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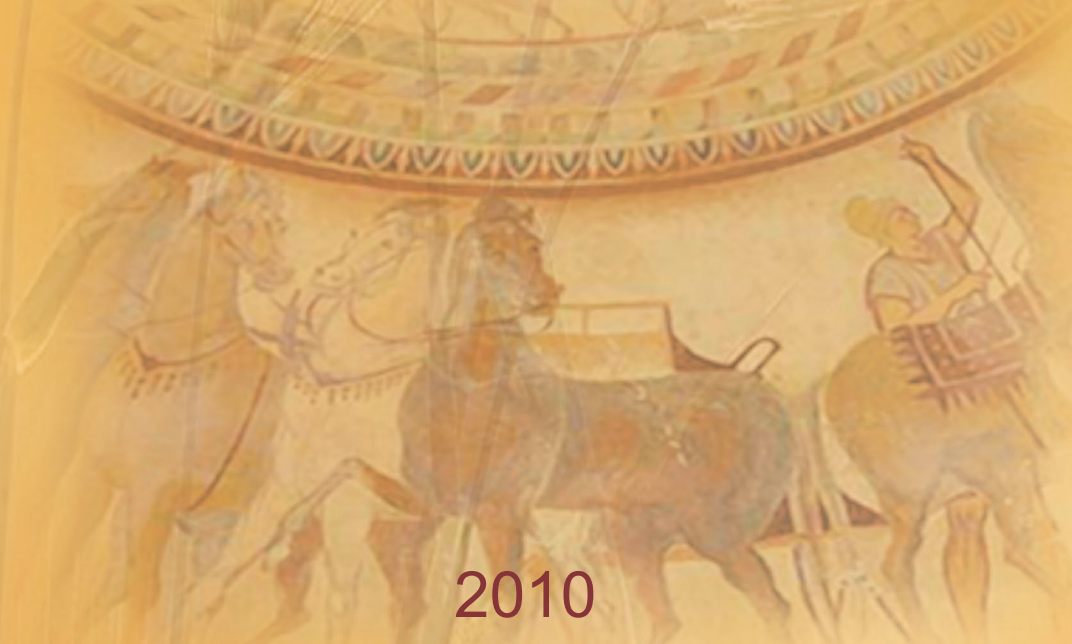

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Evaluation of the stability and adaptability of the Bulgarian lavender (*Lavandula angustifolia* Mill.) sorts yield

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Abstract. *In the years 2005-2009 six Bulgarian sorts of lavender were tested for fresh blossom yield and essential oil yield, as well as one seed population, formed by the seed offspring of these sorts. With all studied sorts and seed population, the fresh raceme yield and the essential oil yield are mostly affected by the specific interaction between the genotype and the current year conditions of cultivation – 69% and 80.4%. The "Druzhba", "Sevtopolis", "Yubileina" and "Hebar" sorts are characterised with a high adaptability, but they retain their yield stability only when the soil and climate conditions of cultivation are good. The "Hemus", and "Raya" sorts and their seed population give highly stable yields even in less favourable conditions of cultivation.*

Keywords: lavender, factors of variation, coefficients of variation, regression coefficient, total adaptation.

Introduction

More than 40 years of selection of lavender sorts in Bulgaria have resulted in the creation of a number of high-yield sorts. Across all essential oil-bearing crops the essential oil yield varies a lot, both in the different stages of blooming, and also in the different phases of the day and night. As a result of extensive research it was found that the highest quantity of essential oil in the fresh lavender racemes accumulates in the warm hours of the day, in quiet and sunny weather, and with 75% blooming of plants (Topalov, 1962). In the last few years it has been noticed that there are significant differences in the yields of fresh racemes and those of the essential oil of various sorts due to the especially varied climatic conditions. That is why, it is considered especially important to identify those sorts, which are characterized by higher stability and adaptability, so that farmers could rely on stable annual yields, regardless of the particular environmental conditions.

In Bulgaria the interaction between genotype and the environment in the case of lavender has not been studied so far, while this has already been done for potatoes, sunflower, *Brassica oleracea* L, broccoli, etc (Antonova, 2003; Mihov and Filipov, 2005; Nacheva, 2004; Todorova et al., 2004).

Material and methods

In the years 2005-2009 six Bulgarian sorts of lavender were tested for fresh blossom yield and essential oil yield, as well as one seed population, formed by the seed offspring of these sorts. The experiments were carried out according to a block method, which included all variants in four replications. The plantation was cultivated in line with the technology commonly used in the country.

The findings were processed mathematically, and subjected to a two-factor dispersion analysis (Lakin, 1990), with an assessment of the influence of the factors of variation (Plohinskii, 1970); coefficients of variation (Genchev et al., 1975) were established, as well as stability parameters: regression coefficient *bi* and the mean square deviation from regression S^2di (Eberhart and Russell, 1966) and the index of total adaptation Xi-bi (Raj et al., 1997).

Results and discussion

As a result of the dispersion analysis it was found that the biggest influence (69%) on the yield of fresh racemes of all sorts and the population is that of the specific interaction of the genotype and the environmental conditions in the year of the experiment. The differences that exist across the five years of studies account for just 23.3 % of the total dispersion of the studied indicators, and the least important is the genotype (sort, population)- 6.7% (Table 1). Similar results were shown by the study of the impact of the factors on the essential oil yields. The sort (genotype) accounts for only 6.2%. Only 13.1% of the total impact is due to the conditions during the year, whereas the specific genotype-environment interaction for the particular year of cultivating is really important – 80.4% of the total dispersion of evaluated indicators (Table 2).

Since the validity of the genotype-environment interaction has been verified, it has become possible to identify the parameters of stability and adaptability of different sorts (Table 3 and 4) with regard to the yields of blossoms and essential oil (Becker and Leon, 1988; Valchinkov, 1990; Stoffella et al., 1984). The data analysis of the fresh blossom R. shows that the variation of this indicator is within very small limits for all sorts – from 15.7% for the seed population to 20.0% for the "Sevtopolis" sort. The highest average productivity over the five years of study is for the "Druzhba" sort, 4.314 t/ha, and the lowest is for the seed population, only 2.478 t/ha. The rest of the sorts have an average yield between 3.4 and 3.9 t/ha. The definition "most stable genotype" applies to "Hemus", whose coefficient is 1.06. "Druzhba" and "Yubileina" can be described as more responsive to more favorable production conditions, as their regression coefficient *bi* is higher that 1.The other sorts with values lower than 1 can be characterized as suitable for cultivation in less favourable conditions, where they will give more stable yields. One value here deserves special attention: the coefficient *bi* for the seed

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Table 1. Dispersion analysis and power of variation factors on fresh lavender raceme yields

Sources of variation	Degree of freedom	Variance	Variation factors power, %
Sort	6	11343.33**	6.7
Year	4	58839.00**	23.3
Sort x year	24	29077.66**	69.0
Residual	102	48.13	

LSD*, ** - variances are valid with P<0,05 and P<0,01, respectively

Table 2. Dispersion analysis and the effect of the factors of variation on lavender essential oil yields

Sources of variation	Degree of freedom	Variance	Variation factors power, %
Sort	6	856.96**	6.2
Year	4	2719.35**	13.1
Sort x year	24	2786.94**	80.4
Residual	102	1.98	

LSD*, ** - variances are valid with P<0,05 and P<0,01, respectively

Table 3. Parameters of stability and adaptability of fresh lavender blossom yields

Sort	Yield	Variation coefficient	Parameters of stability		Index of total adaptability
	t/ha	%	bi	S²di	Xi - bi
Hemus	3.388	19.3	1.060	0.109	2.328
Druzhba	4.314	17.4	1.556	0.030	2.758
Sevtopolis	3.766	20.0	0.723	0.491	3.043
Yubileina	3.874	16.9	1.358	0.093	2.516
Raya	3.588	18.7	0.823	0.346	2.765
Hebar	3.414	17.8	0.871	0.186	2.543
Seed population	2.478	15.7	0.609	0.119	1.869

Table 4. Parameters of stability and adaptability of lavender essential oil yields

Sort	Yield	Variation coefficient	Parameters of stability		Index of total adaptability
	kg/0,1ha	%	bi	S²di	Xi - bi
Hemus	5.929	32.3	0.846	0.759	5.083
Druzhba	7.948	31.4	1.552	0.413	6.396
Sevtopolis	7.830	30.4	1.138	2.719	6.692
Yubileina	8.465	22.0	1.059	0.635	7.406
Raya	8.562	21.2	0.779	1.189	7.783
Hebar	8.068	27.0	1.024	1.066	7.044
Seed population	4.557	26.4	0.559	0.673	3.998

population is only 0.609. The evaluated sorts do not differ significantly in their plasticity. The total adaptation index values for all sorts are between 2.3 (for the "Hemus" sort) and 3.0 (for the "Sevtopolis" sort). The seed population has a lower total adaptation compared with all the other sorts, which shows a more limited adaptability.

Evaluating the stability and adaptability parameters of the essential oil yields for Bulgarian lavender sorts and the seed population, we have found higher values and wider variation coefficient ranges in comparison with those calculated for fresh blossom yields: from 21.2% for "Raya" to 32.3% for "Hemus". A good stability of the essential oil yield in favourable environments is present in the case of the "Druzhba" sort. The most stable genotypes with regard to this indicator are the "Yubileina" and "Hebar" sorts, with regression coefficient values of almost 1. The regression coefficient values for "Hemus", "Raya", and the seed population show that these will give relatively more stable essential oil yields in less favourable conditions of production.

The essential oil average yield values for the five years of study of "Druzhba", "Yubileina", "Sevtopolis", "Raya", and "Hebar" are very close and higher than the arithmetical mean of this group. "Hebar" and the seed population are significantly inferior in yield and have a lower adaptation index. The other genotypes can be described as more adaptable to the various conditions of production.

The comparative analysis of the findings has enabled us to differentiate the studied sorts and the seed population not only with regard to each one of the indicators in the study, but also to describe them with relation to their productivity complex, combining the fresh raceme yields and the essential oil yields, and their respective stability and adaptability. According to the results the following characteristics can be given:

- The "Hemus" sort is not characterized with high productivity, but on the other hand, it is exceptionally stable for its blossom yield, regardless of the conditions of cultivation.

• The “Druzhba” sort is generally characterized by strong growth and powerfully developed tuft during vegetation, leading to high yields, but it offers stable yields only when the conditions of cultivation are favourable.

• The “Sevtopollis” sort combines high productivity and adaptability, as well as higher yield of the blossom in less suitable conditions, but more stable essential oil yield can be expected in better conditions of cultivation.

• The “Yubileina” sort is one of the most productive sorts created here with high adaptability and stability of the essential oil yield, regardless of the cultivation conditions. However, this sort provides higher stability of the blossom yield only if the conditions are relatively good.

• The “Hebar” sort possesses the same characteristics of these indicators as the “Yubileina” sort.

• The “Raya” sort and the seed population differ significantly in their yields and in their adaptability to the environment /the “Raya” sort shows significantly higher raceme and essential oil yields and a higher adaptability/, but both the sort and the population give more stable yields in less favourable conditions of cultivation.

Conclusion

With all studied sorts and seed population, the fresh raceme yield and the essential oil yield are mostly affected by the specific interaction between the genotype and the current year conditions of cultivation.The “Druzhba”, “Sevtopolis”, “Yubileina” and “Hebar” sorts are characterized with high adaptability, but they retain their yield stability only when the soil and climate conditions of cultivation are good. The “Hemus” and “Raya” sorts and their seed population give highly stable yields even in less favourable conditions of cultivation.

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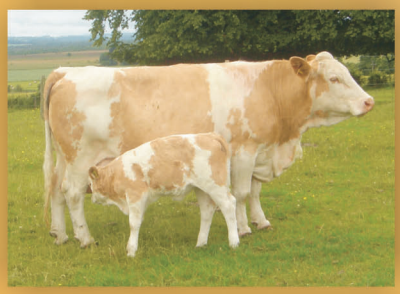

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