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YIELD AND QUALITY PERFORMANCE OF DIFFERENT ROW SPACINGS ON CORIANDER GENOTYPES IN SEMI-ARID CONDITIONS

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Abstract

Increased plant population causes more in-row stress in plants, potentially reducing yield. Narrow row spacing can reduce stress by increasing plant-to-plant spacing within a row. Therefore, it is important to standardize plant row spacing according to various characteristics to achieve higher yield and quality. The purpose of the 2014–2015 study was to ascertain the impact of varying sowing distances (20, 30, 40, and 50 cm) between rows on the yield and agronomic traits of coriander genotypes (Gamze, Kudret, Telci). Four replications of the field research were set up using a "Randomized Blocks Experimental Design." The results indicated that genotype, row spacing, and the genotype x row spacing interaction had a statistically significant impact on seed output, but the years had no discernible influence on seed yield. The production of seed and oil decreased as row spacing increased, while oil content increased. With 20–40 cm row spacing and 1683.4–1846.5 kg da^{-1}, the genotypes of Kudret and Telci produced the maximum seed production. Although the decrease in the number of branches and umbrellas in narrow row spacing had a negative effect on seed yield, the increase in the number of seeds per umbrella and the number of plants per unit area led to an increase in seed yield. When evaluated based on genotypes, although the Kudret and Telci genotypes gave the best results in terms of seed yield, the Kudret genotype gave the best results regarding essential oil ratio and essential oil yield.

Keywords: Coriander; *Coriandrium sativum* L.; Quantity; Yield; Row spacings

Introduction

Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant belonging to the family Apiaceae (Umbelliferae). It is native to Southern Europe and the Mediterranean region and is one of the oldest medicinal and aromatic plants cultivated and consumed in India (Malik & Tehlan, 2013; Bahadur *et al*., 2022). The coriander plant is cultivated in countries with tropical and subtropical climates, such as Romania, France, Spain, Russia, Pakistan, Italy, India, the Netherlands, Mexico, Argentina, Morocco, Cape Verde, and Türkiye (Altaf *et al*., 2019). The fruit size of the coriander is classified into two varieties: *Coriandrum sativum* L. var. *vulgare* Alef. (macro) and *Coriandrum sativum* L var. *Microcarpum* (micro) varieties are available (Mandal & Mandal, 2015).

The use of the fruits is linked to the plant's chemical composition. Fixed and essential oils are the most important components of coriander seeds. In mature and well-dried seeds, the essential oil content varies between 0.33%-1.33%, and fixed oil content varies between 1.63%-24.26% (Emiralioglu & Yaldiz, 2020). Essential oils obtained from coriander fruits are economically important as they are used in various ways in food, pharmaceutical, perfumery, cosmetics, and beverage industries, especially linalool. The main component of essential oil is an important raw material used in perfume and cosmetic products. In almost every region of Türkiye, coriander is cultivated to utilize its seeds or green parts, and mainly the green parts are used fresh, dried, and pickled in salads, soups, and pickles (Silva & Domingues, 2017; Gul & Ozturk, 2021; Fukushima *et al*., 2020). Coriander yield is affected by many factors. Among these factors, row distance and genotype are the most crucial. Plants can exhibit different performances in various ecological conditions. Therefore, according to the regions where different plant varieties are grown, there are also changes in the sowing distance and genotypes they need.

The vegetative and generative growth of plants is influenced by sowing distance, which varies greatly depending on the environment and the kind of production system (Jajarmi *et al*., 2014). Similar to other crops, the key to achieving high-quality yields in coriander is determining at the ideal planting distance and appropriate genotypes. The key to achieving high yields from unit areas is cultivating cultivars with high yield potential in proper climatic conditions and with the right agronomic procedures. It is well-recognized that adequate row spacing improves plant development and increases the number of branches, umbels, and seeds per umbel. Row spacing has a major impact on the output of coriander seeds and oil, according to studies (Tuncturk, 2008; Diwan *et al*., 2018).

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Row spacing in coriander plants varies depending on the cultivar, according to Kaium *et al*., (2015). Numerous investigations were carried out to ascertain the ideal row spacing for coriander in various environmental circumstances, and it was discovered that a row spacing of 20-30 cm produced the maximum seed yield (Kayacetin *et al*., 2018). Tuncturk (2008) determined that row spacing significantly affected coriander plants' yield and essential oil content. He also stated that narrow inter-row distances are suitable for yield, but widening sowing distances are significant for high oil content. Diwan *et al*., (2018) tried three different row spacings (30, 40, and 50 cm) and obtained the highest seed yield (1355 kg ha^{-1}) from 30 cm row spacing. In another study, it was reported that row spacing significantly affected seed yield, and the maximum yield (2.16 t ha^{-1}) was obtained from a 30x10 cm planting distance. A similar yield (2.10 t ha^{-1}) was obtained at 25x10 cm (Kaium *et al*., 2015).

Sowing distances are one of the agronomic characteristics that are crucial for producing higher-quality agricultural goods. Because of this, it is crucial to ascertain the inter-row spacing and variety that are closely linked to yield in circumstances of Türkiye, as well as to select the best yield level and quality that is most cost-effective per unit area. The purpose of this study was to identify the ideal row spacing and variety for coriander production by examining the impact of row spacing on the yield and agronomic traits of coriander varieties.

Material and Methods

Field experiments were done at the Türkiye/Erzurum Atatürk University Plant Production Application and Research Center (39^0 97' N and 41^o 67' E) between 2014 and 2015. The experimental site is situated at an average altitude of 1663 meters above sea level. Soil samples from the 0-20 cm soil layer were used; the Soil Science and Plant Nutrition Department of Ataturk University Agricultural Faculty conducted laboratory analyses to identify the soil properties of the experimental fields. The deep, rather well-drained clay loam soils in the experimental plots in 2014 and 2015 were comprised of slightly alkaline (7.6% every two years) soil. The experimental soils from 2014–2015 had low total nitrogen content (0.7% every two years), low organic matter content (0.83% and 0.75%), high potassium (2250.55 and 2290.45 kg ha^{-1}), and medium available phosphorus (60.1 and 60.2 kg ha^{-1}) levels, and no lime content (1.1% and 1.25%).

Figure 1 presents data on temperature, precipitation, and relative humidity during the plant-growing season. Both growing seasons experienced air temperatures higher than the long-term average. In 2014 and 2015, the average temperature from April to September was slightly above the long-term average, at 16.2^{o}C. The volume and distribution of rainfall varied significantly from year to year. Both 2014 and 2015 received more rainfall than the long-term average. In 2015, the average rainfall was 309.2 mm, which was more than the 231.2 mm recorded in 2014.

Three coriander genotypes (Gamze, Kudret, and Telci) and four-row spacing (20, 30, 40, and 50 cm) were investigated. The plot width varied depending on the row spacing. The experimental units consisted of plots that were four rows wide and 5 m in length. Sowing was carried out on May 03, 2014, and May 05, 2015, with a hand seeder. Ammonium phosphate (21% N) and triple superphosphate (45% P_2O_5) were applied prior to planting at a ratio of 60 kg ha^{-1} to all plots. Hoeing was done twice for weed control until the plants reached a height of 15-20 cm. Sprinkler irrigation was applied four times based on the plant's needs. Harvesting took place between August 25, 2014, and September 8, 2015, when 50% of the fruits reached harvest maturity (indicated by a yellowish-brown color). The middle rows were hand-harvested, taking edge effects into account.

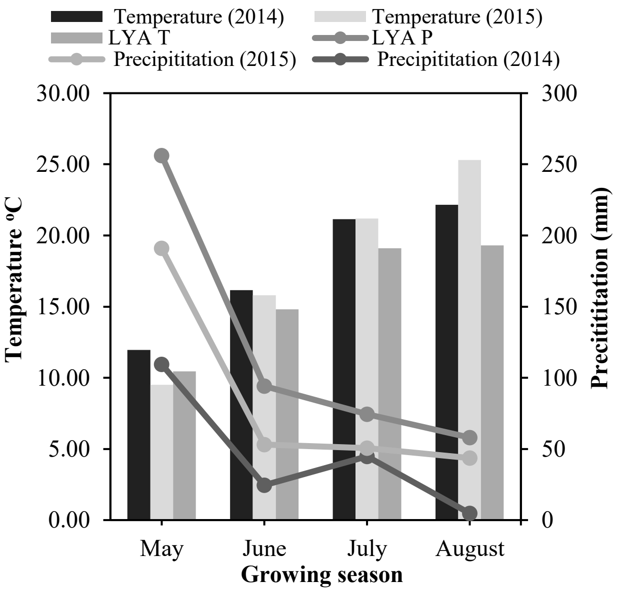

Fig. 1. Some important climate data of the trial area for many years and 2014-2015.

To examine the impact of row spacing and coriander genotypes on plant development and phenology, various plant measurements were collected during the growing seasons (10 observations or samples per plot, unless otherwise indicated) (Table 2). The plant height was determined by measuring the distance between the top fruit on the main stem and the soil surface. The number of branches on each plant was counted. The number of umbels per plant in each plot was counted, and the average was determined. From each plot, the number of seeds per umbel was counted, and an average was calculated. The harvested plants were dried in the shade for three to four days, then threshed by hand using sticks, and the plot and seed yields were calculated. From the seed yield of each plot, five samples of 100 seeds were collected, and the average weight of 1000 seeds was calculated.

To determine the essential oil content of the seeds, 100 g of powdered coriander seed samples from each example were extracted volumetrically (% v/w) using a Neo-Clevenger apparatus of thorough water vapor distillation for three hours, following the standard procedure described in the European Pharmacopoeia (Stainier, 1975).

After the essential oils were removed, the remaining seed pulps were subjected to hot extraction using n-hexane for 6 hours following the Soxhlet method to obtain a constant oil content (Anon., 1990).

Four replications of the field research were set up using a Randomized Block Design. Row spacing and genotypes of coriander were given at random as subplots with four replications. JMP 5.0.1 was used to evaluate the measured parameters (Anon., 2002). Row spacing, genotypes of coriander, and their treatment combinations were included as fixed factors, whereas the following random effects were included: row spacing × year, genotypes of coriander x year, row spacing x genotypes, and row spacing x genotypes × year. At a 5% probability level, significant changes within treatments were evaluated and categorized using the Duncan Multiple Comparison Test.

The row spacing effects averaged over the three coriander genotypes are reported in this research. A supplementary article (Bernhard & Below, 2020) presents the specifics of genotype responses for coriander and how they change with row spacing.

Results

With respect to the traits investigated in the study, statistically significant variations were discovered between years at the $p<0.05$ level for 1000 grain weight and the $p<0.01$ level for plant height and branch count. Significant differences were observed at the $p<0.01$ level in the following genotypes: essential oil content, oil production, plant height, number of branches, number of seeds per umbel, and 1000 grain weight. At the $p<0.05$ level, significant variations in seed production were discovered. Between-row planting spacing differed in oil content and seed yield in statistically significant ways ($p<0.01$). The genotype x inter-row distance interaction was found to have significant differences at the $p<0.05$ level in the number of seeds per umbel and the number of umbels per plant, as well as important differences at the p<0.01 level in the number of branches, plant height, 1000 grain weight, essential oil content, and oil yield. Other sources of variation had a minor impact on the parameters (Table 1).

Plant height: Plant height was longer in 2015 (63.34 cm) than in 2014 (58.55 cm) due to changing climatic factors between years. The highest average plant height in terms of genotypes was obtained from the Kudret (68.19 cm) genotype. The sowing distance between rows was statistically insignificant, and plant height values measured at sowing distances of 20, 30, 40, and 50 cm were 62.27, 61.75, 60.74, and 59.02 cm, respectively. According to these results, it was determined that plant height decreased with increasing sowing distances. The difference between coriander genotypes and sowing distances caused the genotype x row spacing interaction to be significant. The highest plant height (72.24 cm) was obtained from the 30 x Kudret interaction.

Branches per plant: The number of branches of coriander plants averaged 5.7 and 5.9 plant^{-1} in the 2014 and 2015 growing seasons, respectively. Genotypes reacted differently in terms of the number of branches; the highest number of branches was obtained from the Kudret genotype (6.08 no. plant^{-1}), and the lowest number of branches was obtained from the Telci genotype (4.98 no. plant^{-1}) (Table 2). There was a minor increase in the number of branches as the inter-row planting distance rose, even though the difference between the row spacing and the number of branches was not statistically significant. The 50 cm row spacing produced the greatest number of branches (5.36 no. plant^{-1}), whereas the 20 cm row spacing produced the least number of branches (5.43 no. plant-^{1}).

Number of umbels per plant: The average number of umbels was 14.5 and 16.1 no. plant^{-1} in 2014 and 2015, respectively. Regarding genotype, the number of umbels was highest in the Kudret genotype (16.36 no. plant^{-1}) and lowest in the Telci genotype (14.27 no. plant^{-1}). The number of umbels positively correlated with yield gave the highest value (16.97 no. plant^{-1}) at 50 cm row spacing. The reaction of the coriander plant to the sowing distances was different according to genotypes, and the genotype x row spacing interaction was significant. The highest number of umbels (22.19 no. plant^{-1}) was obtained from 50 x Gamze interaction, while the lowest number of umbels was obtained from 20 x Telci interaction (11.39 no. plant^{-1}) (Table 2).

Number of seeds per umbel: The second study year had the most seeds per umbel out of all the years (32.3 no. plant^{-1}), while the Kudret genotype produced the most seeds per umbel out of all the genotypes (34.0 no. plant-1). Table 2 shows that the average number of seeds per umbel varied depending on row spacing treatments, ranging from 29.97 to 32.02 no. plant^{-1}. Twenty-centimeter row spacing produced the greatest number of seeds per umbel (32.02 no. plant^{-1}), whereas forty-centimeter row spacing produced the lowest number of seeds per umbel (29.97 no. plant^{-1}).

Table 1. Variance Analysis results of coriander plant with different genotypes and row distances.

Source of variation	df	P.H	B.P.P	N.U.P.P	N.S.P.U	S.W	S.Y	E.O.C	E.O.Y
Year (Y)	1	**	**	ns	ns	*	ns	ns	ns
Genotype (G)	2	**	**	ns	**	**	*	**	**
Row spacing (RS)	3	ns	ns	ns	ns	ns	**	**	ns
Y x G	2	ns	ns	ns	ns	ns	ns	ns	ns
Y x RS	3	ns	ns	ns	ns	ns	ns	ns	ns
G x RS	6	**	**	*	*	**	**	**	**
Y x SG x RS	6	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)	-	6.23	9.71	8.21	9.45	5.65	10.41	7.01	12.41

** Significant at the 0.01 level. NS, Non-significant. P.H: Plant height (cm); B.P.P: Branches per plant (no. plant-^{1}); N.U.P.P: Number Of umbels per plant (no. plant^{-1}); N.S.P.U: Number of seeds per umbel (no. plant^{-1}); 1000-S.W:1000-Seed weight (g); S.Y: Seed yield (kg da^{-1}); E.O.C: Essential oil content (%); E.O.Y: Essential oil yield (L da^{-1}); CV: Coefficient of variation

Table 2. The mean values of agronomical and quality characteristics of different coriander genotypes and row distances grown in Erzurum in 2014 and 2015, variance analysis results.

Treatments		P.H	B.P.P	N.U.P.P	N.S.P.U	S.W	S.Y	E.O.C	E.O.Y
Year (Y)	2014	63.34a	5.9a	16.1	32.3	10.04a	1717.0	0.36	6.18
	2015	58.55b	5.7b	14.5	29.6	09.60b	1658.0	0.35	5.80
	Mean	61.1	5.8	15.3	30.9	09.8	1687.0	0.35	5.90
Genotype (G)	Gamze	60.15b	5.53b	16.36	32.38a	09.44b	1498.7b	0.35b	5.24b
	Kudret	68.19a	6.08a	15.33	34.00a	07.83c	1749.0a	0.46a	8.05a
	Telci	54.48c	4.98c	14.27	26.36b	12.25a	1814.6a	0.25c	4,54b
	Mean	60.94	5.53	15.32	30.92	09.84	1687.4	0.35	5,91
Row spacing (RS)	20	62.27	5.43	13.87	32.02	09.58	1846.5a	0.33b	6.09
	30	61.75	5.55	14.68	31.50	09.79	1783.4a	0.35b	6.24
	40	60.74	5.56	15.75	29.97	09.98	1683.4a	0.36a	6,06
	50	59.02	5.57	16.97	30.17	10.02	1436.3b	0.38a	5,46
	Mean	60.94	5.53	15.32	30.92	09.84	1687.4	0.35	5,91
Interaction (RS X G)	20 X Gamze	64.27bc	6.08	15.72bc	34.69	08.46e	1660.4cd	0.35d	5.81de
	20 X Kudret	67.55b	5.37	14.52bc	37.84	07.57f	1713.9c	0.43c	7,37bc
	20 X Telci	54.99ef	5.21	11.39c	23.55	12.70a	2165.2a	0.21fg	4,55ef
	30 X Gamze	56.98de	5.06	13.68bc	29.32	09.64d	1270.7e	0.42c	5.34de
	30 X Kudret	72.24a	6.12	12.87bc	36.09	08.32e	2370.9a	0.42c	9.96a
	30 X Telci	56.02e	5.51	17.50ab	29.09	11.39b	1708.6c	0.20g	3.42f
	40 X Gamze	58.64de	5.04	13.84bc	31.54	09.25d	1319.7de	0.35d	4.62ef
	40 X Kudret	67.47b	7.13	18.29ab	33.39	07.47f	1619.7ce	0.51a	8.26b
	40 X Telci	56.10e	4.11	15.12bc	24.97	13.21a	2110.9ab	0.24f	5.07df
	50 X Gamze	60.73cd	5.93	22.19a	33.96	10.42c	1744.0bc	0.28e	4.88df
	50 X Kudret	65.52b	5.68	15.65bc	28.72	07.95ef	1291.4e	0.47b	6.07cd
	50 X Telci	50.82f	5.08	13.07bc	27.83	11.70b	1273.6e	0.37d	4.71df

For each main effect, values within columns followed by the same letter are not significant, P.H: Plant height (cm); B.P.P: Branches per plant (no. plant-^{1}); N.U.P.P: Number of umbels per plant (no. plant^{-1}); N.S.P.U: Number of seeds per umbel (no. plant^{-1}); 1000-S.W: 1000-Seed weight (g); S.Y: Seed yield (kg ha^{-1}); E.O.C: Essential oil content (%); E.O.Y: Essential oil yield (L ha^{-1})

1000-seed weight: While the thousand-grain weight was 9.60 g in 2014, it was determined to be 10.04 g in 2015. According to genotypes, the thousand-grain Weight was determined to be 12.3 g in the Telci genotype, 9.4 g in the Gamze genotype, and 7.8 g in the Kudret genotype (Table 2). The lowest 1000-grain weight was obtained from the control and 20 cm row spacing treatment (9.58 g), while the highest 1000-grain weight was obtained from the 50 cm (10.02 g) row spacing treatment.

Seed yield: The first experimental year's grain yield was, on average, 50.9 kg ha^{-1} greater than the second experimental year's (Fig. 2 and Table 2). The direct relationship between planting distance and seed yield is a known fact. The Telci genotype yielded the most grain (1814.6 kg ha-^{1}), with the Kudret (1749.0 kg ha^{-1}) and Gamze (1498.7 kg ha^{-1}) genotypes following closely behind. In the study, the effect of varying sowing distances on seed yield was negative. The highest yield

(1846.5 kg ha^{-1}) was obtained at 20 cm inter-row sowing distance, while the lowest yield (1436.3 kg ha^{-1}) was obtained at 50 cm. The fact that the response to sowing distances in terms of grain yield was different among genotypes caused the genotype x row spacing interactions to be significant. Indeed, the highest seed yield (2370.9 and 2165.2 kg ha^{-1}) was obtained from 30 x Kudret and 20 x Telci interactions (Table 2).

Essential oil content: Based on the meteorological information for both experiment years, it was found that while the first year had more rainfall than the second, there was no discernible variation in the essential oil content (36% and 35%, respectively) between the years (Fig. 2, Tables 1, 2). The Kudret genotype of coriander yielded the greatest essential oil content (0.46%), whilst the Telci genotype yielded the lowest essential oil level (0.25%). The highest essential oil contents were obtained from 40 cm (0.38%) and 50 cm (0.36%) row spacing treatments, while the lowest essential oil contents were obtained from 20 cm (0.33%) and 30 cm (0.35%) row spacing treatments, respectively. The highest essential oil content (0.51%) was obtained from the 40 x Kudret interaction, while the lowest essential oil content (0.21%) was obtained from the 20 x Telci interaction (Table 2).

Essential oil yield: Although the essential oil yield between years was insignificant, the essential oil yield of the first crop year (6.18 L ha^{-1}) was higher than the second crop year (5.80 L ha^{-1}). In the second crop year, the cold weather conditions in the last part of June, which is the beginning of flowering, caused a decrease in grain yield and, thus, in oil yield. In terms of genotypes, the highest essential oil yield was obtained from the Kudret genotype (8.05 L ha^{-1}), while the lowest essential oil yield (4.54 L ha^{-1}) was obtained from the Telci genotype (Table 2). As a result of the research, it was determined that oil yield increased from 20 to 30 cm planting distance (6.09 and 6.24 L ha^{-1}, respectively) and then decreased at 40 and 50 cm sowing distance (6.06 and 5.46 L ha-1, respectively).

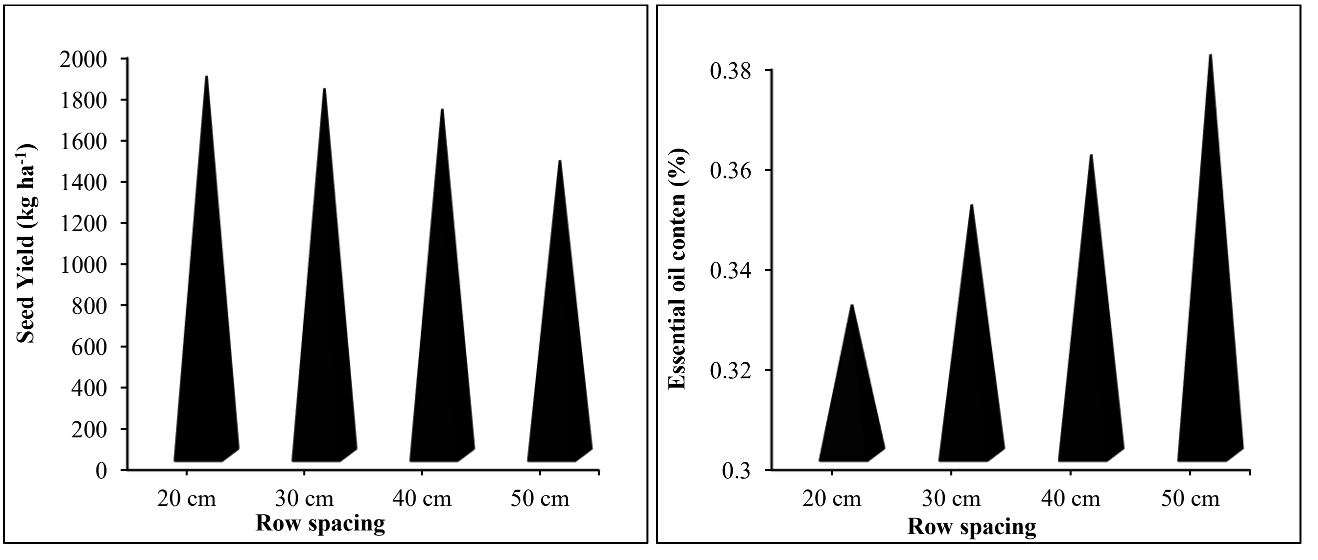

Fig. 2. Influence of row spacings on seed yield and essential oil content of coriander.

Discussion

The decrease in plant height due to plant density in coriander genotypes with increasing planting distance may be due to increased competition among plants for light and regulators necessary for plant growth. It is thought that this difference in plant height may be due to environmental factors such as genetics, climate, and soil fertility (Ai *et al.*, 2017). Datta & Choudhuri (2006) reported that the plant height of coriander lines varied between 42.87-98.77 cm, while Kaium *et al.*, (2015) reported that it varied between 80.37-81.85 cm.

Ecological factors between years played an important role in the number of branches. Indeed, favorable rainfall and temperature in the second year (Fig. 1) increased the number of branches, especially during the flowering period. Variation in the number of branches among genotypes may be affected by genetic traits (Gul & Ozturk, 2021; Sefaoglu & Ozer, 2022). Although there is no significant difference between row spacing and number of branches, a wider row spacing between branches results in higher unit area per plant and better utilization of nutrients, light, water, and other growth-promoting elements. Furthermore, when plants compete more with each other at regular intervals, the number of branches per plant decreases (Kaium *et al.*, 2015; Sharifmoghaddasi & Omidi, 2009).

The difference in the umbel-forming capacity of the genotypes may be due to climate, different cultivation techniques, and environmental conditions (Kaium *et al.*, 2015). As a result of the study, the increase in the inter-row distance between plants generally increased the number of umbels. A smaller number of branches in the plant may cause a decrease in the number of reproductive organs, such as umbels, in the plant as it reduces leaf area and photosynthesis potential (Moniruzzaman *et al.*, 2015). Thus, decreasing inter-row distances and having more plants per unit area will increase the competition between plants and cause a decrease in the number of umbels (Yilmaz & Jordan, 2022).

The number of seeds per umbrella may vary from year to year among genotypes depending on ecological, climatic, and genetic variables (Datta & Choudhuri, 2006; Kaium *et al*., 2015). It has been highlighted that extending the sowing distance would result in more nutrients becoming accessible in the direction of branching, which will reduce the quantity and growth of seeds (Soysal *et al*., 2020; Yilmaz & Jordan, 2022).

Grain weight is a characteristic directly related to climatic conditions, especially during flowering. In the second experimental year, the lack of precipitation and high temperature in the first week of July, the plant's flowering period, may have caused low grain weight (Fig. 1). Beyyavas *et al*., (2011) reported that genotype and ecological conditions were critical factors affecting 1000-grain weight. The difference in thousand-grain Weight among genotypes varies depending on seed size, growing conditions, and genetic and environmental factors (Ozyazici, 2021). While it is expected that the grains will be larger as a result of less competition between plants in the widening row spacing, the decrease in sowing distances increases competition between plants and decreases grain weight as it slows down photosynthesis and other metabolic activities (Caliskan & Caliskan, 2018; Sefaoglu & Ozer, 2022).

Climatic variables have a significant impact on seed yield over the years (Vicianová *et al*., 2020). The yield of coriander depends critically on the climate during flowering. In this regard, cold weather at the start of flowering (end of June) can be responsible for poor seed retention contents and the low yield in the first experimental year. Genetic makeup of genotypes, cultural practices, and environmental factors may cause different results in terms of grain yield (Gul & Coban, 2020; Pacheco-Hernández *et al*., 2021). The narrowing of the inter-row spacing caused a decrease in seed yield in the number of branches, umbels, and 1000-grain Weight. It can be said that the most crucial reason for the positive response of coriander to narrow row spacing is the high number of plants per unit area and the number of seeds in the umbels. In addition, due to the rapid canopy formation with the narrowing of the sowing distance, the increase in leaf area index and better utilization of sunlight and other resources can be explained as the reason for the increase in yield (Mantilla-Perez *et al*., 2017; Haarhoff *et al*., 2022; Sultana *et al*., 2023).

The essential oil content among genotypes was largely determined by the genetic makeup of the plant, while seed size probably also had an effect. Indeed, the Telci genotype had larger seeds than the Kudret and Gamze genotypes. The content of essential oils in the seeds of different species is determined by genetic and metabolic regulation. However, the other regulatory mechanisms operating in different species cause differences in essential oil content among species (Guschina *et al*., 2014; Zafar *et al*., 2019). Essential oil content increased according to the increase in planting distance. Indeed, Moniruzzaman *et al*., (2015) reported that the highest essential oil content was obtained at the highest planting distance. The fact that the response to sowing distances differed among genotypes caused the genotype x row spacing interactions to be significant regarding the essential oil content. Depending on the genetic factors of the plant species used and plant density, fewer plants per unit area will show good development as they will better utilize environmental factors such as nutrients, water, and light (Caliskan & Caliskan, 2018).

Moniruzzaman *et al*., (2015) reported that increasing the plant density in m^2 from 30 to 50 plants and from 20 to 60 plants increased the essential oil yield by 37.4% and 166.7%, respectively. Indeed, plant density is an important parameter affecting seed yield and oil content values (Sefaoglu & Ozer, 2022). Similarly, many researchers have reported that yield is the main reason for high oil yield (Shahri *et al*., 2013).

Conclusion

To maximize the yield and quality of coriander, which is sensitive to agronomic practices, the effects of planting distances and genotypes were examined. Row spacing affected coriander essential oil and phenology along with coriander seed yield. Narrower row spacings throughout the plant's life cycle resulted in better seed yield. Therefore, selecting the appropriate planting distances and genotypes is crucial. The effect of inter-row sowing distances on coriander seed yield and essential oil content was found to be significant in both 2014 and 2015. Different results were obtained based on the inter-row planting distances applied in the study, and differences were determined between the inter-row planting distances in terms of the values obtained.

The effect of years on seed yield was insignificant, whereas the effect of genotype, row spacing, and genotype x row spacing interaction was found to be statistically significant ($p<0.01$) on seed yield. While increasing row spacing increased oil content, seed and oil yield was reduced. The Kudret and Telci genotypes achieved the highest seed yield at 20-40 cm row spacing, ranging from 1683.4 to 1846.5 kg da^{-1}. The highest seed yield (2165.2 and 2370.9 kg da^{-1}) was obtained from 20 x Telci and 30 x Kudret interactions. In coriander genotypes, seed yield increased as the row spacing distance decreased. Although the decrease in the number of branches and umbrellas in narrow row spacing had a negative effect on seed yield, the increase in the number of seeds per umbrella and the number of plants per unit area led to an increase in seed yield.

In areas with semi-arid climates and short vegetation periods dominated by continental climatic conditions, frequent sowing (20-30 cm) for seed production and sparse sowing (40-50 cm) for essential oil production was effective. When evaluated based on genotypes, although the Kudret and Telci genotypes gave the best results in terms of seed yield, the Kudret genotypes gave the best results regarding essential oil ratio and essential oil yield.

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