



Yield, yield components and some quality properties of fenugreek cultivar and lines

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Abstract. Fenugreek (*Trigonella foenum-graecum*) belongs to fabaceae family. It is evaluated as multipurpose and commercially important spice plant. It has lots of health benefits and some of them are listed as diabetes control, decreasing blood sugar levels, cholesterol levels, inflammation, loss of appetite. This research was carried out to determine the yield and some quality properties of one cultivar (Gürarşlan) and 2 fenugreek lines (line-1 and line-2) in 5 different sowing dates (October, November, December, March and April) under Ordu ecological conditions during 2013-2014 years. Experiments were designed and applied in split block design with three replications. Plant height, pod number per plant, seed number per pod, pod length, branche number per plant, 1000 seed weight, biological yield, seed yield, harvest index, crude protein content, crude oil rate were determined as 30.13-63.90 cm, 3.0-11.33 number, 21.33-68.33 number, 10.50-14.0 cm, 1.0-4.33 number, 17-20.82 g, 161.48-378.44 kg da⁻¹, 45.64-86.98 kg da⁻¹, 19.91-43.08%, 9.64-10.32% and 2.26-4.93%, respectively. Significant differences were determined among the fenugreek cultivar and lines except crude protein content and crude oil rate. While the highest seed yield and crude oil rate were found in line-1 in 2nd sowing time, crude protein content was obtained in Gürarşlan cultivar in 2nd sowing time and line-1 in 5th sowing time. Correlation matrix and PCA were conducted to find relationship among the examined properties. Generally, line-1 can be selected for crude protein content and crude oil in 5th sowing time and line 2 can be chosen for seed yield 2nd sowing time.

Keyword: fenugreek, yield characters, lines.

Introduction

Fenugreek is called *Trigonella foenum-graecum* as scientific name and it is an annual herbaceous plant belongs to fabaceae family. It is native to the eastern Mediterranean but it is cultivated in the worldwide extending from Europe to Asia and north and east Africa [DADRASAN *et al.*, 2015]. It is an important both legume and spice plant. Fenugreek is used in food quality sensor, food stabilizer, adhesive, and emulsifying agent for food product developments. It is also utilized in medicinal treatments such as antidiabetic, anticarcinogenic, hypocholesterolemic, antioxidant, and immunological activities [WANI AND KUMAR, 2018]. The seeds of fenugreek included important biochemical properties as steroids such as diosgenin and sapogenin [AHMED *et al.*, 2010]. It is also remarkable economic crop in the pharmaceutical industry because of providing raw material. It is a utility for the partial synthesis of oral contraceptive drugs

and other medicinally used steroids [PURBEY and SEN, 2005]. Fenugreek is grown in summer or winter sown in Turkey. It is usually sown in early-spring in hot regions and late-fall in cold regions [KIZIL and ARSLAN, 2003]. Sowing date is an important factor for crop growth and yield, and sowing date of crops can be effected from these factors such as temperature period of sunshine, relative humidity [SHEORAN *et al.*, 2000]. It was noted that the optimum planting date is an essential agricultural application to have high crop productivity besides applications of fertilizer and pesticide, and plant densities [AL-DALAIN *et al.*, 2012]. Fenugreek is an important cash plant to contribute to farmer or pharmaceutical industry. To have the highest take advantage, quantity and quality yields of this plant should be increased as much as possible. For this reason, the best suitable cultivation management such as sowing time, fertilizer application, and breeding and biotechnological methods



should be carried out immediately [MEHRAFARIN *et al.*, 2011]. Fenugreek is cultivated many part of the world. It can be adapted different ecological conditions and it is also growded different time in a year. This different time a year effects the morphological and yield attributes of fenugreek in different region as positively or negatively. So, in this study was conducted to determine the best sowing time of fenugreek cultivar and two lines for the high yield and quality properties without losing much of these properties.

Material and methods

Plant materials were obtained from Ankara University, Faculty of Agriculture. The materials consist of two selection

lines (line-1 and 2) and one cultivar (Gürarslan). Field experiments were carried out during during 2013-2014 years in 5 different sowing dates (15 October, November, December, March and April) at Ordu University Experimental Farms (40°58'36" N, 37°59'55" E), located at an altitude of approximately 10 m above sea level. Main plots were assigned to lines and cultivar, while sub plots were devoted to sowing date (5 different sowing dates. Climatic data were recorded for five different sowing dates in Figure 1.

The highest average temperature, average relative humidity and total rainfall were determined as 26.6 °C, 75.1% and 175.1 mm, respectively.

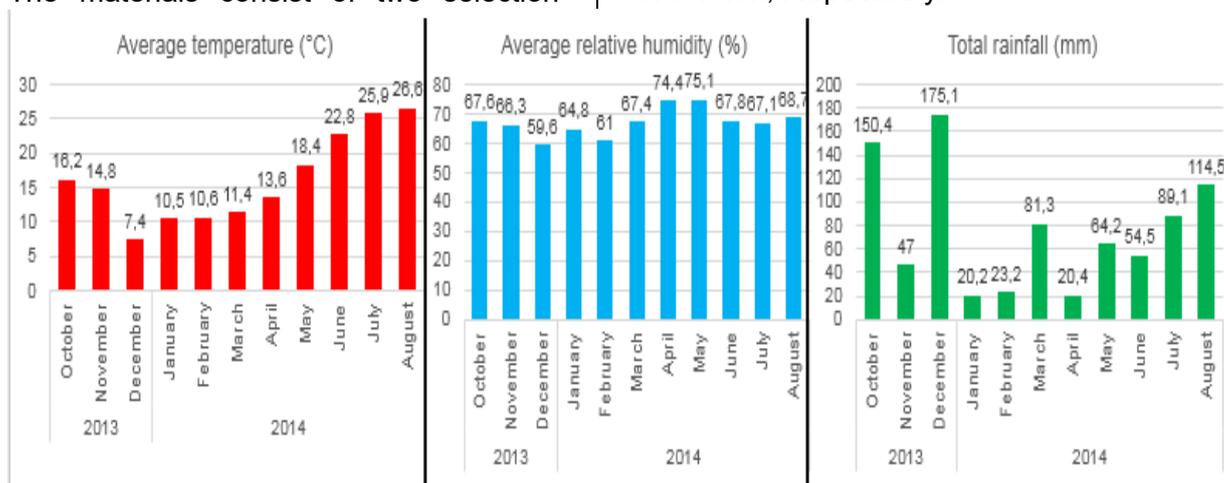


Figure 1. Climatic changes during sowing dates

Climatic data were recorded for five different sowing dates, and the means were as follows; a temperature of 16.76 °C, 81.67 mm of precipitation and 67.25% relative humidity for the growing season (from October to August). The soil in the experimental area was clay-loam with a pH value of 7.8, organic matter content of 4.70%, phosphorus content of 10.3 ppm and potassium ratio of 235 ppm. The experiment was conducted in split block design with three replications.

Each experimental plot consisted of five 4-m long rows with an inter-row distance of 0.3 m; the total block consisted of 45 plot and the total area was calculated as 584 m². As the base fertilizer, 6 kg da⁻¹ diammonium phosphate, and 2 kg da⁻¹ CAN (26% N) were used and then 2 kg da⁻¹ CAN was applied as top fertilizer before flowering

date. Totally 4 kg da⁻¹ CAN fertilizer was applied. In the growing season, the plants were harvested between late July and early August following the sowing date. Before the harvest, the yield components were measured, and laboratory analyses were performed on the seeds of fenugreek cultivar and lines, namely, crude protein content and crude oil rate.

Crude protein content was determined as reported by Çamlıca And Yaldız [ÇAMLICA and YALDIZ 2019a] by using the Kjeldahl method with some modifications. 0.5 g seed was grinded and hydrolysed with 20 ml sulfuric acid (H₂SO₄) and 3.5 g selenium catalyst tablet in a hot block at 240 °C for 30 minutes and 380 °C for 3 h. After this process, the samples were cooled. Then required H₂O and NaOH were added to hydrolysates before titration and neutralization. The total



nitrogen was determined and it was multiplied with 6.25 factor to find the protein content. The crude oil content of fenugreek was found out follow by other researchers [CAMLICA and YALDIZ 2019].

Approximately 10 g fenugreek samples were extracted with n-hexan for 6 h, using Soxhlet apparatus for determining the seed oil content (%). The obtained data were analysed using JMP-13 statistical software and results were compared via least significant difference test (LSD) in order to find differences among the fenugreek cultivar and lines at $p=0.05$. Also, correlation analysis was used the relationships between the

fenugreek cultivar and lines for the examined parameters.

Results and discussion

Plant height (cm): Fenugreek cultivar and lines had plant height between the 30.13–63.90 cm. The highest plant height was found in the plants sown on 1st sowing date (October) in line-2, followed by 2nd sowing date (60.57 cm) in Gürarslan cultivar.

The shortest plan height was observed in the 5th sowing date in line-2 and followed by 1st sowing date of line 2 with 35.83 cm (Table 1). Average of plant height was found 46.43 cm in different sowing date.

Table 1

Morphological and yield properties of fenugreek cultivar and lines

Fenugreek cultivar/lines	SD	PH	BN	PN	PSN	PL	TSW	BY	SW	HI
	1 st	59.33 ^{ab}	3.00 ^{abc}	9.33 ^{abc}	53.67 ^{abc}	10.83 ^{ab}	19.76 ^{ab}	219.40 ^{bc}	75.64 ^{abc}	35.94 ^{abc}
	2 nd	60.57 ^{ab}	2.33 ^{abc}	11.33 ^a	68.33 ^a	14.00 ^a	20.47 ^{ab}	166.22 ^c	66.64 ^{bcd}	41.90 ^{ab}
Gürarslan	3 rd	39.67 ^{de}	2.33 ^{abc}	3.33 ^d	33.33 ^{abc}	12.43 ^{ab}	20.50 ^{ab}	252.59 ^{abc}	82.98 ^{ab}	34.56 ^{abc}
	4 th	48.17 ^{bcd}	1.33 ^{bc}	6.67 ^{a-d}	26.67 ^{bc}	11.83 ^{ab}	20.82 ^a	322.18 ^{ab}	62.98 ^{cde}	19.91 ^c
	5 th	43.00 ^{cde}	4.00 ^{ab}	8.00 ^{a-d}	26.33 ^{bc}	13.73 ^{ab}	18.98 ^{ab}	154.96 ^c	54.32 ^{de}	35.29 ^{abc}
	1 st	35.83 ^{de}	1.00 ^c	5.00 ^{cd}	25.67 ^{bc}	10.50 ^b	19.46 ^{ab}	202.15 ^{bc}	83.69 ^{ab}	41.78 ^{ab}
Line-1	2 nd	43.00 ^{cde}	2.67 ^{abc}	7.67 ^{a-d}	28.33 ^{bc}	11.33 ^{ab}	19.32 ^{ab}	204.22 ^{bc}	86.98 ^a	43.08 ^a
	3 rd	40.40 ^{cde}	3.00 ^{abc}	5.67 ^{a-d}	35.00 ^{abc}	13.23 ^{ab}	18.67 ^{ab}	260.63 ^{abc}	82.14 ^{ab}	32.02 ^{abc}
	4 th	41.07 ^{cde}	1.00 ^c	5.33 ^{bcd}	44.67 ^{abc}	12.13 ^{ab}	18.46 ^{ab}	259.03 ^{abc}	58.33 ^{cde}	23.27 ^{abc}
	5 th	30.13 ^e	2.33 ^{abc}	3.00 ^d	28.33 ^{bc}	12.60 ^{ab}	17.50 ^{ab}	206.51 ^{bc}	52.32 ^{de}	25.4 ^{abc}
	1 st	63.90 ^a	4.33 ^a	8.67 ^{a-d}	60.33 ^{abc}	12.40 ^{ab}	17.00 ^b	309.82 ^{ab}	82.99 ^{ab}	27.51 ^{abc}
Line-2	2 nd	58.40 ^{ab}	1.67 ^{abc}	11.00 ^{ab}	63.67 ^{ab}	13.20 ^{ab}	17.93 ^{ab}	378.44 ^a	82.65 ^{ab}	22.37 ^{bc}
	3 rd	40.67 ^{cde}	1.00 ^c	8.33 ^{a-d}	44.67 ^{abc}	12.50 ^{ab}	18.43 ^{ab}	326.81 ^{ab}	85.98 ^a	26.60 ^{abc}
	4 th	53.20 ^{abc}	1.67 ^{abc}	8.67 ^{a-d}	52.00 ^{abc}	10.97 ^{ab}	19.57 ^{ab}	312.52 ^{ab}	70.15 ^{a-d}	25.16 ^{abc}
	5 th	39.10 ^{de}	1.00 ^c	8.67 ^{a-d}	21.33 ^c	12.10 ^{ab}	19.22 ^{ab}	161.48 ^c	45.64 ^e	31.64 ^{abc}
	Average	46.43	2.18	7.38	40.82	12.25	19.07	249.13	71.56	31.09
	LSD (5%)	12.88	2.78	5.96	39.01	3.42	3.77	132.82	18.98	20.38
	Minimum	30.13	1.00	3.00	21.33	10.50	17.00	154.96	45.64	19.91
	Maximum	63.90	4.33	11.33	68.33	14.00	20.82	378.44	86.98	43.08
	Mean	46.43	2.18	7.38	40.82	12.25	19.07	249.13	71.56	31.09
	SD	10.22	1.08	2.50	15.59	1.04	1.10	68.86	13.94	7.52

ST: Sowing date, PH: Plant Height, BN: Branche Number, PSN: Pod Seed Number, PL: Pod Length, PN: Pod Number, TSW: Thousand Seed Weight, BY: Biological Yield, SW: Seed Weight, HI: Harvest Index, CPC: Crude Protein Content, COR: Crude Oil Rate

The branche number (number plant⁻¹): Number of branche was found between 1.00–4.33 among the fenugreek cultivar and lines. The highest branche number was found from line-2 genotype and followed by Gürarslan cultivar in 5th sowing date. The lowest branche number was observed from 1st, 4th sowing date in line-1 and 3rd sowing date in line-2.

Pod number per plant (number): There was a wide variation for the the pod number per plant. It varied between 3.00–11.33 number among the fenugreek cultivar and lines (Table 1). The greatest pod number was observed in the

fenugreek cultivar of the 2nd sowing date and the lowest value was obtained in line-1 of the 5th sowing period.

Seed number per pod (number): Significant differences were found among the fenugreek cultivar and lines in seed number of per pod in different sowing dates (Table 1). The highest seed number (68.33 number) was recorded by the plants sown on 2nd sowing date in Gürarslan cultivar, followed by 1st sowing date (60.33 number) in line-2. The lowest seed number (21.33 number) was seen in the 5th sowing date in line-2.



Pod length (cm): The data revealed significant differences among the fenugreek cultivar and lines and sowing date of them. The tallest pod length (14.00 cm) was recorded at 2nd sowing date and followed by 5th sowing date with 13.73 cm in Gürarslan cultivar. The shore test pod length (10.50 cm) was found from lines–1 with 10.50 cm in 1st sowing time and followed by Gürarslan cultivar with 10.83 cm in 1st sowing time.

Biological yield (kg da⁻¹): There was found significant differences among the fenugreek cultivar and lines in terms of biological yield (Table 1). The biological yield was found between 154.96–378.44 kg da⁻¹ and mean was notes as 249.13 kg da⁻¹. The highest biological yield was found from 2nd sowing date in line–2 and the lowest value was observed in 5th sowing date in Gürarslan cultivar.

Harvest index (%): Harvest index varied between 19.91–43.80% (Table 1). The greatest harvest index was obtained from line–1 of the 1st sowing period in 2014 and in the line–2 of the 2nd sowing date. The lowest value was seen in Gürarslan cultivar of the 4th sowing date.

Seed yield (kg da⁻¹): The seed yield of fenugreek cultivar and lines ranged from 45.64 to 86.98 kg da⁻¹.

The highest seed yield was observed from 2nd sowing date of line–1, and followed by 3rd sowing date of line–3

with 85.98 kg da⁻¹. The lowest seed yield was found from 5th sowing date of line–2 and followed by line–1 and Gürarslan cultivar with 52.32 kg da⁻¹ and 54.32 kg da⁻¹, respectively. Generally, the best sowing date was observed from 1st, 2nd and 3rd sowing date of fenugreek.

1000 seed weight (g): Different sowing dates showed significant variation in respect of 1000 seed weight (Table 1).

The 1000 seed weight changed from 17.00 to 20.82 g. 4th sowing date of gürarslan cutivar had maximum 1000 seed weight with 20.82 g, and followed by 20.50 g and 20.47 g of 3rd and 2nd sowing dates of gürarslan. Generally, 1000 seed weight of Gürarslan cultivar were found higher than line–1 and line 2 in all sowing dates. 1st sowing date of line–2 gave the lowest 1000 seed weight.

Protein Content: Recorded data showed that there was no statistically significant difference in protein content ($p < 0.05$). The highest protein contents were found from 3rd sowing date of Gürarslan cultivar and 5th sowing date of line–1 with 10.32%. The lowest values were obtained from 4th sowing time of Gürarslan cultivar and 3rd sowing date of line–2 with 9.64% (Figure 2).

Crude oil rate: There was not found differences in terms of crude oil rate of fenugreek cultivar and lines among the different sowing dates (Figure 2).

Table 2**Correlation matrix among the examined properties of fenugreek cultivar and lines**

Traits	BN	PSN	PL	PN	TSW	BY	SW	HI	CPC	COR
PH	0.36	0.93	0.8	0.956	0.314	0.519	-0.307	-0.508	-0.929	-0.958
BN	1	0	0.849	0.073	0.999*	-0.609	-0.998*	0.619	-0.682	-0.615
PSN		1	0.529	0.997*	-0.05	0.793	0.058	-0.785	-0.732	-0.789
PL			1	0.589	0.821	-0.098	-0.817	0.11	-0.966	-0.939
PN				1	0.022	0.747	-0.015	-0.738	-0.779	-0.831
TSW					1	-0.648	-1**	0.658	-0.644	-0.574
BY						1	0.654	-1**	-0.165	-0.251
SW							1	-0.664	0.638	0.568
HI								1	0.153	0.239
CPC									1	0.996

* $p < 0.05$, ** $p < 0.01$, PH: Plant Height, BN: Branche Number, PSN: Pod Seed Number, PL: Pod Length, PN: Pod Number, TSW: Thousand Seed Weight, BY: Biological Yield, SW: Seed Weight, HI: Harvest Index, CPC: Crude Protein Content, COR: Crude Oil Rate

Crude oil rate ranged from 2.07–4.93%. The highest result was found from 3rd sowing date from line–1 and the lowest value was observed from 5th sowing date of Gürarslan cultivar.

Correlation matrix and PCA analysis of fenugreek cultivar and lines: The correlation matrix revealed the relationship among the fenugreek cultivar and lines (Table 2). Totally, five significant

relationships were found from examined properties as positively or negatively.

The positive correlations were found between PN and PSN with $r=0.997$, between BN and TSW with $r=0.999$ and

negative correlation was observed between BN and SW with $r=-0.998$. The highly similar negative correlations were found between TSW and SW and between BY and HI with $r=-1$ (Table 2).

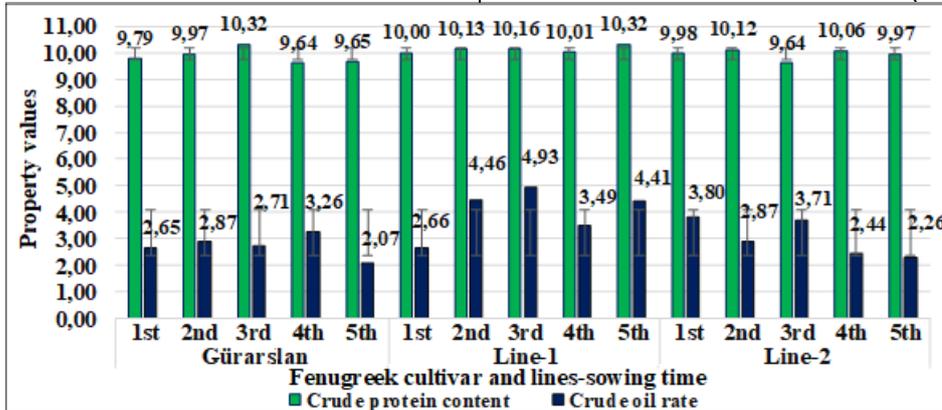


Figure 2. Raw protein content and crude oil rate of fenugreek cultivar and lines

There was not noted any correlation among the other properties in fenugreek cultivar and lines. PCA (Principal Component Analysis) showed two principal components, accounting for 100% of total variation of morphological and yield attributes in fenugreek cultivar

and lines (Figure 3). PC1 showed 56.97% of total variation and strongly influenced by PH, PSN, PL, PN, CPC and COR and PC2 explained 43.03% of total variation and it was strongly associated with BN, TSW, BY, SW and HI.

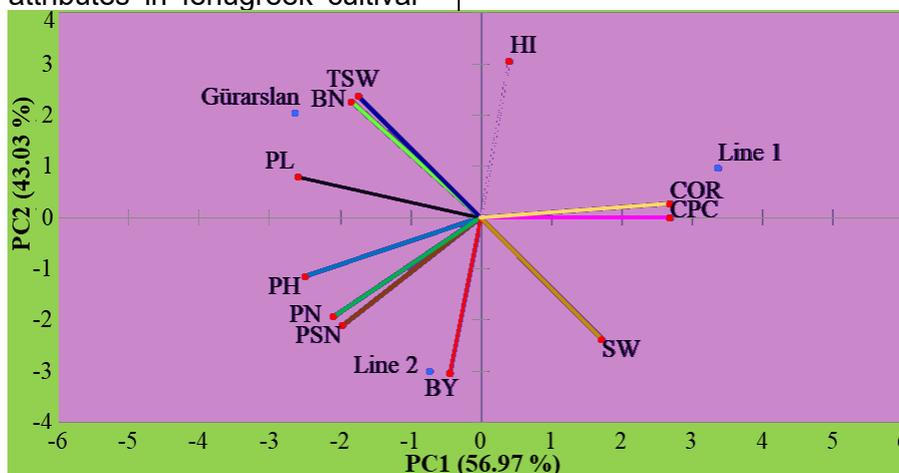


Figure 3. PCA analysis results of fenugreek cultivar and lines

When fenugreek cultivar and lines were evaluated with examined properties, gürarslan cultivar was positively associated with BN, PL and TSW, line-1 was associated positively with HI, CPC and COR and line-2 was positively associated with PH, PN, PSN, BY and SW. Gürarslan cultivar and line-1 were associated with PC1 and line-2 was associated with PC2. Results of PCA analysis, line-2 can be chosen as the best among the cultivar and lines in PC2 in terms of SW.

Discussion

In recent years, there has been a marked increase in the interest in fenugreek research in the world. Thus, this interest is also reflected in the number of scientific publications. However, it is clearly seen that the studies on determining the most suitable sowing time in terms of yield for fenugreek, which can be grown in all seasons, are not satisfactory. For this reason, our study, in which we investigated 5 different sowing time, will add richness to the scientific



literature and it will be also important for the producer. So, some researchers conducted to determine the effect of different sowing date in different country or region and it was reported that sowing date could effect some properties of fenugreek in previous studies. In this context, Anitha and *collab.* reported that mid–october was the best sowing date for fenugreek to find out the highest values from 15 October to 15 December in Venkataramannagudem, India [ANITHA *et al.*, 2016]. Maletić and Jevdžović carried out a study between the first April to end of the May as 7 different sowing date with 10 days between dates of each sowing [MALETIĆ and JEVDŽOVIĆ 2007]. They reported that the highest yield of fenugreek was obtained from in the first two weeks in April in the region of South Banat of Belgrade.

Fenugreek cultivar and lines had different morphological and yield properties depending on different sowing time in this study. Results of study was compared the previous studies and different or similar data were obtained from this study. In this study, results of the plant height were in agreement with those of the study by Tunçtürk and *collab.*, who reported that the plant height changed between 36.1–42.7 cm and reported by Çamlıca and Yaldız as 24.95–85.15 cm in different places of Turkey [TUNÇTÜRK *et al.*, 2011, ÇAMLICA and YALDIZ 2019b]. Similarly, Senkal and *collab.* found that plant height ranged from 32.42 cm to 46.58 cm and 27.28–32.95 cm reported by Tiwari and *collab.* in different plant spacing [SENKAL *et al.*, 2018, TIWARI *et al.*, 2016].

The obtained branch number results were found similar with 2.4–3.2 number Tunçtürk, and *collab.*, 2.85–3.15 number Tiwari and *collab.* and 2.65–4.40 number Beyzi and Gürbüz [BEYZI and GÜRBÜZ, 2020, TUNÇTÜRK, 2011, BEYZI and GÜRBÜZ, 2020].

Present findings for the pod number per plant were found partly similar with the findings of several studies [TUNÇTÜRK, 2011; TUNÇTÜRK *et al.*, 2011; TIWARI *et al.*, 2016].

Seed number per pod was found between 13.86–17.47 number Gurjar and *collab.*, 11.46–14.09 number Boori and *collab.* and 10.9–12.1 number [GURJAR *et al.*,

2016. BOORI *et al.*, 2017, FARHAD *et al.*, 2015]. The obtained results were found higher than previous studies. These higher values can be explained different genotype, environmental conditions and sowing time of the fenugreek. It can be think that sowing time may be affect the seed number of per pod as positively and this situation shows the importance of our study.

Tunçtürk and *collab.* reported that pod length of fenugreek was reported between 11.30–13.60 cm and Tunçtürk and *collab.* also noted it was varied between 10.80–12.20 cm [TUNÇTÜRK *et al.*, 2011]. Similarly, Gurjar and *collab.* noted that pod length changed from 9.82 to 12.19 cm and Meena and *collab.* reported between 10.10–11.30 cm in different fenugreek genotypes. The obtained results were found similar with previous studies [GURJAR *et al.*, 2016, MEENA *et al.*, 2016].

It was noted that biological yield of fenugreek changed from 184.81 to 872.22 kg da⁻¹ depending on sowing date and humic acid application on fenugreek [BEYZI and GÜRBÜZ, 2020], 355.40–416.90 kg da⁻¹ in different levels of nitrogen, phosphorus and bio–fertilizers Mehta and *collab.* The obtained results were found similar with the values of other authors [BEYZI and GÜRBÜZ, 2020, MEHTA *et al.*, 2012].

Present values for harvest index in fenugreek cultivar and lines were found similar with the values of Bhutia and *collab.* with 21.15–31.14%, Boori and *collab.* with 28.43–9.83%, Shokati and Zehtab–Salmasi with 32.53–44.36% [BHUTIA *et al.*, 2017, BOORI *et al.*, 2017, SHOKATI and ZEHTAB–SALMASI 2014].

The seed yield of fenugreek was reported between the 46.90–85.30 kg da⁻¹ in different nitrogen and sulphur applications on fenugreek Tunçtürk and *collab.*, 24.84–28.39 kg da⁻¹ in different sowing time Maletić and Jevdžović, and 28.89–49.95 in different plant spacing [TUNÇTÜRK *et al.*, 2011, MALETIĆ and JEVDŽOVIĆ, 2007, TIWARI *et al.*, 2016]. The obtained results were found higher than Tiwari and *collab.* and Maletić and Jevdžović and they were found similar with [TIWARI *et al.*, 2016, MALETIĆ and JEVDŽOVIĆ 2007, TUNÇTÜRK *et al.*, 2011]. These differences could be explained depending



on growth and environmental conditions or genetic property of used fenugreek.

Many researchers reported that 1000 seed weight of fenugreek was changed under different growth conditions 11.10–19.10 g, 1.3–1.7 g [GURJAR *et al.*, 2016. RAJE *et al.*, 2003]. Our results were found higher than reported by researchers. This situation may be because of using different material, ecological and growing conditions or different applications.

Protein content of fenugreek changed between 22.10–24.20% reported by other researchers [TUNÇTÜRK *et al.*, 2011] and 8.95–12.90% reported by other researchers [ANITHA *et al.*, 2016]. Our obtained results were found less than previous studies. It was noted that the sowing date of crops affected the protein content [TAYLOR *et al.*, 1997; RATHORE AND PORWAL, 2008].

The differences may be depending on environmental, growth conditions and genetic property or sowing date of fenugreek.

It was reported that crude oil rate of two fenugreek genotypes was found as 3.54% and 5.69% [AL-SEBAEAI *et al.*, 2017]. Our results were found partly similar with the [AL-SEBAEAI *et al.*, 2017]. These differences may be due to genotype of fenugreek or growth, ecological conditions.

Conclusions

Fenugreek is sensitive crop to sowing date in different ecological conditions. The sowing date increased or decreased the fenugreek morphological and yield properties as significantly. To find the most suitable sowing dates, studies can be conducted the growing place. Generally, it was found that 2nd (15 November) and 3rd (15 December) sowing dates gave the highest morphological and yield properties and these can be recommended.

Seed yield is the most important trait to contributed in fenugreek and this trait had the highest values in line–2. So, line–2 should be evaluated by the farmers or breeders for different sowing time except 5th sowing time (15 April).

Conflict of Interest: The authors declare that they have no conflict of interest.

References

1. Ahmed, M.A.; Ibrahim, O.M.; Elham, A.B. Effect of bio and mineral phosphorus fertilizer on the growth, productivity and nutritional value of fenugreek (*Trigonella foenum-graecum* L.) in newly cultivated land. *Research Journal of Agriculture and Biological Sciences*, **2010**, 6(3), 339–48.
2. Al-Dalain, S.A.; Abdel-Ghani, A.H.; Al-Dala'een, J.A.; Thalaen, H.A. Effect of planting date and spacing on growth and yield of fennel (*Foeniculum vulgare* Mill.) under irrigated conditions. *Pakistan Journal of Biological Sciences*, **2012**, 15(23), 1126–1132.
3. Al-Sebaeai, M.A.; Alfawaz, M.; Kr.Chauhan, A.; AL-Farga, A.; Fatma, S. Physicochemical characteristics and nutritional value of fenugreek seeds and seed oil. *International Journal of Food Science and Nutrition*, **2017**, 2(6), 52–55.
4. Anitha, B.; Lakshmi Narayana Reddy, M.; Dorajee Rao, A.V.D.; Kiran Patro, T.S.K.K.; Salomi Suneetha, D.R. Effect of sowing date on yield and quality of fenugreek. *Plant Archives*, **2016**, 16(1), 479–484.
5. Beyzi, E.; Gürbüz, B. Influence of sowing date and humic acid on fenugreek (*Trigonella foenum-graecum* L.). *Journal of Applied Research on Medicinal and Aromatic Plants*, **2020**, 16, 100234.
6. Bhutia, K.C.; Bhutia, S.O.; Chatterjee, R.; Chattopadhyay, N. Growth, phenology and yield of fenugreek (*Trigonella foenum-graecum* L.) as influenced by date of sowing. *International Journal of Current Microbiology and Applied Sciences*, **2017**, 6(10), 1810–1817.
7. Boori, P.K.; Shivran, A.C.; Giana, G.K.; Jat, M.L.; Yadav, G.; Meena, S. Growth and production potential of fenugreek as influenced by intercropping systems and Sulphur levels. *Journal of Pharmacognosy and Phytochemistry*, **2017**, 6(4), 1945–1949.
8. Çamlıca, M.; Yıldız, G. A Research on Yield and Adaptation of Bitter Melon (*Momordica Charantia* L.). 2nd International Agricultural Congress, 21–24 November, **2019a**, Ayaş/Ankara, Turkey.
9. Çamlıca, M.; Yıldız, G. Characterization of morphological and yield variation of fenugreek (*Trigonella foenum-graecum* L.) genotypes. *Legume Research—An International Journal*, **2019b**, 42(4), 500–504.
10. Çamlıca, M.; Yıldız, G. Effect of cultural condition on seed growth and content of essential oil of two populations and one



- cultivar of genus *Nigella*. *Annals of Phytomedicine*, **2019**, 8(1), 56–62.
11. Dadrasan, M.; Chaichi, M.R.; Pourbabaee, A.A.; Yazdani, D.; Keshavarz-Afshar, R. Deficit irrigation and biological fertilizer influence on yield and trigonelline production of fenugreek. *Industrial Crops and Products*, **2015**, 77, 156–162.
 12. Farhad, I.S.M.; Bhowmik, S.K.; Amir Faisal, A.H.M.; Chowdhury, M.M.U.; Bhowal, S.K. Effect of Variety and Planting Time on the Productivity of Fenugreek in Coastal Area. *World Journal of Agricultural Sciences*, **2015**, 11(3), 164–168.
 13. Gurjar, M.; Naruka I.S.; Shaktawat R.P.S. Variability and correlation analysis in fenugreek (*Trigonella foenum-graecum* L.). *Legume Research*, **2016**; 39(3), 459–465.
 14. Kızıl, S.; Arslan, N. Investigation of the effects on yield and yield components of different sowing rates in some fenugreek (*Trigonella foenum-graecum* L.) lines. *Journal of Agricultural Sciences*, **2003**, 9, 395–401.
 15. Maletić, M.; Jevdović, R. Sowing date—the factor of yield and quality of fenugreek seed (*Trigonella foenum graecum* L.). *Journal of Agricultural Sciences*, **2007**, 52(1), 1–8.
 16. Meena, S.S.; Meena, R.; Mehta, R.S.; Kakani, R.K. Effect of crop geometry, fertilizer levels and genotypes on growth and yield of fenugreek (*Trigonella foenum-graecum* L.). *Legume Research*, **2016**, 39(5), 792–796.
 17. Mehrafarin, A.; Rezazadeh, Sh.; Naghdi Badi, H.; Noormohammadi, Gh.; Zand, E.; Qaderi, A., A Review on biology, cultivation and biotechnology of fenugreek (*Trigonella foenum-graecum* L.) as a valuable medicinal plant and multipurpose. *Journal of Medicinal Plants*, **2011**, 10(37), 6–24.
 18. Mehta, R.S.; Anwer, M.M.; Aishwath, O.P.; Meena, R.S. Growth, yield and quality of fenugreek (*Trigonella foenum-graecum* L.) as influenced by nitrogen, phosphorus and bio-fertilizers. *Indian Journal of Horticulture*, **2012**, 69(1), 94–97.
 19. Purbey, S.K.; Sen, N.L. Effect of bioinoculants and bioregulators on productivity and quality of fenugreek (*Trigonella foenum-graecum*). *Indian Journal of Agricultural Sciences*, **2005**, 75(9), 608–611.
 20. Raje, R.S.; Singh, D.; Singhania, D.L. Inheritance of giant mutant plant type in fenugreek (*Trigonella foenum-graecum* L.). *Journal of Spices and Aromatic Crops*, **2003**, 11(2), 141–142.
 21. Rathore, H.S.; Porwal, M.K. Nutrient uptake, protein content and relative economics of fenugreek (*Trigonella foenum-graecum*) as influenced by sowing dates, microbial inoculation and weed management. *Indian Journal of Agricultural Sciences*, **2008**, 78(6), 560–62.
 22. Senkal C.B.; Cesur, C.; Uskutoğlu, T.; Dogan, H.; Kose, F. Determination of yield performance of fenugreek (*Trigonella foenum-graecum* L.) and coriander (*Coriandrum sativum* L.) plants grown in Yozgat ecological conditions. 3rd International Bozok Symposium Regional Development and Socio-Cultural Structure. 03–05 May, **2018**, Yozgat p. 33.
 23. Sheoran, R.S.; Sharma, H.C.; Panuu, P.K.; Niwas, R. Influence of sowing time and phosphorus on, phenology, thermal requirement and yield of fenugreek (*Trigonella foenum-graecum* L.) genotypes. *Journal of Spices and Aromatic Crops*, **2000**, 9(1), 43–46.
 24. Shokati, B.; Zehtab-Salmasi, S. Effect of different intercropping patterns on yield and yield components of dill and fenugreek. *Azarian Journal of Agriculture*, **2014**, 1(1), 1–5.
 25. Taylor, W.G.; Zaman, M.S.; Mir, Z.; Mir, P.S.; Acharya, S.N.; Mears, G.J.; Elder, J.L. Analysis of steroidal sapogenins from amber fenugreek (*Trigonella foenum-graecum*) by capillary gas chromatography and combined gas chromatography/mass spectrometry. *Journal of Agricultural and Food Chemistry*, **1997**, 45(3), 753–59.
 26. Tiwari, D.; Upadhyay, S.; Paliwal, A. Plant spacing response on growth and yield of fenugreek in high altitude of Uttarakhand. *International Journal of New Technology and Research*, **2016**, 2(10), 33–35.
 27. Tunçtürk, R. The effects of varying row spacing and phosphorus doses on the yield and quality of fenugreek (*Trigonella foenum-graecum* L.). *Turkish Journal of Field Crops*, **2011**, 16(2), 142–148.
 28. Tunçtürk, R.; Esen Çelen, A.; Tunçtürk, M. The effects of nitrogen and sulphur fertilizers on the yield and quality of fenugreek (*Trigonella foenum-graecum* L.). *Turkish Journal of Field Crops*, **2011**, 16(1), 69–75.
 29. Wani, S.A.; Kumar, P. Fenugreek: A review on its nutraceutical properties and utilization in various food products. *Journal of the Saudi Society of Agricultural Sciences*, **2018**, 17, 97–106.

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