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STABILITY OF PRODUCTIVE TRAITS OF GENOTYPES OF CULTIVATED MEDICINAL PLANTS OF THE FAMILY *APIACEAE*

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ABSTRACT
Stability of productive traits (fruit yield, essential oil content) of varieties of cultivated medicinal plants belonging to the species of the family Apiaceae was studied (anise, coriander, dill, parsley and fennel). The trial was carried out in five locations in 2001. The estimate of stability parameters was done after the method of Eberhart and Russell (1966).
As expected, significant differences for the fruit yield and the essential oil content were determined among studied genotypes. Significant F-test differences were obtained for locations, while the genotype x environment interaction, as a source of variability for the identification of the growing region, had significant values of the F-test. This was a starting point for the analysis of stability parameters of these traits.
The most stable genotype is the one whose value of S^2di tends towards 0. Bearing this in mind, the most, i.e. the least stable yield was recorded in coriander, i.e. parsley, respectively. A somewhat different situation arises from the values of S^2di in relation to the essential oil content. According to the value of this parameter, the most, i.e. the least stable essential oil content was found in fennel, i.e. parsley, respectively.

Keywords: anise, coriander, dill, essential oil, fennel, parsley, stability, yield,

Introduction
Medicinal plant species express variability of quantitative and qualitative traits, and due to it, they have adapted to and grow under different agroecological conditions. It should be emphasised that medicinal plant genotypes with a lower yielding potential, similar to other plant species, often have a broader adaptability and better stability of the yield than high-yielding genotypes.

It is well known that a genotype is a result of effects of genetic and ecological factors and their interactions. Therefore, the genotype x environment interaction is a principal reason for the determination of differences in stability of traits among various genotypes.

The present study encompasses representatives of the family *Apiaceae*. Umbelliferae with about 3000 species belonging to 300 genera is a very large family. They are cosmopolitan species although are more commonly found in temperate regions. Annual or perennial herbaceous plants (rarely semi-shrubs or shrubs) are primarily the representatives of the family. Their stems have prominent nodes. Although herbaceous plants, their height can be 1-3 m due to very developed stem collenchyma. Leaves, are usually, alternate, notched or divided, often with extremely developed sheaths. All organs have secretory cavities. The small flowers are aggregated into compound inflorescences, in umbels. According to the symmetry, flowers are actinomorphous or weakly zygomorphous (terminal inflorescences). Flowers are most often hermaphrodite (there are unisexual flowers). Petals are usually white and yellow. There are five stamens alternatively replacing petals. Each carpel of the schizocarp is of a specific structure.

Several procedures for the determination of stability parameters and their application in the analysis of breeding material of different cultivated plants have been developed. One of the first studies based on the application of the regression analysis was performed by Yates and Cochran (15), and then by Finlay and Wilkinson (4). Plaisted and Peterson (12) developed a procedure that provided the evaluation of the proportion of the each genotype x environment interaction in the total variance of the genotype x environment interaction.

The model coined by Yates and Cochran was modified by Eberhart and Russell (1). Their model is based on the calculation of the linear regression (*bi*) for each genotype in relation to the environmental conditions, as well as, the deviation from regression S^2di. Afterwards, similar other developed methods were also based on the regression analysis (5, 10).

The objective of this study was to evaluate stabilities of the fruit yield and essential oil content of different species of the family *Apiaceae*, with the application of the model, which provides not only regression coefficient *bi*, but also a second parameter of stability, standard deviation form regression S^2di (1).

Material and Methods
The development of genotypes of the high-yielding cultivated plants is the most important task of breeding and selection. A high-yielding potential is expressed via yield components and a complex of other plant traits under appropriate environmental conditions. From the practical point of view, the adaptive

component, i.e. yield stability, is a very important, considering the fact that one variety, a genotype, is cultivated in various locations.

Therefore, the following five varieties of cultivated medicinal plants of the family *Apiaceae*, each represented with one genotype, were chosen to perform studies on stability of productive traits (fruit yield and essential oil content):

- anise (*Pimpinella aniseum* L.), variety N 210

The stem is erect and branched in the upper part. Lower leaves are kidney-shaped to oval, intact, toothed, and upper leaves are 1-3 times divided by linear-lanceolate segments. Umbels have 8 to 12 rays and countless number of white five-sepaled flowers. The fruit is egg-shaped, slightly hairy, and has pleasant and aromatic odour. It contains essential oil (1.5-5% with approximately 80% anethole), fatty oil, proteins, coumarin.

- coriander (*Coriandrum sativum* L.), variety: Domaći sitnozrni /Domestic small-seeded coriander/

The stem is erect, glabrous, stripped. Lower leaves are once or twice pinnately divided into wedged lobes, while upper leaves are 2-3 times pinnately divided into thready lobes. Umbels have 3-7 rays. Petals are white or reddish, outer ones are larger. Spherical fruit is brown or yellowish. It contains up to 1% of essential oil with 60-70% linalool.

- dill (*Anethum graveolens* L.), variety: Domaća aromatična /Domestic aromatic dill/

The stem is round, glabrous, hollow, finely furrowed and branched in the upper part. Leaves are divided three or four times into pinnate sections. Umbels are large with 30-50 rays. Flowers are small and yellow. The yellowish-brown, 5-ridged, flattened, ovoid fruit contains up to 4% of essential oil (carvone, dillapiol), kafen and chlorogenic acid, fatty oil, coumarin (umbeliferon, skopoletin).

- parsley (*Petroselinum sativum* Hoffm.), variety: Domaći lišćar /Domestic flat-leaf parsley/

The stem is erect. Leaves are glossy, dark green, pinnately divided. Umbels have 7-30 rays. Petals are white and yellowish-green. The oval fruit is green-grey to grey-brown. The whole plant smells pleasantly. In the fruit (seed): essential oil (2-6% phenylpropanoids, apiol and myristicin are dominant), fatty oil, flavonoids (α-pinene), furocoumarin in traces (bergaptene).

- fennel (*Foeniculum vulgare* Mill.), variety: Vojvođanski /Vojvodian fennel/

The stem is hollow, round, finely furrowed. Glabrous, green to grey-blue leaves are pinnately divided into almost thready sections. Umbels are large with 4-25 rays. Flowers are dark yellow. Yellow-green to yellow-brown fruit is elongated, oval with prominent ribs. It contains 2-6 % of essential oil, fatty oil, flavonoids, proteins, organic acids.

These five species were selected as they are produced directly from the seed (fruit), and the aim of the production is mainly seed (fruit), which is used as a medicinal raw material. The studied plant species are, within the filed of alternative medicine, grown for their fruits that contain essential oils composed of numerous ingredients that are more or less complex organic compounds. The ingredients cause their pharmacological effect, i.e. therapeutic effect and medicinal applications. In addition to their use in alternative medicine, these plant species are commonly used as aromatic and spice plants.

The three-replicate trial was carried out according to randomised block design in five locations (1 - Kučevo, 2 - Veliko Gradište, 3 - Smederevo, 4 - Stara Pazova, 5 - Inđija) in 2001. Each variety was grown in three 5-m long rows per a replication. The inter-row distance was 20, 25, 30, 30 and 50 cm for anise, coriander, dill, parsley and fennel, respectively. Common cropping practices, such as in the regular production, were applied during the growing period.

The task of each regression analysis related to the genotype x environment interaction is to separate the agronomically most important effects. The model developed by Eberhart and Russell (1) has been adopted in our country, as well as, world wid. The model combines the analysis of variance and the regression analysis. Stability parameters are calculated on the basis of the regression of each genotype in the ecological index experiment, as well as, on the function of the variance from regression (square deviation).

Based on the following mathematical model developed by Eberhart and Russell (1), the values of stability parameters (*bi*) for each genotype and the deviation form the regression line (S^2di) were used to estimate stability of yields:

$$Yij = \mu i + biIj + \delta ij,$$

where:

Yij - mean of genotypes *i* at the location *j*

μi - grand mean of genotypes *i* at all locations

bi - regression coefficient of genotypes *i* over locations

δij - deviation form regression

Ij - environmental index (ecological index) calculated as a difference of means of all genotypes at the location *j* and the total mean in all locations - *grand mean.*

$$Ij = (\sum_i Yij/g) - (\sum_i \sum_j Yij/gn),\ \sum_j Ij = 0$$

The first stability parameter is a standardised regression coefficient (*bi*), which is standardised in relation to 1:

$$bi = \sum_j YijIj : \sum_j I^2j$$

The analysis of variance after the model of Eberhart and Russell (1) does not separate locations and years, but provides their observation as an eco-environment. The total sum of squares is divided into the part belonging to the genotypes and the part included into the effect of uncontrolled factors (errors). Uncontrolled factors encompass the eco-environment, the genotype x environment interaction and other uncontrolled elements (**Table 1**). Sums of squares belonging to the effects of environments and the genotype x environment interaction,

TABLE 1

ANOVA after the model of Eberhart-Russell (1), that is included into the regression analysis

Source of variation	d.f.	Sum of squares	Mean squares
Total	gn-1	$\sum_i \sum_j Y_{ij}^2$ -C.F-	
Genotypes (g)	g-1	$\left[\sum_i Y_i^2 / n\right]$-C.F.	MS1
Eco-environment (E)+GxE	(n-1)+(g-1)(n-1)=(n-1)g	$\sum_i \sum_j Y_{ij}^2 - \sum_i Y_i^2 / n$	
E (linear)	1	$\left[\sum_j (Y_j I_j)^2 / g\right] / \sum_j I_j^2$	
GxE (linear)	g-1	$\left\{\sum_i \left[(\sum_j Y_{ij} I_j)^2 / \sum_j I_j^2\right]\right\} - \left\{\left[(\sum_j Y_j I_j)^2 / g\right] / \sum_j I_j^2\right\}$	MS2
Total deviation	(n-2)g	$\sum_i \sum_j \delta_{ij}^2$	MS3
Genotype 1 . . Genotype n	n-2 . . n-2	$\left[(\sum_j Y_{1j}^2) - (Y_1^2 / n)\right] - \left[(\sum_j Y_{1j} I_j)^2 / \sum_j I_j^2\right] = \sum_j \delta_{1j}^2$ . . $\left[(\sum_j Y_{gj}^2) - (Y_g^2 / n)\right] - \left[(\sum_j Y_{gj} I_j)^2 / \sum_j I_j^2\right] = \sum_j \delta_{gj}^2$	
Total error	n(r-1)(g-1)		

as well as, the deviation from the regression are separated from the sum of squares of errors by the regression analysis. Hence, the sum of squares of the environment (E) and the genotype x environment interaction (GxE) is decomposed into the eco-environment (linear), the genotype x environment interaction (linear) and the total deviation from regression. The ecological index is considered constant in this model. The sum of squares of the linear regression of the ecological mean for the ecological index equals the ecological sum of squares with one degree of freedom (E - linear). GxE (linear) means heterogeneity of coefficients of regression.

Behaviour of each genotype can be predicted on the basis of the regression line equation $\hat{Y}ij = \bar{x} + biIj$. Deviations $[\hat{\delta} = Yij - \hat{Y}ij]$, digressions of each individual regression from the average regressions (b=1) can be squared (variance) and added in order to represent another stability parameter S^2di.

Statistical significance of the regression coefficient (*bi*) is estimated by the group F-test or the individual t-test.

Another stability parameter is the standard deviation from regression that is estimated by the definition:

$S^2di = (\Sigma\delta ij : (n\text{-}2)) - Se : r$, where:

Se - error mean squares from the analysis of variance, *n* - number of locations and, *r* - number of replications.

Se^2/r is obtained from the total error, i.e. variance of a genotype mean at the location/eco-environment *j*.

$$\sum_j \delta_{ij}^2 = \left[(\sum_j Y_{ij}^2) - (Y_i^2 / n)\right] - \left[(\sum_j Y_{ij} I_j)^2 / \sum_j I_j^2\right]$$

In such a way, the GxE interaction of each genotype is divided into the variation caused by the genotype response to the variation of the ecological index (sum of squares belonging to the regression) and to unexplained deviations from regression for the ecological index.

According to this model, a desirable genotype is the one with the expected mean, coefficient of regression of 1 (*bi* =1) and with the smallest possible deviation from the regression (S^2di=0). The value of the coefficient of regression higher than 1 (*bi*>1) points to a genotype better adopted to more favourable agroecological conditions, while values of this parameter lower than 1 (*bi*<1) is characteristic for genotypes better adjusted to conditions with a lower potential for a certain trait (yield, etc.).

The significance of differences among averages of genotypes (X_0: $\mu_1 = \mu_2 = ... = \mu_g$) is tested by the F-test: F≈MS1/MS3 (**Table 1**).

The hypothesis of the non-existence of genetic differences for their regressions for the ecological index (X_0: $\beta_1 = \beta_2 = ... = \beta_g$) is tested by the F-test F≈MS2/MS3 (**Table 1**). The significance of differences of the coefficient of regression of 1 is tested by the t-test. Testing deviations form regression for each genotype can only be calculated by the division of their mean squares with the total error (ε_{ij}):

TABLE 2

Fruit yield (kg ha^{-1})

Species	Variety	Locations					Average (kg)	Rank	C V (%)
		1	2	3	4	5			
Anise	N210	405	482	481	313	477	432	5	15.3
Coriander	Domaći sitnozrni	649	964	1213	807	751	877	2	22.4
Dill	Domaća aromatična	614	789	812	827	756	760	4	10.0
Parsley	Domaći lišćar	1642	2341	2210	2014	2085	2058	1	11.0
Fennel	Vojvođanski	1020	894	751	814	823	860	3	23.0
	Average	866	1094	1093,4	955	978.4			
	$LSD_{0.05}$ $LSD_{0.01}$	23.79 31.70							

TABLE 3

Essential oil content (%)

Species	Variety	Locations					Average (%)	Rank	C V (%)
		1	2	3	4	5			
Anise	N210	1.40	1.63	1.84	2.17	3.07	2.02	4	29,0
Coriander	Domaći sitnozrni	0.72	0.80	0.50	1.20	0.96	0.84	5	28,0
Dill	Domaća aromatična	2.62	3.15	3.74	1.86	2.81	2.84	3	21,8
Parsley	Domaći lišćar	4.16	2.31	3.27	2.07	2.58	2.88	2	26,3
Fennel	Vojvođanski	3.11	2.50	3.69	2.78	3.56	3.13	1	12,0
	Average	2.402	2.078	2.608	2.016	2.596			
	$LSD_{0.05}$ $LSD_{0.01}$	0.19 0.26							

$$F \approx [\sum_i \hat{\delta}_{ij}^2 /(n-2)]/\varepsilon_{ij}.$$

The lack of significance of an F value of a certain genotype points to its better stability under given ecological conditions.

Conclusions on genotype stabilities are drawn by ranking deviations of the coefficient *bi* from 1 and values of variance of deviations from the regression s^2di.

Results and Discussion

As it was dealt with several species whose varieties had responded differently to the production conditions, means of traits over locations were also different. Pursuant to means of analysed traits, their variations were also dissimilar. The fruit yield varied as shown by the coefficient of variation (10.0% - dill to 23.0% - fennel), while the variation of the essential oil content was more pronounced and ranged from 12.0% (fennel) to 29.0% (anise), (**Table 2** and **Table 3**). A relatively high coefficient of variation points to a different response of genotypes to environmental conditions. It is another reason to analyse stability parameters of both, the yield and the essential oil content of the family *Apiaceae*.

The average fruit yield varied from 432 kg ha^{-1} (anise) do 2058 kg ha^{-1} (parsley). Veliko Gradište and Smederevo were the most suitable locations for the cultivation of these medicinal plant species, while Kučevo was the least favourable location (**Table 2**). The location Kučevo was the most unfavourable for the growth of coriander, dill and parsley, while fennel grew best, and had the highest achieved yield (1020 kg ha^{-1}), (**Table 2**). Coriander throve in Smederevo, which was the least favourable location for the cultivation of fennel. The best conditions for the cultivation of dill, i.e. parsley were recorded in Stara Pazova, i.e. Veliko Gradište, respectively. Anise had the lowest (313 kg ha^{-1}), i.e. highest (482 kg ha^{-1}) fruit yield in Inđija, i.e. Veliko Gradište, respectively (**Table 2**).

The average essential oil content (%) varied from 0.84% (coriander) to 3.13% (fennel) (**Table 3**). Smederevo with the highest average essential oil content (2.608%) was the most suitable location for the production of these medicinal plant species. On the other hand, Stara Pazova was the least

TABLE 4

Analysis of variance for fruit yield and essential oil content

Source of variation	df	MS	
		fruit yield	essential oil content
Genotype	4	5780515.50**	13.22**
Location	4	184749.34	1.18
Genotype x location	16	77018.41**	1.16**
Error	50	1051.12	0.07

TABLE 5

Stability parameters for fruit yield and essential oil content

Species	Traits							
	fruit yield				essential oil content			
	bi	Rank	Sdi_1^2	Rank	bi	Rank	Sdi_1^2	Rank
Anise	1,161	1	11981,92	1	0,737	1	0,485	4
Coriander	1,969	4	3832,58	2	-0,553	5	0,037	2
Dill	0,531	2	5008,28	3	1,448	2	0,392	3
Parsley	2,034	5	24700,89	5	1,666	3	0,639	5
Fennel	-0,695	3	5482,07	4	1,703	4	0,012	1
Se_{bi}	0,469				1,031			

suitable location for such production as the average essential oil content amounted to 2.016%. Dill and fennel (3.74%) had the highest average essential oil content in Smederevo. In the same location, coriander had the lowest average essential oil content (0.50%). Kučevo, as a location, was the most suitable for the parsley cultivation and the least suitable for the anise cultivation. The highest average essential oil content of coriander (1.20%) was registered in Stara Pazova. This location was the least suitable for the cultiavion of dill and parsley. The highest average essential oil content of anise (3.07%) was detected in Inđija, while fennel had the lowest average essential oil content (2.50%) in Veliko Gradište (**Table 3**). The majority of genotypes are significantly distinguishable from one another for the yield and the essential oil content, hence these difference are not going to be stated in this paper. The variation among species of this family related to these traits is extreme, due to specific biological differences of each of the species and their different adaptedness to growing conditions. The variability of these two traits is significantly affected by genotypes, i.e. studied varieties, as well as, the genotype x environment interaction (**Table 4**).

According to the values of the stability parameter *bi*, the most stable fruit yield was recorded in anise (b=1.161), while the value of S^2d=11981.918 points out that anis ranked fourth with only parsley lagging behind (**Table 5**). Parsley responded best to favourable production conditions (b=2.034), while fennel responded best to unfavourable production conditions (b=-0.695). The most stable genotype is the one in which *bi* = 1 and S^2di tends to 0. Based on the values of the stability parameter *bi*, the most and the least stable are anise and fennel, respectively. On the other hand, based on the second stability parameter S^2di, the most and the least stable are coriander and parsley, respectively.

According to the values of the stability parameter *bi*, relatively the most stable essential oil content was recorded in anise (b=0.737), (**Table 5**). Fennel responded best to favourable production conditions (b=1.703), while coriander responded best to unfavourable production conditions (b=-0.553). Information based on the values of S^2di are somewhat different for these two traits. Hence, the most, i.e. the least stable essential oil content was detected in fennel, i.e. parsley, respectively. The values of stability parameter *bi* for the yield and the essential oil content were not significant, probably due to a low number of studied genotypes, hence the value *S.E.* was very high ($S.E._{(bi)}$=0.469 for the yield and $S.E_{.(bi)}$=1.031 for the essential oil content). Furthermore, these values were probably affected by the fact that varieties, and not genotypes of a species, were included into studies.

Significant differences for the fruit yield and the essential oil content were determined among studied genotypes, as expected. Significant F-test differences were obtained for locations, while the genotype x environment interaction, as a source of variability for the identification of the growing region, had significant values of the F-test, **Table 4**. This was a starting point for the analysis of stability parameters of these traits in this family (**Table 5**).

On the basis of the values of the stability parameter *bi*, the most stable yield and essential oil content were registered in anise (b=1.161 and b=0.737, respectively **Table 5**). The best response to favourable, i.e. unfavourable growing conditions was revealed by parsley (b=2.034), i.e. fennel (b=-0,695), respectively. The most stable genotype is the one whose value of S^2di tends towards 0. Bearing this in mind, the most, i.e. the least stable yield was recorded in coriander, i.e. parsley, respectively. Furthermore, the most, i.e. the least stable essential oil content was found in fennel, i.e. parsley, respectively. The values of stability parameter *bi* for the yield and the essential oil content were not significant, probably due to a low number of studied genotypes, hence the *S.E.* values were high (*S.E.bi*=0.469 and *S.E.bi*=1.031 for the yield and the essential oil content, respectively) and because varieties, and not genotypes of a species, were included into the study.

Relatively high coefficients of variations for the observed traits confirm the pronounced effect of the environment. Certain genotypes of these more or less heterogeneous varieties are more or less affected by environmental conditions and are more or less in the interaction with them. This effect affected the variation of yields over locations in a very wide interval (CV varies from 10 to 23% in friut yield and from 12 to 29% in the essential oil content, (**Table 2** and **Table 3**). This was also confirmed by the analysis of variance (**Table 4**). The effect of genotypes on the variation of these traits is more significant than the effect of locations, as different species within one family were studied. A statistically significant genotype x eco-factor interaction resulted in the application of the analysis of stability parameters. This analysis should point out to stability of studied traits and responses to favourable and unfavourable growing conditions. Knowing responses of species can contribute to the improvement of their zonation. This information can be useful for breeding programmes of these species.

The values of year x environment interaction are generally lower in genotypes of the broad genetic base (populations) than in those of the narrow genetic base (hybrids and inbreds lines; (1, 13, 14). These authors assume that it is possible, in the process of selection, to develop genotypes of a narrow genetic base with a high-yielding potential and of satisfactory adaptability. This conclusion is quite important, as today, broad genetic base populations and varieties, with greater stability of the yield and other traits are used in the production of medicinal plants. Out of such a breeding material, it is possible to derive genotypes of high stability and high yields but of a narrow genetic base.

It is quite common that better yielding genotypes also respond better to environmental conditions and vice versa (2, 7, 16), which was also confirmed by these studies (variety of parsley, **Table 5**). In relation to the essential oil content, it can be stated that genotypes with a higher content responded better to favourable growing conditions (**Table 5**; dill, parsley and fennel). Petrović et al. (11) determined that the yield dependence and the values of regression coefficient could be positive and negative, as was also established in these studies (**Table 2**, **Table 3** and **Table 5**). These authors emphasise that genotypes, improved by selection, have not only better combining abilities for the yield, but also respond better to favourable growing conditions than the initial populations. These results are in accordance with results obtained by Moll et al. (8), Fakorede and Mock (3) and others.

Fakorede and Mock (3) studied heterogeneous and heterozygous genotypes (populations, synthetic varieties and hybrids) that represented mixed genotypes and that differently responded to the growing conditions and concluded that the regression coefficient (*bi*) had been more significant than the deviation from the regression line (S^2di) for such genotypes. Our results also confirm that *bi*, as a stability parameter, is more significant than S^2di in heterogeneous and heterozygous genotypes. Lamky and Hallauer (7) found a significant value of S^2di in seven out of 45 maize populations. The values of S^2di were high in these studies. This points out to a more significant deviation from regression and an unsatisfactory stability of studied genotypes, as values of this parameter did not tend to 0. In order to additionally improve these genotypes, it is necessary to analyse variability and stability of the yield of each genotype within the population (heterogeneous and heterozygous variety), (6, 9).

It should be underlined that the direct comparison of our results with results obtained by other authors is not possible, as there are no literature data on stability of these species under production conditions in our country. Such studies have generally been performed with more important field crops for which the zonation, was, more or less, established. Medicinal plants were to a smaller extent included in such studies, hence it is necessary to determine stability, first of all, for the yield and the essential oil content of these species.

The analysis of variance and stability of these traits in observed species of the family *Apiacae* in several locations, facilitates the implementation of breeding programmes of these species and provides a possibility for their more reliable zonation.

Conclusions

Significant differences for the fruit yield and the essential oil content were determined among studied genotypes, as it was expected. In the analysis of variance, the effect of the location on variability of the yield and the essential oil content was not significant, while the genotype x environment interaction, as a source of variability for the identification of growing regions, expressed a significant effect. This was a starting point for the analysis of stability parameters of these traits.

The most stable fruit yield and the essential oil content were detected in anise (b=1.161 and b=0.737). On the other hand, the least stable fruit yield and the essential oil content were determined in parsley (b=2.034) and coriander (b=-0.553). The best response to favourable, i.e. unfavourable production conditions was shown by parsley (b=2.034), i.e. fennel (b=-0.695), respectively. With the respect to the essential oil content, fennel (b=1.703), i.e. coriander (b=-0.553) responded best to the favourable, i.e. unfavourable growing conditions, respectively.

The comparison of heterogeneity of coefficients of regressions with the values of the standard error of coefficients of regressions - $S_e(bi)$ shows that the higher value of this parameter was in the essential oil content ($S_e(bi)$= 1.031). This means that the observed species differed in stability. These differences were expressed by the coefficient of regression for this trait.

Obtained results point out to the need for further studies on relations between genotypes and environments with the aim to identify the most suitable regions for the cultivation of these plant species.

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