

THE DROUGHT RESISTANCE OF *SALVIA SCLAREA* L. AND *LAVANDULA ANGUSTIFOLIA* MILL. VARIETIES

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Abstract: The early-, mid- and late-ripening *Salvia sclarea* varieties are resistant to drought; they accumulate high amounts of essential oils, provide a production of 15.1-22.4 t/ha of inflorescences in two years of plantation exploitation and guarantee yields of 41.1-72.4 kg/ha of essential oil depending on the variety. The productivity amounts to 12.1-18.7 t/ha of raw material and 32.5-58.8 kg/ha of essential oil as early as in the second year of vegetation. The producing capacity of early-ripening varieties is higher than of those with medium and late vegetation period. The efficiency of *Salvia sclarea* varieties ranges between 2.8 and 3.6 kg/t. The essential oil content of *Lavandula angustifolia* varieties is higher (5.103-6.164%) in dry years than in those with normal atmospheric depositions. The productivity of the lavender varieties is higher and makes 7-12 t/ha of inflorescences and 132-245 kg/ha of essential oil. The efficiency varies from 14.0 to 19.8 kg of essential oil per tonne of inflorescences.

Keywords: drought resistance, variety, clary sage, lavender, essential oil, productivity

Introduction

Salvia sclarea (clary sage) and *Lavandula angustifolia* (lavender) from the family of *Lamiaceae* have been known since the antiquity as the species of medicinal, aromatic, melliferous and ornamental plants. The products derived from these species have been used for ages as a therapeutic agent (Gonceariuc, 2014, 2018; Haiying Cui et al., 2015) in traditional medication of Asia, Europe, ancient Greece and Rome. Their utilization in medicine, pharmacology, phytotherapy, perfumery is due to essential oil, its components isolated from inflorescences. Like other essential oils, those derived from sage and lavender have an excellent antioxidant,

antiinflammatory, antimicrobial and antifungal action and have a positive impact on general health condition (Behmanesh et al., 2015; Haiying Cui et al., 2015; Hancianu et al., 2013; Hyo Jung Yang et al., 2014; Turgut et al., 2017). Sage and lavender oils have been demonstrated to present a viable option in treating such neurologic disfunctions as stroke, the effect being due to their antioxidant properties (Uehleke et al., 2012). Both essential oil and inflorescences are used to cure migraine, headache, heart problems with a nervous substrate through regulation of the excitement states of intern receptors; neuro-vegetative dystonias, insomnia, rheumatic diseases, flu conditions and colds (Seol et al., 2013; Uehleke et al., 2012).

The above mentioned have constantly influenced the researches conducted to develop new hybrids, cultivars that would ensure enhanced production of inflorescences with a higher content of essential oil and of the quality corresponding to the aim proposed for employment.

During the last decades, such researches have apparently intensified as a result of climatic changes, slow but steady processes of global warming, creation of desert conditions in some areas, including south-eastern Europe where agricultural crops are affected by drought and scorching heat more and more frequently.

Simultaneously, our researches prove that the cultivars of aromatic and medicinal plants (*Lavandula angustifolia*, *Salvia sclarea*, *Salvia officinalis* etc.) provide an enhanced production of raw material and high quality essential oil in dry years. Some of these cultivars such as of lavender accumulate a content that is even higher in dry years than in the years with normal atmospheric depositions.

Material and methods

The biological material comprises sage and lavender cultivars of different origin. Thus, the *S. sclarea* cultivars are hybrids with permanent heterosis of different complexity: simple (Dacia-50, Dacia-99, V-Junior, Victor), triple (Nataly-Clary, Parfum Perfect), backcross (Ambra Plus) and stepwise (Balsam) hybrids. The *L. angustifolia* cultivars have been developed through hybridization between the genotypes of different genetic and geographic origin. The promising F1 hybrids with a high heterosis effect for a number of quantitative characters, inclusive essential oil content, have been reproduced vegetatively resulting in the cultivars Moldoveanca 4, Vis magic 10, Alba 7, Aroma Unica etc. The validation of the agronomic

quantitative characters in both *S. sclarea* and *L. angustifolia* has been performed under legal methods. The essential oil content was assessed in fresh inflorescences at the stage of industrial maturity through hydrodistillation in the Ginsberg apparatus and recalculated for dry matter.

Results and discussions

The previous researches have shown that intraspecific hybridization is an efficient method to develop valuable genotypes through pronounced variability of the indices of bio morphological character values including the content and components of essential oil in lavender and clary sage (Gonceariuc, 2008, 2014 and 2018). Importantly, hybrids, our cultivars are strongly resistant to drought. In contrast to other *S. sclarea* cultivars, the ones we have developed begin flowering in the first year of vegetation providing both production of 3-5 t/ha of inflorescences and a very high content of essential oil. The cultivar Ambra Plus is distinguished by abundant flowering and, in favourable years, the yields of inflorescences make up to 10-11 t/ha in the first year. In the dry 2015 year all the cultivars produced between 1.5 and 4.8 t/ha of raw material in dependence on the cultivar. The content of essential oil was higher in the cultivar Balsam (1.286%). The production of essential oil varied between 5.7 kg/ha in the cultivar Nataly Clary and 11.6 and 12.5 kg/ha in the cultivars Ambra Plus and Balsam, respectively. Also, in the year 2015, the second year of vegetation, all the varieties produced high quantities of raw material (12.1-18.7 t/ha) and essential oil (46.3-58.8 kg/ha) (Fig. 1). The inflorescence yields, the content and production of essential oil are supported by a number of quantitative traits. The indices of their values were remarkable in the dry 2015 year: the plants formed a great number of floral stems per m² and the plant's height of 117.7-125.1 cm, long strongly ramified inflorescences (56.7-64.3 cm), enhanced content of essential oil, the fact proving their excellent development in drought conditions (Table 1).

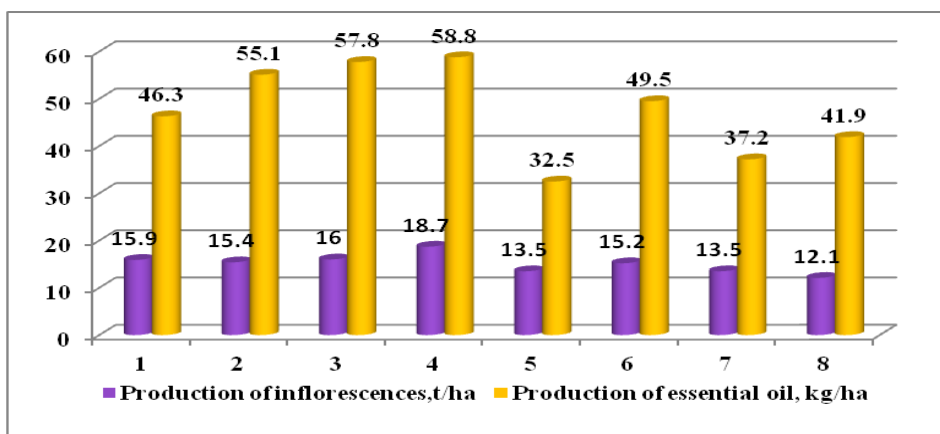


Figure 1. Producing capacity of the *Salvia sclarea* varieties in the second dry year of vegetation, 2015: 1- Dacia-50, st.; 2- Ambra Plus; 3- Balsam; 4- Parfum Perfect; 5- Dacia 99; 6- V. Junior; 7- Victor; 8- Nataly Clary.

In two years of exploitation (2014-2015), the yields of raw material made 15.1 t/ha – 22.4 t/ha, the essential oil production varied between 14.1 and 77.4 kg/ depending on the variety ha (Fig. 2). The *Salvia sclarea* cultivars provide raw material and essential oil production in the third year of vegetation, as well, in conditions of fertilization and weed control.

Table 1
Values of some indices of producing capacity in the *Salvia sclarea* cultivars in comparative competitive cultivars, the second year of vegetation, 2015

Soiuri	Number floral stems/ m ²	Plant height, -cm- X ± Sx	Inflorescences length -cm- X ± Sx	No. inflorescence branches		Essential oil cont., % (dry matter)
				Grade I X ± Sx	Grade II X ± Sx	
Dacia-50, st.	54,5	121,2±5,9	59,9±5,9	14,2±1,8	19,6±5,0	0,796
Ambra Plus	48,9	120,6±6,9	63,0±6,5	14,8±2,2	20,8±6,3	1,192
Balsam	60,1	120,8±6,9	60,5±8,4	14,5±2,1	21,6±5,1	1,205
Parfum Perfect	53,1	125,1±6,6	64,3±5,4	14,9±2,2	21,7±6,6	1,049
Dacia-99	51,7	123,4±6,9	60,1±6,9	14,8±2,0	22,4±6,1	0,803
V-Junior	56,9	117,7±7,1	56,7±6,7	14,5±1,9	21,1±5,9	1,085
Victor	62,4	119,5±8,7	58,7±5,6	15,2±1,9	23,0±6,1	0,918
Nataly-Clary	59,2	118,6±4,0	57,7±6,9	21,6±6,4	21,6±6,4	1,154

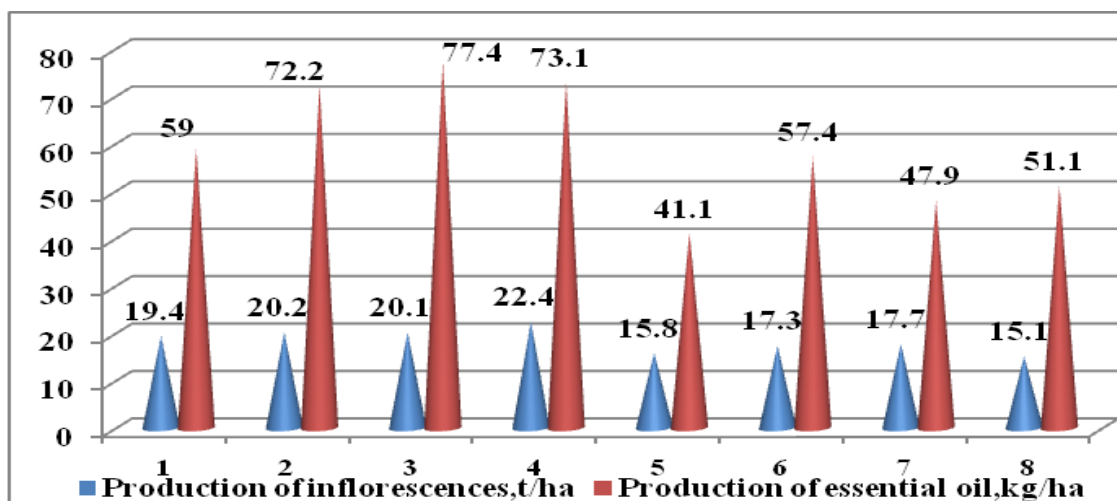


Figure 2. The Producing capacity of the *Salvia sclarea* cultivars in two years of plantation exploitation, 2014-2015: 1. Dacia-50, st.; 2. Ambra Plus; 3. Balsam; 4. Parfum perfect; 5. Dacia 99; 6. V. Junior; 7. Victor; 8. Nataly Clary

The 2018 year in the Republic of Moldova was also dry. Under these conditions, the varieties of *Salvia sclarea* formed high yields (10.7-13.9 t/ha) of high content of essential oil (0.859-2.202%). Essential oil production in the second year of vegetation consisted of 27.6 to the standard variety up to 43.1 kg/ha at variety Ambriela (Tab.2).

Table 2
Productivity of *Salvia sclarea* L. varieties, first & second years of vegetation, 2017-2018

Variety, hybrids with constant heterosis	Row material yield, t/ha		Essential oil content, %		Production of essential oil, kg/ha		Efficiency, kg/t	
	2017 I st year	2018 II nd year	2017 I st year	2018 II nd year	2017 I st year	2018 II nd year	2017 I st year	2018 II nd year
Dacia-50, st.	3.7	10.7	1.120	0.858	12.5	27.6	3.3	2.7
Ambra Plus	11.7	11.8	1.163	0.916	40.9	32.6	3.5	2.9
Balsam	8.9	12.8	1.131	1.015	30.1	39.4	3.4	3.1
Ambriela	8.3	11.9	1.215	1.202	30.3	43.1	3.6	3.6
Parfum Perfect	7.8	12.2	1.132	1.086	26.5	39.9	3.4	3.3
Dacia 99	3.8	12.2	1.097	1.070	12.6	39.2	3.3	3.2
Nataly Clary	3.8	13.9	1.187	1.036	13.7	43.3	3.6	3.1

The efficiency of all varieties is very high: 3.3-3.6 kg/t in the first year of vegetation and 2.7-3.6 kg/t in the second year of vegetation that was dry.

The hybrids, cultivars of *Lavandula angustifolia* accumulate more enhanced content of essential oil in dry years than in the years not affected by drought (Table 3). In the year 2015, this important trait ranged from 4.575-6.164% in the cultivar Vis Magic 10 to 6.164% in the cultivar FR.5S8-24.

It is well known that severe drought has a negative effect on perennial species both in the year of major humidity deficiency and in the years that follow. The consequences of the 2015 drought were different in the case of the lavender cultivars. The F1 hybrids recorded higher content of essential oil in the year 2015 than in the years 2014, 2016 and 2017 exceeding the maternal form of origin (Goncareiuc, 2018). Similar results were recorded in the years of severe drought 2007 and 2012 years.

Table 3

The content of essential oil in the cultivars (hybrids) of *Lavandula angustifolia*

Hybrids, varieties	Conținut ulei esențial, % (s.u.)			
	2014	2015, dry year	2016	2017
Moldoveanca 4	4,893	5,404	4,318	4,981
Fr.8-5-15V	4,545	5,803	4,691	5,454
Vis Magic 10	4,423	4,575	4,597	4,518
VM-18V	4,710	5,103	4,924	4,829
Alba 7	5,298	5,762	5,915	5,256
Fr.5S8-24	5,087	6,164	5,786	5,915

As mentioned above, the year 2018 in the Republic of Moldova was dry. The soil was covered by deeply cracks. Under these drought conditions the young plantations (first year of vegetation) of lavender, the varieties Vis Magic 10 and Alba 7 had an abundant flowering twice - in June and August, demonstrating a high resistance to drought (Fig.3.).



Figure 3. A lavender plantations founded in November 2017, Colonița, Republic of Moldova, first year of vegetation, second bloom, 2018, August 27; up variety Vis Magic 10; down variety Alba 7.

The average producing capacity of the lavender cultivars with different vegetation period ranges between 7 t/ha of raw material (inflorescences) in the cultivar Vis magic 10 and 10-12 t/ha in the cultivars Moldoveanca 10, Alba 7 and Aroma Unica. The production of essential oil makes 132-245 kg/ha depending on the cultivar and cultivation conditions (Gonceariuc, 2018). These cultivars are also distinguished by high efficiency – one tonne of raw material ensures from 14.0 to 19.8 kg of essential oil with content of linalyl acetate making 28 to 39%. This index is 44% in the new cultivars Aroma Unica etc. It should be mentioned that all the cultivars, hybrids developed have a low concentration (0.21-0.27%) of camphor in the essential oil (Gonceariuc, 2014, 2018), this component being important as it diminishes the quality and perfumery value of essential oil in high concentrations (more than 2%).

Conclusion

1. The *Salvia sclarea* cultivars Ambra Plus, Balsam, Parfum Perfect, Dacia 99; V. Junior; Victor; Nataly Clary are resistant to drought; they accumulate high amounts of essential oils, provide a production of 15.1-22.4 t/ha of inflorescences and guarantee yields of 41.1-72.4 kg/ha of essential oil depending on the variety.
2. The efficiency of *Salvia sclarea* varieties ranges between 2.7 and 3.6 kg/t of essential oil per tonne of raw material.
3. The essential oil content of *Lavandula angustifolia* cultivars is higher (5.103-6.164%) in dry years than in those with normal atmospheric depositions (4.423-5.915%).
4. The productivity of the cultivars Moldoveanca 4, Vis Magic 10, Alba 7 și Aroma Unica etc. ensures yields of 7-12 t/ha of inflorescences and 132-245 kg/ha of essential oil depending on the variety.
5. The efficiency varies from 14.0 to 19.8 kg of essential oil per tonne of raw material.

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