



The Effects of Bacterial Inoculation on Agricultural and Quality Characteristics of Fenugreek (*Trigonella foenum-graecum* L.) Cultivars

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Abstract: This study was conducted in Kayseri ecological conditions in 2022 to determine the effects of bacterial inoculation on some agricultural and quality characteristics of fenugreek cultivars. In the study, the experiment was set up according to the experimental design of randomized blocks split plots with four replications. Bacterial inoculation (with and without bacteria) was placed in the main plots, and cultivars (Güraslan, Çiftçi and Berkem) were placed in the sub-plots. In the experiment, plant height varied between 43.73-46.38 cm, first pod height varied between 17.10-21.08 cm, pod length varied between 11.59-12.69 cm, number of pods per plant varied between 11.50-16.38 pods plant⁻¹, number of seeds per pod varied between 7.70-9.06 seeds pod⁻¹, thousand seed weight varied between 17.93-19.80 g, biological yield varied between 375.73-473.49 kg da⁻¹, seed yield varied between 75.98-109.62 kg da⁻¹, harvest index varied between 19.04-25.35% and crude oil content varied between 5.26-5.74%. At the end of the study, bacterial inoculation was found to be statistically insignificant. In addition, cultivars were found to be statistically significant in thousand seed weight and biological yield, and bacterial inoculation x cultivar interaction was found to be statistically significant in seed yield and harvest index. Eight different fatty acid components were identified and the main component of these was linoleic acid. Consequently, it can be said that the cultivation of Berkem cultivar without bacterial inoculation in terms of seed yield, and the cultivation of Güraslan cultivar inoculated with bacteria in terms of UFA (unsaturated fatty acids) are the most suitable practices for fenugreek cultivation in Kayseri conditions.

Keywords: Fenugreek, bacterial inoculation, seed yield, fatty acid composition, linoleic acid

Çemen (*Trigonella foenum-graecum* L.) Çeşitlerinin Tarımsal ve Kalite Özellikleri Üzerine Bakteri Aşılmasının Etkileri

Öz: Bu çalışma, 2022 yılında bakteri aşılmasının çemen çeşitlerinin bazı önemli tarımsal ve kalite özellikleri üzerine etkilerinin belirlenmesi amacıyla Kayseri ekolojik koşullarında yürütülmüştür. Çalışmada deneme tesadüf bloklarında bölünmüş parseller deneme desenine göre dört tekerrürlü olarak kurulmuştur. Ana parsellere bakteri aşılması (bakterili ve bakterisiz), alt parsellere ise çeşitler (Güraslan, Çiftçi ve Berkem) yerleştirilmiştir. Denemede bitki boyu 43.73-46.38 cm, ilk bakla yüksekliği 17.10-21.08 cm, bakla boyu 11.59-12.69 cm, bitkide bakla sayısı 11.50-16.38 adet bitki⁻¹, baklada tohum sayısı 7.70-9.06 adet bakla⁻¹, bin tohum ağırlığı 17.93-19.80 g, biyolojik verim 375.73-473.49 kg da⁻¹, tohum verimi 75.98-109.62 kg da⁻¹, hasat indeksi %19.04-25.35 ve sabit yağ oranı ise %5.26-5.74 arasında değişmiştir. Çalışma sonunda bakteri aşılması istatistiki olarak önemsiz bulunmuştur. Ayrıca çeşitler bin tohum ağırlığı ve biyolojik verim özelliklerinde ve bakteri aşılması x çeşit interaksyonu ise tohum verimi ve hasat indeksi özelliklerinde istatistiki olarak önemli bulunmuştur. Bununla beraber ana bileşen linoleik asit olan, 8 farklı yağ asidi bileşeni tespit edilmiştir. Sonuç olarak, tohum verimi açısından bakteri aşılması yapılmayan Berkem çeşidi ekimi ve UFA (doymamış yağ asitleri) açısından ise bakteri aşılması yapılan Güraslan çeşidi ekiminin Kayseri koşullarında çemen yetiştiriciliği için en uygun uygulamalar olduğu söylenebilir.

Anahtar Kelimeler: Çemen, bakteri aşılması, tohum verimi, yağ asidi kompozisyonu, linoleik asit

1. Introduction

Fenugreek, whose species name is *Trigonella foenum graecum* L., is an annual medicinal and aromatic plant belonging to the legume (Fabaceae) family (Arslan et al., 1989). The plant grows approximately 60 cm tall, and its leaves are in triple form. The stems are hard and hollow. Petals may be pinkish or white. Its fruit is called pod, and it has 10-20 seeds in each pod. Its seeds can

have colors ranging from dirty yellow to dark brown (Baytop, 1984; Köroğlu, 1985).

It is evaluated for both the seeds and the vegetative parts of the fenugreek plant. Its seeds contain minerals, oil, protein and vitamins etc. Due to this rich content, its seeds are consumed as a meal flavoring and its leaves are consumed as vegetables. It also has forage plant value due to its high protein content (Acharya et al.,

2008; Dutta et al., 2011).

There are three cultivars of the plant registered in Türkiye as a result of breeding studies. These cultivars are Gürarlan cultivar registered by Ankara University, Faculty of Agriculture, Berkem cultivar registered by Dicle University, Faculty of Agriculture and Çiftçi cultivar registered by Transitional Zone Agricultural Research Institute (Anonymous, 2023).

When the latest TUIK data was examined, fenugreek was grown in Afyonkarahisar, Amasya, Ankara, Karaman, Kastamonu, Kayseri, Konya, Samsun, Sivas, Tokat, Yozgat and Çorum provinces in Türkiye. In total of these provinces, the fenugreek cultivation area was approximately 8900 decares in 2022. In addition, approximately 1040 tons were produced from this area and a yield of 117 kg da⁻¹ was obtained (TUIK, 2023).

Fenugreek, as a legume plant, performs nitrogen fixation. Nitrogen fixation is a process that occurs as a result of the symbiotic relationship of *Rhizobium* bacteria with legume plants and is carried out through the nodules formed by the bacteria. In this process, the fenugreek plant both meets its own nitrogen needs and enriches the soil with nitrogen. The effective bacteria for fenugreek was reported to be *Rhizobium meliloti* in studies, so this bacteria was applied in this study (Sarioğlu et al., 1993; Tunçtürk, 2010). This study was

carried out to determine the changes in the agronomic and quality characteristics of different fenugreek cultivars due to bacterial inoculation.

2. Material and Methods

2.1. Material

Three different cultivars of fenugreek (Çiftçi, Berkem and Gürarlan) were used in the study. In addition, *Rhizobium meliloti* bacteria used in the inoculation of seeds in the study were obtained from Soil, Fertilizer and Water Resources Central Research Institute.

2.2. Climate and soil characteristics of the experimental site

The climate characteristics of the study area and the properties of the study soil taken from a depth of 30 cm are given in Table 1. When the climate data were examined, in the months when the experiment was conducted, the highest temperature was in August (26.1 °C), the highest relative humidity was in May (62.1%) and the highest rainfall was in June (56.7 mm). When the soil properties were examined, it was determined that the trial soil had a neutral pH value, no salt, medium organic matter content, calcareous content, high phosphorus content and clayey texture (Table 1).

Table 1. Climate and soil characteristics of the trial site
Çizelge 1. Deneme alanının iklim ve toprak özellikleri

Climate properties						
Months	Monthly average temperature (°C)		Monthly average relative humidity (%)		Monthly total precipitation (mm)	
	2022	Long years	2022	Long years	2022	Long years
April	13.8	10.7	46.6	58.9	13.2	46.9
May	14.2	15.1	62.1	59.0	46.0	57.9
June	20.3	19.3	59.2	54.5	56.7	40.6
July	22.0	22.7	48.2	46.8	0.6	11.9
August	26.1	22.6	39.6	46.7	-	9.5
Soil properties						
Texture	EC (mmhos cm ⁻¹)	Organic matter (%)	Lime (%)	P ₂ O ₅ (kg da ⁻¹)	pH	
Clayey soil	0.176	2.24	1.43	20.73	7.05	

2.3. Bacterial inoculation of the seeds

Bacterial inoculation (*Rhizobium meliloti* bacteria) was applied to the fenugreek seeds before sowing, with the calculation of 1 kg of bacteria per 100 kg of seeds (Tunçtürk, 2010). The application was made in an environment without sunlight and the seed planting was carried out without wasting time.

2.4. Conducting field experiments

The field study was established on the land of Erciyes University Agricultural Research and

Application Center on April 2, 2022, according to the experimental design of randomized blocks split plots. In the study, bacterial inoculation (with and without bacteria) was placed in the main plots, and different cultivars of fenugreek (Gürarlan, Çiftçi and Berkem) were placed in the sub-plots. In the study, the parcels were formed in 6 rows in each parcel, with row spacing of 30 cm and parcel length of 4 m. In the trial, the sowing rate was 3 kg da⁻¹ (Gökçe, 2015). Before sowing in the trial area, basic fertilization was made at 6 kg of pure phosphorus per decare (Gökçe, 2015). The water needs

of the plants were met with the help of drip irrigation pipes placed in each row, and weeds were constantly cleaned to prevent competition with the plants.

2.5. Plant harvests and obtaining data

In the study, harvest was carried out manually on August 2, 2022, by removing the first and last rows in each parcel as edge effect. All weighing, measurements and calculations were made on plants harvested from the middle four rows. At the end of the study, plant height, first pod height, pod length, number of pods per plant, number of seeds per pod were determined from 10 randomly selected plants in each plot. Biological yield was determined by taking the weight of all plants in each plot, and seed yield was determined by taking the weight of the seeds blended from all plants harvested in each plot. While calculating the thousand seeds weight, 4x100 groups of threshed seeds in each parcel were counted, their weights were averaged, and the resulting value was multiplied by 10. The crude oil content was determined as a percentage by analyzing the ground fenugreek samples (3 g) with petroleum ether in an automatic oil determination device. Fatty acid components were determined with the help of GC device (Schimadzu, GC 2010 plus). The fatty acid peaks obtained during the analysis were identified by

comparison with the standard (Sigma Supelco 37 Fame Mix).

2.6. Statistical analysis

Variance analysis of the study findings was determined with the help of the MSTAT-C package program, in accordance with the experimental design of randomized blocks split plots with four replications. The significance level of differences between subjects was determined by the Duncan Test, and the significance level of differences in terms of bacterial inoculation was determined by the t-test (Düzgüneş et al., 1987).

3. Results

Variance analysis results in the characteristics of fenugreek cultivars as a result of bacterial inoculation were given in Table 2. In the study, bacterial inoculation was found to be statistically insignificant in all parameters examined ($p>0.05$). The cultivars were found to be statistically significant at 1% levels ($p<0.01$) in thousand seed weight and 5% levels ($p<0.05$) in biological yield. However, the bacterial inoculation x cultivar interaction was found to be statistically significant at the 1% levels ($p<0.01$) in seed yield and harvest index (Table 2).

Table 2. Variance analysis results in the characteristics of fenugreek cultivars as a result of bacterial inoculation

Çizelge 2. Bakteri aşılamaı sonucunda çemen çeşitlerinin özelliklerinde oluşan varyans analiz sonuçları

Sources of variation	Bacterial inoculation	Cultivars	Bacterial inoculation x Cultivar interaction
Plant height	ns	ns	ns
First pod height	ns	ns	ns
Pod length	ns	ns	ns
Number of pods per plant	ns	ns	ns
Number of seeds per pod	ns	ns	ns
Thousand seed weight	ns	**	ns
Biological yield	ns	*	ns
Seed yield	ns	ns	**
Harvest index	ns	ns	**
Crude oil content	ns	ns	ns

ns: non-significant, **: Significant at 1% level, *: Significant at 5% level

3.1. Plant height (cm), First pod height (cm) and Pod length (cm)

In this study, the effects of bacterial inoculation, cultivars and bacterial inoculation x cultivar interaction in plant height, first pod height and pod length were found to be statistically insignificant ($p>0.05$) (Table 2). In average values, plant height varied between 43.73-46.38 cm. The averages of plant height in with and without bacterial inoculation were 45.17 and 45.03 cm, respectively. In addition, the averages of plant height in Çiftçi, Berkem and Gürarlan cultivars were 43.84, 45.83 and 45.64 cm, respectively. In average values,

first pod height varied between 17.10-21.08 cm. The averages of first pod height in with and without bacterial inoculation were 19.98 and 19.42 cm, respectively. In addition, the averages of first pod height in Çiftçi, Berkem and Gürarlan cultivars were 18.95, 20.68 and 19.48 cm, respectively. In average values, pod length varied between 11.59-12.69 cm. The averages of pod length in with and without bacterial inoculation were 12.30 and 12.13 cm, respectively. In addition, the averages of pod length in Çiftçi, Berkem and Gürarlan cultivars were 12.60, 12.02 and 12.04 cm, respectively (Table 3).

Table 3. Average values of the examined parameters of different fenugreek cultivars as a result of bacterial inoculation**Çizelge 3.** Bakteri aşılama sonucunda farklı çemen çeşitlerinde incelenen parametrelerin ortalama değerleri

Bacterial inoculation	Fenugreek cultivars							
	Çiftçi	Berkem	Gürarşlan	Mean	Çiftçi	Berkem	Gürarşlan	Mean
	Plant height (cm)				First pod height (cm)			
With bacteria	43.73	45.40	46.38	45.17	20.80	20.28	18.88	19.98
Without bacteria	43.95	46.25	44.90	45.03	17.10	21.08	20.08	19.42
Mean	43.84	45.83	45.64	-	18.95	20.68	19.48	-
	Pod length (cm)				Number of pods per plant (pods plant⁻¹)			
With bacteria	12.50	11.92	12.49	12.30	15.28	14.20	16.38	15.28
Without bacteria	12.69	12.11	11.59	12.13	15.48	15.10	11.50	14.03
Mean	12.60	12.02	12.04	-	15.38	14.65	13.94	-
	Number of seeds per pod (seeds pod⁻¹)				Thousand seed weight (g)			
With bacteria	8.83	7.70	8.91	8.48	18.93	17.98	19.18	18.70
Without bacteria	9.06	8.46	8.77	8.76	19.80	17.93	19.55	19.09
Mean	8.95	8.08	8.84	-	19.37 a	17.96 b	19.37 a	-
	Biological yield (kg da⁻¹)				Seed yield (kg da⁻¹)			
With bacteria	375.73	383.28	473.49	410.83	89.77 ab	75.98 b	109.14 a	91.63
Without bacteria	388.28	421.98	447.40	419.22	94.14 ab	109.62 a	87.60 ab	97.12
Mean	382.01 B	402.63 B	460.44 A	-	91.96	92.80	98.37	-
	Harvest index (%)				Crude oil content (%)			
With bacteria	23.18 ab	20.10 b	23.12 ab	22.13	5.45	5.36	5.41	5.40
Without bacteria	23.23 ab	25.35 a	19.04 b	22.54	5.49	5.74	5.26	5.50
Mean	23.20	22.72	21.08	-	5.47	5.55	5.33	-

Lowercase letters indicate different groups at the 1% level, Capital letters indicate different groups at the 5% level

3.2. Number of pods per plant (pods plant⁻¹) and Number of seeds per pod (seeds pod⁻¹)

In this study, the effects of bacterial inoculation, cultivars and bacterial inoculation x cultivar interaction in number of pods per plant and number of seeds per pod were found to be statistically insignificant ($p>0.05$) (Table 2). In average values, number of pods per plant varied between 11.50-16.38 pods plant⁻¹. The averages of number of pods per plant in with and without bacterial inoculation were 15.28 and 14.03 pods plant⁻¹, respectively. In addition, the averages of number of pods per plant in Çiftçi, Berkem and Gürarşlan cultivars were 15.38, 14.65 and 13.94 pods plant⁻¹, respectively. In average values, number of seeds per pod varied between 7.70-9.06 seeds pod⁻¹. The averages of number of seeds per pod in with and without bacterial inoculation were 8.48 and 8.76 seeds pod⁻¹, respectively. In addition, the averages of number of seeds per pod in Çiftçi, Berkem and Gürarşlan cultivars were 8.95, 8.08 and 8.84 seeds pod⁻¹, respectively (Table 3).

3.3. Thousand seed weight (g) and Biological yield (kg da⁻¹)

In this study, cultivars were found to be statistically significant at 1% levels ($p<0.01$) in thousand seed weight and 5% levels ($p<0.05$) in biological yield. In addition, the effects of bacterial inoculation and bacterial inoculation x cultivar interaction were found to be statistically insignificant ($p>0.05$) (Table 2). In

average values, thousand seed weight varied between 17.93-19.80 g. The averages of thousand seed weight in with and without bacterial inoculation were 18.70 and 19.09 g, respectively. In cultivars, the highest values in thousand seed weight were obtained from Çiftçi and Gürarşlan cultivars (19.37 g) which are in the same statistical group. The lowest value in thousand seed weight was taken in the Berkem cultivar (17.96 g). In average values, biological yield varied between 375.73-473.49 kg da⁻¹. The averages of biological yield in with and without bacterial inoculation were 410.83 and 419.22 kg da⁻¹, respectively. In cultivars, the highest value in biological yield was obtained from the Gürarşlan cultivar (460.44 kg da⁻¹). The lowest values were obtained from Berkem (402.63 kg da⁻¹) and Çiftçi (382.01 kg da⁻¹) cultivars, which are in the same statistical group.

3.4. Seed yield (kg da⁻¹) and Harvest index (%)

In this study, bacterial inoculation x cultivar interaction was found to be statistically significant at 1% levels ($p<0.01$) in seed yield and harvest index. In addition, the effects of cultivars and bacterial inoculation were found to be statistically insignificant ($p>0.05$) (Table 2). In average values, seed yield varied between 75.98-109.62 kg da⁻¹. Although the highest seed yield value was taken from the Berkem cultivar without bacterial inoculation (109.62 kg da⁻¹), no statistical difference was observed in all applications

except for the Berkem cultivar inoculated with bacteria. The lowest seed yield value was obtained from the Berkem cultivar inoculated with bacteria (75.98 kg da⁻¹). The averages of seed yield in with and without bacterial inoculation were 91.63 and 97.12 kg da⁻¹, respectively. In addition, the averages of seed yield in Çiftçi, Berkem and Gürarlan cultivars were 91.96, 92.80 and 98.37 kg da⁻¹, respectively. In average values, harvest index varied between 19.04-25.35%. The highest harvest index value was obtained from the Berkem cultivar without bacterial inoculation (25.35%) and the lowest value was obtained from the Gürarlan cultivar without bacterial inoculation (19.04%). The averages of harvest index in with and without bacterial inoculation were 22.13 and 22.54 %, respectively. In addition, the averages of harvest index in Çiftçi, Berkem and Gürarlan cultivars were 23.20, 22.72 and 21.08%, respectively (Table 3).

3.5. Crude oil content (%) and Fatty acid composition (%)

In this study, the effects of bacterial inoculation, cultivars and bacterial inoculation x cultivar interaction in crude oil content were found to be statistically insignificant ($p>0.05$) (Table 2). In average values, crude oil content varied between 5.26-5.74%. The averages of crude oil content in with and without bacterial inoculation were 5.40 and 5.50%, respectively. In addition, the averages of crude oil content in Çiftçi, Berkem and Gürarlan cultivars were 5.47, 5.55 and 5.33%, respectively. The average results of the fatty acid composition of different fenugreek cultivars as a result of bacterial inoculation are given in Table 4.

Accordingly, 8 different fatty acid components were determined, and linoleic acid was determined as the main component of these components. In addition, apart from this component, α -linolenic acid, oleic and palmitic acid rates were found to be high. In the study, it was determined that the linoleic acid ratio varied between 43.83-45.19%, α -linolenic acid ratio varied between 23.78-25.77%, oleic acid ratio varied between 13.35-13.87% and palmitic acid ratio varied between 8.60-10.01%. The highest linoleic acid ratio was obtained from the Gürarlan cultivar inoculated with bacteria and the lowest value was obtained from the Çiftçi cultivar inoculated with bacteria. The highest α -linolenic acid ratio was obtained from the Çiftçi cultivar inoculated with bacteria and the lowest value was obtained from the Berkem cultivar without bacterial inoculation. The highest oleic acid ratio was obtained from the Berkem cultivar without bacterial inoculation, and the lowest value was obtained from Çiftçi cultivar inoculated with bacteria. In addition, the highest palmitic acid ratio was obtained from the Berkem cultivar inoculated with bacteria and the lowest value was obtained from the Gürarlan cultivar inoculated with bacteria. In the study, the SFA ratio varied between 14.5-15.7% and the UFA ratio varied between 84.3-85.5%. Accordingly, the highest SFA ratio was obtained from the Berkem cultivar inoculated with bacteria. The lowest value was obtained from the Gürarlan cultivar inoculated with bacteria. The highest UFA ratio was obtained from the Gürarlan cultivar inoculated with bacteria and the lowest value was obtained from the Berkem cultivar inoculated with bacteria (Table 4).

Table 4. Average values of fatty acid compositions (%) of different fenugreek cultivars as a result of bacterial inoculation

Çizelge 4. Bakteri aşılamaı sonucunda farklı çemen çeşitlerinin yağ asidi kompozisyonlarının (%) ortalama değerleri

Components	Formula	With bacteria			Without bacteria		
		Çiftçi	Berkem	Gürarlan	Çiftçi	Berkem	Gürarlan
Palmitic acid	C16:0	9.63	10.01	8.60	9.51	9.87	8.70
Palmitoleic acid	C16:1	0.26	0.26	0.15	0.27	0.27	0.28
Stearic acid	C18:0	4.95	5.05	5.40	5.24	5.07	5.34
Oleic acid	C18:1	13.35	13.38	13.59	13.58	13.87	13.86
Linoleic acid	C18:2	43.83	44.19	45.19	44.45	44.70	44.78
γ -Linolenic acid	C18:3n6	1.61	1.67	1.67	1.78	1.77	1.66
α -Linolenic acid	C18:3n3	25.77	24.77	24.88	24.54	23.78	24.78
Behenic acid	C22:0	0.60	0.66	0.52	0.64	0.68	0.61
	SFA	15.2	15.7	14.5	15.4	15.6	14.7
	UFA	84.8	84.3	85.5	84.6	84.4	85.3

SFA: saturated fatty acid, UFA: unsaturated fatty acid

4. Discussion

Many studies have been conducted on bacterial

inoculation of fenugreek (Tunçtürk and Çiftçi, 2011; Gendy, 2013; Żuk-Gołaszewska et al., 2015; Tunçtürk

et al., 2016; Tunçtürk and Tunçtürk, 2017; Rezaei-Chiyaneh et al., 2021). Tunçtürk and Çiftçi (2011) reported that the effect of bacterial application on plant height, number of pods per plant, number of seeds per pod, thousand seed weight and seed yield was statistically significant in the combined averages of the two years in fenugreek. Gendy (2013) emphasized that as a result of bacterial inoculation in fenugreek, there was no significant change in plant height in both growing seasons compared to the application without inoculation, but there was an increase in the number of pods per plant and crude oil ratio. However, it was reported that there was no significant effect on seed yield, which is an important feature, in the first year with bacterial inoculation, and that there was an increase in the second year. Żuk-Gołaszewska et al. (2015) inoculated fenugreek seeds with *Rhizobium meliloti* bacteria and reported that bacterial inoculation was ineffective on plant height, number of pods per plant, thousand seed weight and crude oil properties. In addition, it was reported that bacterial inoculation significantly reduced the number of seeds per pod and harvest index properties compared to the control. Tunçtürk et al. (2016) tested different bacterial strains on the fenugreek. This study reported that bacterial inoculation had no effect on plant height, first pod height, pod length, number of pods per plant and thousand seed weight in fenugreek. Tunçtürk and Tunçtürk (2017) reported that bacterial inoculation affected the plant height, number of pods per plant, number of seeds per pod and seed yield characteristics of fenugreek plants and noted that there were increases in these parameters compared to the control. However, it was reported that bacterial inoculation did not statistically affect the pod length, thousand seed weight and oil ratio. Rezaei-Chiyaneh et al. (2021) examined intercropping systems with fenugreek and black cumin plants and reported that the highest plant height, number of pods per plant, number of seeds per pod, thousand seed weight and seed yield values were obtained from the bacterial inoculation application in sole fenugreek sowing. In our study, results of plant height are similar with Tunçtürk et al. (2016), Gendy (2013), Żuk-Gołaszewska et al. (2015), results of thousand seed weight are similar with Tunçtürk and Tunçtürk (2017), Żuk-Gołaszewska et al. (2015) and Tunçtürk et al. (2016), results of pod length are similar with Tunçtürk et al. (2016), Tunçtürk and Tunçtürk (2017), results of crude oil ratio are similar with Tunçtürk and Tunçtürk (2017) and Żuk-Gołaszewska et al. (2015), results of number of pods per plant are similar with Żuk-

Gołaszewska et al. (2015) and Tunçtürk et al. (2016), and results of first pod height are similar with Tunçtürk et al. (2016). No effects of bacterial inoculation were seen in this study. The reason for this may depend on many factors. In particular, soil temperature, rainfall conditions, and insufficient macro and micro element contents in the soil may limit the functioning of the bacteria.

Studies have been carried out in which cultivars were tested on the fenugreek plant. In previous studies, Aşkın (2021) reported the average of plant height as 58.61 cm in Çiftçi cultivar and 62.19 cm in Gürarlan cultivar; Evci (2019) as 35.40 cm in Gürarlan cultivar; Aslantaş (2023) as 53.20 cm in Gürarlan cultivar; Güzel and Özyazıcı (2021) as 78.70 cm and 71.70 cm in Berkem and Gürarlan cultivars, respectively. Also, Aşkın (2021) reported the average of first pod height as 26.03 cm in the Çiftçi cultivar and 27.30 cm in Gürarlan cultivar; Köksal (2021) as 25.40 cm in the Gürarlan cultivar; Güzel and Özyazıcı (2021) as 41.76 cm and 34.45 cm in Berkem and Gürarlan cultivars, respectively. In previous studies, Aşkın (2021) reported the average of pod length as 9.86 cm in the Çiftçi cultivar and 9.58 cm in the Gürarlan cultivar; Köksal (2021) as 14.45 cm in the Gürarlan cultivar; Bulut (2023) as 15.50 cm in the Gürarlan cultivar. In addition, Aşkın (2021) reported the average of number of pods per plant as 21.75 pods plant⁻¹ in the Çiftçi cultivar and 18.95 pods plant⁻¹ in the Gürarlan cultivar; Köksal (2021) as 20.16 pods plant⁻¹ in the Gürarlan cultivar; Bulut (2023) as 26.44 pods plant⁻¹ in the Gürarlan cultivar; Güzel and Özyazıcı (2021) as 14.80 ve 12.35 pods plant⁻¹ in Berkem and Gürarlan cultivars, respectively. In previous studies, Aşkın (2021) reported the average of number of seeds per pod as 12.95 seeds pod⁻¹ in the Çiftçi cultivar and 12.24 seeds pod⁻¹ in the Gürarlan cultivar; Köksal (2021) as 13.67 seeds pod⁻¹ in the Gürarlan cultivar; Güzel and Özyazıcı (2021) as 14.39 and 12.55 seeds pod⁻¹ in Berkem and Gürarlan cultivars, respectively. Also, Aşkın (2021) reported the average of thousand seed weight as 16.30 and 16.39 g in Çiftçi and Gürarlan cultivars, respectively; Köksal (2021) as 18.29 g in the Gürarlan cultivar; Güzel and Özyazıcı (2021) as 16.74 and 17.45 g in Berkem and Gürarlan cultivars, respectively. In previous studies, Köksal (2021) reported the average of biological yield as 441.48 kg da⁻¹ in the Gürarlan cultivar; Bulut (2023) as 416.00 kg da⁻¹; Beyzi (2016) as between 184.81-350.56 kg da⁻¹ in first year and between 492.59-872.22 kg da⁻¹ in the second year. In addition, Evci (2019) reported the average of seed yield as 70.6 kg da⁻¹ in the

Gürarslan cultivar; Aslantaş (2023) as 101.2 kg da⁻¹ in the Gürarslan cultivar; Köksal (2021) as 150.00 kg da⁻¹ in the Gürarslan cultivar; Bulut (2023) as 171.0 kg da⁻¹. In previous studies, Aşkın (2021) reported the average of harvest index as 21.54 and 22.08 % in Çiftçi and Gürarslan cultivars, respectively; Köksal (2021) as 34.24% in Gürarslan cultivar; Bulut (2023) as 41.46 %. In previous studies, Evci (2019) reported the average of crude oil content as 5.1% in the Gürarslan cultivar; Aslantaş (2023) as 6.3% in the Gürarslan cultivar; Köksal (2021) as 6.59% in the Gürarslan cultivar; Bulut (2023) as 4.45%. In different recent studies, Ciftci et al. (2011) reported that the ratios of palmitic, oleic, linoleic and α -linolenic acid varied between 9.8-11.2, 12.6-17.1, 45.1-47.5 and 18.3-22.8%, respectively. Sulieman et al. (2008) reported in another study that the palmitic acid ratio was 11%, oleic acid ratio was 16.7%, linoleic acid ratio was 43.2% and linolenic acid ratio was 22%.

5. Conclusion

The aim of this study is to determine the changes in the agricultural and quality characteristics of fenugreek as a result of bacterial inoculation. In the study, bacterial inoculation was found to be statistically insignificant ($p>0.05$) on all characteristics. At the end of the study, cultivars were found to be significant in biological yield ($p<0.05$) and thousand seed weight ($p<0.01$), while bacterial inoculation x cultivar interaction was found to be significant in seed yield ($p<0.01$) and harvest index ($p<0.01$). Eight different fatty acid components were determined in the fatty acid composition analysis. Among these components, linoleic acid was found to be the main component. This component was followed by α -linolenic acid, oleic and palmitic acid, respectively. As a result, it can be said that the cultivation of the Berkem cultivar without bacterial inoculation due to its high seed yield value, and the cultivation of the Gürarslan cultivar inoculated with bacteria due to its high unsaturated fatty acid (UFA) ratio are the most suitable practices for fenugreek cultivation in Kayseri conditions. In addition, it is concluded that the experiment should be repeated for a few more years in order to better determine the effect of bacterial inoculation in fenugreek cultivation.

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