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RESEARCH ON PRODUCTIVITY AND YIELD QUALITY OF *SALVIA OFFICINALIS* L. SPECIES GROWN IN ORGANIC AGRICULTURE CONDITIONS

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Abstract

Organic agriculture is an alternative to conventional farming system, promoting environmentally friendly agricultural technologies which exclude synthetical chemicals, and provid healthy agricultural products that contribuite to consumers' health, environmental protection and conservation of natural resources. Organic agriculture production system is particularly important as it includes medicinal and spice crops which are intended primarily to guarantee consumers' health; by definition, these plants must be free of synthetic chemical residues, originating from fertilizers or pesticides. Research had been performed on Salvia officinalis L. species grown in organic agriculture condition, in Moara Domnească Experimental Field, Ilfov County – Romania, situated on a reddish preluvosoil, over three years (2009-2011). The three years of experiments show a positive reaction of Salvia officinalis L. species to the tested ecological fertilizers, i.e. peat and Tecamin Max (leaf fertilizer), which are fertilizers accepted in organic agriculture. The reaction of Salvia officinalis L. species to fertilization consists in important production increases, in comparison with unfertilized crop. The highest average multiannual production of Salviae folium was of 11,624.21 kg/ha fresh matter, or 3,407.99 kg/ha dry matter and the highest average multiannual production of Salviae herba, was of 13,343.72 kg/ha fresh matter, or 4,387.10 kg/ha dry matter. The yield quality of Salviae herba was reflected in 95.63% dry matter and 2.11% volatile oil content. It is to recommende the fertilization of Salvia officinalis L. organic crop grown on the reddish preluvosoil from South Romania with Peat 10,000 l/ha or Tecamin Max 3 l/ha.

Key words**:** *organic agriculture, Salvia officinalis L., organic fertilizers*.

INTRODUCTION

Organic agriculture has become an important alternative to intensive, conventional farming. International understanding of organic agriculture as a production and processing management system is based on the standards set up by International Federation of Organic Agriculture Movements (IFOAM), national and community lows and programs [1].

The production and use of medicinal and spice plants in the organic agriculture system is an alternative to the conventional farming system, promoting environmentally friendly agricultural technologies which exclude synthetical chemicals. Also, it is providing healthy agricultural products that ensure consumers' health, environmental protection and conservation of natural resources. *Salvia* is a fascinating plant genus. *Salvia officinalis* L. species is one of the widest-spread members of *Labiatae* family, its features are prominently in the pharmacopoeias of many countries throughout the world [3].

Sage originates in the sub-mountainous areas of the Mediterranean, from where it was spreaded to the coast areas and further to European, Asian and North African countries. It has been known as a medicinal plant since antiquity. Today, sage is much cultivated in Southern Europe and less in Central Europe, the UK, and the US. In Romania, it is less used as food and, therefore, it is occasionally grown by amateurs on small areas, especially in Southern and South-Western regions.

Sage is a perennial species that is maintained in culture for 5-6 years. The previously crops

must be removed from the land earlier and leave the soil in good fertility conditions.
Sage is grown for its leaves (*Salviae folium*) or for herba (*Salviae herba*). The volatile oil content is 0.38% in fresh leaves and 0.38-2.5% in dry leaves [2].

MATERIAL AND METHOD

The experiments on *Salvia officinalis* L. species, grown in an organic agriculture conditions in Moara Domnească Experimental Field were organized according to rigorous rules and methodologies.
Experiments were carried out over a three-year period (2009, 2010 and 2011).
The experiments on *Salvia officinalis*, genotype "De Răzmireşti" were established by seedling planting on the experimental field on 15th of October 2007.
The following variants were tested: Control-unfertilized; Peat fertilization, 10,000 l/ha; Leaf fertilization with Tecamin Max, 3 l/ha; Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha.
The *Salvia officinalis* L. crop density was of 40,816 plants/ha, with 70 cm distance between rows and 35 cm distance between plants.
Observations and measurements
The following morphological measurements were performed: number of offshoots/plant; offshoots length; number of leaves/offshoot; number of leaves/plant; lamina size (length and width); number of inflorescences/plant.
The following productivity measurements were performed on *Salviae folium* fresh matter and dry matter, and on *Salviae herba* fresh matter and dry matter.
Morphological and biometric measurements were performed in the first and second year of cultivation while productivity measurements were analysed in all three years of the experiments.
Yield quantity analysis included dry matter and volatile oils content.
Laboratory analysis methods were according to the quality standards used to measure total lipids content from seeds and other vegetal products – SR EN ISO/CEI 17025:2005 for physical, chemical and microbiological analysis of food products.

RESULTS AND DISCUSSIONS

Research conducted during 2009-2011 on *Salvia officinalis* L. species grown in organic agriculture conditions, was based on the genotype "De Răzmireşti", in the Moara Domnească Experimental field.
The research carried out shows *Salvia officinalis* L. positive reaction to the tested ecological fertilizers, i.e. Peat and Tecamin Max (leaf fertilizer), which are fertilizers accepted in organic agriculture.
The reaction of the *Salvia officinalis* L. species to fertilization results in important yield increase (statistically assured from significant to highly significant), compared to unfertilized plants.
Salvia officinalis L. plants recorded following average morphological characteristics: 42 branches (offshoots/plant), 23.54 cm average shoot length, 10 leaves/shoot, 431 leaves/plant, 5.58 cm lamina length and 1.65 cm lamina width, and 42 inflorescences/plant.
Between 2009 and 2011, two harvests were performed in *Salvia officinalis* L. in each year of experimentation: the first harvest in June-July, and the second in September-October.
Results obtained in 2009. The highest average annual yield (16,272.10 kg/ha) of *Salviae folium* fresh matter, was obtained in the experimental variant V_3 – "Leaf fertilization with Tecamin Max, 3 l/ha"; after drying, the highest average annual yield was 4,432.84 kg/ha *Salviae folium* – dry matter, obtained in the experimental variant V_4 – "Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha". *Salvia officinalis* L., organically grown in the experimental field of Moara Domnească, produced an average of 13,430.75 kg/ha *Salviae folium* fresh matter; after drying, the result was 3,701.19 kg/ha *Salviae folium* dry matter, with an average rate on drying of 3.63:1 (Table 1).
The highest average annual yield (21,482.39 kg/ha) of *Salviae herba* fresh matter, was obtained in the experimental variant V_4 – "Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha"; after drying, the highest average annual yield was 6,609.88 kg/ha *Salviae herba* dry matter, obtained in the

experimental variant V_3 – "Leaf fertilization with Tecamin Max, 3 l/ha".

Salvia officinalis L., organically grown in the experimental field of Moara Domnească, produced in average 18,228.43 kg/ha *Salviae herba* fresh matter; after drying, the result was 5,561.44 kg/ha. *Salviae herba* dry matter, with an average rate on drying of 3.29:1 (Table 2).

Results obtained in 2010. The highest average annual yield in the second year was 9,413.69 kg/ha *Salviae folium* fresh matter; after drying, the highest average annual yield was 3,000.69 kg/ha *Salviae folium* dry matter, obtained in the experimental variant V_4 – "Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha".

In the second year, *Salvia officinalis* L., organically grown in the experimental field, produced in average 7,931.85 kg/ha *Salviae folium* fresh matter; after drying, the result was 2,536.19 kg/ha *Salviae folium* dry matter, with an average rate on drying of 3.13:1 (Table 3).

Table 1. Influence of fertilization on *Salviae folium* yields fresh matter and *Salviae folium* yields dry matter in the first experimental year (2009)

Nr. crt.	Experimental variants	Yield of *Salviae folium* – fresh matter			Yield of *Salviae folium* – dry matter		
		Yields		Difference	Yields		Difference
		kg/ha	%	(kg/ha)	kg/ha	%	(kg/ha)
V_1	Control-unfertilized	9,206.41	100	Mt.	2,492.75	100	Mt.
V_2	Peat fertilization, 10,000 l/ha	12,270.58	133.28	3,064.17	3,471.42	139.26	978.67
V_3	Leaf fertilization with Tecamin Max, 3 l/ha	16,272.10	176.75	7,065.69 **	4,407.74	176.82	1,914.99 **
V_4	Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha	15,973.93	173.51	6,767.52 **	4,432.84	177.83	1,940.09 **
Average		**13,430.75**	**DL 5% = 3,738.73 kg/ha / 40.61% DL 1% = 5,376.49 kg/ha / 58.40% DL 0.1% = 7,907.57 kg/ha / 85.89%**		**3,701,19**	**DL 5% = 980.08 kg/ha / 39.32% DL 1% = 1,409.40 kg/ha / 56.54% DL 0.1% = 2,072.91 kg/ha / 83.16%**	

Table 2. Influence of fertilization on *Salviae herba* yields fresh matter and *Salviae herba* yields dry matter in the first experimental year (2009)

Nr. crt.	Experimental variants	Yield of *Salviae herba* – fresh product			Yield of *Salviae herba* – dry product		
		Yields		Difference	Yields		Difference
		kg/ha	%	(kg/ha)	kg/ha	%	(kg/ha)
V_1	Control-unfertilized	13,561.39	100	Mt.	3,948.46	100	Mt.
V_2	Peat fertilization, 10,000 l/ha	17,438.32	128.59	3,876.93 *	5,324.88	134.86	1,376.42 *
V_3	Leaf fertilization with Tecamin Max, 3 l/ha	20,431.64	150.66	6,870.25 **	6,609.88	167.40	2,661.42 ***
V_4	Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha	21,482.39	158.41	7,921.00 ***	6,362.53	161.14	2,414.07 ***
Average		**18,228.43**	**DL 5% = 3,259.63 kg/ha / 24.04% DL 1% = 4,687.52 kg/ha / 34.57% DL 0.1% = 6,894.26 kg/ha / 50.84%**		**5,561.44**	**DL 5% = 1,101.28 kg/ha / 27.89% DL 1% = 1,583.70 kg/ha / 40.11% DL 0.1% = 2,329.26 kg/ha / 58.99%**	

In 2010, the highest average annual yield of *Salviae herba* fresh matter, was 10,778.39 kg/ha; after drying, the highest average annual yield was 3,880.80 kg/ha *Salviae herba* dry matter obtained in the experimental variant V_4 – "Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha".

In the second year *Salvia officinalis* L., organically grown in the experimental field, produced in average 9,651.19 kg/ha *Salviae herba* fresh matter; after drying, the result was 3,201.08 kg/ha *Salviae herba* dry matter, with an average rate on drying of 3.03:1 (Table 4).

Results obtained in 2011. In 2011, the highest average annual yield of *Salviae folium* fresh matter was 9,787.31; kg/ha; after drying, the highest average annual yield was 2,978.49 kg/ha *Salviae folium* dry matter, obtained in the experimental variant V_4 – "Leaf fertilization

with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha".

Salvia officinalis L. organically grown in the experimental field of Moara Domnească, produced in average 8,154.46 kg/ha *Salviae folium* fresh matter; after drying, the result was 2,412.95 kg/ha *Salviae folium* dry matter, with an average rate on drying of 3.42:1 (Table 5).

In the third year the highest average annual yield of *Salviae herba* fresh matter, was 7,770.39 kg/ha, after drying, the highest average annual yield was 2,917.96 kg/ha *Salviae herba* dry matter obtained in the experimental variant V_4 – "Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha".

Table 3. Influence of fertilization on *Salviae folium* yields fresh matter and *Salviae folium* yields dry matter in the second experimental year (2010)

Nr. crt.	Experimental variants	Yield of *Salviae folium* – fresh matter			Yield of *Salviae folium* – dry matter		
		Yields		Difference	Yields		Difference
		kg/ha	%	(kg/ha)	kg/ha	%	(kg/ha)
V_1	Control-unfertilized	5,799.62	100	Mt.	1854.54	100	Mt.
V_2	Peat fertilization, 10,000 l/ha	7,700.86	132.78	1,901.24	2,451.80	132.21	597.26
V_3	Leaf fertilization with Tecamin Max, 3 l/ha	8,813.21	151.96	3,013.59 *	2,837.75	153.02	983.21 *
V_4	Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha	9,413.69	162.32	3,344.07 *	3,000.69	161.80	1,146.15 **
Average		**7,931.85**	**DL 5% = 2,435.20 kg/ha / 41.99% DL 1% = 3,501.94 kg/ha / 60.38% DL 0.1% = 5,150.55 kg/ha / 88.81%**		**2,536.19**	**DL 5% = 713.41kg/ha / 38.47% DL 1% = 1,025.92 kg/ha / 55.32% DL 0.1% = 1,508.90 kg/ha / 81.36%**	

Table 4. Influence of fertilization on *Salviae herba* yields fresh matter and *Salviae herba* yields dry matter in the second experimental year (2010)

Nr. crt.	Experimental variants	Yield of *Salviae herba* – fresh matter			Yield of *Salviae herba* – dry matter		
		Yields		Difference	Yields		Difference
		kg/ha	%	(kg/ha)	kg/ha	%	(kg/ha)
V_1	Control-unfertilized	6,998.45	100	Mt.	2272.81	100	Mt.
V_2	Peat fertilization, 10,000 l/ha	10,791.17	154.19	3,798.72	3,347.08	147.27	1,074.27 *
V_3	Leaf fertilization with Tecamin Max, 3 l/ha	10,036.77	143.41	3,038.32	3,303.63	145.35	1,030.82 *
V_4	Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha	10,778.39	154.01	3,779.94	3,880.80	170.75	1,607.99 **
Average		**9,651.19**	**DL 5% = 4089.94 kg/ha / 58.44% DL 1% = 5881.55 kg/ha / 84.04% DL 0.1% = 8650.41 kg/ha / 123.60%**		**3201.08**	**DL 5% = 963.19 kg/ha / 42.38% DL 1% = 1385.12 kg/ha / 60.94% DL 0.1% = 2037,19 kg/ha / 89.63%**	

Salvia officinalis L., organically grown in the experimental field, produced an average of 6,099.35 kg/ha *Salviae herba* fresh matter; after drying, the result was 2,253.02 kg/ha *Salviae herba* dry matter, with an average rate on drying of 2.72:1 (Table 6). It is remarkable the experimental variant V_3 – "Leaf fertilization with Tecamin Max, 3 l/ha", with the average multiannual yield of 11624.21 kg /ha *Salviae folium* fresh matter (Fig. 1). The average multiannual yield was mainly influenced by the yield of the first experimentation year (2009); after drying, the highest average multiannual yield was 3,407.99 kg/ha *Salviae folium* dry matter (Fig.2). The highest average multiannual yield was 13,343.72 kg/ha *Salviae herba* fresh matter (Figure 3), after drying, the highest average multiannual yield was 4,387.10 kg/ha *Salviae folium* dry matter (Fig. 4), obtained in the experimental variant V_4 – "Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha".

Table 5. Influence of fertilization on *Salviae folium* yields fresh matter and *Salviae folium* yields dry matter in the third experimental year (2011)

Nr. crt.	Experimental variants	Yield of *Salviae folium* – fresh matter			Yield of *Salviae folium* – dry matter		
		Yields		Difference	Yields		Difference
		kg/ha	%	(kg/ha)	kg/ha	%	(kg/ha)
V_1	Control-unfertilized	5,435.28	100	Mt.	1,473.89	100	Mt.
V_2	Peat fertilization, 10,000 l/ha	8,145.44	149.86	2,710.16 **	2,455.57	166.60	981.68 **
V_3	Leaf fertilization with Tecamin Max, 3 l/ha	9,787.31	180.07	4,352.03 ***	2,978.49	202.08	1504.60 ***
V_4	Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha	9,249.80	170.18	3,814.52 **	2,743.84	186.16	1269.95 ***
Average		**8,154.46**	**DL 5% = 1,813.69 kg/ha / 33.37% DL 1% = 2,608.18 kg/ha / 47.99% DL 0.1% = 3,836.03 kg/ha / 70.58%**		**2,412.95**	**DL 5% = 588.45kg/ha / 39.93% DL 1% = 846.22 kg/ha / 57.41% DL 0.1% = 1,244.60 kg/ha / 84.44%**	

Table 6. Influence of fertilization on *Salviae herba* yields fresh matter and *Salviae herba* yields dry matter in the third experimental year (2011)

Nr. crt.	Experimental variants	Yield of *Salviae herba* – fresh matter			Yield of *Salviae herba* – dry matter		
		Yields		Difference	Yields		Difference
		kg/ha	%	(kg/ha)	kg/ha	%	(kg/ha)
V_1	Control-unfertilized	4,095.80	100	Mt.	1,466.36	100	Mt.
V_2	Peat fertilization, 10,000 l/ha	5,747.01	140.31	1,651.21 **	2,136.45	145.70	670.09 **
V_3	Leaf fertilization with Tecamin Max, 3 l/ha	6,784.18	165.64	2,688.38 ***	2,491.29	169.90	1,024.93 ***
V_4	Leaf fertilization with Tecamin Max, 3 l/ha + Peat fertilization with 10,000 l/ha	7,770.39	189.72	3,674.59 ***	2,917.96	198.99	1,451.60 ***
Average		**6,099.35**	**DL 5% = 856.29 kg/ha / 20.91% DL 1% = 1,231.39 kg/ha / 30.06% DL 0.1% = 1,811.09 kg/ha / 44.22%**		**2,253.02**	**DL 5% = 422.20 kg/ha / 28.79% DL 1% = 607.14 kg/ha / 41.40% DL 0.1% = 892.96 kg/ha / 60.90%**	

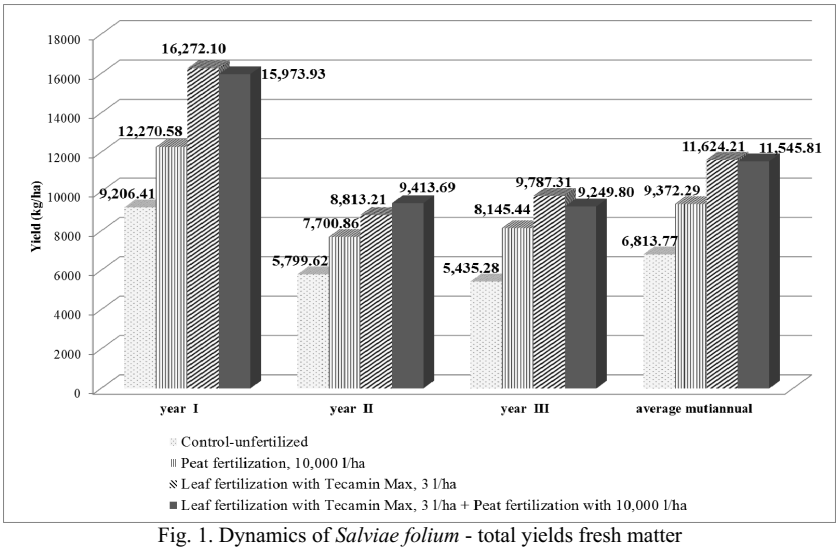

Fig. 1. Dynamics of *Salviae folium* - total yields fresh matter

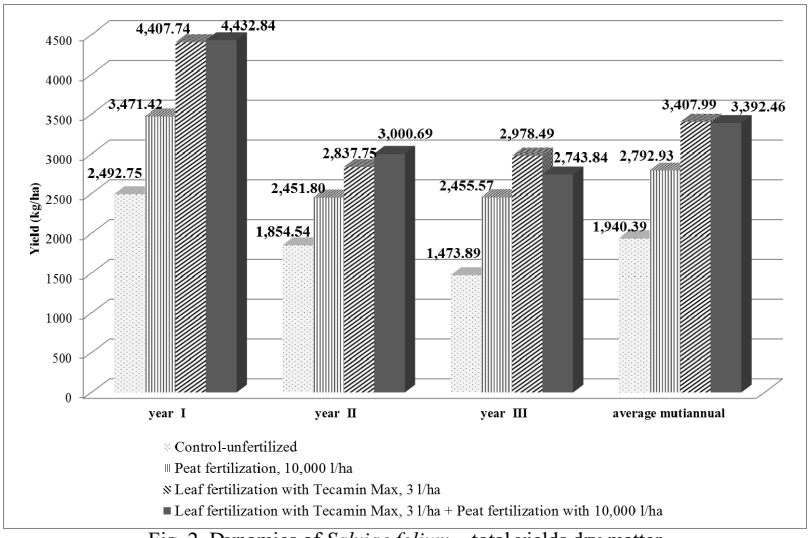

Fig. 2. Dynamics of *Salviae folium* – total yields dry matter

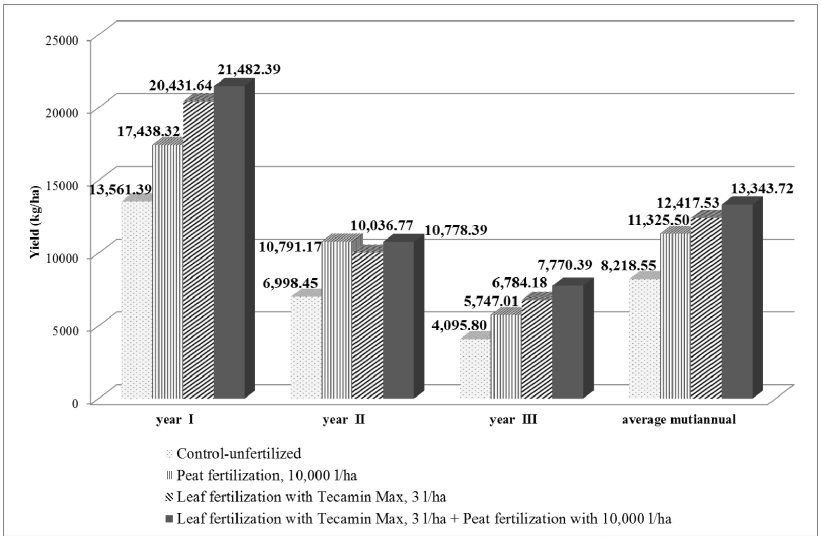

Fig. 3. Dynamics of *Salviae herba* – total yields fresh matter

Yield quality. The *Salviae herba* yield quality, air dried matter, resulted in the pedoclimatic conditions of Moara Domnească, was represented by: 4.37% moisture, 95.63% dry matter and 2.11% volatile oil.

A decreasing content in volatile oil was noted in the experimental variants that had been treated with fertilizers. The application of organic fertilizers favoured no accumulation of volatile oil in *Salviae herba* product; however, higher yields were obtained, which can supply singificantly higher amounts of volatile oil.

The average production of volatile oil in *Salviae herba*, dry matter, was 49.78 l/ha. The highest yields of volatile oil resulted from the experimental variant V_4 – "Leaf fertilization (Tecamin Max, 3 l/ha) + Peat fertilization (10,000 l/ha)", i.e. 64.23 l/ha, while the lowest yield of volatile oil was recorded in variant V_1 – "Control-unfertilized" (34.49 l/ha), even though the percentage of volatile oil in this

variant was 2.24%. In the variant V_3 – "Leaf fertilization with Tecamin Max, 3 l/ha", the amount of volatile oil was 56.16 l/ha, 8.07 l less than the experimental variant V_4 – "Leaf fertilization with Tecamin Max, 3 l/ha + peat fertilization with 10,000 l/ha" and 12.74 l more than the variant V_2 – "Peat fertilization, 10,000 l/ha", where the yield of volatile oil was 43.42 l/ha.

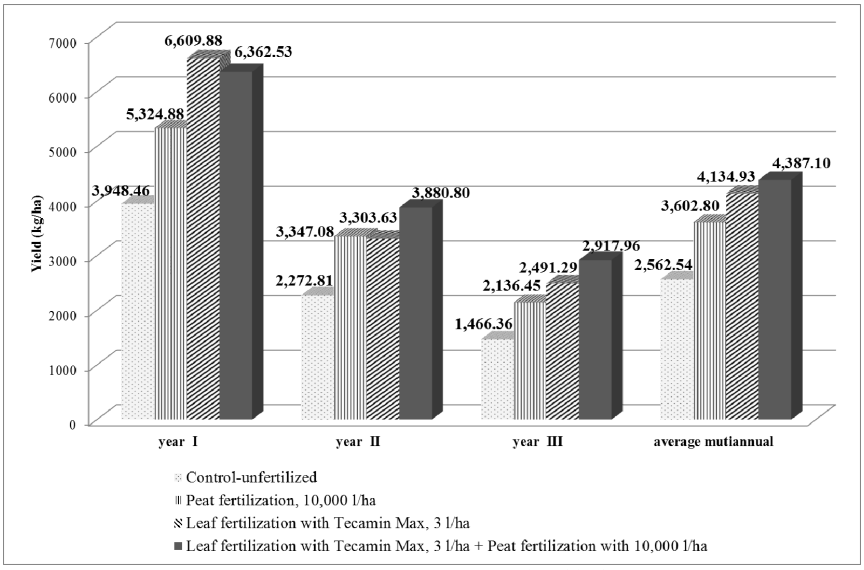

Fig. 4. Dynamics of *Salviae herba* – total yields dry matter

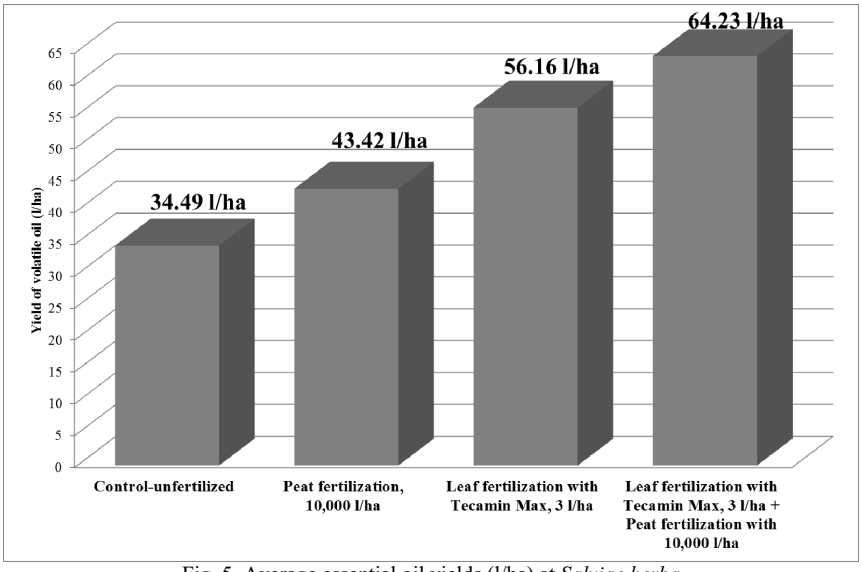

Fig. 5. Average essential oil yields (l/ha) at *Salviae herba*

CONCLUSIONS

The research carried out in the period 2009-2011 on *Salvia officianalis* L. species grown in organic agriculture conditions and under the influence of the organic fertilizers, resulted in the following conclusions:

- The area from South Romania, situated on a reddish preluvosoil where research was performed meets favourable conditions for the growth and development of *Salvia officinalis* L. species, both in terms of climate and soil characteristics. Therefore, this species can be grown in organic agriculture condition.
- *Salvia officinalis* L. plants grown in organic agriculture conditions recorded a positive reaction to the tested organic fertilizers, i.e. peat and Tecamin Max (leaf fertilizer) i.e., both fertilizers accepted in organic agriculture system. The reaction of the *Salvia officinalis* L. species to fertilization resulted in important yield increase (statistically assured from significant to highly significant), compared with the unfertilized plants.
- The application of organic fertilizers favoured no accumulation of volatile oil in the *Salviae herba* product; however, a higher amount of plant biomass was obtained, which can supply significantly higher amounts of volatile oil.

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