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The effect of foliar fertilisation with Ekolist S on yield and quality of motherwort herb (Leonurus cardiaca L.)

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Abstract. In 3-year field experiment on loamy soil effect of foliar fertilization with Ekolist S (containing macro- and microelements) on growth and yielding of motherwort was studied. Ekolist S was applied in form of 1% solution in the first year of vegetation twice: at the end of May and in middle of June, while in the second year – three times: at rosette stage (April/May), 3 week later, and 2 weeks after first harvest. Ekolist S, irrespective of plant age (in first and second year of vegetation) had beneficial influence on plant growth and brought about higher yields of herb (on average by 85% in the first year and by 42% in the second one).

The effect of Ekolist S on quality of herb was not univocal. In the first year of vegetation it resulted in advantageous decrease of stalk contribution in herb but acted conversely on the second year during the first harvest. Effect of Ekolist S on flavonoids content was not clear: noticeable increasing tendency in the first year of vegetation and decreasing in the second (regards first harvest) indicates an interrelation with contribution of stalk in herb (the higher contribution the lower flavonoids content). Theoretical yields of flavonoids (resultant of herb yield and flavonoids content) every year were markedly higher in object, where Ekolist S was applied.

Key words: Ekolist S, motherwort, foliar fertilization

INTRODUCTION

Foliar application of nutrients is effective in culture of leafy species. According to Szewczuk and Michałojć (2003) it is advisable to divide whole dose of fertilizer in 2–3 portions and apply them in form of low concentration liquid in intervals of 10–14 days. Ekolist S is an universal fertilizer assigned for foliar nutrition large group of plants (both – field and horticultural). It contains macro- and microelements (N – 10%, K_2O – 6%, MgO – 2,7% as well as vestigial amounts of boron, copper, iron, manganese, molybdenum and zinc). In the paper there is described the effect of Ekolist S on plants growth as well as on yield and quality of herb one- and two-year-old plants (in first and second year of vegetation).

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MATERIAL AND METHODS

The experiment was carried out on a loamy soil in years 2001–2004 (plantations established in 2001, 2002 and 2003 were maintained two consecutive years). The soil contained moderate quantity of magnesium, high of potassium and very high of phosphorus (Table 1).

Table 1. Content of macro- and microelements in soil [mg kg^{-1}]

Macroelements:	P	K	Mg
	144	151	51

Microelements:	B	Cu	Mn	Zn	Fe
	0,36	2,7	276,0	11,8	915,0

The most important weather elements (rainfall and air temperature) during motherwort vegetation are presented in Table 2.

Soil fertilization was performed according to recommendation for this species (Mordalski et al., 1994; Załęcki et al., 1994). Fertilizers were applied in the spring of every year in following amounts (in kg of pure nutrient calculated per hectare): N – 80, P – 21.8, K – 66.4. Motherwort seedlings were produced in greenhouse and planted on the field at the beginning of May (at phase 6–8 leaves) in a distance of 50 x 30 cm. The experimental design was randomized blocks (in four replications), plot area 16 m^2.

In the first year of vegetation Ekolist S was applied twice: at the end of May and in middle of June, while in

Table 2. Sum of rainfall and mean daily air temperature during growth period of motherwort

Month	Decade	Rainffal [mm]				Temperature [ºC]			
		2001	2002	2003	2004	2001	2002	2003	2004
April	1	15	6	10	25	9.6	3.5	0.7	5.6
	2	3	2	27	10	5.4	10.3	7.5	9.0
	3	47	10	3	3	10.5	12.0	11.2	9.6
	total/mean	65	18	40	38	8,5	8.6	6.5	8.0
May	1	0	0	9	10	15.4	17.9	16.5	13.8
	2	3	3	41	11	14.2	15.9	14.3	10.9
	3	17	26	22	17	13.5	19.9	19.6	15.4
	total/mean	20	29	72	38	14,4	17.9	16.8	13.4
June	1	28	65	3	4	13.7	15.7	19.1	15.2
	2	13	33	15	26	14.9	18.9	17.0	15.8
	3	7	19	22	20	17.2	18.7	16.1	16.4
	total/mean	48	117	40	50	15,3	17.8	17.4	15.8
July	1	34	69	25	5	20.1	21.5	17.5	16.9
	2	20	53	44	28	22.9	22.9	19.4	17.2
	3	208	4	30	58	23.8	22.5	24.6	20.0
	total/mean	262	126	99	91	22,7	22.3	20.5	18.0
August	1	55	9	1	15	20.4	21.5	20.1	18.8
	2	0	9	7	9	21.6	19.8	19.2	19.6
	3	13	0	20	25	19.2	22.2	17.5	17.3
	total/mean	68	18	28	49	20.4	21.2	18.9	18.6
Total/mean for growth period		463	308	279	266	16.2	17.5	16.0	14.8

the second year – three times: at rosette stage (April/May), 3 week later, and 2 weeks after first harvest (in the last decade of July). Ekolist S was applied in form of 1% solution in amount of 400 l per hectare.

Plants were harvested at flowering stage (in the first year of vegetation – once and in the second year – twice). Before harvest, on every plot 10 plants were measured (height, length of inflorescence, thickness of stem at base and number of branches). Cut herb was dried in drying house with forced air circulation (temperature 40ºC) and weighted after 2 days. Next, in air dry samples (0.5 kg) stalks were separated (the least valuable part of raw material) and their percentage in herb was calculated. In the other samples content of flavonoids (as a hyperoside) was determined by colorimetric method (European Pharmacopoeia, 2003).

Numerical data were statistically analysed with Tukey's test and the least significant differences (at 5% of error) were calculated.

RESULTS AND DISCUSSION

Characteristic of plant growth

In the first year of vegetation motherwort produced one branched stem, the height of it varied from 63 to 98 cm (Table 3). The analysis of weather conditions in vegetative periods shows that very low rainfall in April and May, accompanied by relatively high temperature in 2002 (Table 2) resulted in the smallest plant height. Ekolist S, on average brought about a substantial increase in the height of plants (the exception however was the year 2001 characterized by abundant rainfall).

Number of branches was the most steady feature of the stem (19.6–20.9 in control plants and 18.0–19.3 when Ekolist S was applied). It is characteristic that restraining effect of Ekolist S on ramification in the same time positively affected the thickness of stems (Table 3). Every year spraying plants with Ekolist S resulted in significant increase length of inflorescence (on average by 21%). Positive effect of Ekolist S on height of herbal plants (golden rod, thyme and blue weed) was recorded by Kołodziej (2008) and Król (2008, 2009). In the case of golden rod the marked increase in the length of inflorescences was registered, too (Kołodziej, 2008).

In the second year of vegetation, growth and development of plants were more advanced which enabled two harvests. Plants developed several stems (9.8–10.2 up to first harvest) which were taller than in first year of vegetation, but had much shorter inflorescences (Table 4). Height of plants varied in particular years, Ekolist S however resulted in significant increase of height every year. Number of stems and branches (per stem) did not depend from ap-

Table 3. Effect of Ekolist S on morphological features of motherwort in the first year of growth.

Treatment	Year	Height of plants [cm]	Number of branches	Thickness of stem [mm]	Length of inflorescence [cm]
Control	2001	98.1	19.6	6.1	21.1
	2002	63.0	20.0	6.4	21.8
	2003	86.0	20.9	7.0	25.9
	mean	82.4	20.2	6.5	22.9
Ekolist S	2001	97.8	19.3	6.7	26.5
	2002	74.1	19.2	6.9	28.2
	2003	93.2	18.0	7.5	28.4
	mean	88.4	18.8	7.1	27.7
LSD (0.05)		5.3	0.7	0.1	1.7

Table 4. Effect of Ekolist S on morphological features of motherwort in the second year of growth (first harvest).

Treatment	Year	Height of plants [cm]	Number of stems per plant	Number of branches per stem	Thickness of stem [mm]	Length of inflorescence [cm]
Control	2002	111.0	9.6	11.2	6.3	12.1
	2003	128.1	11.1	11.6	6.1	12.2
	2004	138.5	8.6	13.5	7.3	11.7
	mean	125.9	9.8	12.1	6.6	12.1
Ekolist S	2002	125.8	10.1	11.5	6.9	14.5
	2003	135.5	10.3	11.9	6.8	14.1
	2004	152.1	10.2	12.5	7.7	13.9
	mean	137.8	10.2	12.0	7.1	14.2
LSD (0.05)		4.3	0.9	0.6	0.1	1.5

Table 5. Effect of Ekolist S on morphological features of motherwort in second year of growth (second harvest).

Treatment	Year	Height of plants [cm]	Number of stems per plant	Number of branches per stem	Thickness of stem [mm]	Length of inflorescence [cm]
Control	2002	67.2	19.6	7.6	3.1	7.8
	2003	61.1	12.8	4.9	3.1	10.4
	2004	40.9	23.9	6.3	2.5	7.9
	mean	56.4	18.8	6.2	2.9	8.7
Ekolist S	2002	73.0	28.8	7.0	3.0	9.1
	2003	72.1	21.8	6.6	3.3	11.1
	2004	48.3	33.3	6.9	2.6	11.1
	mean	64.5	28.0	6.8	2.9	10.4
LSD (0.05)		4.1	2.2	0.5	ns	2.0

ns – not significant

plication of Ekolist S (the only exception was number of stems in 2004). Every year Ekolist S resulted in significant increase thickness of stem and length of inflorescence (on average, respectively by 7% and 17%).

During the second harvest plants had much more stems (their number doubled in the control treatment and almost tripled in case of plants treated with Ekolist S). Their height however did not reach those during the first harvest. Ekolist S caused marked increase height of plants, irrespectively of weather conditions in particular years (Table 5). There is characteristic, that in case of regrowth, Ekolist S had no effect on thickness of stems and length of inflorescences (the only exception was inflorescence in 2004).

Yields and quality of herb

Due to new technology of seedling production (in greenhouse with use of multicell trays), yield of air-dry herb in the first year of motherwort vegetation was very high in comparison with those from productive (farmer's) plantations (Poradnik plantatora..., 1991). Every year application of Ekolist S stimulated growth of plants, especially their height and number of stems, resulting in significant increase of yields (on average by 85%) – Table 6. What is more, Ekolist S caused decrease of stems share in herb (they are an inferior component of raw material). In an experiment led by Kołodziej (2008) with golden rod, Ekolist S resulted in increase of herb yield by 8% while in another experiment with thyme (Król, 2009) foliar fertilization (Ekolist S and Tytanit) generated not only increase of herb yields (13.5–23%) but also beneficial decrease of stem contribution in yields.

Flavonoids content in herb varied in particular years with visible tendency to decrease when higher yields were obtained (Table 6). The effect of Ekolist S on flavonoid content was not univocal and seems to be an unimportant factor in this range. Theoretical yield of flavonoids (being the result of herb yield and content of flavonoids) every year was markedly higher in the treatment where Ekolist S was applied (on average twofold higher).

Yield of two-year-old plants consisted of two crops (first harvest and aftermath). The first crop was over twofold higher than the second one (Table 7). Generally, in the sec-

Table 6. Yield and quality of air-dry herb in the first year motherwort vegetation.

Treatment	Year	Yield [t ha^{-1}]	Stems contribution [%]	Flavonoids content [%]	Theoretical yield of flavonoids [kg ha^{-1}]
Control	2001	2.10	40.5	0.45	9.5
	2002	2.29	40.6	0.36	8.2
	2003	1.99	44.4	0.49	9.8
	mean	2.13	41.9	0.43	9.2
Ekolist S	2001	2.90	39.2	0.49	14.2
	2002	3.34	38.7	0.51	17.0
	2003	5.61	41.7	0.37	20.8
	mean	3.95	39.9	0.46	18.2
LSD (0.05)		0.22	1.6	-	-

Table 7. Yields of air-dry herb during first and second harvest and total yield of flavonoids in second year of plants vegetation.

Treatment	Year	First harvest [t ha^{-1}]	Second harvest [t ha^{-1}]	Total yield [t ha^{-1}]	Total theoretical yield of flavonoids [kg ha^{-1}]
Control	2002	3.60	2.18	5.78	24.6
	2003	4.99	2.02	7.01	33.5
	2004	5.65	1.04	6.69	16.8
	mean	4.75	1.75	6.50	25.0
Ekolist S	2002	5.88	3.03	8.91	31.5
	2003	6.36	3.81	10.17	43.7
	2004	6.89	1.68	8.57	24.3
	mean	6.38	2.84	9.22	33.2
LSD (0.05)		0.59	0.76	-	-

Table 8. Quality characteristics of crops in second year of motherwort vegetation.

Treatment	Year	Stems contribution [%]		Flavonoids content [%]	
		first harvest	second harvest	first harvest	second harvest
Control	2002	63.0	55.8	0.36	0.53
	2003	60.0	34.3	0.46	0.52
	2004	65.7	42.3	0.26	0.20
	mean	62.9	44.1	0.36	0.42
Ekolist S	2002	63.5	54.4	0.30	0.46
	2003	62.0	31.7	0.40	0.48
	2004	70.2	42.1	0.25	0.42
	mean	65.2	42.7	0.32	0.45
LSD (0.05)		1.8	1.5	-	-

ond year of growth, total yield of herb was by 158% higher than in the first one. Positive effect of Ekolist S was significant every year and at each harvest. On average, Ekolist S resulted in 34% increase of yield during the first harvest and 62% during the second one. In an experiment led by Sugier and Gawlik-Dziki (2009) foliar nutrition of arnica with Ekolist S resulted in an increased yield of inflorescences in the second year of vegetation (by 16.9%) but had no univocal influence on the quercetine content.

Content of flavonoids varied through the years, the lowest being in 2004, when both: yields and contribution of stalks in herb were the highest (Table 7 and 8). In general, flavonoids content was slightly higher in herb of second harvest (aftermath). This phenomenon apparently is related with lesser contribution of stalks in herb (Table 8). Theoretical total yield of flavonoids in two crops varied greatly in years, every year however was markedly higher in the treatment where Ekolist S was applied (on average by 32.8%).

Stem contribution in herb during first harvest of two years old plants was much higher in comparison with one year old plants. During the second harvest, the contribution of stems markedly decreased (Table 8). Ekolist S caused significant increase of stem share during the first harvest, while during the second one did not influence markedly this feature.

CONCLUSIONS

1. Field experiment on foliar feeding of motherwort with Ekolist S (fertilizer containing macro- and microelements) showed positive effects on growth and development of plants in the first and second year of vegetation.
2. Independently of plant age Ekolist S resulted in taller plants, thicker stems and longer inflorescences. In the second year of vegetation foliar feeding additionally brought about increased number of stems (per plant) and branches per stem.
3. Beneficial changes in plant growth and structure resulted in significant increase of herb yields (by 85% in the first year of vegetation and by 42% in the second one).
4. Positive effects of Ekolist S on quality of herb was expressed by the lower contribution of stalks (especially in the first year of vegetation). As regards flavonoids content, it was slightly higher, probably due to decreased contribution of stalks in herb.

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