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Adaptive Potential of Fenugreek Species at Different Sowing Times

Abstract. Among the unexplored technological elements of growing fenugreek in the conditions of Ukraine is the creation of conveyor cultivation of the culture. Therefore, the problem of the influence of sowing dates on the growth and development of plants, the parameters of the harvest and the qualitative composition of marketable products is acute. The purpose of this study was to substantiate the optimal sowing dates of fenugreek species to increase the yield of dried products in the conditions of Polissia on sod-podzolic soils. The leading methods employed to investigate this issue were the field method – to find the interaction of the object of research with biotic and abiotic factors, statistical method – to evaluate the research results to find the parameters of fenugreek's adaptive capacity. During 2012-2014, for different sowing periods, the average yield of dry mass in blue fenugreek varied from 0.5 to 1.3 t/ha, and in hay fenugreek – from 0.6 to 1.5 t/ha. The early spring period and the late spring period of the 1st sowing period were characterized by the highest overall adaptive capacity. The highest value of the specific adaptive capacity was established during the late spring 2nd sowing period. The relative stability index ranged from 2.6 to 11.4. Blue fenugreek during the late spring 1st and 2nd sowing periods responds well to improved growing conditions (b_i >1), and fenugreek hay during the late spring 2nd and summer sowing periods. Early spring and late spring 1st sowing period samples are characterized by high breeding value. An increase in the sum of effective temperatures by 1°C contributed to the fluctuation of green mass yield from 4.82 to 128 kg/ha, and dry mass yield from 0.401 to 6.63 kg/ha. At the same time, an increase in precipitation by 1 mm affected the fluctuation of the yield of green mass from 15.0 to 146 kg/ha, and of dry mass from 0.145 to 25.9 kg/ha. Commercial production of fenugreek species was formed within the range of the sum of air temperatures (>10°C) 383.9-487.1°C, the amount of precipitation 70.7-144.3 mm, and the growing season ranged from 35 to 55 days. The highest productivity of fenugreek species was found during sowing from the second decade of April to the first decade of May. The materials of this paper are of practical value for expanding the species diversity of vegetables and increasing the supply of the population with valuable food products and during the application of new and improved elements of technologies for growing valuable rare crops to achieve the maximum effect of fulfilling the genetic potential of plants

Keywords: blue fenugreek, hay fenugreek, sowing time, selection value of the genotype

INTRODUCTION

Since ancient times, fenugreek has been used as a spice, food, and medicinal crop, and more recently as a functional food (food that provides health and wellness benefits in addition to nutrients) [1]. Fenugreek seeds contain a considerable amount of fibre, phospholipids, glycolipids, oleic acid, linolenic acid, linoleic acid, choline, vitamin A, B1, B2, C, nicotinic acid, niacin, and many other functional elements [2; 3]. It is necessary to focus on the development of new cultivated varieties, to completely fulfil their potential as edible plants along with medicinal value [4].

Fenugreek is grown on different continents, in different soil and climatic conditions [5]. However, the development of plants is influenced not only by soil and climatic conditions, but also by technological interventions [6]. Sowing time and row width are important agronomic factors directly affect the yield level [7; 8]. The optimal timing of sowing opens the way to more efficient use of light, temperature, precipitation, and other environmental factors [9]. In general, early sowing times are better because of the expected beneficial effect on seed

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germination, plant growth and development, duration of the growing season, and yield [10].

Numerous studies have shown that climate change has adverse effects on food production and food security, and, according to forecasts, adverse effects will increase in the future [11-13]. Climate variability, such as being too wet or too dry, also affects yield [14; 15]. High average air temperatures affect crops through several mechanisms, including acceleration of plant growth and total evapotranspiration, and thus yields will decrease in response to increased temperatures [16]. Crops are especially sensitive to strong heat during the reproductive period, when it can substantially reduce the amount of grain and the final yield, and in the most negative cases lead to a complete loss of the harvest [17].

The changes in temperature and precipitation predicted by global climate models for the 2050s will lead to a global decrease in crop yields if planting and harvesting dates stay unchanged. However, adaptation of sowing dates and variety selection increases yield in temperate regions and allows avoiding 7-18% losses [18].

Technologies aimed at maximizing the protective reactions of the plant organism to adverse environmental conditions are of particular importance in vegetable production. Such technologies have a prominent degree of flexibility, considering environmental conditions in connection with a change in the set of technological operations, which are most suitable in particular conditions of the growing season [19]. The defining element in such technologies is the variety due to its biological, morphological, and genetic features, the constructed strategy for the selection of the predecessor, tillage, fertilizers, sowing, crop care, and harvesting.

A variety, as a biological system, should be considered in terms of the fulfilment of genetic potential in a particular ecological region [20]. The value of varieties is determined by their plasticity and stability, or the ability to form a certain level of yield in different environmental conditions [21]. The genotype × environment interaction must be considered when developing selection programs focused on nutrition quality parameters, since selection in particular soil conditions can provide further optimization of nutrition quality [22; 23].

The purpose of this study was to find the best date of sowing to obtain the highest yield of dry mass of fenugreek species on sod-podzolic soils of Polissia.

MATERIALS AND METHODS

The research was conducted during 2012-2014 at the National University of Life and Environmental Sciences of Ukraine at the collection site of the Fruit Orchard, in the Kyiv Oblast. Two local samples of fenugreek were investigated: blue fenugreek (*Trigonella coerulea* (Desr.) Ser.) and hay fenugreek (*Trigonella foenum graecum* L.). Species were sown simultaneously in four terms: early spring – II-III decade of April (April 10 – 2012, April 24 – 2013, April 10 – 2014); late spring of the 1st term – 3rd decade of April – 1st decade of May (04/25 – 2012, 05/08 – 2013, 04/29 – 2014); late spring of the 2nd term – the 2nd decade of May (May 15, 2012, May 17, 2013, May 14, 2014); summer – 1st decade of June (06/10 – 2012, 06/04. – 2013, 06/05 – 2014). Moreover, the seeds for the early spring and the first late spring terms in 2013 had to be sown later due to the prolonged cold spring. Control – early spring sowing period (II-III decade of April). Repetition – three times with randomization. The registered area of the site was 5 m^2. Calculations were carried out on 30 plants – 10 from each repetition. The seeding scheme for fenugreek was 45×15 cm. The depth of wrapping the seeds of blue fenugreek was 1.0-1.5 cm, hay fenugreek – 2-3 cm.

The field research method was used to determine the quantitative assessment of the effect of the researched factors on growth, development, plant productivity, and crop quality. The reliability of the obtained results was determined using a statistical method.

Analysis of variance (ANOVA) and correlation analysis were performed using the XLSTAT add-on in MS Excel. It was considered that the differences are significant when α=0.95 [24].

The indicator of general adaptive capacity (GAC) was defined as the average value of the trait in various environmental conditions, and specific adaptive capacity (SAC) as a deviation from the general adaptive capacity in a certain environment [25]. The method of evaluating the GAC and SAC is based on testing a population of *n* genotypes in *m* environments. The number of repetitions is equal to *c*. Then (1):

$$x_{ikr} = U + V_i + d_k + (Vd)_{ik} + e_{ikr} \quad (1)$$

where x_{ikr} is the phenotypic value of (*i*) genotype grown in (*k*) environment in (*r*) replication; *U* is the overall average of the entire population of phenotypes; V_i is the effect of (*i*) genotype; d_k is the effect (*k*) of environment; $(Vd)_{ik}$ is the effect of interaction of (*i*) genotype with (*k*) environment; e_{ikr} is an effect due to random causes and attributed to the (*ekr*) phenotype.

The following restrictions were imposed on the elements of the model (2):

$$\sum_i v_i = \sum_k d_k = \sum_k (vd)_{ik} = \sum_k (vd)_{ik} = \sum e_{ik} = 0 \quad (2)$$

GAC effects (3):

$$GAC_i = V_i = X_i - u \quad (3)$$

The parameters of the adaptive capacity of fenugreek species were as follows (4; 5):

$$\sigma^2\, SAC_i = \frac{1}{m-1} * \sum_R (d_R + Vd_{iR})^2 - \frac{m-1}{m} * \sigma^2 \quad (4)$$

$$\sigma\, SAC_i = \sqrt{\sigma^2\, SAC_i} \quad (5)$$

To compare the variability of various features upon investigating fenugreek species and habitats, the relative stability of the species according to the following S_{gi} feature was used (6):

$$S_{gi} = \frac{\sigma_{SAC_i}}{U + GAC} * 100\ \% \tag{6}$$

The reaction of fenugreek species to the improvement of environmental conditions was determined by the value of the regression coefficient b_i (7):

$$b_i = \frac{\sum X_{iR} * d_R}{\sum_R d_R^2} \tag{7}$$

To select fenugreek species that combine productivity and stability, the selection value of the genotype was used (8):

$$SVG_i = U + GAC_i - p\ \sigma_{SAC_i} \tag{8}$$

To figure out when a certain stage of plant development will occur ("sowing-seedlings", "seedlings-beginning of budding", "beginning of budding-beginning of flowering", "beginning of flowering-beginning of ripening of beans", "seedlings-beginning of ripening of beans") the Growing Degree Days method was used, which is based on the real temperature [26]. The sum of effective air temperatures for the interphase period was calculated using the formula (9):

$$\sum t_{ef} = (t_{avg} - B) * n \tag{9}$$

where Σt_{ef} is the sum of the effective air temperatures for the period; °C, t_{avg} is the average active air temperature for the period, °C; B is the biological minimum, which in this study was taken as 10°C; n is the number of days in the period.

RESULTS AND DISCUSSION

The duration of the phenological phases of development of blue fenugreek from the 2nd decade of April to the 1st decade of June was established as follows: "sowing-seedling" ranged from 6 to 12 days and took place at total air temperatures (>10°C) of 21.3-70.5°C and total precipitation of 10.3-45.3 mm; "seedling–beginning of budding" – from 28 to 39 days, for total air temperatures (>10°C) of 310.0-316.2°C and total precipitation of 47.7-123.3 mm; "the beginning of budding–the beginning of flowering" – from 4 to 7 days, for the total air temperatures (>10°C) of 48.2-78.9°C and the total precipitation of 2.3-24.1 mm; "the beginning of flowering–the beginning of ripening of beans" – from 3 to 6 days, for the total air temperatures (>10°C) of 35.4-61.7°C and the total precipitation of 3.6-23.7 mm; "seedlings–the beginning of ripening of beans" – from 36 to 52 days, for the total air temperatures (>10°C) of 398.9-450.6°C and the total precipitation of 70.7-133.3 mm (Fig. 1).

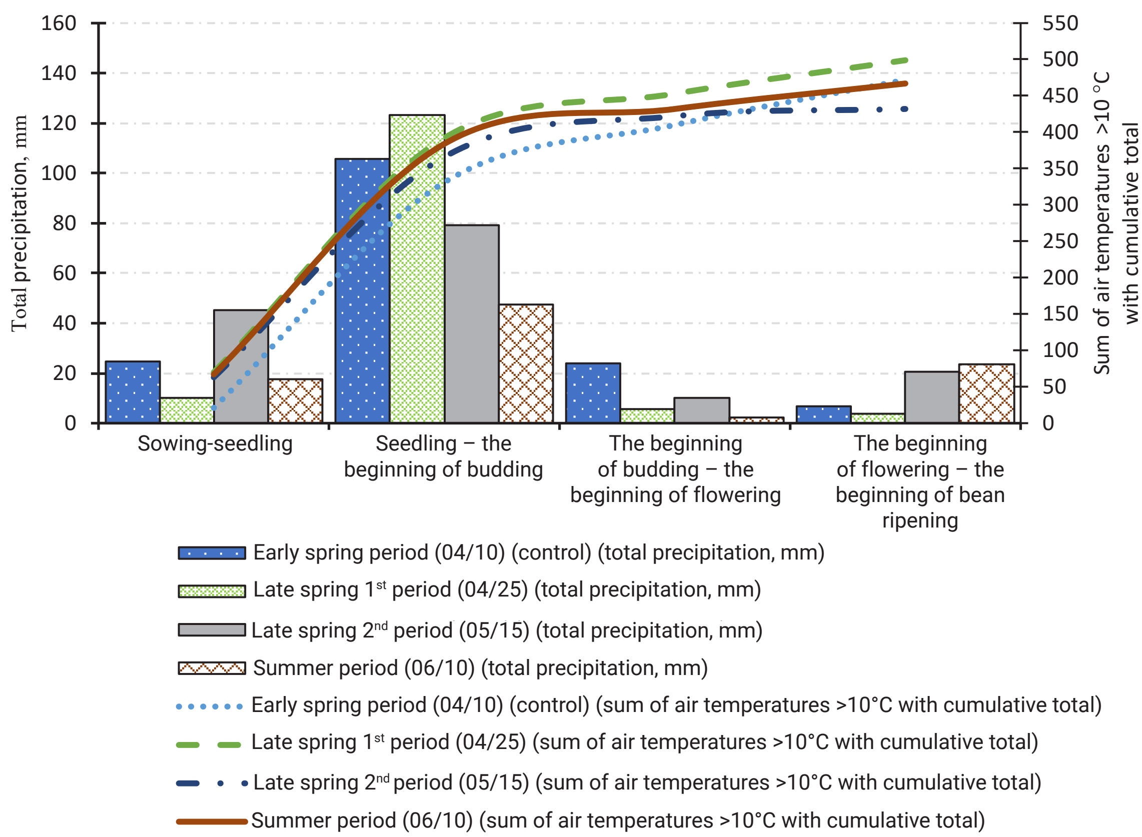

Figure 1. The sum of air temperatures above 10°C with a cumulative total and the total precipitation necessary to complete the phenological phases of the development of blue fenugreek at different sowing times (average for 2012-2014)

Depending on the timing of hay fenugreek sowing, the ranges of phenological phases of development were established as follows: "sowing–seedling" ranged from 7 to 12 days and took place during the total air temperatures (>10°C) of 24.6-82.1°C and the total precipitation of 12.0-20.7 mm; "seedling–beginning of budding" – from 26 to 37 days, for total air temperatures (>10°C) of 287.7-325.1°C and total precipitation of 40.7-122.0 mm; "the beginning of budding–the beginning of flowering" – from 5 to 6 days, for the total air temperatures (>10°C) 48.0-63.0°C and the total precipitation 3.0-28.7 mm, "the beginning of flowering – the beginning of ripening beans" – from 3 to 12 days, for total air temperatures (>10°C) of 30.3-135.6°C and total precipitation of 21.3-35.7 mm; "seedlings–the beginning of ripening of beans" – from 35 to 55 days, for the total air temperatures (>10°C) 383.9-487.1°C and the total precipitation 71.3-144.3 mm (Fig. 2).

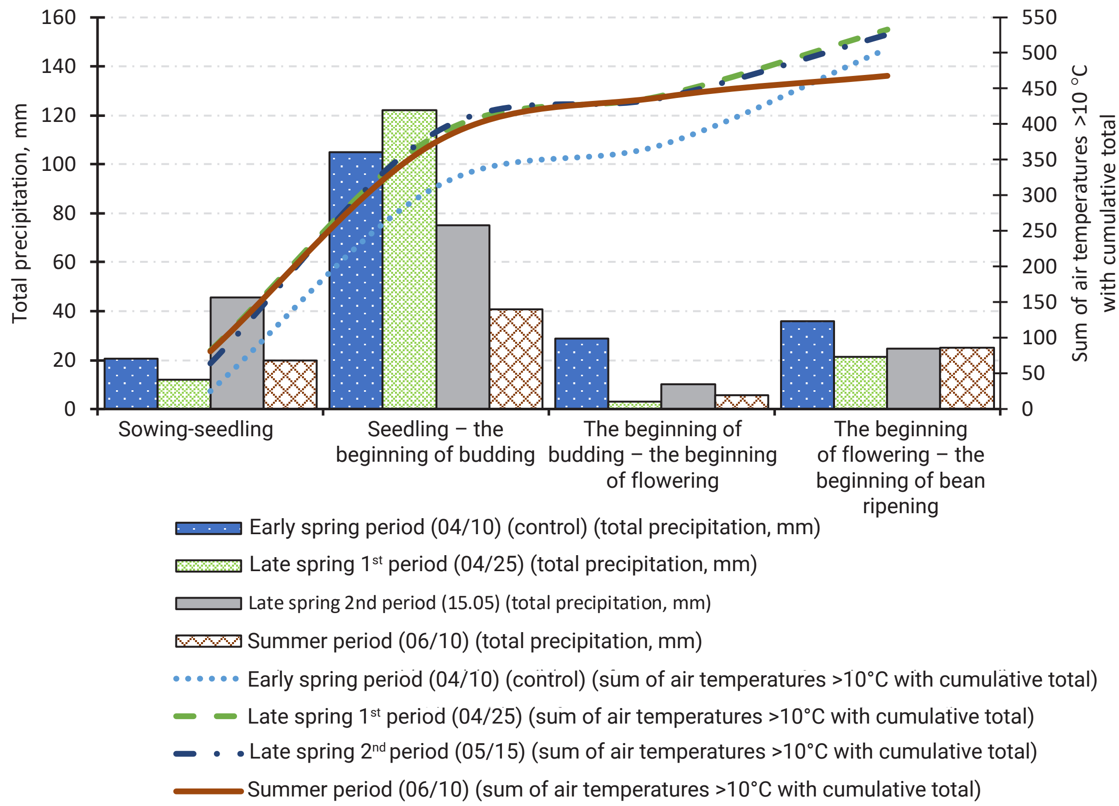

Figure 2. The sum of air temperatures above 10°C with a cumulative total and the sum of precipitation necessary to complete the phenological phases of hay fenugreek development during different sowing periods (average for 2012-2014)

C. Karma *et al.* (2017) found that different sowing dates in West Bengal differed significantly in number of days to germination, sowing on 30 December showed the maximum number of days (14.13 days) and the minimum number of days was achieved by fenugreek plants sown on 30 October (9.38 days) [27]. R. Sheoran *et al.* (2000) found that during a 14-day delay in sowing, the analysed fenugreek varieties formed inflorescences earlier and ripened faster. Furthermore, late sowing reduced plant requirements for warm temperatures, which is critical when plants requiring higher temperatures must be adapted to grow in more severe climates [28]. Ionescu and Roman (2013) note that fenugreek ripened in the third decade of July, after 95 days of vegetative growth, and the number of accumulated heat units was 922.2 (>10°C) [29].

In general, culture needs a cool climate during vegetative growth, and a dry climate during seed maturation [30]. Plants sown at the optimal time have more chances to achieve the correct phenological development. A delay in sowing, on the contrary, shortens the duration of the vegetation period of plants and successive phases in growth and development [31].

Based on the conducted analysis of variance, it was established that the yield of fenugreek species considerably depended on the genotype, environment, repetitions, and interaction of factors with the share of their influence being 18%, 36%, 24%, and 18%, respectively, with the predominance of the influence of the environment (Fig. 3)

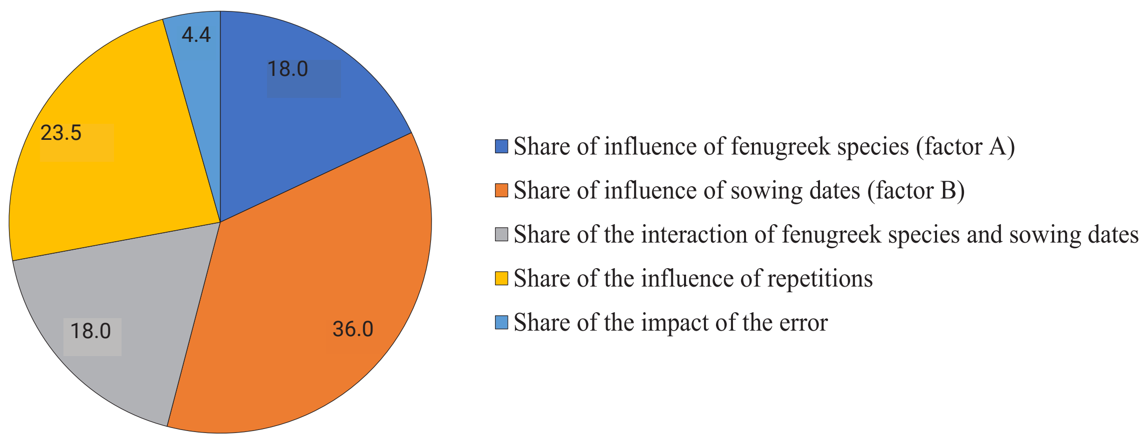

Figure 3. The share of influence of individual elements of the experiment on fenugreek productivity, % (average for 2012-2014)

Among the features of fenugreek species under study, yield is of particular importance as a holistic indicator of genetic potential. The range of yield variation shows the difference between the minimum and maximum value and characterizes the stability of a certain genotype. Varieties with a smaller range of variation have better adaptability. During the research period, the best value in terms of variation stability can be identified for fenugreek in the early spring period (0.2 t/ha) and late spring of the 1st sowing period (0.3 t/ha), and for blue fenugreek in the early spring period (0.3 t/ha), which were characterized by a high yield of dry mass within 1.1-1.4 t/ha (Table 1). The widest range of yield fluctuations (0.5 t/ha) was noted during the late spring 2nd period of fenugreek sowing. The time of sowing is crucial for the growth and development of plants and obtaining the highest possible yield. Sowing too early or too late can hinder growth, reduce yield, and worsen the quality of the crop [32]. Radojka and Jevdjovic (2007) found that sowing in the first two weeks of April resulted in considerably higher yields compared to sowing at the end of April and during May [33]. In Kansas, A. Obour *et al.* (2015) reported no effect of sowing between April 1 and May 22 on dry matter yield [34]. In Poland, T. Bienkowski *et al.* (2016) found that sowing seeds as early as possible or with a delay of 10 days did not cause a significant decrease in seed yield, although delaying the sowing date by 20 days could reduce seed yield by 3-13%. Early sowing of fenugreek in West Bengal (October 30) is recommended for fast growth and high yield [35].

Table 1. Parameters of adaptive capacity by dry mass yield (average for 2012-2014)

Type (factor A)		**Blue fenugreek**				**Hay fenugreek**			
Sowing terms (factor B)		**Early spring term (04/10) (control) 2012-2014**	**Late spring 1st term (04/25) 2012-2014**	**Late spring 2nd term (05/15) 2012-2014**	**Summer term (06/10) 2012-2014**	**Early spring term (04/10) (control) 2012-2014**	**Late spring 1st term (04/25) 2012-2014**	**Late spring 2nd term (05/15) 2012-2014**	**Summer term (06/10) 2012-2014**
Dry mass yield, t/ha	Min	1.0	0.9	0.8	0.5	1.3	1.1	0.9	0.6
	Max	1.3	1.3	1.2	0.7	1.5	1.4	1.4	1.0
	Average	1.2	1.1	1.0	0.6	1.4	1.3	1.1	0.8
	Range of variation	0.3	0.4	0.4	0.2	0.2	0.3	0.5	0.4
Coefficient of variation (V), %		13.1	18.2	21.5	16.7	7.1	12.1	27.1	27.2
GAC_i		125	58	-75	-442	358	225	25	-275
SAC_i		61.4	82.4	86.0	36.6	36.6	61.4	121.1	86.0
Relative stability (S_{gi})		5.3	7.5	8.9	6.1	2.6	4.8	11.4	11.2
Plasticity (b_i)		0.84	1.16	1.21	0.58	0.58	0.84	1.57	1.21
Selection value (SVG_i)		742	529	371	347	1147	842	228	171

On average, the coefficient of yield variation for blue fenugreek was 17%, depending on individual sowing dates – from 13% to 22%; for hay fenugreek – 18%, depending on individual sowing dates – from 7% to 27%. In the case of blue fenugreek, a slight variation of the trait was found during the early spring sowing period, medium – late spring 1st season and summer, significant – late spring 2nd period. For hay fenugreek, a slight variation was found for the early spring sowing period, medium – for the late spring 1st sowing period, significant – for the late spring 2nd sowing period and summer.

Plasticity and stability allow predicting the behaviour of varieties in production conditions. Varieties where the regression coefficient is significantly lower than 1 belong to the neutral type. They do not respond well to changes in the environment. Under conditions of intensive farming, they do not reach high indicators, but under poor conditions, their indicators decrease to a lesser extent compared to varieties of the intensive type [36].

Varieties with a regression coefficient above 1 belong to the intensive type. In years with unfavourable weather conditions, including when there is a low agricultural background, they sharply reduce productivity. A close to zero or zero value of the regression coefficient reflects a variety that does not respond to environmental changes. With a smaller square deviation of the real indicators compared to the theoretically expected ones, the variety is more stable [37].

The coefficient of regression of dry weight yield of fenugreek species was different. During the late spring 1st and 2nd sowing periods, blue fenugreek responds well to improved growing conditions (b_i >1): with an increase in average yield by 1 kg/ha, the increase in dry weight was 1.16 and 1.21 kg/ha, respectively. The lowest sensitivity to changes in environmental conditions for blue fenugreek was established during the early spring and summer sowing period: with an increase in average yield by 1 kg/ha, the increase in dry weight was 0.84 and 0.58 kg/ha, respectively.

Hay fenugreek is characterized by high sensitivity (b_i>1) to the improvement of growing conditions during the late spring 2nd and summer sowing periods: with an increase in the average level of yield by 1 kg/ha, the increase in dry weight was 1.57 and 1.21 kg/ha, respectively. Hay fenugreek reacted the least to the improvement of growing conditions during the early spring and late spring 1st sowing period: with an increase in the average level of yield by 1 kg/ha, the increase in dry mass was 0.58 and 0.84 kg/ha, respectively.

GAC characterizes the ability of a cultivated plant to obtain a consistently prominent yield under any conditions, and SAC indicates the plasticity of a cultivated plant, i.e., the ability to adapt to specific conditions (low temperature, drought, pests, etc.) [38].

At different sowing dates, the samples of fenugreek species under study ranged widely – from -442 to 358 according to the GAC parameter. The maximum GAC value was noted in hay fenugreek during the early spring and late spring 1st sowing period, with indicators of 358 and 225, respectively. For blue fenugreek, the maximum value was also established for the early spring and late spring 1st sowing period with indicators of 125 and 58, respectively. Summer sowing is characterized by the lowest GAC value.

The highest SAC value (86.0) for blue fenugreek was established in the late spring 2nd sowing period, and the lowest (36.6) – in the summer. For hay fenugreek, the highest SAC value (121.1) was established for the late spring 2nd sowing period, and the lowest (36.6) – for the late spring 1st sowing period.

The best variety for the test zone is the one that had the maximum GAC value, forms the highest yield under favourable growing conditions (weather and climatic conditions of the area, appropriate agricultural technology) and ensures prominent yield stability [39].

A variety with a high but unstable yield cannot guarantee maximum productivity in production conditions with insufficient care and adverse weather conditions. An integrated indicator that characterizes the combination of high productivity and stable yield in a variety is the selection value of the genotype (SVG_i) [40]. Early spring and late spring 1st sowing period samples are characterized by high breeding value.

Using correlation dependence calculations, the relationship between the parameters that evaluate the adaptive properties of genotypes was established (Table 2).

Table 2. Matrix of correlations between parameters of the adaptive capacity of fenugreek species (average for 2012-2014)

Indicator	Dry mass yield, t/ha	Range of variation, t/ha	Coefficient of variation (V), %	GAC_i	SAC_i	Relative stability (S_{gi})	Plasticity (b_i)	Selection value (SVG_i)
Dry mass yield, t/ha	1							
Range of variation, t/ha	-0.08	1						
Coefficient of variation (V), %	-0.60	0.82	1					

Indicator	Dry mass yield, t/ha	Range of variation, t/ha	Coefficient of variation (V), %	GAC_i	SAC_i	Relative stability (S_{gi})	Plasticity (b_i)	Selection value (SVG_i)
GAC_i	0.99	-0.08	-0.60	1				
SAC_i	-0.07	0.99	0.82	-0.07	1			
Relative stability (S_{gi})	-0.54	0.86	0.99	-0.54	0.86	1		
Plasticity (b_i)	-0.11	0.99	0.85	-0.11	0.99	0.88	1	
Selection value (SVG_i)	0.81	-0.64	-0.94	0.81	-0.64	-0.92	-0.66	1

The calculation of the correlation coefficient showed that the average yield has a direct strong relationship with the GAC index (r=0.99) and selection value (r=0.81) and an average inverse relationship with the coefficient of variation (r=0, 60) and relative stability (r=0.54).

GAC has a strong direct relationship with the index of average yield (r=0.99) and selection value (r=0.81) and an inverse average relationship with the coefficient of variation (r= -0.60).

The SAC index has a strong direct relationship with the range of variation (r=0.99), plasticity (r=0.99), relative stability (r=0.86), and coefficient of variation (r=0.82).

A direct strong relationship was established between relative stability and the coefficient of variation (r=0.99), plasticity (r=0.88), range of variation (r=0.86), SAC (r=0.86) and inverse average relationship with GAC (r= -0.54).

The plasticity indicator has a direct strong relationship with the SAC index (r=0.99), the range of variation (r=0.99), relative stability (r=0.88) and the coefficient of variation (r=0.85) and an inverse average relationship with selection value (r= -0.66).

Selection value has a direct strong relationship with average yield (r=0.81), and an inverse average relationship with GAC (r=0.81). An inverse relationship was found between the selection value and the coefficient of variation (r= -0.94), relative stability (r= -0.66), SAC (r= -0.64), and range of variation (r= -0.64).

A direct strong relationship was found between dry mass yield at different sowing dates and the total effective temperatures (r=from 0.66 to 0.99). An inverse medium and strong relationship (r=from -0.48 to -0.99) was found between the yield of dry mass at different sowing times and the amount of precipitation.

According to the results of the regression equations, it was found that an increase in the total effective temperatures by 1°C contributed to the fluctuation of the yield of the blue fenugreek: in the early spring period (control) – by 128 kg/ha (green mass) or by 6.06 kg/ha (dry mass); in the late spring 1st period – by 53.0 kg/ha (green mass) or by 3.98 kg/ha (dry mass); in the late spring 2nd period – by -11.1 kg/ha (green mass) or by -1.81 kg/ha (dry mass); in the summer period – by -4.82 kg/ha (green mass) or by -0.401 kg/ha (dry mass). An increase in the amount of precipitation by 1 mm affected the yield: in the early spring period (control) – by 146 kg/ha (green mass) or by 5.38 kg/ha (dry mass); in the late spring 1st period – by 28.3 kg/ha (green mass) or by 0.145 kg/ha (dry mass); in the late spring 2nd period – by -96.7 kg/ha (green mass) or by -22.7 kg/ha (dry mass); in the summer period – by -16.1 kg/ha (green mass) or by -3.42 kg/ha (dry mass).

An increase in the total effective temperatures by 1°C contributed to the fluctuation of hay fenugreek yield: in the early spring period (control) – by 14.1 kg/ha (green mass) or by 1.58 kg/ha (dry mass); in the late spring 1st period – by 33.9 kg/ha (green mass) or by 2.21 kg/ha (dry mass); in the late spring 2nd period – by 21.2 kg/ha (green mass) or by 6.63 kg/ha (dry mass); in the summer period – by 10.25 kg/ha (green mass) or by 4.33 kg/ha (dry mass). An increase in the amount of precipitation by 1 mm affected the yield: in the early spring period (control) – by 15.0 kg/ha (green mass) or by 1.07 kg/ha (dry mass); late spring 1st period – by 22.7 kg/ha (green mass) or by -0.693 kg/ha (dry mass); in the late spring 2nd period – by -77.3 kg/ha (green mass) or by 25.9 kg/ha (dry mass); in the summer period – by 18.4 kg/ha (green mass) or by 6.80 kg/ha (dry mass).

CONCLUSIONS

The obtained results suggest that the air temperature at different times of sowing had a great influence on the growth and development of plants, namely, the "sowing-seedling" period of fenugreek species varied from 6 to 12 days and passed for the total air temperatures (>10°C) 21.3-82.1°C and the total precipitation of 10.3-45.3 mm, "seedling–start of budding" – 26-39 days, 287.7-325.1°C, 40.7-123.3 mm; "beginning of budding–beginning of flowering" – 4-7 days, 48.0-78.9°C, 2.3-28.7 mm; "the beginning of flowering, the beginning of ripening of beans" – 3-12 days, 30.3-135.6°C, 3.6-35.7 mm; "seedling – the beginning of ripening of beans" – 35-55 days, 383.9-487.1°C, 70.7-144.3 mm.

Blue and hay fenugreek have the highest breeding value of the genotype (SVG_i =742 and 1,147, respectively) in terms of yield, high ecological stability (S_{gi} =5.3 and 2.6, respectively) and plasticity (b_i =0.84 and 0.58%, respectively) received during the early spring (II-III decade of

April) sowing period. To obtain a high yield of dry mass of plants, fenugreek should be grown during the early spring (II-III decade of April) and 1st late spring (III decade of April-I decade of May) sowing period, during which a more developed vegetative mass was formed and a higher yield of dry mass was established 1.3-1.4 t/ha – hay fenugreek and 1.1-1.2 t/ha blue fenugreek. The practical significance of the obtained results lies in the scientific substantiation of the best sowing dates of fenugreek for correcting the cultivation technology on the sod-podzolic soils of Polissia.

Elucidating the use and potential of particular fenugreek species is a promising area for research, as the complex relationships between nutritional value, water availability, and soil quality remain understudied, as well as their consumer appeal and opportunities for inclusion in value-added chains.

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Адаптивний потенціал видів пажитника за різних строків сівби

Анотація. Серед невивчених технологічних елементів вирощування пажитника в умовах України залишається створення конвеєрного вирощування культури, тому гостро стоїть проблема впливу термінів сівби на ріст і розвиток рослин, параметри врожаю та якісний склад товарної продукції. Мета досліджень полягала в обґрунтуванні оптимальних строків сівби видів пажитника для підвищення врожайності сушеної продукції в умовах Полісся на дерново-підзолистих ґрунтах. Провідними методами дослідження цієї проблеми є польовий – для визначення взаємодії об'єкта досліджень із біотичними та абіотичними факторами, статистичний – проведення оцінювання результатів досліджень для визначення параметрів адаптивної здатності пажитника. Упродовж 2012–2014 рр. за різного строку сівби середня врожайність сухої маси в пажитника голубого змінювалася в межах від 0,5 до 1,3 т/га, а в пажитника сінного від 0,6 до 1,5 т/га. Найвищою загальною адаптивною здатністю характеризувався ранньовесняний строк та пізньовесняний 1-го строку сівби. Найбільше значення специфічної адаптивної здатності встановлено за пізньовесняного 2-го строку сівби. Показник відносної стабільності коливався від 2,6 до 11,4. Пажитник голубий за пізньовесняного 1-го та 2-го строку сівби добре реагує на покращення умов вирощування (b_i>1), а пажитник сінний за пізньовесняного 2-го та літнього строку сівби. Високою селекційною цінністю характеризуються зразки за ранньовесняного й пізньовесняного 1-го строку сівби. Збільшення суми ефективних температур на 1 °С сприяло коливанню врожайності зеленої маси від 4,82 до 128 кг/га, а сухої маси від 0,401 до 6,63 кг/га. Водночас збільшення суми опадів на 1 мм вплинуло на коливання урожайність зеленої маси від 15,0 до 146 кг/га, а сухої маси від 0,145 до 25,9 кг/га. Товарна продукція видів пажитника формувалася в межах суми температур повітря (>10°С) 383,9–487,1°С, кількості опадів 70,7–144,3 мм, а вегетаційний період коливався від 35 до 55 днів. Найбільшу продуктивність видів пажитника виявлено під час сівби від ІІ декади квітня по І декаду травня. Матеріали статті становлять практичну цінність для розширення видового різноманіття овочів і підвищення забезпечення населення цінними продуктами харчування та під час застосування нових та удосконалених елементів технологій вирощування цінних малопоширених культур для досягнення максимального ефекту реалізації генетичного потенціалу рослин

Ключові слова: пажитник голубий, пажитник сінний, термін сівби, селекційна цінність генотипу