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Adaptive possibility and yield stability of varieties of oil-bearing roses

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Abstract. *Oil bearing roses are traditionally grown in regions like the famous "rose valley" in Bulgaria where the climate is known to be favorable for high rose flower and essential oil yield. However, environmental conditions could vary within the microregions of the rose valley as well as between years. In the current study four oil rose cultivars (cv. Yanina, cv. Elejna, cv. Iskra and cv. Svezhen) have been evaluated for the stability and adaptability of the yield of fresh flower and essential oil. The adaptive potential and response of the four cultivars to unfavorable environmental conditions* are *discussed. The study is a first step for implementing targeted distribution of oil rose planting material to different microregions of the "rose valley" and other rose growing regions.*

Keywords: oil-bearing roses, adaptability, stability

Introduction

The climatic changes during the last several years have brought periods of long drought. These changes have led to substantial drop of the oil rose flower yields and respectively rose essential oil. The amount of rose flowers necessary for production of 1 kg of rose oil has dramatically increased. While in the past the necessary amount of rose flowers for production of 1 kg of rose oil was around 3000-3500 kg, today this amount has reached 4000-4500 kg of rose flowers. This has influenced the prime cost of the product rose oil and its competitiveness. Until now research on the stability and adaptability of the yield of the oil rose cultivars has not been done in Bulgaria. This leads to the necessity Bulgarian cultivars to be characterized in terms of their adaptability and stability of yield under industrial conditions in the "rose valley" (the valley of the town of Kazanlak).

As a result of the numerous studies on the biodiversity of the Kazanlashka oil rose population done by Topalov (1978), Staykov and Astadzhov (1975), Astadzhov (1975), the cultivars Iskra and Svezhen have been created. Tsvetkov (1984) has created 14 clones through ionizing radiation and supermutagens. Two of them with a proven cold resistance and resistance to important from economic point of view diseases have been proposed for cultivar registration - cv. Eleyna and cv. Yanina. Subject of the current study are the above-mentioned above four cultivars. Data is presented related to the index of productivity of fresh flower (t/ha) and rose oil yield (kg/ha) for the period 2006-2009.

The aim of the current research is to evaluate the Bulgarian rose oil cultivars for their effectiveness for production based on the adaptive potential and resistance to changing environmental conditions.

Material and methods

Rose growing and flower harvesting

The rose cultivars have been grown on the territory of IRAP using the block method, with 4 variants (cultivars) in 3 repetitions at 16 m^2 planted area for each. The flower has been harvested each day during the whole flowering period and the total harvest has been accounted for at the end of the rose-picking season.

Rose oil distillation

The content of rose oil was estimated through microdistillation of mean samples of the particular variants.

Statistic analysis of the data

The statistical processing of the data was done using the BIOSTAT statistical package (AnalystSoft, Biostat). The data obtained were mathematically processed by dispersion analysis of two factors (Genchev et al., 1975; Lakin, 1990) assessing the strength of influence of the factors of variation (Plohinskii, 1970). The coefficients of variation (Genchev et al., 1975), the parameters of stability: coefficient of regression *bi* and the mean square deviation from the regression S^2di (Penchev, 2009; Eberhart and Russell, 1966) and the index for general adaptation *xi – bi* (Valchinkov, 1990) were estimated. Using the model of Eberhart and Russell (1966), the coefficient of determination has been presented calculated on the basis of correlation between the mean values for the particular genotype under the conditions of analysis and the mean values of all assessed genotypes under the same conditions.

Results and discussion

The results from the combined analysis on the yield of fresh flower and essential oil are presented in Table 1. The effects of the year, the genotype and their interaction with the exception of "year" and "cultivar x year" over flower yield are with high significance ($p<0,01$, $p<0,05$). Based on the total variance, the greatest variation is caused by the genotype followed by the effect of the year and the interaction between them. The genetic diversity has a dominating influence - 65.58% and 26.05%, respectively, over the productivity of the analyzed cultivars. Only 3.10% and 19.34% are due to the differences among the years. The separation of the dispersion on components reveals the specific interaction genotype x environment which has an influence of 4.62% and 26.73% over the changes in the

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Table 1. Dispersion analysis and influence of the factors of variation over the yield of fresh flower and essential oil

Sources of variation	Degree of freedom	Variance		Strength of influence of the factors of variation	
		Fresh flower yield	Essential oil yield	Fresh flower yield (%)	Essential oil yield (%)
Cultivar	3	23.09**	0.76***	65.58	26.05
Year	3	1.09	0.56**	3.10	19.34
Cultivar X Year	9	0.54	0.26*	4.62	26.73
Residual	30	0.83	0.07		

*, **, *** - demonstrated at p>0.05, p>0.01, p> 0.001

yield of fresh flower and the production of essential oil respectively. The observed differences for the interaction genotype x environment ($p<0,05$) in respect to the yield of essential oil demonstrate the response of the genotype to the different environment. This allows a reliable evaluation of the stability and adaptability to be carried out.

The parameters for stability and adaptability in relation to the yield of fresh flower are presented in Table 2. Finlay and Wilkinson (1963) define a stable genotype as one showing bi=0, while Eberhart and Russell (1966) - with bi=1. Most of the authors consider the S^2di to be the parameter for stability rather than the bi. Eberhart and Russell (1966) emphasize the necessity of linear (bi) and non-linear (S^2di) components of the interaction genotype x environment to be inspected together in order a given genotype to be defined as stable at a high significance of the analyzed traits. The wide adaptability of the genotype is defined with bi=1 and a high stability with $S^2di=0$.

The analysis of the data related to the productivity of fresh flower reveals that the variation of this trait is between 17,64% and 23,15% where the best productivity (higher than the average 5,60 t/decare for the genotype) is observed for cv. Yanina (Table 2). The values of the regression coefficient (bi) vary from 0,874 (cv. Yanina) to 1,071 (cv. Elejna) for flower yield. The calculated parameters for stability define cv. Elejna and cv. Iskra for which $bi>1$, as responsive in unfavorable environmental conditions or with unstable behavior at a wider range of environmental conditions. The high value of $S^2di>0$ defines their behavior as more difficult for prognosis during environmental changes which is supported by the lower coefficients of determination.

The yields of cv. Svezhen can be defined as stable since they

Table 2. Stability and adaptability of the fresh flower yield

Cultivars	Yield	Coefficient of variation	Parameters of stability			Index of total adaptation
	t/ha	*%*	*bi*	*S²di*	*R²*	*xi-bi*
Iskra	5.50	20.31	1.063	1.099	0.647	4.437
Svezhen	5.37	22.94	1.017	0.269	0.441	4.353
Elejna	5.53	23.15	1.071	0.595	0.787	4.459
Yanina	5.97	17.64	0.874	0.433	0.791	5.096
Mean	5.60					

are close to the so called “mean stability” showing values for bi = 1,017, which is close to the theoretical model $bi=1$, $S^2di=0$. On the other hand, the coefficient of determination is the lowest and does not support its stability. Cv. Yanina has a high yield with a regression coefficient lower than 1 (*bi=0,874)* and therefore it may be considered well adapted to all environments. Yanina shows relatively small deviations from the regression, the highest coefficient of determination and it can be considered as stable genotype.

The index of general adaptation defines Yanina as a cultivar with wider adaptability relative to the productivity. The rest of the cultivars show similar plasticity lower than Yanina which is an indication for their narrower adaptability.

The yield of essential oil is a function of the yield of fresh flower and the content of essential oil in the flowers. Several factors have a substantial influence on the yield of essential oil, including: relative humidity in the early morning hours, temperature, storage of the harvested flower, technological parameters of the distillation process. The results from microdistillation reveal significant yield diversity among the cultivars.

The coefficient of variation for essential oil yield is between 8,94% and 25,12% and the highest productivity above the average is demonstrated by cv. Yanina and cv. Iskra. Cv. Iskra is not well adapted and is responsive to unfavorable environmental conditions, demonstrating the highest deviations of the analyzed indicator, where bi>1, $S^2di>0$, xi-bi= -0.28 (Table 3). Yanina is again the most stable and adaptive cultivar which is supported by the coefficient of regression bi<1, small deviation from the regression, high coefficient of determination and index of general adaptation.

The other two cultivars (cv. Svezhen and cv. Elejna) show a

Table 3. Stability and adaptability of the essential oil yield

Cultivars	Yield	Coefficient of variation	Parameters of stability			Index of total adaptation
	t/ha	*%*	*bi*	*S²di*	*R²*	*xi-bi*
Iskra	1.71	25.12	1.987	0.0901	0.542	-0.28
Svezhen	1.37	15.18	0.5027	0.0652	0.246	0.87
Elejna	1.45	8.94	0.296	0.02802	0.288	1.15
Yanina	1.86	19.16	0.2226	0.0873	0.468	1.64
Mean	1.60					

regression coefficient bi<1 and essential oil yield lower than the average for the genotype which is an indication that they offer a higher resistance to the changes in the environment with lower deviation of the analyzed indicator (S^2di= 0,065 and 0,028). Cultivar Elejna has a wider adaptability, where (xi-bi= 1,15).

The analysis of the obtained results allows the differentiation of the cultivars to be based not only on the general indicators of productivity but also on their adaptive potential and resistance to unfavorable environmental conditions. Since oil bearing roses are grown in different regions alike (warmer and drier regions south of the Stara planina mountain, colder and more humid in the south slopes of the Stara planina mountain, in higher areas of the "rose valley" and at altitude over 400 meters), the results obtained could be used for defining cultivars suitable for the different regions of cultivation. The demonstrated diversity of plasticity over the analyzed four cultivars gives opportunities for their more successful regional distribution in the different microregions of the "rose valley".

Conclusion

Cultivar Yanina shows the highest productivity of fresh flower, essential oil and shows a wide adaptability where stability of the yields could be expected during unfavorable environmental conditions. Cultivar Elejna shows lower productivity than the average for the genotype and is more sensitive to the environment in respect to fresh flower yield but has a higher stability and high adaptability in respect to essential oil yield. Cultivar Iskra shows a good general productivity, stability of the yields but only under favorable environmental conditions due to the low ability for adaptation especially in respect to essential oil yield. Cultivar Svezhen shows the lowest productivity indicators combined with moderate stability of fresh flower yield and elevated stability of essential oil yield together with low adaptability of the yields.

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