collected and used in fennel, which spreads naturally. The effect of ecological factors on yield and quality is important in medicinal and aromatic plants than in the other cultivated plants. Thus, it is important to find high-quality and high-yielding varieties that are adapted to different ecologies. In this study, it was aimed to determine the yield and yield components of some sweet fennel (*Foeniculum vulgare* Mill.var. *dulce*) populations in Yozgat ecological conditions.

2. Materials and Methods

2.1. Material

The research was carried out in the spring of 2019. Sweet fennel (*Foeniculum vulgare* Mill. var. *dulce*) populations obtained from the provinces of Isparta, Konya and Tokat were used as material in the study. One of the fennel populations was obtained from the Central Black Sea Transition Zone Agricultural Research Institute (Tokat), the other from Süleyman Demirel University Faculty of Agriculture (Isparta) and the other two populations from local producers in Konya province. The research was carried out in Yozgat Bozok University, Faculty of Agriculture, Topçu Application and Research Area, in May-September 2019. Topçu site has an altitude of 1165 m and is located 17 km south of Yozgat province.

2.2. Methods

The trial was established according to the Random Blocks Trial Design with three replications. Each plot is 12 m^2, each block is 48 m^2 and the total area covered by the experiment is 144 m^2. Weed hoeing was done on 05.07.2019 as maintenance work. No fertilizer was used in the experiment. The soil characteristics of the area where the experiment was conducted are given in Table 1.

Table 1. Experimental field soil analysis results

Variant	Measurement Values	
Clay (g/kg)	476	-
Silt (g/kg)	138	-
Sand (g/kg)	386	-
Ph	7.09	C
Salt (%)	0.178	Neutral
CaCO3 (%)	7.15	Lightly salted
Organic matter e (%)	2.49	Medium chalky
Total N (%)	0.15	Medium
P (µg/g)	78	Sufficient
K (µg/g)	728	Much
Ca (µg/g)	7060	Much
Mg (µg/g)	5604	Too much
Fe (µg/g)	8.08	Much
Cu (µg/g)	2.84	Sufficient
Zn (µg/g)	0.62	Little
Mn (µg/g)	4.07	Little

The searched phenological observations included: Sowing – Emergence Time (days), Emergence – Branching Time (days), Emergence – Flowering Time (days), Emergence – Fruit Setting Time (days), Sowing – Ripening Time (days). Morphological and Yield Related Characteristics were included: Biological Yield (kg/da), Plant Height (cm), Number of Branches Per Plant (pieces/plant), Number of Umbellets Per Plant (pieces/plant), Number of Small Umbellets Per Plant (pieces/plant), Number of Seed Per Plant (pieces) /plant), Seed Yield per Plant (g/plant), Seed Yield (kg/da), 1000 Seed Weight (g), Essential oil content (%), Essential oil yield (L/da) (Kalkan (2015, Özyılmaz (2015), Karataylı (2020)). The abbreviations used in Principal Components Analysis are: BB: Plant height, BDS: Number of branches per plant, BBSS: Number of umbellats per plant, BBSMS: Number of small umbellats per plant, BBMS: Number of seed per plant, BBMV: Seed yield per plant, BMA: 1000 seed weight, BVER: Biological yield, MVER: Seed yield, UYAGOR: Essential oil rate, UYAGVER: Essential oil yield.

2.3. Statistical Analysis

The data obtained from the examined features were analyzed using the SAS 9.1 package program according to the randomized blocks experimental design. When a significant difference emerged as a result of the statistical analysis, the LSD multiple comparison test was applied at a significance level of $P \leq 0.05$ to compare the means. The data of the yield characteristics of the populations were subjected to Principal component analysis (TBA) and Biplot analysis in the XLSTAT 2020 (Addinsoft, New York, USA) statistical program (SAS, 1998).

3. Results and Discussion

3.1. Phenological Observations

The sowing of fennel populations was done on 02 May 2019. The seed emergency and ripening time of populations are given in Table 2.

Table 2. Phenological observations

Phenological Observations	Day	Date
Sowing – Emergence Time (days),	19	21 May 2019
Emergence – Branching Time (days)	28	18 June 2019
Emergence – Flowering Time (days)	60	19 July 2019
Emergence – Fruit Setting Time (days)	78	6 August 2019
Sowing – Ripening Time (days)	128	07 September 2019

3.2. Yield and yield components

In this study, which was carried out to determine the yield characteristics of some sweet fennel populations. The biological yield (kg/da), plant height (cm), number of branches per plant (pieces/plant), number of umbellets per plant (pieces/plant), number of small umbellets per plant (pieces/plant), number of seed per plant (pieces) /plant), seed yield per plant (g/plant), seed yield (kg/da), 1000 seed weight (g), essential oil content (%), essential oil yield (L/da) were investigated. According to Table 3, it was observed that the biological yield values varied between 708.70-1972.00 kg/da. The highest value was observed in the Tokat population with 1972.00 kg/da, and the lowest value was observed in the Isparta population with 708.70 kg/da. When our study was

compared with other studies, Karataylı (2020) found that the average of biological yields in his study in Kahramanmaraş ecological conditions changed between 2310.10-3035.40 kg/da. According to another study, it was determined that the biological yield was between 484.00-2663.90 kg/da in Tokat conditions and similar results were obtained with our data (1517.47 kg/da) (Özyılmaz, 2015). The highest plant height was determined from the Tokat population with 59.56 cm, followed by the Isparta population with 53.33 cm and the Konya 1 population with 49.80 cm. The shortest plant height was obtained in Konya 2 population with 48.33 cm (Table 2). In the study conducted by Karataylı (2020) in Kahramanmaraş, the plant height was found as between 79.73-89.66 cm. According to similar studies, the plant height of the fennel plant was found to be 55.57-76.23 cm (Cosge et al., 2007), 73.1-79.2 cm (Özyılmaz, 2007) and 51-64 cm (Yıldırım et al., 2008). When our data is compared with other studies, it is thought that these differences are affected by climate, genotype and growing times. According to Table 2, in the data of the sweet fennel populations in the study, the lowest value in the number of branches per plant was found in the Isparta population with 5.00, while the highest value was the Tokat population with 5.96 branches. Number of umbellate per plant was found to be 14 in the Tokat population, followed by 10.83 in the Isparta population. The lowest values were obtained as 10.66 in Konya 2 population and 8.96 in Konya 1 population, respectively. While the number of small umbellate per plant was obtained from the Tokat population (163.83), the lowest values were determined as 110.47 in the Isparta population, 108.30 in the Konya 2 population and 81.33 in the Konya 1 population, respectively (Table 3). According to other studies conducted with sweet fennel, the number of branches per plant is 7.56-12.26 according to the study conducted in Kahramanmaraş conditions (Karataylı, 2020), the number of branches in the study conducted under Tokat conditions is 3.4-5.7 (Özyılmaz, 2007), the number of branches in the study conducted in Tokat conditions is 9.7 number/plant (Dirican, 2013) The number of branches obtained in Erzurum climatic conditions was found to be 5.0-6.5 (Çoban et al., 2019). Mahfouz and Eldin (2007) stated that the number of branches is 6.20-8.11 in his study to determine the difference between organic and mineral fertilizers. Looking at other studies, Tunçtürk et al. (2011) found that the average number of umbellate between years was 10.55-8.66 in the study of the effect of different nitrogen and phosphorus doses on yield and quality in Van conditions. Uzun et al. (2011) Considering the characteristics of fennel populations in Central Black Sea conditions, the number of umbellate was stated as 4.61-9.59. When we look at these studies, the effects of fertilization applied to the plant and different climates on plant growth have been observed. In the study conducted by Karataylı (2020) in Kahramanmaraş conditions, the number of umbellate per plant was determined as 112.70-143.33. It is similar to our data. However, in the study conducted by Özyılmaz (2015) in Tokat conditions, the average number of umbellate was stated as 188.41.

Table 3. Some morphological characteristics of fennel populations

Population	Biological yield (kg/da)	Plant height (cm)	Number of branches per plant	Number of umbellats per plant	Number of small umbellats per plant
Konya 1	1299	49.80ab	5.33	8.96b	81.33b
Konya2	1242	48.33b	5.20	10.66b	108.30b
Isparta	709	53.33ab	5.00	10.83ab	110.47b
Tokat	1972	59.56a	5.96	14.00a	163.83a
CV:	38.05	6.78	13.77	9.65	11.81
LSD:	1504.10	10.83	2.241	3.2493	41.49

CV= coefficient of variation, LSD= least significant difference

According to Table 4, the highest number of seeds per plant was obtained from the Tokat population with 967.37, followed by the Isparta population with 888.80 and the Konya 2 population with 796.50. The lowest value was obtained in Konya 1 population as 741.07. In addition, the highest seed yield per plant was obtained from Konya 1 population with 13.60 g, while the lowest values were determined as 9.63 g in Tokat population, 8.69 g in Konya 2 population and 8.52 g in Isparta population, respectively. According to the study conducted by Özyılmaz (2015), the average number of seeds per plant was determined as 993.27 and it is seen to be compatible with our data. However, according to the study conducted by Yıldırım and Kan (2006) in Konya ecological conditions, the number of seeds per plant was determined as 98-194. According to the literature, in the study of Karataylı (2020) in Kahramanmaraş conditions, seed yield per plant was 16.66-35.13 g, and Coşge et al. (2007) reported 5.04-11.21 g in their study in Ankara conditions, 0.8-1.7 g in Yıldırım and Kan (2006)'s study in Konya conditions, and 2.87-4.67 g in Özkan and Gürbüz (2000)'s studies in Ankara conditions.

When we look at Table 4, the 1000 seed weight of the sweet fennel plant was determined by the Konya 1 population at the most, 7.34 g, while the least weight was obtained from the Konya 2 (4.06 g), Tokat (3.98 g) and

Isparta (3.82 g) populations, respectively. In addition, the highest seed yield was determined as 198.43 kg in Tokat population per decare. In the second place, the highest seed yield was obtained from Konya 1 population (115.00 kg/da), while the lowest yield was determined from Konya 2 (76.70 kg/da) and Isparta (67.96 kg/da) populations, respectively. Karataylı (2020) stated that the 1000 seed weight was 5.93-7.85 g in their study, while Çoban et al. (2019) in Erzurum ecological conditions, it was determined that it was 8.31 g in different water levels, and Ayritman (2015) found that the 1000 seed weight was 5.82 g in his study at different nitrogen levels. Kalkan (2015) found that the 1000 seed weight was 8.52 g (different row spacings) in Erzurum conditions, Ehsanipour et al. (2012) stated that the 1000 seed weight in Iran was 3.79-4.01 g. When we look at these studies, we can conclude that maintenance studies (irrigation, fertilization, etc.), genetic characteristics of plants, climate and environmental factors may have effects on 1000 seed weight. Ghanbari-Odivi et al. (2013) stated that the yield was between 474-1019 kg/da in the study where fennel was carried out at different planting times, whereas Malik et al. (2009) found the seed yield to be lower (202.4-215.00 kg/da) in his study in India. In addition, Kırıcı et al. (2010) stated that the seed yield was 43-331 kg/da in their study in Adana ecological conditions. Nakhaei et al. (2012) examined the effects of different nitrogen applications and planting frequency on the yield characteristics of fennel plants in Iranian ecological conditions, and they stated that the effect of planting distances and nitrogen doses were important in all data.

In Table4, the lowest essential oil ratio was obtained from Konya 2 population with 3.64%, while the highest was found in Konya 1 population with 4.14%. Also, the highest yield of essential oil was obtained from Tokat population with 15.06 L, followed by Konya 1 population with 9.49 L/da, and the lowest yield was Konya 2 (5.61 L/da) and Isparta populations (5.35 L/da), respectively (Table 4). Environmental factors (temperature, precipitation, duration and intensity of lighting, altitude, direction, drought, salinity, soil texture and nutrients, etc.) affect the synthesis and accumulation of the active substance. The alkaloid and essential oil contents of medicinal and aromatic plants grown in hot and arid regions are higher than those grown in cool and rainy regions (Baydar, 2020). Karayel (2019) obtained 1.83% essential oil in Kütahya conditions, and Karataylı (2020) found 1.60-2.00% essential oil in Kahramanmaraş conditions. In the study conducted by Şahin (2013) in Konya conditions, it was stated that the essential oil ratio was between 2.4-4.2% and Doğan (2020) was between 2.37-3.24%. According to other studies, the essential oil yield of fennel was determined as 6.24-14.65 L/da in Karayel (2020) and 3.65 L/da in Özyılmaz (2015).

Table4. Yield, yield component, essential oil percentage and yield characteristics of fennel populations

Population	The number of seed per plant	Seed yield per plant (g/plant)	1000seed weight (g)	Seed yield (kg/da)	Essential oil percentage (%)	Essential oil yield (L/da)
Konya 1	741.07b	13.60a	7.34a	115.00b	4.14	9.49 b
Konya2	796.50ab	8.69b	4.06b	76.70c	3.64	5.61 c
Isparta	888.80ab	8.52b	3.82b	67.96c	3.96	5.35 c
Tokat	967.37a	9.63b	3.98b	198.43a	3.80	15.06 a
CV:	7.21	7.98	2.49	3.53	12.09	8.30
LSD:	185.41	2.45	0.36	12.27	1.42	2.23

CV= coefficient of variation, LSD= least significant difference

3.3. Principal Component Analysis of Yield Characteristics

Principal components analysis (PCA), which is a dimension reduction method, was performed using the yield characteristics data set and 100% of the total variation was obtained from the 3 principal component axes (Table 5). The amounts, percent variances and percent cumulative values of the principal components are given in Table 3. The first component (TB1) represents 61.817% of the total variation. In the first component, BBSEMS, BBSS, BB, BDS, BBMS, MVER, UYAGVER and BVER had the highest coefficients, respectively. In the second component (TB2), 30.015 % of all variation was explained. In this component, BBMV, BMA, UYAGOR, UYAGVER, MVER, BVER, BDS and BB showed the highest coefficients. The third component (TB3) explained 8.168% of the total variation. In this component, UYAGOR, BB, BBMS, BBSS, BBSEMS, BBMV and UYAGVER had the highest coefficients, respectively. In principal component analysis, the fact that the eigenvalues of the principal component weight are greater than 1 indicates that the values are in the reliable range.

3.4. Biplot Analysis of Yield Characteristics

A biplot plot showing the relationship with 11 traits examined in sweet fennel populations is given in Figure 1. The biplot plot, where 61.82% of the represented variation is represented by principal component 1 (First major component) and 30.02% by principal component 2 (Second main component), explains 91.84% of the total variation (Figure 1, Table 5).

According to Principal Component Analysis results, the distribution of traits is between 0 and 1 and between 0 and -1, and the distribution of populations is between 0

and 4; It ranged from 0 to -2. It shows the closeness of the features as the angle of the vectors gets narrower, and the weaker the relationship between the features as it gets wider.

Biplot plot shows that sweet fennel populations are located in three different regions (Figure 1). It has been determined that the vector that affects TB1 the most is BBSEMS, and the vector that affects TB2 the most is BBMV (Figure 1). BBŞEMS vector showed positive correlation with BBMS, BBSS, BB, MVER, UYAGVER and BVER vectors. On the other hand, in the region where Konya 1 population is located, it was determined that BBMV vector showed a positive relationship with BMA and UYAGOR properties. The vectors MVER, BVER, BDS, UYAGVER showed a partially negative correlation with the BBMV trait (Table 5, Figure 1). It is seen that the Tokat population has a close positive relationship with the characteristics of BBMS, BBSS, BB, MVER, UYAGVER and BVER. Konya 2 and Isparta populations were found to be negatively correlated with all characteristics. It can be said that genotypes located in the same direction and in the same circle have values close to each other. In this study, populations with high yield and quality in terms of some agricultural characteristics were tried to be determined.

Table 5. Principal component analysis of the yield traits studied

Yield characteristic	PC1	PC2	PC3
BB	0.348	0.031	0.438
BDS	0.338	0.242	-0.185
BBSS	0.373	-0.124	0.031
BBSEMS	0.375	-0.114	0.024
BBMS	0.332	-0.186	0.389
BBMV	-0.121	0.522	0.004
BMA	-0.188	0.479	-0.030
BVER	0.303	0.255	-0.422
MVER	0.330	0.279	-0.039
UYAGOR	-0.159	0.362	0.664
UYAGVER	0.313	0.318	0.003
Eigen value	6.800	3.302	0.898
Variance (%)	61.817	30.015	8.168
Cumulative (%)	61.817	91.832	100.000

BB= plant height, BDS= number of branches per plant, BBSS= number of umbellets per plant, BBSMS= number of small umbellets per plant, BBMS= number of seed per plant, BBMV= seed yield per plant, BMA= 1000 seed weight, BVER= biological yield, MVER= seed yield, UYAGOR= essential oil rate, UYAGVER= essential oil yield

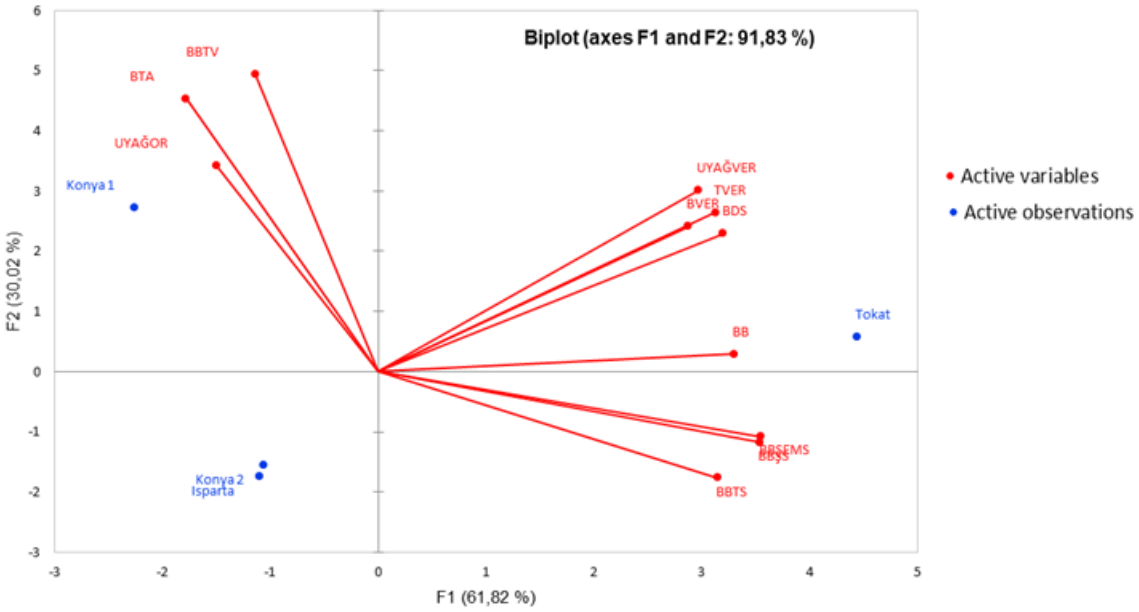

Figure 1. Principal COMPONENT ANALYSIS. BB= plant height, BDS= number of branches per plant, BBSS= number of umbellets per plant, BBSMS= number of small umbellets per plant, BBMS= number of seed per plant, BBMV= seed yield per plant, BMA= 1000 seed weight, BVER= biological yield, MVER= seed yield, UYAGOR= essential oil rate, UYAGVER= essential oil yield.

4. Conclusion

According to the results of this study on some yield characteristics of sweet fennel, it is thought that sweet fennel can be grown in Yozgat conditions. When this study and the studies in the literature were compared, it was observed that there were similarities and differences. The reason for these differences is thought to be due to factors such as climate, irrigation, fertilization, planting frequency and differences between genotypes. According to principal component analysis, Tokat population has a close positive relationship with the characteristics of BBMS, BBSS, BB, MVER, UYAGVER and BVER. Konya 2 and Isparta populations were found to be negatively correlated with all characteristics.

Considering the examined characteristics,it is thought that the populations that are found to be important can be used for production purposes in future studies and can be evaluated as materials in breeding studies. The prominent population in this study was the Tokat population.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	S.G.Ç	H.D.
C	50	50
D	100	
S		100
DCP	50	50
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

Acknowledgments

The study is a part of the master's thesis titled 'Determination of Yield and Yield Characteristics of Some Sweet Fennel (*Foeniculum vulgare* Mill. var. *dulce*)' conducted at Yozgat Bozok University, School of Graduates Studies, Department of Field Crops.

References

Ayırtman S. 2015. Farklı azot seviyelerinin rezene (Foeniculum vulgare Mill. var. dulce)'nin verim, verim özellikleri ve uçucu yağ oranı üzerine etkisi. Yüksek lisans Tezi, Atatürk Üniversitesi, Ziraat Fakültesi, Tarla Bitkileri Bölümü, Erzurum, Türkiye, ss: 49.

Baydar H. 2005. Tıbbi aromatik ve keyf bitkileri bilim ve teknolojisi. Süleyman Demirel Üniversitesi Yayınları, Yayın No: 51, Isparta, Türkiye, ss: 216.

Baydar H. 2013. Tıbbi aromatik ve keyf bitkileri bilim ve teknolojisi. Süleyman Demirel Üniversitesi Ziraat Fakültesi Yayın No:51, Genişletilmiş, 4. Baskı, Isparta, Türkiye, ss: 466.

Baydar H. 2020. Tıbbi ve aromatik bitkiler bilimi ve teknolojisi. Nobel Akademik Yayıncılık, Yayın No:2328, Genişletilmiş 8. Baskı Ankara, Türkiye, ss: 466.

Ceylan A. 1997. Tıbbi bitkiler 2 (uçucu yağ bitkileri). Ege Üniversitesi Ziraat Fakültesi, Yayını No: 481, İzmir, Türkiye, ss: 306.

Coşge B, Gürbüz B, Day S. 2007. Ankara Ekolojik koşullarına adapte olabilen yüksek drog verimi ve uçucu yağ oranına sahip tatlı rezene (*Foeniculum vulgare* Mill. var. *dulce*) hatlarının seleksiyonu. Türkiye VII. Tarla Bitkileri Kongresi, 25-28 Haziran, Türkiye, Erzurum, ss: 407-410.

Çoban F, Özer H, Şahin Ü, Örs S, Yıldız G. 2019. Farklı sulama seviyelerinin rezene (*Foeniculum vulgare* Mill) bitkisinde verim ve verim unsurları ile su kullanımına etkisi. Mediter Agri Sci, 32(2): 229-235.

Damjanovic B,Lepojevık Z, Zıvkovıc V, Tolıc A. 2005. Extraction of fennel (*Foeniculum vulgare* Mill.) seeds with supercritcal CO_2: Comparison with hydrodistillation. Food Chem, 92: 143–149.

Davis D. 1984. Flora of Turkey and the east Aegean islands. Edinburg University Press, Edinburg, Scotland, pp: 568.

Dirican A. 2013. Tokat florasında doğal yayılış gösteren yabani rezene (*Foeniculum vulgare* Mill.) popülasyonlarının morfolojik ve kimyasal özeliklerinin belirlenmesi. Yüksek Lisans Tezi, Gaziosmanpaşa Üniversitesi, Fen Bilimleri Enstitüsü, Tokat, Türkiye, ss: 63.

Doğan H. 2020. Bazı anason (*Pimpinella anisum* L.) ve tatlı rezene (*Foeniculum vulgare* Mill. var. *dulce*) popülasyonlarının uçucu yağ bileşenlerinin belirlenmesi. Iğdır Üniv Fen Bilim Enstit Derg, 10(3): 2235-2241.

Ehsanipour A, Razmjoo J, Zeinali H. 2012. Effect of nitrogen rates on yield and quality of fennel (*Foeniculum vulgare* Mill). Indust Cropsand Prod, 35: 121–125.

Erberk G, Onaral A, Fidan H, Çalış Ö. 2019. Burdur rezene üretim alanlarında tehditkâr fungal patojen: Cescosporidium punctum. Ziraat Fak Derg, 14(1): 68-73.

Ghanbari-Odivi A, Rahimi R, Tahmasebi B.K, Safari A, Bahrampour B Farrokhi M. 2013. Effect of sowing date on the yield yield components and essential oil content of three population of fennel (Foeniculum vulgare Mill.). Adv Environ Biol, 7(6): 1034-1039.

Kalkan F. 2015. Sıra aralığı mesafelerinin rezene (*Foeniculum vulgare* Mill. var. *ducle*) bitkisinin verim verim unsurları ve bazı kalite özelliklerine etkileri. Yüksek Lisans Tezi, Atatürk Üniversitesi, Fen Bilimleri Enstitüsü, Erzurum, Türkiye, ss: 44.

Karataylı K. 2020. Kahramanmaraş ekolojik koşullarında bazı rezene (*Foeniculum vulgare* Mill. var. *dulce*) genotiplerinin tarımsal ve kalite özelliklerinin belirlenmesi. Yüksek lisans Tezi, Sütçü imam Üniversitesi, Fen Bilimleri Enstitüsü, Kahramanmaraş, Türkiye, ss: 52.

Karayel H. 2019. Kütahya-Gediz koşullarında yetiştirilen rezene (*Foeniculum vulgare* Mill.) bitkisinin uçucu yağ bileşenlerinin

belirlenmesi. Avrupa Bil Teknol Derg 16: 131-135.

Karayel H. B. 2020. Doğal bor madeni kullanımının rezene (Foeniculum Vulgare Mill.)'de uçucu yağ oranı ve bileşimi üzerine etkisi. J Instit Sci Technol, 10(2): 1389-1395.

Kırıcı S, İnan M, Kaya D.A. 2010. Determination of morphologicalproperties agronomic characters and essential oil composition of wild growing *foeniculum vulgare* Mill. in Southeastern Mediterranean region of Turkey. Biomed, 5(1): 6-17.

Koru T. 2019. *Foeniculum vulgare* Miller (rezene) bitkisinin fitoterapide kullanımı. Yüksek Lisans Tezi, Ege Üniversitesi, Sağlık Bilimleri Enstitüsü, İzmir, Türkiye, ss: 64.

Mahfouz S.A, and Sharaf-Eldin M.A. 2007. Effect of mineral vs. biofertilizer on growth yield and essential oil content of fennel (*Foeniculum vulgare* Mill.). Int Agrophys, 21: 361-366.

Malik TP,Teylan SK, Thakral KK. 2009. Performance of fennel (*Foeniculum vulgare*) genotypesfor seed yield. Annal Horticult, 2(2): 243-245.

Nakhaei A,Moosavi SG, Baradaran R, Nasrabad AA. 2012. Effect of nitrogen and plant density levels on yieldandyield components of fennel (Foeniculum vulgare L.). Inter J Agri Crop Sci, 4(12): 803- 810.

Özkan Fi Gürbüz B. 2000. Tatlı rezene (*Foeniculum vulgare* Mili. var. *dulce*)' de bitki sıklığının verim ve verim özellikleri üzerine etkileri. Tarla Bit Merkez Araş Enstit Derg, (9): 1-2.

Özyılmaz B. 2007. Farklı sıra aralığı ve ekim normlarının rezene (*Foeniculum Vulgare* mill. Var. *Dulce*)'de verim verim unsurları ve bazı kalite özelliklerine etkileri. Yüksek Lisans Tezi, Gaziosmanpaşa Üniversitesi Fen Bilimleri Enstitüsü, Tarla Bitkileri Anabilim Dalı, Tokat, Türkiye, ss: 94.

Özyılmaz B. 2015. Farklı yörelerden temin edilen tatlı rezene (*Foeniculum vulgare* var. *dulce*) popülasyonlarının karakterizasyonu. Doktora Tezi, Gaziosmanpaşa Üniversitesi, Fen Bilimleri Enstitüsü, Tokat, Türkiye, ss: 149.

Rosti LA, Bettinelli M, Rosti D. 1998. Anise and fennel tea drunk by nursing mothers reported toxic to newborns. Acta Pediat, 83: 683.

SAS Institute. 1998. INC SAS/STAT users' guide release. 7.0 Cary, New York, USA.

Şahin B. 2013. Farklı ekim zamanlarında yetiştirilen bazı tıbbi bitkilerin verim ve kalite özelliklerinin belirlenmesi. Yüksek Lisans Tezi, Selçuk Üniversitesi, Fen Bilimleri Enstitüsü, Tarla Bitkileri Anabilim Dalı, Konya, Türkiye, ss: 143.

Tunçtürk R, Tunçtürk M, Türközü D. 2011. Van ekolojik koşullarında değişik azot ve fosfor dozlarının rezene (*Foeniculum vulgare* Mill.)'de verim ve kalite üzerine etkisi. Van YYÜ Zir Fak Derg, 21(1): 19-27.

Uzun A, Kevseroğlu K, Yılmaz S. 2011. Orta Karadeniz bölgesi için geliştirilen rezene (*Foeniculum vulgare* Mill. var. *dulce*) hatlarının bazı tarımsal özellikleri bakımından incelenmesi. Gaziosmanpaşa Üniv Zir Fak Derg, 28(2): 1-8.

Yıldırım B, Tunçtürk M, Okut N, Türközü D. 2008. Farklı sıra arası mesafeleri ve fosfor dozlarının rezene (Foeniculum vulgare Mill.) bitkisinde bitki gelişimi ve verime etkisi. Van YYÜ Fen Bilim Enstit Derg, 13(2): 69-72.

Yıldırım N, Kan Y. 2006. Farklı dozlarda uygulanan azot ve çinkonun rezene (*Foenicilum vulgare* Mill. var. *dulce*)'de verim ve verim öğeleri üzerine etkisi. Selçuk Üniv Zir Fak Derg, 20(40): 94-101.