Yuzuncu Yil University
Journal of Agricultural Sciences
(Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi)
https://dergipark.org.tr/en/pub/yyutbd

ISSN: 1308-7576 e-ISSN: 1308-7584

Research Article

Some Morphological, Yield and Quality Characteristics of Cumin (*Cuminum cyminum* L.) Poulations from Different Countries

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Article Info

Received: 25.01.2022
Accepted: 01.05.2022
Online Published: 15.06.2022
DOI: 10.29133/yyutbd.1062735

Keywords

Cumin,
Population,
Yield,
Quality

Abstract: *Cuminum cyminum* L. is one of the most widely consumed spices worldwide and in Turkey. This spice, whose cultivation sites and volume are continually changing annually, is essential, particularly in dry areas. In this research, nationwide seeds cultivated in India, Iran, Syria, Pakistan, Afghanistan, and Turkey (Denizli Province) were used. This study was carried out in the production season of 2020-2021 in Bekilli city of Denizli province as a randomized block design with three replications. In this study, plant height (cm), the number of branches per plant (number), the number of umbels per plant (number), the number of umbellates per plant (number), the number of seeds per umbellate (number), the weight of 1000 seeds (grams), the seed yield (kg/da^{-1}), fixed oil ratio (%) and fixed oil yield (%) of cumin plant were determined. The results of the two-year study have been determined as follows: plant height was 24.72 cm, the number of branches was 5.96, the number of umbels was 33.86, the number of umbellate per umbel was 3.63, the number of seeds was per umbellate 4.82, the weight of 1000 seeds was 3.4 g, seed yield was 59.88 kg/da^{-1}, fixed oil ratio was 11.28%, the fixed oil yield was 6.67 kg/da^{-1}. Türkiye (Denizli) population has reached higher values than other populations in terms of yield and quality characteristics.

Karık, Ü, 2022. Some Morphological, Yield and Quality Characteristics of Cumin (*Cuminum cyminum* L.) Poulations from Different Countries. *Yuzuncu Yil University Journal of Agricultural Sciences*, 32(2): 331-338. DOI: https://doi.org/10.29133/yyutbd.106735

1. Introduction

Cuminum cyminum L. is the most prevalent spice worldwide after pepper (Kanani et al., 2019). This spice is among the oldest and most widely grown plants with various medicinal, nutritional, and healing properties. *Cuminum cyminum* L. is broadly used in the beverage, food, distillery, pharmaceutical, and perfumery industries (Bhatt et al., 2017). It is widely grown in dry and semi-arid areas, such as Egypt, China, Turkey, Saudi Arabia, and the Mediterranean, particularly India and Iran. India is also the largest consumer of cumin, while China is its largest exporter. *Cuminum cyminum* L. is traditionally used as an astringent, anti-flatulence, coagulant, stimulant, and effective against diarrhea, indigestion, epilepsy, toothache, pertussis, indigestion, and jaundice (Rebey et al., 2017; Bhatt et al., 2017; Thippeswamy et al., 2005; Piri et al., 2019).

Cuminum cyminum L. is approximately 30-60 cm tall, hairless, branched, and thin. It contains compound leaves and an umbel with thread-like leaflets. Each cumin branch has 3-9 umbels with 5-7 umbels composed of small white or pink hermaphrodite flowers. It consists of two mericarps and a fruit

approximately 6 mm long. The fruit is a schizocarp 1.5 mm wide with a crown-shaped calyx (Piri et al., 2019; Soltani et al., 2019).

Essential oils in cumin seeds vary between 2% to 4% depending on the area of cultivation and production materials used (Kanani et al., 2019). In studies conducted in different countries, the main component of the essential oil has been determined as *Cuminum cyminum* L. aldehyde, Y-Terpinene, 7-alp Cymene, and B-Pinene. *Cumin cyminum* L. seeds also have fixed oils. The amount of fixed oil in the seeds varies from 10% to 20%, and as the main component, it contains 60% oleic acid and 30% linoleic acid (Kanani et al., 2019; Moghaddam et al., 2015).

Cuminum cyminum L. is cultivated in late autumn and winter in temperate climates and in summer and early spring in tropical climates. About 5 to 6 months after planting, the seeds grow and bear fruit and are harvested. While in Turkey in 2019, the total cultivation area was 321 889 da and the total production was 20 245 tons, in 2020, the total cultivation area dropped to 212 132 da, and the total production decreased to 13 926 tons. The biggest issue of *Cuminum cyminum* L. production areas worldwide and in our country is root diseases and low yields. Hence, the statistics of cultivation areas and yield values show great changes every year.

This is the main reason for the decline in yield for all seeds used in areas where cultivation belongs to the local population. In this study, population seeds of important producing countries of *Cuminum cyminum* L. have been used. This study aims to determine disease-resistant populations and seed yield in cumin, prepare materials for breeding studies and determine some agronomic characteristics and quality yield in field conditions.

2. Materials and Methods

2.1. Materials

Materials studied included *Cuminum cyminum* L. seeds obtained from six different countries: India, Iran, Syria, Pakistan, Afghanistan, and Turkey (Denizli). A commercial company brings the seeds, and they all have a demographic nature.

Table 1 lists the average of many years and the amount of rainfall and temperature in 2020 and 2021 related to Bekilli city of Denizli province. According to Table 1, the region has continental climatic characteristics. The total rainfall over the years is 302 mm. Also, the total rainfall in 2020 was 286.2 mm and in 2021 was 294.5 mm. On the other hand, the average temperature was 14.1 ^{0}C for many years. Also, the average temperature in 2020 was 14.3 ^{0}C, and 14.5 ^{0}C was measured in 2021. In general, the weather data of the studied year matches the average of several years to a large extent.

Table 1. Trial years and long term mean temperature (^{o}C) and total precipitation (mm) values of Bekilli ecological conditions

Climate Factors	Years	**Months**												
		Jan.	Feb.	Mar	Apr.	May	June	July	Aug	Sep.	Oct.	Nov	Dec	Av.
Average Temperature (C^0)	2020	2.3	6.4	8.8	12.3	16.3	22.2	24.4	25.1	20.7	15.3	9.8	8.6	14.3
	2021	2.5	6.9	9.7	13.2	17.3	23.3	25.2	24.8	19.1	15.4	9.5	7.7	14.5
	Long Yeras	2.4	4.3	5.2	10.3	15.3	20.6	23.7	25.4	23.2	19.8	13.3	5.2	14.1
Total Precipitation (mm)	2020	20.2	60.3	42.4	12.8	21.5	10.7	0.0	7.2	6.3	7.6	6.4	90.8	282.6
	2021	25.2	62.4	32.8	10.8	24.6	6.2	0.0	2.3	3.7	10.5	20.7	95.3	294.5
	Long Yeras	32.4	77.6	32.5	12.3	22.7	12.6	0.7	6.9	7.2	8.8	7.5	80.8	302.0

The soil structure and content of the experimental area are given in Table 2. According to the table, the soil structure of the experimental area is loamy. There is no problem in the soil regarding the amount of salt and lime, and its pH level is moderately alkaline. At the intermediate levels in soils containing organic matter, there are no problems with phosphorus and potassium.

Table 2. Some physical and chemical properties of soil in the experimental area

Lab. No:	Depth	Saturation	EC_{25} (1:2.5)	pH (1:2.5)	Lime (%)	Alkaline matter (%)	Absorbable phosphorous	Absorbable potassium
PT-9692	0-30	42	0.19	7.39	4.4	2.83	9	448
		Loamy	Devoid of salt	Medium alkaline	Low	Medium	Medium	High

2.2. Methods

This study was performed with three replications based on the randomized blocks experimental design in the producer farm in Bekilli city of Denizli province for two years (2020 and 2021). The study was carried out in dry conditions. Seeds of demographic nature from six different countries used in this study were planted manually in six rows with a plot length of 6 m and a row spacing of 20 cm. Height, width, and total plot area were selected as 6 m, 1 m, and 6 m^2, respectively. 30 kg of 20.20.20 composed fertilizer was given per decare during seed sowing. According to the plot area, 1 kg cultivation softness was calculated and evenly distributed among the rows. Weed control was done manually, and no pesticides were used to control diseases and pests. The plants were planted in 4 rows. During the harvest, only the middle two rows were evaluated by discarding the side rows, and the harvest area was 6 m^2. In the first year, seeds were sown on February 17th and harvested on July 12th. In the second year, the seeds were sown on February 19th and harvested on July 16th. Parameters investigated in this study include plant height (cm), number of branches per plant (number), number of umbels per plant (number), number of umbellates per plant (number), number of seeds per umbellate (number), the weight of 1000 seeds (g), seed yield (kg/da^{-1}), fixed oil ratio (%) and fixed oil yield (%).

Fixed oil ratio (%)

The dried seeds were milled with a laboratory type miller (Retch GM200) then the oil of the seeds was extracted successively with petroleum ether using a soxhlet extractor (Büchi, Fat Extractor E-500) for 3 h. Oil content was calculated as % on dry matter bases.

The data obtained in the field studies as a result of the measurements and observations were subjected to variance analysis according to the randomized blocks trial design in the Costat 6.03 version package program. The LSD (5%) test was used to determine the significance level of the difference between the means.

3. Results and Discussion

The means and grouping of the obtained data are listed in Table 3. Statistical analysis showed a significant difference between populations in terms of all studied traits in both years of study Table 3.

According to Table 3, the highest heights with 27.63 cm and 27.26 cm were obtained for the first and second years of the study in Turkey (Denizli), respectively. The lowest heights of 21.26 cm and 20.73 cm were obtained for Pakistan in 2020 and 2021, respectively. A significant difference was obtained in terms of plant height between years in the study. The average plant heights in 2020 and 2021 were 25.11 cm and 24.32 cm, respectively.

According to cumin plant height in studies, Mahajan et al., (2012) in their study in India with 22 populations: from 28.21 to 33.31 cm; Bahraminejad et al., (2011) in their study in Iran with 49 different populations: from 17.24 to 35.48 cm; Mirhosseini et al., (2011), in their study in Iran with nine different populations: from 19.45 to 38.16 cm; Keskin (2015) in his study with two cultivars and one population in Isparta ecological conditions: from 23.08 to 24.42 cm. Also, according to the researchers, the height of the cumin plant varies considerably between populations. The lowest and highest plant heights obtained in this study were consistent with the results reported by the researchers.

There was a statistically significant difference between the populations used in the study regarding the number of branches per plant. The highest number of branches in the first year of the study was 6.46 in Turkey, 6.20 in Syria, and 6.16 in Iran population. In the second year, the population of Turkey with 6.36 branches was in the first group. The lowest number of branches per plant values in both experiment years were obtained from the population of Pakistan as 5.56 and 5.63 branches, respectively (Table 3). In studies conducted in previous years regarding the number of branches,

Bahraminejad et al., (2011), in a study with 49 populations in Iran, recorded the number of branches between 4.17 to 7.82. Mirhosseini et al., (2011), in their study with nine different populations in Iran, reported the number of branches between 4.82 to 27.00. Supporting the results of this study, they stated that the number of branches recorded by different researchers varied significantly depending on the cultivars and populations they used.

A significant difference was observed in the study in terms of the number of umbels per plant between populations and years (Table 3). In both years, the highest number of umbels was recorded for the population of Turkey (Denizli) 39.30 in the first year and 36.70 in the second year. The lowest number of umbels in the first and second years belonged to the population of India, 31.36 and 29.60, respectively. The average number of umbels in the first year was 34.74 and in the second year was 32.99.

In studies performed in different ecological conditions regarding the number of umbels in *Cuminum cyminum* L., Bahraminejad et al., (2011), in a study with 49 different populations of cumin in Iran, recorded the number of umbels between 19.42 and 43.74. Also, Mirhosseini et al., (2011), in a study with nine different populations in Iran, recorded the number of umbels between 22.18 and 34. Furthermore, Keskin (2015), in a study with two cultivars and one population in Isparta ecological conditions, recorded a number 11.27 to 22.73. In general, the number of umbels obtained from studies in different ecological conditions and with different populations of cumin was different from our findings.

Table 3. Average plant height, number of branches, and number of umbels in Cuminum cyminum L.

Source	Plant height (cm)			Number of branches per plant (number)			Number of umbels per plant (number)		
	2020	2021	Average	2020	2021	Average	2020	2021	Average
India	23.40c	21.76d	22.58d	5.80b	5.70c	5.75c	31.36d	29.6e	30.48e
Afghanistan	25.50b	24.40c	24.95c	5.80b	5.66c	5.73c	32.53d	31.63d	32.08d
Pakistan	21.26d	20.73d	21.00e	5.56b	5.63e	5.60c	32.10d	30.83d	30.46d
Iran	26.93ab	25.86b	26.40b	6.16a	6.13b	6.15b	35.56c	33.80c	34.68c
Syria	25.93b	25.93b	25.93b	6.20a	6.13b	6.16b	37.60b	35.40b	36.50b
Turkey	27.63a	27.26a	27.45a	6.46a	6.36a	6.41a	39.30a	36.70a	38.00a
Average	25.11A	24.32B	24.72	6.00	5.93	5.96	34.74A	32.99B	33.86
LSD (5%)	1.43	1.19	0.88	030	0.11	0.15	1.57	0.86	0.85
CV	3.21	2.76	3.00	2.88	1.12	2.19	2.55	1.46	2.10
Source	**	**		**	**		**	**	
Year	**			ns			**		
Source*Year	ns			ns			ns		

** : p<0.01; ns: non-significant

According to Table 4, in both years, a significant difference was observed between the populations regarding the number of umbellates per umbel obtained in the study. The population of Turkey (Denizli) with 3.86 and 4.03 umbellates per umbel in both years is in the first place. The lowest number of umbellates inside the umbel, with 3.36 in both years, is related to Afghanistan. Bahraminejad et al., (2011), in a study with 49 different populations in Iran, reported the number of umbellates per umbel from 2.96 to 5.13. Mirhosseini et al., (2011) in their results, show that the number of umbellates per umbel was between 3.48 and 4.96 and reported the difference between the populations in terms of the number of umbellates per umbel. Also, Mehriya et al., (2020) in their study, reported the number of umbellates inside umbels was between 4.60 and 5.07.

In the evaluations that were done in terms of the number of seeds per umbellate, a significant difference was observed between the populations in both years. The highest number of seeds (5.20 to 5.23) was recorded for the cumin population of Turkish origin in both experimental years. The number of seeds per umbellate for the population of Afghanistan with 4.53 and 4.56 seeds is the lowest in 2020 and 2021, respectively (Table 4). Mehriya et al., (2020). In their study in India, they reported the number of seeds per umbellate to be 4.70 to 5.34. Bahraminejad et al., (2011) In a study with 49 different populations in Iran, the number of seeds per umbellate was 3.18 to 6.43. Mirhosseini et al., (2011), in a

study with nine different populations in Iran, reported 4.26 to 6.12 seeds per umbellate. As a result of this study, the researchers stated that the number of seeds in the umbellate varies considerably depending on the cumin population.

There was a statistically significant difference between the populations used in the study in terms of 1000 seeds weight. In this study, the maximum weight of 1000 seeds (4.23 g-4.26 g) for both years belongs to the population of Turkey. The lowest weight of 1000 seeds in the first year belongs to Pakistan (3.73 g) and in the second year to India (3.76 g) (Table 4). In the study of 1000 seed weight, Mehriya et al., (2020) In a study in India recorded values of 3.99 to 4.67. (1999) Chaudhary, in a study in India, recorded values of 4.61 to 5.52. Azizi and Kahrizi (2008) reported 2.60 to 4.93 in their study in Iran. Mahajan et al., (2012) in their study in India, they recorded 3.68 to 4.20. Uğur (2016) recorded a value of 4.36 to 4.99 in a survey of oblique ecological conditions. Bahraminejad et al., (2011), in a study in Iran with 49 different populations, recorded values between 2.83 to 4.12. Mirhosseini et al., (2011), in a study in Iran with nine different populations, recorded the value of 3.12 to 4.08. Keskin (2015) recorded a value between 2.28 and 3.88 in a 2-cultivar, 1-population study of Isparta ecological conditions. In general, it can be seen that the values obtained in terms of the weight of 1000 seeds vary depending on the population.

Table 4. The average number of umbellates per umbel, number of seeds per umbellate, and weight of 1000 seeds

Source	Umbellates per umbel (number)			Seeds per umbellate (number)			Weight of 1000 seeds (g)		
	2020	2021	Average	2020	2021	Average	2020	2021	Average
India	3.50c	3.43c	3.46d	4.70c	4.60c	4.65c	3.76de	3.76c	3.76d
Afghanistan	3.36d	3.36c	3.36e	4.53d	4.56c	4.55d	3.83cd	3.83c	3.83cd
Pakistan	3.53c	3.43c	3.48d	4.63cd	4.60c	4.61cd	3.73e	3.86c	3.80d
Iran	3.73b	3.70b	3.71c	4.83b	4.80b	4.81b	3.90c	3.86c	3.88c
Syria	3.83ab	3.83b	3.83b	5.13a	5.13a	5.13a	4.13b	4.13b	4.13b
Turkey	3.86a	4.03a	3.95a	5.20a	5.23a	5.21a	4.23a	4.26a	4.25a
Average	3.63	3.63	3.63	4.83	4.82	4.82	3.93	3.95	3.94
LSD (5%)	0.11	0.13	0.08	0.13	0.14	0.09	0.09	0.10	0.06
CV	1.83	2.15	1.99	1.54	1.69	1.61	1.33	1.45	1.40
Source	**	**		**	**		**	**	
Year	**			ns			**		
Source*Year	ns			ns			ns		

** : p<0.01; ns: non-significant

According to Table 5, the highest seed yield was recorded in 2020 (68.30 kg/da^{-1}) and 2021 (68.73 kg/da^{-1}) related to the population of Turkey. The lowest seed yields with 53.53 kg/da^{-1} and 52.60 kg/da^{-1} for the first and second years, respectively, belong to Afghanistan.

In a study of seed yield values, Chuadhary (1999), in a study in India, recorded between 23.40 kg/da^{-1} and 33.00 kg/da^{-1}. Azizi and Kahrizi (2008), in a study in Iran, recorded the value 57.44 kg/da^{-1} to 105.00 kg/da^{-1}. Mehriya et al., (2020). In a study in India recorded values between 53.90 kg/da^{-1} and 139.50 kg/da^{-1}. Uğur (2016) reported a value between 58.50 kg/da^{-1} and 89.58 kg/da^{-1} in a survey of oblique ecological conditions. Bahraminejad et al., (2011) reported 39.50 kg/da^{-1} to 145.02 kg/da^{-1} in their study in Iran with a different population. Mirhosseini et al., (2011), in their study in Iran with a different population, recorded the value of 31.20 kg/da^{-1} to 69.74 kg/da^{-1}. Keskin (2015), in a study with a population of 1 and cultivars 2 in the ecological conditions of Isparta, reported values from 25.93 kg/da^{-1} to 97.00 kg/da^{-1}. Parashar et al., (2014) recorded a 45 kg/da^{-1} to 60 kg/da^{-1} in a 9-cultivar study in India. In studies conducted using ecological conditions and different populations with different characteristics, it is observed that cumin seed yield varies significantly depending on the population.

In terms of the amount of fixed oil obtained in the seeds of *Cuminum cyminum* L., the interaction of population, year, and year population was significant. According to the populations, it is observed that the highest percentage of fixed oil belongs to the Indian populations in 2020 (17.49%) and 2021

(18.68%). The lowest percentage of fixed oil belonged to the Iranian population (7.48% and 8.45% for the first and second years, respectively). The average population for 2020 and 2021 were 10.84% and 11.72%, respectively Table 5. In studies on the percentage of fixed oil in the seeds of *Cuminum cyminum* L., Siddarth et al., (2018) reported 17.07% in their study in India. Alfekaiki (2018) recorded 12.5 to 17.16% in their study in Iraq. Hajip et al., (2020), in a study in Morocco, recorded 16.30 to 25.70%. Singh et al., (2017), in a study in India, recorded a value of 10%. Allaq et al., (2020) recorded a value of 10% in a study in Malaysia. Al-Snafi (2016) recorded 10.00% in Iraq. Uğur (2016) recorded 4.63 to 7.41% in the study of oblique ecological conditions. Keskin (2015), in a study on the ecological conditions of Isoarta with a population of 1 and cultivars 2, recorded values of 27.07 to 29.03%. It is observed that to the materials used and the areas in which the study was performed, completely different results are obtained regarding the percentage of fixed oil in cumin.

In this study, the interaction of population, year, and year population was significant in terms of fixed oil yield in cumin. The highest fixed oil yields were recorded for the Indian population in both experimental years (9.38 and 9.88 for the first and second years, respectively). Also, the lowest fixed oil yield for the first and second years was recorded as 4.60 kg/da^{-1} and 5.23 kg/da^{-1} for the population of Iran, respectively. Looking at the years according to Table 5, we can see that the average fixed oil was 6.43 kg/da^{-1}in the first year and 6.91 kg/da^{-1}in the second year. Kesin (2015) recorded a steady-state oil yield between 7.06 kg/da^{-1}and 28.20 kg/da^{-1} in Isparta ecological conditions, and the values he obtained are higher than the values of the current study.

Table 5. Average seed yield, fixed oil percentage, and fixed oil yield for *Cuminum cyminum* L.

Source	Seed yield (kg/da^{-1})			Fixed oil percentage (%)			Fixed oil yield (kg/da^{-1})		
	2020	2021	Average	2020	2021	Average	2020	2021	Average
India	53.66e	52.90e	53.28e	17.49a	18.68a	18.08a	9.38a	9.88a	9.36a
Afghanistan	53.53e	52.60e	53.06e	9.67d	10.19d	9.93d	5.18e	5.36e	5.27e
Pakistan	57.83d	57.53d	57.68d	10.54c	11.19c	10.86c	6.09c	6.43c	6.26c
Iran	61.53c	61.90c	61.71c	7.48f	8.45f	7.96f	4.60f	5.23d	4.91f
Syria	65.70b	64.36b	65.03b	8.66e	9.65e	9.16e	5.69e	6.21c	5.95d
Turkey	68.30a	68.73a	68.51a	11.19a	12.16b	11.67b	7.64b	8.35b	8.00b
Average	60.09	59.67	59.88	10.84B	11.72A	11.28	6.43B	6.91A	6.67
LSD (5%)	1.92	1.99	1.31	0.07	0.09	0.05	0.25	0.25	0.17
CV	1.79	1.87	1.83	0.37	0.46	0.42	2.26	2.10	2.17
Source	**	**		**	**		**	**	
Year	**			ns			**		
Source*Year	ns			ns			ns		

** : p<0.01; ns: non-significant

4. Conclusion

In this research that addressed some agronomic characteristics and quality yield of *Cuminum cyminum* L. seeds cultivated in different countries, it was observed that there is a significant difference between the populations in terms of the studied parameters. As a result, the evaluation was performed according to these parameters at which the populations of Turkey ranked first: year and population, plant height (27.63 cm), number of branches (6.46), number of umbels (39.30), number of umbellates per umbellate (4.03), number of seeds per umbellate (5.23 pcs.), 1000 seed weight (3.95 g) and seed yield (68.73 kg/da^{-1}). India's population ranks first in fixed oil content (18.68%) and fixed oil yield (9.88 kg/da^{-1}). Overall, it can be seen that the agricultural value of the plant is quite low. In our country and globally, cumin is grown in rainfed areas - sometimes alternately with wheatgrass and sometimes as fallow - cumin. Since this spice is grown in areas with very low rainfall and poor soils, its yield value is also low. Yield is also very poor because it is cultivated in areas with very low rainfall and poor soils. Especially in the period between April and May, the dry season prevents the growth of cumin and causes the reproductive period to occur in a short time. As a result, performance is reduced. Another important issue in cumin cultivation is root diseases. This plant is very susceptible to root diseases. Although the

major cumin-producing countries worldwide have been working for years to develop disease-resistant cultivars, to date, no positive results have been achieved in this regard. In this study, it was found that the import was not optimal in terms of seed yield. Cumin is essential for our country, and there is a need to improve the cultivation methods in the cultivation areas and study the breeding of root disease-resistant varieties from the local population.

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