

THE PERSPECTIVE POLYCROSS HYBRIDS OF *Lavandula angustifolia* MILL.

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Abstract. One hundred forty F₁ heterotic polycross hybrids of *Lavandula angustifolia* MILL. were studied and evaluated in the third year of vegetation. From these, ten perspective hybrids were selected that differ in the value of quantitative characters: the vegetation period, content of essential oil, the colour of corolla etc. and the effect of heterosis manifested in these characters. The plant height of the perspective polycross hybrids is 48-67 cm, the length of inflorescence is from 24.0 to 35.3 cm, and the length of floral ear is from 4.5 to 7.4 cm. content of essential oil is 4.032%-5.165% (dry matter). The effect of heterosis manifested by the F₁ polycross hybrids on the characters "plant height" recorded the values from +1.0% to +36.1%; "the number of floral stems" from +11.4 to +10-9.8%, and "the length of inflorescence" from 1.3% to 82.0%. These results were evaluated by comparison with the maternal forms. The manifestation of heterosis effect on the character "the content of essential oil" of the lavender hybrids is the highest and it varied in limits of +64.3 and +110.5%. The most performing late hybrid is Fr. 8-5-34V, with the biggest indices of heterosis that has the highest contents of essential oil -5.098% (dry matter).

Keywords: *L. angustifolia*, polycross hybrid, heterosis, essential oil.

Rezumat. Hibrizi policross perspectivi de *Lavandula angustifolia* MILL. Au fost evaluați 140 hibrizi policross F₁ de *L. angustifolia* în anul al treilea de vegetație și s-au selectat 10 hibrizi de perspectivă, care se deosebesc prin valorile caracterelor cantitative: perioada de vegetație, culoarea corolei florilor etc. și efectul heterozisului manifestat la aceste caractere. Hibrizii policross perspectivi au talia plantelor de 48-67 cm, lungimea inflorescenței de la 24,0 până la 35,3 cm și lungimea spicului floral de la 4,5 până la 7,4 cm. Conținutul de ulei esențial la hibrizii perspectivi variază în limitele 4,032 % - 5,165 % (s.u.). Efectul heterozisului manifestat de hibrizii policross F₁ în raport cu forma maternă la caracterul „talia plantei” a înregistrat valori de la +1,0 % până la +36,1 %; la numărul de tulpini florale - de la +11,4 până la +109,8 %, iar la lungimea inflorescenței de la 1,3 % până la 82,0 %. Efectul heterozisului manifestat de hibrizii de levănțică la conținutul de ulei esențial este cel mai înalt și variază în limitele +64,3 - +110,5 %. Mai performant este hibridul tardiv Fr. 8-5-34V, cu cei mai ridicați indici ai heterozisului, la care și conținutul de ulei esențial este mai ridicat - 5,098 % (s.u.).

Cuvinte cheie: *L. angustifolia*, hibrid policross, heterozis, ulei esențial.

INRODUCTION

In order to create varieties and hybrids with increased productivity, in plant breeding, the phenomenon of heterosis is used. The term "heterosis" was introduced in 1914 by G. Shull and it means the state of hybrid, characterized by higher values of some parameters such as adaptability, productivity, disease and critical temperature resistance etc. compared with the parental forms (GONCEARIUC et al., 2011). Heterosis is manifested not only by the morphological characters, but by the physiological too. The practical importance of heterosis is very high because through this phenomenon is possible to achieve the significant increase of production, namely 30-40% higher than the parental forms (GONCEARIUC, 2008). *L. angustifolia* (Lavender) is an important aromatic and medicinal plant for agriculture and economy of the Republic of Moldova and other countries (BUIUCLI, 1969; GONCEARIUC, 2005). In our country the cultivation of lavender started in 1946 and the first industrial plantation were developed in 1948 (GONCEARIUC, 2005; MUSTEAȚĂ, 1980). In the pedoclimatic aspect, Moldova is a favourable area for lavender cultivation as it ensures a high production of raw material and essential oil with high quality. At present in our country industrial plantations of lavender occupy over a thousand hectares and continue to expand and the produced essential oil is destined for export.

The objective of this investigation is the evaluation of perspective hybrid genotypes of *L. angustifolia* and the selection of those which will combine harmoniously the remarkable indices of the main biological and crop characters such as the yield of raw materials and essential oil, resistance to winter frost and drought, disease and pests resistance, the increased content of essential oil in raw material, confirmed by the heterosis expression in quantitative characters.

MATERIALS AND METHODS

The used plant materials are represented by 140 F₁ polycross hybrids of *Lavandula angustifolia* MILL. in the third year of vegetation. The origin of the maternal form of the studied hybrids is from France. For hybridization, the varieties-clone created in Ukraine, Republic of Moldova and French genotypes were used as parental form. The research was carried out in the experimental fields of the Institute of Genetics and Plant Physiology, Academy of Sciences of Moldova. Hybrids were planted in the autumn of 2007 on the nutrition area 1m x 0.5 m. The evaluation of the studied hybrids was carried out according to the existing methods (BUIUCLI, 1969; GONCEARIUC, 2004; SHULL, 1952; DOSPEHOV et al., 1990). In this context, some quantitative characters that directly influence the productivity such as plant height, length of inflorescence, length of flower stalk, and floral ear, number of verticils per inflorescence, number of inflorescences per

plant, the vegetation period, the content and composition of essential oil were evaluated. Statistical analysis of the data was performed by DOSPEHOV (1985). The essential oil was separated from fresh flowers during the complete flowering through the hydrodistillation in the Ginsberg apparatus. Essential oil content was determined in percentage and was recalculated to the dry matter. The effect of heterosis was calculated in percentage in relation to the maternal form.

Qualitative and quantitative composition of essential oil was determined by gas-chromatographic analysis in tandem with the mass spectrometry (GC-MS). The analysis equipment included: gas-chromatograph Technologies Agilent 7890 equipped with Selective Mass Detector with Quadruple MSD Agilent Technologies 5975C, capillary column (30 m/0.25 mm/0.25 µm) with non-polar stationary phase HP-5ms. Analysis was performed at a temperature of 250°C injector and detector - 280 ° C, using a temperature gradient from T1 = 70 ° (2 min), T2 = 200 ° C (5 ° C/min), T3 = 300°C (20°C/min, 5 min). Mobile phase: Helium 1ml/min, injected volume - 0.03 ml essential oil, split rate - 1:100. Identification of chromatographic peaks was performed using the software package AMDIS™, coupled with the NIST database.

RESULTS AND DISCUSSION

During the vegetation period there were evaluated 140 F₁ polycross hybrids of lavender. The biodiversity of hybrids genotypes is very large. Hybrids vary by the vegetation period, plant height, length of inflorescence, number of floral stem, colour of flower corolla and calyx. Thus, there were identified the hybrids with various periods of vegetation: early, middle ripening, and late that are distinctive by several quantitative characters, as well as colour of flower corolla that vary from blue to purple with different nuances (Figs. 1, 2, 3). The perspective polycross hybrids from the early group are: Fr.1-3-23V and Fr.1-3-29V. The semi early groups include 6 hybrids: Fr.8-5-8V; Fr.8-5-10V; Fr.8-5-33V; Fr.8-5-40V; Fr.8-5-28V and Fr.1-3-12V. The group with late ripening vegetation period consists of 2 hybrids: Fr.8-5-34V and Fr.1-3-5V (Table 1).

Table 1. Heterosis effect in the *L. angustifolia* F₁ polycross hybrids for the same quantitative characters, compared with the maternal form.

Maternal forms, Polycross hybrids F ₁	Plant height, cm	Heterosis effect, %	Inflorescence length, cm	Heterosis effect, %	No. flower stems per plant	Heterosis effect, %
Fr.1, maternal form	50.0	-	23.7	-	305	-
Fr.8, maternal form	49.6	-	19.4	-	325	-
early hybrids						
Fr.1-3-23V	50.5	+ 1.0	30.7	+ 29.5	385	+ 26.2
Fr.1-3-29V	52.5	+ 5.0	24.7	+ 4.2	352	+ 15.4
middle ripening hybrids						
Fr.8-5-8V	55.5	+ 11.9	32.5	+ 67.5	540	+ 66.2
Fr.8-5-10V	58.0	+ 16.9	26.0	+ 34.0	520	+ 60.0
Fr.8-5-33V	62.0	+ 25.0	30.7	+ 58.2	565	+ 73.8
Fr.8-5-40V	57.0	+ 15.0	29.4	+ 51.5	420	+ 29.2
Fr.8-5-28V	59.5	+ 20.0	27.0	+ 39.1	484	+ 48.9
Fr.1-3-12V	58.5	+ 17.0	24.5	+ 3.4	340	+ 11.4
late ripening hybrids						
Fr.8-5-34V	67.5	+ 36.1	35.3	+ 82.0	682	+ 109.8
Fr.1-3-5V	48.0	- 4.0	24.0	+ 1.3	485	+ 59.0

The result of F₁ lavender polycross hybrids evaluation showed that they are valuable by some quantitative characters such as: plant height, length of inflorescence, number of floral stem (Table 1).



Fig. 1. Lavender early polycross hybrid, Fr.1-3-29V with dark violet corolla (original).



Fig. 2. Lavender medium ripening polycross hybrid Fr.8-5-10V, with light violet corolla (original).



Fig. 3. Lavender late polycross hybrid Fr.8-5-34V with blue corolla (original).

For these characters, there were determined the heterosis effect, compared with the maternal form. The examination of hybrids by the character “plant height”, that ranges from 48.0 cm to 62.0 cm allowed identifying eight hybrids where the heterosis was manifested, recording the indices from +1.0% to +36.1%. The effect of heterosis with negative value (-4%) was attested in the hybrid Fr.1-3-5V.

Regarding the character “length of inflorescence” all evaluated hybrids recorded positive effects of heterosis, most of them having indices with value ranges from +29.5% to 82.0%. The studied F₁ polycross hybrids of lavender are perspective also due to the possibility of each plant to form a large number of floral stems. This character determines the production of raw material. It is important to mention that in the hybrids Fr.8-5-34V the effect of heterosis for this character is the highest, registering the value of +109.8%. The quantitative characters of the inflorescence such as length of flower ear, number of verticiles per flower ear, content of essential oil were studied (Table 2).

For the selected hybrids, the length of floral ear ranges from 4.5 to 7.0 cm, and the highest index of heterosis for this character was +23.3% recorded in the late hybrid Fr. 8-5-34V. The number of verticiles per flower ear directly influences the content and lavender essential oil production. From all evaluated hybrids, only six manifested the heterosis with positive indices.

Table 2. The heterosis effect in the F₁ polycross hybrids of *L. angustifolia* for the quantitative characters of inflorescence, compared with the maternal form.

Maternal form, polycross hybrid F ₁	Floral ear length, cm	Heterosis effect, %	No. verticiles per floral ear	Heterosis effect, %	Essential oil content, % (s.u.)	Heterosis effect, %
Fr.1, maternal form	5.8	-	5.5	-	2.601	-
Fr.8, maternal form	6.0	-	5.5	-	2.421	-
early hybrids						
Fr.1-3-23V	6.9	+ 18.9	6.5	+ 18.1	5.165	+ 98.5
Fr.1-3-29V	4.7	- 18.9	4.6	- 16.3	4.453	+ 74.2
middle ripening hybrids						
Fr.8-5-8V	7.2	+ 20.0	6.3	+ 14.5	4.613	+ 90.5
Fr.8-5-10V	6.8	+ 13.3	6.0	+ 9.1	4.350	+ 79.6
Fr.8-5-33V	6.0	+ 0.0	5.8	+ 5.4	4.125	+ 70.3
Fr.8-5-40V	7.0	+ 16.6	6.5	+ 18.1	4.172	+ 72.3
Fr.8-5-28V	5.0	- 16.6	4.9	- 10.5	4.120	+ 70.1
Fr.1-3-12V	5.7	- 1.7	4.7	- 14.5	4.032	+ 82.3
late ripening hybrids						
Fr.8-5-34V	7.4	+ 23.0	6.6	+ 16.3	5.098	+ 110.5
Fr.1-3-5V	4.5	- 22.4	4.5	- 18.0	4.274	+ 64.3

Regarding the content of essential oil, all evaluated hybrids exceed the maternal form; they registered the value of 4.032 - 5.165% (dry matter). For this character, the heterosis effect is from +64.3% to 110.5%. The highest indices were recorded in the hybrids:

- Fr.8-5-34V F₁ – 5.098% (dry matter) of essential oil, heterosis effect + 110.5%;
- Fr.1-3-23V F₁ – 5.165 % (dry matter) of essential oil, heterosis effect + 98.5 %;
- Fr. 8-5-8V F₁ – 4.613 % (dry matter) of essential oil, heterosis effect + 90.5 %.

From the above mentioned results it can be seen that it was created a vast initial material to obtain the lavender varieties-clones, represented by polycross hybrids and characterized by high indices of quantitative characters and first of all by the increased content of essential oil. GC-MS analysis of essential oil separated from the fresh flowers of the hybrids with the highest oil content showed a significant variability of qualitative and quantitative composition (Table 3). The biodiversity of hybrids is expressed only by the concentration of major and minor constituents that consists of the same number - 31. It is known that the quality of lavender oil depends on the concentration of linalyl acetate. If the concentration of this component is higher, then the essential oil quality is higher.

The evaluated *L. angustifolia* genotypes contain the same three major components of essential oil: linalool, linalyl acetate and terpinen-4-ol. Thus, these genotypes take part in a single chemotype – linalool/linalyl acetate/terpinen-4-ol. The biodiversity of hybrids and maternal forms is expressed by the concentration of each component and the number of minor components. The maternal forms differ through a small number of components (17-30), in particular, the form N3 Fr. 1V the concentration of linalyl acetate ranges from 32.377% in the hybrid Fr.1-3-23V to 64.146% in the hybrid Fr.8-5-34V. For the second major component – linalyl acetate, the concentration range from 21.209 in the hybrid Fr.8-5-34V to 25.444% in the hybrid Fr.1-3-23V.

The same diversity is observed in the concentration of major component terpinen-4-ol where the high concentration was registered in the hybrid Fr.1-3-23V (22.523%), for whom the maternal form was N3.1V.

Table 3. The essential oil components of *L. angustifolia* polycross hybrids F₁, compared with the maternal form.

№	Compound, %	Area (%)			
		maternal forms		polycross hybrids F ₁	
		N3 Fr. 1V	N5 Fr. 8V	Fr.1- 3-23V	Fr. 8-5-34V
1	α-pinene			0.055	
2	n-octen-1-ol		0.028	0.043	0.256
3	3-octenonă	1.107	0.492	0.087	0.897
4	β-myrcene		0.264	0.280	0.127
5	3-octanol		0.107		0.257
6	3-caren		0.350	0.102	0.124
7	o-cymene			0.169	
8	limonene		0.177	0.205	0.076
9	eucalyptol	0.914	0.417	2.623	0.632
10	trans-ocimene	1.829	0.999	3.117	0.498
11	cis-ocimene	1.183	0.591	0.516	0.180
12	γ-terpinene		0.035	0.276	
13	hexyl acetate			0.359	0.044
14	cis-linalool oxii		0.142		0.409
15	α-Terpinene		0.236	0.165	0.438
16	linalool	42.960	34.928	32.377	64.146
17	n-octen-1-yl- acetate	1.302	0.417	1.239	0.227
18	3-octanol acetate		0.116		
19	camphor		0.259	0.279	0.337
20	borneol	0.843	0.650	0.754	0.784
21	4-terpineol	8.541	0.606	22.523	1.345
22	carvacrol			0.092	0.056
23	α-terpineol	4.742	5.432	2.838	2.784
24	nerol	0.687	0.797	0.385	0.366
25	geraniol				0.049
26	linalyl acetate	27.282	43.829	25.444	21.209
27	bornyl acetate		0.182	0.180	0.053
28	lavandulol acetate	3.253	0.487	0.266	0.297
29	thymol		0.614		
30	nerol acetate	0.958	1.138	0.483	0.436
31	geranyl acetate	1.769	2.106	0.888	0.743
32	β-caryophyllene	1.601	2.027	2.451	1.363
33	germacren D		0.074	0.121	0.056
34	γ-cadinen		0.2	0.09	0.065
35	caryophyllene oxide	0.516	0.412	0.554	0.563
36	β-cadinen	0.512		0.405	0.309
	Identified compounds	17	30	31	31
	Total, %	99.999	98.052	99.366	99.398

The concentration of terpinen-4-ol component is also high (8.541%). The essential oil of the hybrid Fr.8-5-34V contains 1.345% terpinen-4-ol, but its maternal form (N5 Fr.8V) – 0.606%. It can be concluded that the hybrids inherit the concentration of terpinen-4-ol component in the essential oil and manifested the heterosis for this character. However, we cannot affirm the same situation regarding the concentration of linalool and linalyl acetate. On the contrary, the concentration of linalyl acetate in essential oil separated from the hybrids inflorescences is lower than in the oil of their maternal form.

CONCLUSION

One hundred forty F₁ heterotic polycross hybrids of *L. angustifolia* were studied and evaluated in the third year of vegetation. From these, ten perspective hybrids were selected. The quantitative characters of these hybrids, such as the vegetation period, content of essential oil, the colour of corolla, etc. and the effect of heterosis manifested in these characters are different.

The plant height of the perspective polycross hybrids is 48-67 cm, the length of inflorescence is from 24.0 to 35.3 cm, the length of floral ear is from 4.5 to 7.4 cm and content of essential oil is 4.032%-5.165% (dry matter).

The effect of heterosis manifested by the F₁ polycross hybrids on the characters “plant height” recorded values from +1.0% to +36.1%; “the number of floral stems” from +11.4 to +10-9.8%, and “the length of inflorescence” from 1.3% to 82.0%. These results were evaluated in comparison with the maternal forms.

The manifestation of heterosis effect on the character “the content of essential oil” of the lavender hybrids is the highest and varied in limits of +64.3 and +110.5%.

The most performing late hybrid is Fr.8-5-34V, with the biggest indices of heterosis that has the highest content of essential oil - 5,098% (dry matter).

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