of various diseases it is too early to draw conclusions about complex disease resistance, but for further breeding work in this direction it is possible to select such samples as 'C-10/17', 'C-12/17' , 'C-16/17', 'Sur 13/224', 'Sur 13/200', 'Hc-2652', 'Ex 8142/01', 'Ex 5342/01', 'Ex1085 / 01', which were not affected by rot, various leaf spots, rust, bacterial wilt. Vertical wilting and phomosis were detected in these samples. False powdery mildew was recorded in hybrids 'C-10/17', 'C-16/17', 'Sur 13/224', 'Sur 13/20'. In hybrid 'Ex 8142/01' gray rot and rust were diagnosed on the leaves and anthodium.

Keywords: *sunflower; fungal, bacterial diseases; species composition of pathogens; immunological evaluation of hybrids; phytopathogens.*

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Plant protection and nutrient supply studies of fenugreek (*Trigonella foenum-graecum* L.)

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Purpose. The aim of our experiment was to determine the changes of fenugreek (*Trigonella foenum-graecum*) nutrient content and biomass in the two years under study as a result of nutrient supply, plant protection and irrigation. Fenugreek is an annual herbaceous plant belonging to the legumes (Fabaceae) family. It is a multifunctional crop for use in domestic and farm animal feeds, wild fodder, herbs and spices. **Methods.** The experiment was carried out in open field on 100 m^2 plots in Kecskemét. Novatec premium fertilizer (15 N – 3 P_2O_5 – 20 K_2O – 2 MgO) was used in the research. The herbicide Pantera 40 EC (active ingredient content: 40 g/l quizalofop-P-tefuryl) was used for weed control. **Results**. In both years, after the crop emerged fenugreek seeds within a week. In 2018, the average height of plants was 30 cm for the start of harvest. On a plot of 100 m^2, the dry weight of mowed fenugreek is 13.15 kg dry weight (300 kg/ha Mg treatment). According to our observations, the height of the fenugreek stock reached 50 cm in 2019. The dry weight after harvest is 28.2 kg dry weight (300 kg/ha Mg treatment). The results of the second experimental year are higher than the first year. **Conclusions.** The magnesium fertilizer resulted in an increase in the green weight of the fenugreek.

Keywords: *weed control; Fenugreek (Trigonella foenum-graecum L.); nutrient supply; open field experiment; yield*

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is an annual plant belonging to the *Fabaceae* family of legumes (*Fabales*) (Provorov, 1985). The plant is a Mediterranean one native to the Mediterranean coast. In countries of temperate climate, it is grown as a spring-sown plant (Antal, 2005). It is grown as a winter-sown plant in Egypt, Morocco and India (Makai et al., 1996a; http[1]). In Hungary, Sámuel Diószegi and Mihály Fazekas published in the Hungarian Phenomenon in 1807 as a wild herb (Makai and Makai, 2004). In Hungary before 1945 years, fenugreek was cultivated in the Southern part of the country as a horticultural crop. Later, in 1969-1970, the Agrobotany Institute in Tápiószele started the experimental cultivation. From 1982, research on the technology of cultivating fenugreek and the production of new, intensive varieties began in Mosonmagyaróvár. Then in 1987, a new Hungarian fenugreek variety has been bred, known under the name 'Óvári-4'.

This variety was accepted by the state later, in 1994 (Makai et al., 1996b). Currently, fenugreek is grown on less than 100 hectares in Hungary.

It is grown for feeding purposes in the following countries: United States, Spain, Algeria, Tunisia, Egypt, Ethiopia, Afghanistan, Iran, India, China (Kalmár, 1999). It is used as a green manure plant in the USA (California State), Chile and South France. India is the largest producer of fenugreek in the world (Vidyashankar, 2016). During 2011-2012, production was 121,775 tonnes of seeds from an area of 96,304 hectares (http[2]). Its seed is traded as a spice, and in an oil extract form as oleoresin. India consumes most of the seeds (Petropoulos, 2003). Its export was 21,800 tonnes in 2011–2012 (Vidyashankar, 2016). It was exported to UAE, Sri Lanka, Japan, and European countries of UK, Netherlands, Germany and France (Fotopoulos, 2003).

The use of fenugreek is very versatile: herb, spice, fodder plant, various recipes and other utilization options (Bernáth, 2000; Nybe, 2007; Parthasarathy et al., 2008; Chapman, 2009; http[3]). The *T. foenum-graecum* crop has several advantages. *Rhizobium meliloti* is a nitrogen-binding bacterium on its roots that can bind about 70–90 kg/ha of nitrogen in the soil (Makai et al., 1996a). Due to its high protein content, fenugreek is well suited for feeding domestic and wild animals. Its medical value is also mentioned by Ebers papyrus, B.C. II. Millenium, used as anti-burn medicine (Varga, 2001). The infusion of its coarse grind gives a refreshing tea that stimulates digestion, soothes diarrheal (Stark és Madar, 1993; Bremness, 1997). Fenugreek of Mediterranean origin was already grown in ancient Egypt and Babylon. Its seeds were eaten and also used for healing. To a greater extent, it is used as a green manure plant and green fodder (Czimber, 2001; Makai et al., 2007). The seeds of fenugreek (*Trigonella Foenugraeci semen*) contains alkaloids, choline, bitter substances, mucus, fatty oil, protein and vitamin C (Máthé, 1975). Its medical use (especially externally) became widespread in the Middle Ages. Fenugreek seed is also an official drug in European medical books (Ph. Hg. VIII. – Hungarian; Ph. Helv. – Swiss; DAB – German; ÖAB – Austrian) (Bicsérdy, 2012).

The aim of our experiment was to determine the content of *T. foenum-graecum* and the value of biomass in the research years 2018-2019 as a result of nutrient supplementation, plant protection and irrigation. The experiment was repeated in 2020 at the Faculty of Agriculture of the University of Szeged, in Hódmezővásárhely.

Materials and research methods

The experiment was carried out in the study garden of John von Neumann University, Faculty of Horticulture and Rural Development (Kecskemét) in 2018–2019.

The 2018 experiment: Sowing was carried out on 9 April in designated 100 m^2 plots. For sowing we used the 'Óvári-4' varieties of fenugreek seeds bought in 2017. The treatments calculated for the active ingredient (kg) during the research are the following: 150 kg/ha Mg, 300 kg/ha Mg, 450 kg/ha Mg. Two replicates per treatment were used. The fertilizer used: Novatec premium (15 N – 3 P_2O_5 – 20 K_2O – 2 MgO_2). The fertilizer was applied in two doses (17 April and 4 June) and the legumes utilize the nutrient supply more efficiently. The weed control ability of fenugreek in the post-emergence period (1-3 weeks) is very poor, so we had to use chemical weed control. Pantera herbicide (40 g/l quizalofop-β-tefuril) was applied at a dose of 3 l/ha in 100 m^2 experimental plots. Time of protection: 26 April. Harvest of *T. foenum-graecum* on 3 July. At harvest, the fresh weight value (kg) of the mowed plant was weighed and then dried in a greenhouse in a ventilated place. The weight of the air-dried plants was measured on 2 August. The determination of the content values of the plants (macro elements) took place in the laboratory of the Soil and Plant Research, John von Neumann University, Faculty of Horticulture and Rural Development. For elemental studies powdered samples were digested in a microwave device by means of concentrated nitric acid and hydrogen peroxide (Milestone Ethos Plus). Main macro element content was measured by optical emission spectrometer (ICP-AES method) (Hüvely, 2005). Nitrogen content in leaf and stem were determined using the Kjeldahl method after sulphuric acid digestion (FOSS Kjeltec 2300). Macro element (N, P, K, Ca, Mg, and Na) contents were calculated in m/m% dry matter.

The 2019 experiment: Time of sowing: 10 April. The treatment applied during the research: 300 kg/ha Mg. This treatment proved to be the most successful, so in 2019 we used only one type of treatment. Two replicates were used. The fertilizer used: Novatec premium (15 N – 3 P_2O_5 – 20 K_2O – 2 MgO_2). The fertilizer was again applied to the open field in two batches for better utilization of the plant. Date of application: 30 April and 21 May. A herbicide was also used in the second experimental year. The Pantera herbicide was applied at a dose of 3 l/ha in the 100 m^2 experimental plot. Time of protection: 17 April. Harvest time for fenugreek: 28 June 2019. At mowing, the fresh weight of the plant (kg) was measured. The mowed plant was dried in a greenhouse in a ventilated place. The weight of air-dried plants was measured on 1 August. The determination of the content values of the plants (macro elements) took place in the laboratory of the Soil and Plant Research, John von Neumann University.

Biometric (statistical) evaluation of the results, p-value was determined by Tukey-HSD test (Huzsvai, 2004). IBM SPSS v19 programs were used to evaluate the measurement data.

Soil samples were taken from the Kecskemét experimental area. The Table 1 shows the soil sample values.

Table 1

Soil characteristics of the experimental area (2018)

Denomination	Measurement unit	Value
pH_{KCL}	–	7.61
K_A	–	28
Water soluble salt	m/m%	< 0.02
Humus	m/m%	1.43
$CaCO_3$	m/m%	2.62
NO_2-NO_3-N	mg/kg	1.43
P_2O_5	mg/kg	548
K_2O	mg/kg	104
Mg	mg/kg	106
Na	mg/kg	6.61
Cu	mg/kg	13.1
Mn	mg/kg	55
Zn	mg/kg	9.72
Fe	mg/kg	64.1
SO_4	mg/kg	8.4
pHKCL	–	7.61

Fertilizer used in the research was NovaTec premium 15-3-20 (+2 MgO+10 S) + TE. Technical data of the fertilizer: 15.0 % total nitrogen (N); 8.0 % ammoniacal nitrogen (NH_4-N); 7.0 % nitrate nitrogen (NO_3-N); 0.0 % carbamide nitrogen (NH_2-N); 3.0 % phosphate (P_2O_5) soluble in neutral ammonium citrate and water; 2.4 % phosphate (P_2O_5), water soluble; 20.0 % potassium oxide (K_2O), water soluble; 2.0 % total magnesium oxide (MgO); 1.6 % magnesium oxide (MgO), water soluble; 10.0 % total sulphur (S); 8.0 % sulphur (S), water soluble; 0.02 % total boron (B); 0.0 % total copper (Cu); 0.06 % total iron (Fe); 0.0 % total manganese (Mn); 0.01 % total zinc (Zn); 0.8 % nitrification inhibitor 3.4-dimethylpyrazole-phosphate (DMPP) related to total of NH_4-N and NH_2-N; low in chlorine (Cl). Physical properties: 1, physical appearance: solid, granulated; 2, colour: purple; 3, bulk density: 1,250 ± 100 kg/m^3; 4, granulometry: 90 % = 2–4 mm; 5, average granule size (d50): 3.2 ± 0.4 mm; 6, pH (1:10 in water): 4.5–5.5 (http[4]).

Description of the herbicide: The herbicide used in the 2018–2019 trial year is Pantera 40 EC. Active substance content: 40 g/l quizalofop-P-tefuril, category II agent (http[5]).

Results of researches

In both years, fenugreek hatched within a week of sowing. We performed weed control in the third week in 2018 and in the first week after emergence in 2019 so that the development of the

crop would not be damaged by the weed. A further aim of our experiment is that the fertilizer treatment increases the green mass of the plant and the content of macro elements accumulating in it. The biomass value and content value of fenugreek were the highest in the case of 300 kg/ha magnesium basic fertilizer treatment, which was previously indicated in the literature (Vojnich et al., 2019a, Vojnich et al., 2019b). The effect of magnesium base fertilizer treatment has been previously studied (Kiss, 1980; Kiss, 1983; Verzárné and Kiss, 1980), according to which magnesium has an effect on plant growth and flowering.

Results of the 2018 experiment: In 2018, by the start of the harvest, the average height of the plants was 30 cm. The values of fresh weight and dry weight of fenugreek mown on plots of 100 m^2 are shown in Table 2 and Table 3.

Table 2

Values of fresh weight (kg) of fenugreek in an area of 100 m^2 (2018)

Treatments	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Mini-mum	Maxi-mum
					Lower Bound	Upper Bound		
150 kg/ha Mg	2	14.05	2.1920	1.550	-5.644	33.744	12.50	15.60
300 kg/ha Mg	2	26.55	3.3234	2.350	-3.309	56.409	24.20	28.90
450 kg/ha Mg	2	18.40	1.9799	1.400	0.611	36.188	17.00	19.80
Total	6	19.66	6.0138	2.455	13.355	25.977	12.50	28.90

Table 3

Values of dry weight (kg) of fenugreek in an area of 100 m^2 (2018)

Treatments	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Mini-mum	Maxi-mum
					Lower Bound	Upper Bound		
150 kg/ha Mg	2	7.75	1.0606	0.750	-1.7797	17.2797	7.00	8.50
300 kg/ha Mg	2	13.15	1.7677	1.250	-2.7328	29.0328	11.90	14.40
450 kg/ha Mg	2	5.05	0.7778	0.550	-1.9384	12.0384	4.50	5.60
Total	6	8.65	3.8182	1.558	4.6430	12.6570	4.50	14.40

Table 4 summarize the results of the content values of fenugreek dry matter (m/m%) in the above-ground part (stem, leaf).

Table 4

Macro element (N, P, K, Ca, Mg) contents were calculated in m/m% dry matter (2018)

Repetitions	Treatments	N	P	K	Ca	Mg
I.	150 kg/ha Mg	3.50	0.415	1.15	2.75	0.404
	300 kg/ha Mg	3.19	0.530	0.831	3.31	0.466
	450 kg/ha Mg	2.91	0.310	0.822	3.44	0.424
II	150 kg/ha Mg	3.21	0.408	1.01	2.80	0.379
	300 kg/ha Mg	3.53	0.457	1.11	2.57	0.389
	450 kg/ha Mg	3.51	0.360	1.04	3.36	0.416

Previous experiments show that the values of 150 kg/ha magnesium treatment (excluding Ca) are lower for 300 kg/ha Mg treatment, while the data for 450 kg/ha magnesium treatment decreased for N, P and K.

Results of the 2019 experiment: According to our observations, in 2019, the height of the fenugreek stock reached 50 cm. The fresh weight (kg) and dry weight (kg) values after harvest are presented in Table 5.

Table 5

Values of fresh weight (kg) and dry weight (kg) of fenugreek in an area of 100 m^2 (2019)

Repetitions	Treatments	Fresh weight	Dry weight
I	300 kg/ha Mg	155.0	32.8
II	300 kg/ha Mg	92.0	23.6

The effect of irrigation was more pronounced in the second experimental year because *T. foenum-graecum* was able to develop in an even area without border effect than in 2018. The values of the macroelement testing are presented in Table 6.

Table 6

Macro element (N, P, K, Ca, Mg) contents were calculated in m/m% dry matter (2019)

Repetitions	Treatments	N	P	K	Ca	Mg
I	300 kg/ha Mg	2.71	0.340	1.14	1.57	0.294
II	300 kg/ha Mg	2.95	0.398	0.985	2.07	0.341

Conclusions

Based on our observations, the average height of the plant in the second experimental year was 20 centimetres higher than in 2018.

The development of the dry weight value was influenced by several factors, as a result of which the value of the 300 kg/ha Mg treatment doubled in 2019. In addition to the 2018 designated parcel areas, a row of hedges stretched, so that due to the border effect, fenugreek could not develop smoothly. Therefore, in 2019, the plots were relocated 20 meters further in the Demonstration Garden, but this did not affect the soil values because the soil is uniform and homogeneous. We increased the amount of seeds in the second year of the study, as a result of which our area became almost completely weed-free after the plant protection control, the stock developed evenly.

Changes in content values in the two years studied: in the 2018 experiment, the values of N, P, Ca, and Mg are higher, while the values of K are lower than the 2019 macronutrient values.

As a result of the 300 kg/ha magnesium treatment, the green mass value and the content value of fenugreek developed favourably. In the first year, the macro element values dominated, while in the second year, the dry weight value dominated. Without artificial irrigation, we would not have been able to produce as much biomass as we achieved in 2019 (28.2 kg dry weight per 100 m^2).

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