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YIELD AND QUALITY OF CHAMOMILE (*Chamomilla recutita* (L.) Rausch.) RAW MATERIAL DEPENDING ON SELECTED FOLIAR SPRAYS AND PLANT SPACING

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Abstract. Chamomile is a valued medicinal plant of high economic importance and therefore agronomic practices in growing this plant are continually improved. One of methods to improve the quantitative and qualitative parameters of herbal raw material can be the application of foliar sprays (growth stimulators, foliar fertilizers, Effective Microorganisms). Row spacing, which has an effect on the use of fertilizers by the plant and natural habitat conditions, is of great importance in chamomile growing practices. During the period 2011–2013, a field experiment was conducted, the aim of which was to determine the effects of selected foliar-applied sprays and different row spacings on the yield and quality of chamomile cv. 'Złoty Łan' raw material. The study included three formulations: Asahi SL, Ekolist P, and EM Farming. Plots without the application of these foliar sprays were the control treatment. The other factor included in the experiment was row spacing, which was as follows: 25, 35, and 45 cm. Plant height and number of inflorescences per stem, total yield of raw material and the content of essential oil and flavonoids in raw material were determined. The growth stimulator Asahi SL was proven to positively affect the yield and quality of chamomile raw material. Ekolist P had a lower effect on the improvement in the parameters analyzed. The reports of some authors that Effective Microorganisms (EM Farming) had no effect whatsoever on plant productivity were confirmed in this study. It was shown that growing chamomile in rows 45 cm apart, or at a row spacing of 35 cm, was most beneficial for the yield and quality of chamomile raw material. A narrow row spacing (25 cm) contributed to a decrease in yield and deterioration in its quality.

Key words: productivity, essential oil, flavonoids, Asahi SL, Ekolist P, EM Farming, interrow width

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INTRODUCTION

German chamomile (*Chamomilla recutita* (L.) Rausch.) is one of the oldest and most known medicinal plant. Chamomile herbal material comprises flower heads and crushed material that includes ligulate and disk flowers as well as undeveloped or immature seeds. Essential oil and flavonoids are important ingredients of chamomile raw material. The cultivation of chamomile is widespread in many countries due to its great medicinal and industrial importance [Bruni et al. 1993, Letchamo 1996, Surmacz-Magdziak and Wiśniewski 2009]. The great medicinal qualities of chamomile and a high demand for its raw material encourage researchers to undertake research on the modification of existing agronomic practices in growing this plant. New agronomic solutions can beneficially affect raw material yield and quality (essential oil and flavonoid content). Formulations that perform the role of growth and yield stimulators are used more and more frequently in agricultural practice. One of them is Asahi SL (Atonik) which is recommended for field, vegetable, fruit and nursery crops [Przybysz et al. 2010, Kwiatkowski et al. 2013] as well as in herbal plantations [Kołodziej 2004, Kwiatkowski 2011, Kwiatkowski and Juszczak 2011]. The main ingredients of this biostimulator are natural active compounds found in the plant world: 5-nitroguaiacolate as well as ortho- and para-nitrophenols in the form of potassium salts [Król 2009]. Another possibility to increase the yield and quality of crops is to apply foliar fertilizers which supply macro- and micronutrients to plants and can even reduce infection by diseases and pests [Berbeć et al. 2003]. The results of some studies allow one to presume that the use of Effective Microorganisms (EM) technology can be a method for improving the yield and quality of chamomile raw material. It has been shown that this microbiological formulation can be successfully used in the production of vegetable or ornamental plants, affecting yields and increasing the content of important chemical constituents in plant raw material. [Borgen and Davanlou 2000, Xu 2000, Javaid 2006, Singh 2007]. This microbiological formulation includes, among others, lactic bacteria (*Lactobacillus casei*, *Streptococcuc lactis*), photosynthetic bacteria (*Rhodopseudomonas palustrus*, *Rhodobacter spae*), yeasts (*Saccharomyces albus*, *Candida utilis*), actinobacteria (*Streptomyces albus*), and mold fungi (*Aspergillus oryzae*, *Mucor hiemalis*) [Higa 1998, Valarini et al. 2003].

Some authors [Kołodziej and Zejdan 2000, Gruszczyk 2001, Sugier 2004, Surmacz-Magdziak and Wiśniewski 2009] draw attention to the important role of row spacing, which is often dependent on the adopted method of plant tending, fertilization and crop protection, in growing herbal plants in order to obtain satisfactory yields.

Taking into account the above premises, in the present study a hypothesis was made that the use of biological preparations in chamomile crops would contribute to increased yields of this plant and to obtaining raw material of better quality compared to the control treatment (without foliar application). An assumption was also made that this research would allow optimal row spacing for this species to be determined in combination with the use of foliar sprays. The aim of this study was to determine the yield structure and selected quality parameters of chamomile raw material depending on foliar sprays (biostimulator, foliar fertilizer, EM) and different row spacings.

MATERIALS AND METHODS

A field experiment in growing German chamomile (*Chamomila recutita* (L.) Rausch.) was carried out in the period 2011–2013 in Fajsławice 22° 57'E, 51°06'N (the central Lublin region). The experiment was set up as a split-plot design with 3 replicates, in 10 m^2 plots. The total experimental area was 360 m^2. Chamomile (cv. 'Złoty Łan') was grown on incomplete podzolic soil (pH in 1 mole KCl = 6.3), classified as good wheat complex. On average during the study period, the soil was characterized by a medium content of available macronutrients (P = 79.2; K = 84.2; Mg = 30.2). The soil total N content was 3.01 $g \cdot kg^{-1}$, while the soil humus content was 1.41%.

The content of total nitrogen (N) was determined by the Kjeldahl method, phosphorus (P) and available potassium (K) by the Egner-Riehm method, available magnesium (Mg) by AAS after extraction of 0.0125 mole $CaCl_2 \cdot dm^3$ (PN-R-04020:1994), soil pH was determined electrometrically in a 1-molar solution of KCl, whereas humus content by the Tiurin method.

The experimental design included the following factors:

I. Foliar sprays:

A – No application of foliar sprays (control treatment);

B – Foliar spraying with Asahi SL – Atonik* (1.0 ml in dm^{-3} of water) – 0.25 $dm^3 \cdot ha^{-1}$;

C – Foliar spraying with Ekolist P (5.0 ml in dm^{-3} of water) – 1.25 $dm^3 \cdot ha^{-1}$;

D – Foliar spraying with EM Farming – EMa (50.0 ml in dm^{-3} of water) – 12.5 $dm^3 \cdot ha^{-1}$.

*The specific composition of the sprays used in this experiment is shown in Table 1.

II. Spacing of individual rows:

1. 25 cm apart;
2. 35 cm apart;
3. 45 cm apart.

Table 1. Components of the sprays used in the experiment

Name of mixing	Composition of mixing
Asahi SL	sodium para-nitrophenolate – 0.3%, sodium ortho-nitrophenolate – 0.2%, sodium 5-nitroguaiacolate (5NG) – 0.1%
Ekolist P	phosphorus (as P_2O_5) – 35%, nitrogen (as $N\text{-}NH_2$) – 7.5%, boron (B) – 0.42%, zinc (Zn) – 0.47%
EM Farming	anaerobic organisms which release free, chemically uncombined oxygen into the environment during metabolic processes (photosynthetic bacteria, actinobacteria, lactic acid bacteria, fermentation fungi, yeasts) – the percentage contributions of particular microorganism strains in the spray is the manufacturer's secret (patent) and this information is not included in any available data sheets

In each year of the study, the previous crop for chamomile was white mustard (*Sinapis alba* L.) cv. 'Borowska' grown for green manure. Each year, the same mineral fertilization was used before sowing chamomile, in the following amounts ($kg \cdot ha^{-1}$): 50 N (applied in the form of 34% ammonium nitrate), 25 P (in the form of 46% granulated triple superphosphate), 70 K (in the form of 50% potassium salt). Chamomile seeds were sown at a rate of 2.5 $kg \cdot ha^{-1}$ in the second 10-day period of April every year. Weed control in the chamomile plantation was carried out using mechanical and chemical weed control which is common in the Lublin region and consistent with the recommendations of the Institute of Plant Protection [Zalecenia ochrony roślin... 2010] (a spike tooth harrow before emergence + herbicide Chwastox 500 SL – MCPA – 0.6 $dm^3 \cdot ha^{-1}$) as well as mechanical weed control in the interrows (a hand hoe) at the 3–5-leaf stage of chamomile.

The foliar sprays (treatments B-D) were applied using a field sprayer (Kwazar RS/30, 10 dm^3) under a pressure of 0.25 MPa. The preparations were applied only once at the initial stage of generative stem formation of chamomile plants (in the third 10-days of June).

3–5 days before the harvest of herbage, chamomile plant height and number of inflorescences per stem were determined. The measurements were made based on 30 plants randomly selected from each plot.

The herbage, including inflorescences used for the production of crushed flowers, was harvested after about 10 days from the beginning of flowering (half developed flower heads – in the second/third 10-day period of August). The harvested herbage was dried at 35ºC in an air circulation drying oven and subsequently it was threshed and separated from dried crushed flowers. The crushed herbal material (flowers) obtained was weighed and divided into particular fractions using sieves with the following mesh sizes: 3.0, 1.0, 0.8, and 0.4 mm. The fractions obtained, i.e. disk flowers, ligulate flowers and seeds, were weighed, whereas the other plant parts, e.g. receptacles, ground stems and leaves, were rejected.

The content of essential oil (the method of steam distillation using the Deryng apparatus) and flavonoids was determined based on an average sample consisting of flower heads from three successive harvests. The essential oil was isolated from dried raw material by the distillation method described in European Pharmacopoeia VII [2011] using 20 g of crushed plant material, a 1000 mL round-bottomed flask, and 400 mL of water as distillation liquid. Xylene (0.5 ml in a graduated tube) was added to take up the essential oil. The distillation time was 2 h at a rate of 2–4 mL/min. Flavonoids (flavonols expressed as quercetin) were determined by spectrophotometry using Christ-Müller's method [Christ and Müller 1960] according to the modified Polish Pharmacopoeia VI [2002] procedure (based on measuring the absorbance of a coloured complex of flavonoids with aluminium chloride).

The results were analyzed statistically by analysis of variance. LSD values were determined by Tukey's test at $\alpha = 0.05$.

The study results obtained did not differ significantly between experimental years; therefore, the averages for 2011–2013 are shown in the tables.

The total rainfall during the chamomile growing seasons (May – August) as well as the annual rainfall totals in the period 2011–2013 were similar and at the same time distinctly lower than the long-term means. The mean air temperatures were also almost identical in individual growing seasons but higher than the long-term mean temperatures. Throughout the study period, however, there were certain differences for some months of the chamomile growing period (tab. 2).

Table 2. Rainfall and air temperature in April – August of 2011–2013 as compared to the long-term means (1974–2003) in Fajsławice

	Year	Month						
		April	May	June	July	August	total/ mean IV–VIII	total/ mean I–XII
Rainfall, mm	2011	18.2	45.8	79.3	52.2	41.7	237.2	547.2
	2012	16.0	66.3	36.7	99.7	23.9	242.6	539.9
	2013	52.4	26.6	66.1	66.8	37.8	249.7	550.1
	mean 1974–2003	44.2	58.7	80.4	79.0	68.2	330.5	609.2
Temperature, ºC	2011	7.3	16.7	17.0	19.3	18.2	15.7	7.7
	2012	6.5	15.9	17.4	19.4	18.3	15.5	7.5
	2013	7.7	11.6	17.5	19.8	18.4	15.0	7.6
	mean 1974–2003	7.7	13.6	16.5	17.9	17.6	14.6	7.6

In order to get a more complete analysis of thermal and rainfall conditions, Selyaninov's hydrothermal coefficient (K) was calculated according to Radomski [1987]:

$$K = \frac{P}{0.1\sum t} \tag{1}$$

where:

P – total rainfall for a given month (mm);

$\sum t$ – the sum of mean temperatures for a given month (ºC).

Table 3. Selyaninov's hydrothermal coefficient (K)

Year	Month				
	April	May	June	July	August
2011	0.8*	0.9	1.5	0.9	0.9
2012	0.8	1.3	0.7	1.6	0.4**
2013	2.2	0.6	1.1	1.1	0.8
Mean for 1974–2003	1.9	1.4	1.6	1.4	1.3

*K < 1.0 = dry spell; **K < 0.5 = drought

The analysis of the values of the hydrothermal coefficient calculated for the individual chamomile growing seasons shows (tab. 3) that in 2011 optimal conditions for the growth of this herbal plant prevailed only in June, whereas in 2012 the months of May and July were favourable, but in turn, in August a drought occurred. In 2013 favourable hydrothermal conditions were recorded in April, June, and July. In May 2013 there was a dry spell during the initial period of chamomile growth, which reduced biomass accumulation by plants and their growth. These data thus show that there were periods of adverse hydrothermal conditions in each year of chamomile growth and that in the period 2011–2012 such periods predominated over favourable periods. Therefore, the effect of the foliar sprays used (Asahi SL, Ekolist P, EM Farming), which contribute to an improvement in general condition of plants and their growth rate, could be manifested.

RESULTS

Among the foliar sprays tested in the experiment, the biostimulator Asahi SL had the most beneficial effect on chamomile plant height, regardless of row spacing (tab. 4). In the treatments with application of the above-mentioned biostimulator, chamomile plants were significantly higher (by 2.3 cm and 2.6 cm, respectively) than those in control treatment A and in treatment D (EM Farming). Ekolist P also affected positively chamomile plant height, but at a statistically insignificant level. Regardless of the foliar sprays, significantly higher chamomile plants (on average by 2.7 cm) were observed under the conditions of 45 cm row spacing compared to those found in the treatment with 25 cm row spacing. Significantly the highest chamomile plants were found in the treatment with 45 cm row spacing and foliar application of Asahi SL (tab. 4).

Table 4. Chamomile plant height (cm) – mean for 2011–2013

Treatments	Foliar sprays				
Row spacing	control	Asahi SL	Ekolist P	EM Farming	mean
25 cm	26.4	27.6	27.1	26.2	26.8
35 cm	28.1	30.2	28.7	27.9	28.7
45 cm	28.5	32.3	29.2	28.0	29.5
Mean	27.7	30.0	28.3	27.4	–

$LSD_{\alpha = 0.05}$
foliar sprays (A) = 2.10
row spacing (B) = 2.03
interaction (A × B) = 2.06

On average during the study period, Asahi SL and Ekolist P contributed to a significantly higher number of inflorescences per stem in chamomile plants, compared to control treatment A and treatment D (EM Farming), by respectively 27.3–24.0% and

12.5–10.0% (tab. 5). At the same time, chamomile plants treated with Asahi SL had significantly more inflorescences per stem than those sprayed with Ekolist P (on average by 16%). Growing chamomile at a row spacing of 25 cm contributed to a significantly lower number of inflorescences per stem (on average by 9 and 20%) compared to row spacings of 35 cm and 45 cm. Statistically proven, the highest number of inflorescences per stem in chamomile plants was found in the treatment with rows 45 cm apart and foliar spraying with the biostimulator Asahi SL (tab. 5).

Table 5. Number of inflorescences per chamomile stem (pcs.) – mean for 2011–2013

Treatments	Foliar sprays				
Row spacing	control	Asahi SL	Ekolist P	EM Farming	mean
25 cm	49.4	63.8	54.9	53.1	55.3
35 cm	54.2	72.3	60.5	55.0	60.5
45 cm	59.7	86.4	71.2	60.3	69.4
Mean	54.4	74.2	62.2	56.1	–

$LSD_{\alpha = 0.05}$
foliar sprays (A) = 6.02
row spacing (B) = 5.13
interaction (A×B) = 9.45

Table 6. Total yield of chamomile raw material ($t \cdot ha^{-1}$) – mean for 2011–2013

Treatments	Foliar sprays				
Row spacing	control	Asahi SL	Ekolist P	EM Farming	mean
25 cm	0.80	1.01	0.91	0.82	0.88
35 cm	0.87	1.06	1.02	0.90	0.96
45 cm	0.89	1.19	1.05	0.88	1.00
Mean	0.85	1.09	0.99	0.87	–

$LSD_{\alpha = 0.05}$
foliar sprays (A) = 0.086
row spacing (B) = 0.077
interaction (A × B) = 0.098

The use of EM Farming (treatment D) had no effect on chamomile yield; it was almost identical as that in control treatment A (tab. 6). However, foliar spraying with Asahi SL and Ekolist P significantly affected the yield of chamomile raw material compared to control treatment A and treatment D (an increase in yield by about 22 and 14%, respectively). Moreover, the chamomile raw material yield obtained in treatment B (Asahi SL) was significantly higher (on average by 9%) than that in treatment C (Ekolist P). Irrespective of the application of foliar sprays, the lowest chamomile raw material yield was found in the treatment with 25 cm row spacing compared to row spacings of 35 and 45 cm (by 8 and 12%, respectively). Growing chamomile at a row spacing of 45 cm and the use of the biostimulator Asahi SL resulted in significantly the highest yield of herbal raw material (1.19 t ha^{-1}) relative to all the other experimental treatments (tab. 6).

Disk flowers by far dominated in the total yield of crushed herbal material of chamomile, accounting for about 83% of the raw material (tab. 7). Ligulate flowers (about 7%) and seeds (about 5%) had a lower percentage in the total yield structure. Among the foliar sprays used, Asahi SL and Ekolist P significantly affected a higher percentage of disk flowers in the yield compared to the control treatment. Besides, Asahi SL contributed to a significantly higher percentage of seeds in the total yield compared to the other experimental treatments. The study found a significantly higher weight of disk flowers and seeds in the treatments where chamomile was grown at a row spacing of 45 cm compared to a row spacing of 25 cm (tab. 7).

Table 7. Weight of disk flowers, ligulate flowers and seeds in the total yield of chamomile raw material (t·ha^{-1}) – mean for 2011–2013

Foliar sprays/row spacing	Disk flowers	Ligulate flowers	Seeds
Control	0.75	0.06	0.04
Asahi SL	0.94	0.08	0.07
Ekolist P	0.87	0.07	0.05
EM Farming	0.76	0.06	0.05
$LSD_{\alpha = 0.05}$	0.098	n.s.	0.018
25 cm	0.79	0.05	0.04
35 cm	0.85	0.06	0.05
45 cm	0.89	0.05	0.06
$LSD_{\alpha = 0.05}$	0.096	n.s.	0.016

The study did not find a statistically proven effect of the foliar spays on the essential oil content in chamomile disk flowers (tab. 8). It can only be stated that there was a trend towards a positive effect of Asahi SL on the content of this constituent. It was proved, however, that growing chamomile at a row spacing of 35 cm, and in particular at 45 cm, positively influenced the essential oil content in the raw material compared to a row spacing of 25 cm (tab. 8).

The flavonoid content in disk flowers of chamomile was significantly dependent on both experimental factors (tab. 9). Foliar spraying with Asahi SL (treatment B) had an effect on increasing the flavonoid content, relative to the other treatments, by 0.4% DW (treatments A and C) and by 0.7% DW (treatment D). Regardless of the application of foliar sprays, a significantly higher content of flavonoids was found in the treatment with 45 cm wide interrows in relation to the narrowest row spacing – 25 cm (tab. 9).

Table 8. Essential oil content in disk flowers of chamomile (% DW) – mean for 2011–2013

Treatments	Foliar sprays				
Row spacing	control	Asahi SL	Ekolist P	EM Farming	mean
25 cm	0.50	0.54	0.51	0.51	0.51
35 cm	0.57	0.62	0.59	0.56	0.58
45 cm	0.62	0.67	0.63	0.60	0.63
Mean	0.56	0.61	0.58	0.56	–

$LSD_{\alpha = 0.05}$
foliar sprays (A) = n.s.
row spacing (B) = 0.066
interaction (A × B) = n.s.

Table 9. Flavonoid content in disk flowers of chamomile (% DW) – mean for 2011–2013

Treatments	Foliar sprays				
Row spacing	control	Asahi SL	Ekolist P	EM Farming	mean
25 cm	3.5	4.0	3.6	3.4	3.6
35 cm	3.8	4.2	3.8	3.6	3.8
45 cm	4.0	4.5	3.9	3.6	4.0
Mean	3.8	4.2	3.8	3.5	–

$LSD_{\alpha = 0.05}$
foliar sprays (A) = 0.38
row spacing (B) = 0.37
interaction (A × B) = n.s.

Regardless of the yield traits analysed, the effects of the foliar sprays used in the experiment on chamomile plants varied. The biostimulator Asahi SL had by far the most beneficial effect on the yield and quality of chamomile raw material. During the particular growing seasons, the thermal conditions generally differed from the optimal values, but Selyaninov's hydrothermal coefficient was favourable at the time of the application of the foliar sprays (June) and in July (tab. 3). It can therefore be presumed that some sprays (EM Forming) reveal a positive effect only under long-term adverse conditions.

DISCUSSION

Among the foliar applied formulations tested in the experiment, the biostimulator Asahi SL had a significantly beneficial effect on chamomile yield. Woropaj-Janczak et al. [2011] also found a significant increase in chamomile yield as influenced by Asahi SL, similarly to Kwiatkowski [2011] as well as Kwiatkowski and Juszczak [2011] on the example of garden thyme and sweet basil. Vavrina [1998], Czeczko and Mikos-Bielak [2004], Djanaguirman et al. [2005] also show positive results of the action of Asahi SL.

The present study did not find Ekolist P to be highly useful in chamomile cultivation. Woropaj-Janczak et al. [2011] draw attention to the low usefulness of Ekolist P used in chamomile crops under the conditions of humidity deficit and high temperatures. Król [2009] also showed the lower importance of foliar fertilizers (Mikrosol U) compared to a growth stimulator (Asahi SL) in determining the yield of herbal plants. Szewczuk and Juszczak [2003] also indicate the greater usefulness of growth stimulators than foliar fertilizers when evaluating their effect on bean yield.

Effective Microorganisms can be soil or foliar applied or as a seed dressing [Sinqueira et al. 1993, Javaid 2006, Janas and Grzesik 2006]. In the present study, foliar applied EM Farming in a chamomile plantation had no effect on plant height, number of inflorescences, total yield of raw material and its quality (the content of essential oil and flavonoids). The results of studies on the effect of EM on yields of crop plants are ambiguous. The use of EM can cause a distinct increase in yield components and plant biometric features and, as a consequence, an increase in yield by even 20% [Higa 1998, Xu 2000, Condor et al. 2006, Singh 2007]. Shamshad et al. [2001] found an increase in maize grain yield and protein content in crops in which Effective Microorganisms were used. In turn, Sulewska and Ptaszyńska [2005] observed only an insignificant increase in maize yield after EM application. On the other hand, Martyniuk and Księżak [2011] did not observe a significant effect of EM Farming on 1000 grain weight, moisture content and yield of maize grain. Van Vliet et al. [2006] did not also show an increase in grass biomass after the application of EM.

Irrespective of foliar sprays, the highest total yield of chamomile and the best yield structure were obtained at a row spacing of 45 cm. In this situation, chamomile plants were the highest and produced most inflorescences on the stem. Surmacz-Magdziak and Wiśniewski [2007, 2009], Kołodziej and Zejdan [2000] as well as Sugier [2004] draw attention to the most beneficial effect of wider row spacing on yields of chamomile and other herbal plants.

The essential oil content in chamomile plants depends on three groups of factors: genotype, weather, and agrotechnical factors [Bettray and Vömel 1992; Nikolova et al. 1997]. The statistical analysis of the results of this study did not show the foliar sprays to significantly affect the essential oil content in chamomile raw material. This could have been caused by the greater effect of the foliar sprays on chamomile productivity than on the chemical composition of the raw material, which is noted by Król [2009]. Similarly, Woropaj-Janczak et al. [2011] did not find a higher content of essential oil in German chamomile as a result of the use of Asahi SL. In the study of Król [2009], the foliar formulations used (Asahi SL, Bio-algeen, Tytanit, Mikrosol) caused a slight decrease in essential oil content in garden thyme raw material. Salamon [2007] pointed to the fact that growth regulators affected not only plant growth and an increase in flower number but also the essential oil content in chamomile plants, yet he noted that the cost of application of those agents was higher than the production effect. Woropaj-Janczak et al. [2011] recorded the essential oil content in inflorescences of the chamomile cultivars 'Dukat' and 'Mastar' at a level of 0.46–0.50%. In the present study, the oil content in disk flowers of the chamomile cultivar 'Złoty Łan' ranged between 0.50 and 0.67%. Surmacz-Magdziak and Wiśniewski [2009] found the essential oil content in cv. 'Złoty Łan' at a level of 0.51–0.75%. As in the present study, these authors observed the lowest essential oil content in crops with a narrow row spacing of 25 cm. But Salomon

[1994] did not find row spacing to affect the essential oil content in raw material. In this experiment, wider row spacing was found to have a beneficial effect on the essential oil content in disk flowers obtained in the production of crushed herbal material. Kołodziej and Zejdan [2000] as well as Sugier [2004] also observed a beneficial effect of wider row spacing on the example of fenugreek seeds and dandelion roots.

Bruni et al. [1993] and Letchamo [1996] report that the flavonoid content in chamomile raw material can reach 7%. Węglarz and Rosłon [2002] claim that the amount of flavonoids can range from 4.3 to 4.8%. In the present experiment, the flavonoid content in disk flowers was from 3.4 to 4.5%. The use of Asahi SL affected an increase in flavonoid content in chamomile inflorescences, whereas EM Farming caused a decrease in the content of this component. There were favourable weather conditions during the growing seasons of chamomile throughout the entire study period. Soil nutrient availability was also at a good level. Hence, the study did not find a positive effect of EM Farming on the chemical composition of chamomile. In the opinion of some authors [Xu 2000, Singh 2007], the stimulating activity of Effective Microorganisms particularly manifests itself under adverse agro-climatic conditions.

The response of plants to foliar sprays can be different, depending on species and components analyzed [Skupień and Oszmiański 2007]. In the studies of Kwiatkowski [2011] as well as Kwiatkowski and Juszczak [2011], the absence of application of growth stimulators was more beneficial for the chemical composition of garden thyme and sweet basil raw material. In another study, Kwiatkowski et al. [2013] observed growth stimulators (in particular Asahi SL) to have a beneficial effect on the chemical composition of carrot roots. The positive influence of Asahi SL on the chemical composition of plant raw material is confirmed by the research of Panajatov et al. [1997] and Kołodziej [2008a, b]. The latter author thinks that the action of growth stimulators is closely related to factors such as humidity, air temperature, and soil nutrient availability. It can be generally stated that the positive action of foliar sprays is manifested more strongly under stress conditions for plants (e.g. soil water deficit, an insufficient amount of available nutrients in the soil) [Bączek-Kwinta and Seidler-Łożykowska 2004, Bączek-Kwinta et al. 2006].

CONSLUSIONS

1. Among the foliar sprays tested in the experiment, the growth stimulator Asahi SL (Atonik) had a significant effect on the yield and quality of chamomile raw material. Ekolist P had a smaller positive effect on chamomile productivity compared to Asahi SL.
2. Effective Microorganisms (EM Farming) were not shown to be useful in chamomile growing practices.
3. The use of a row spacing of 45 cm had the most beneficial effect on the biometric characteristics of plants, the yield structure of dried crushed flowers and the quality of chamomile raw material.
4. In the light of the results obtained, we can recommend the use of the biostimulator Asahi SL in chamomile plantations and the cultivation of this plant using 45 cm wide interrows.

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PLON I JAKOŚĆ SUROWCA RUMIANKU POSPOLITEGO (*Chamomilla recutita* (L.) Rausch.) W ZALEŻNOŚCI OD WYBRANYCH PREPARATÓW DOLISTNYCH ORAZ ROZSTAWY ROŚLIN

Streszczenie. Rumianek pospolity jest cenioną rośliną leczniczą o dużym znaczeniu gospodarczym. Ciągle aktualne jest więc doskonalenie agrotechniki tej rośliny. Jednym ze sposobów poprawy parametrów ilościowych i jakościowych surowca zielarskiego może być aplikacja preparatów dolistnych (stymulatorów wzrostu, nawozów dolistnych, Efektywnych Mikroorganizmów). Dużą rolę w agrotechnice rumianku może odgrywać rozstawa rzędów, która wpływa na wykorzystanie przez roślinę nawożenia oraz naturalnych warunków siedliska. W latach 2011–2013 przeprowadzono doświadczenie polowe, którego celem było określenie wpływu wybranych preparatów aplikowanych dolistnie oraz zróżnicowanej rozstawy rzędów na plonowanie rumianku pospolitego i jakość pozyskanego surowca. W badaniach uwzględniono trzy preparaty: Asahi SL, Ekolist P oraz EM Farming. Obiektem kontrolnym były poletka bez stosowania preparatów dolistnych. Drugim czynnikiem uwzględnionym w doświadczeniu była rozstawa pojedynczych rzędów wynosząca: 25, 35 i 45 cm. Określano wysokość roślin i liczbę kwiatostanów na łodydze rumianku, ogólny plon surowca oraz zawartość w surowcu olejku eterycznego i flawonoidów. Dowiedziono, że na plonowanie i jakość surowca rumianku pospolitego dodatnie wpływał stymulator wzrostu Asahi SL. Ekolist P wpływał w mniejszym stopniu na poprawę analizowanych parametrów. Potwierdzono doniesienia niektórych autorów o całkowitym braku wpływu Efektywnych Mikroorganizmów (EM Farming) na produkcyjność roślin. Wykazano, iż najkorzystniejszą dla plonu i jakości surowca rumianku pospolitego jest uprawa w rzędach odległych o 45 cm, ewentualnie w rozstawie 35 cm. Wąska rozstawa rzędów (25 cm) przyczyniała się do regresu plonów i pogorszenia ich jakości.

Słowa kluczowe: produkcyjność, olejek eteryczny, flawonoidy, Asahi SL, Ekolist P, EM Farming, szerokość międzyrzędzi

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