Reaction of German chamomile (*Chamomilla recutita* L. Rauschert) cultivars to biostimulants and foliar fertilisation

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S u m m a r y

In three series of pot experiments (2006–2008) there was investigated a reaction of two cultivars of chamomile (*Chamomilla recutita* L. Rauschert): diploid 'Mastar' and tetraploid 'Dukat', with use of biostimulants: Asahi SL and Bio-Algeen S-90 as well as microelement fertiliser Ekolist P. The experiments were performed under stress triggered by high air temperature and low soil moisture. According to the pot experiment results, the application of Asahi SL was the only one which increased the chamomile herb yield. The effect of Asahi SL was tested in a field experiment (2008/2009) which also recorded an increase in the herb yield, yet only in 'Dukat' plants. The 'Dukat' plants produced higher yield of herb, of a higher content of essential oil in herb than the 'Mastar' plants, nevertheless the 'Mastar' plants bloomed more abundantly and contained more essential oil in inflorescences. No benefits were observed from application of the microelement fertilizer Ekolist P or the biostimulant Bio-Algeen S-90 to chamomile grown as exposed to moisture deficit and high temperatures.

Key words: *Asahi, Bio-Algeen, chamomile herb, diploid cultivar, Ekolist, tetraploid cultivar*

INTRODUCTION

Chamomile (*Chamomilla recutita* L. Rauschert) is one of the oldest and best defined medicinal plants. It is one of the most frequently grown medicinal plants. The pharmaceutical material is made up by chamomile inflorescences (*Anthodium Chamomillae*), while herb constitutes material from which the essential oil is obtained. At home and abroad, next to diploid cultivars, many tetraploid cultivars have been bred. Polish tetraploid cultivars demonstrate, e.g. a greater inflorescence weight and greater 1000 seed weight, higher yields of essential oil and flavonoids, as compared to diploid ones [1]. The content of essential oil changes with various development stages, differently in di- and tetraploid cultivars [2].

Both foliar fertilisation with microelements and agents stimulating plant growth are often used both in agricultural and vegetable plantations. The preparations, referred as biostimulants, contain substances common in plant world. Their effect on the plants does not come from direct participation in regulation of vital processes but from the effect on metabolism. The substances accelerate the flow of cytoplasm, the uptake of minerals, synthesis of assimilation products, they reinforce the cell walls, and enhance the resistance of the plant to diseases and various stress conditions, including the air and soil drought [3].

According to the principles of good agricultural practise in medicinal plants growing, the application of microelement fertilisers and biostimulants is allowed. The biostimulants and microelement fertilisers have been already tested on few medicinal plants species – feverfew, common thyme, wild ginseng, narrow-leaf plantain, golden rod [4-8]. Very good effects were reported by applying Atonik in growing feverfew, the plant representing, just like chamomile, the Asteraceae family [5].

The aim of the study was to evaluate the response of di- and tetraploid chamomile cultivar exposed to low soil moisture and high air temperature to the application of foliar fertilisation and two biostimulants.

The working hypothesis assumed that at least one of the preparations would increase the yield of the chamomile herb or flower heads. Due to a variation in the morphological structure of di- and tetraploid plants, there was also expected a varied reaction of chamomile cultivars to the foliar treatments applied.

MATERIALS AND METHODS

The research was performed in three series of pot experiments in 2006–2008 and a series of field experiment in the 2008/2009 growing season. The pot experiments were set up as two-factor experiments in three replications.

I. The chamomile cultivars used were:

a. 'Mastar' - diploid

b. 'Dukat'- tetraploid

II. The biostimulants or microelement fertiliser application used were:
a. control – no preparations applied
b. Bio-Algeen S-90
c. Ekolist P
d. Asahi SL

The characteristics of the agents applied:

Bio-Algeen S-90: biostimulant produced from seaweed, rich in microelements, amino acids, vitamins, algic acid;

Asahi SL (commercial name of Atonik, Asahi Chemical MFG. Co, Ltd., Osaka, Japan): biostimulant the active substance of which are phenolic compounds;

Ekolist P: microelement fertiliser with nitrogen and phosphorus added.

The first pot experiment was set up on October 10, 2006. The chamomile achenes were sown into containers filled with light arable-layer soil; for soil properties (tab. 1). The containers were dug into soil to avoid freezing of seedlings. In March 2007 the containers were transferred into the glasshouse and the plants were bedded out into pots filled with 5.5 kg of soil (tab. 1). Each pot was planted with 15 plants, and after they rooted, 10 of the plants were kept. Two successive series of pot experiments were set up in a similar way, yet sowing was performed in February and the plants were bedded out into pots in the first week of April. Results of the experiments established in autumn and in February are presented in separate tables. For first three weeks the soil moisture in the pots was kept at the level of 60% field water capacity, and then up to the end of the growing period – at a level of 40% of field water capacity. From the time of chamomile planting into pots to the beginning of May the day temperature was kept from 20 to 25°C, and night from 15 to 17°C. Then, until harvest, 27–30°C and 20–22°C, respectively.

The preparations, in a form of spraying, were applied at two development stages of chamomile plants:
1. at the initial stage of generative stem formation,
2. at the initial flowering stage.

Table 1.

Acidity, carbon content and richness in basic nutrients of the soil used in experiment

year	pH	humus content (%)	content of available forms ($mg \cdot 100g^{-1}$ of soil)		
			P	K	Mg
2006	6.3	2.20	8.1	8.9	6.9
2007	6.5	2.02	9.3	8.7	5.3
2008	6.3	2.04	9.1	8.5	4.3

In the pot experiments each time the following doses of agents were applied: Bio-Algeen S 90 – 1 ml, Ekolist P – 0.25 ml, Asahi SL – 0.05 ml in 0.05 dm^3 of water (the amount was used for a total of 3 pots constituting the replications). The control treatments involved the use of water only. The plants were cut at full flowering stage. The following traits were determined: the plant height, number of inflorescences per plant and the yield of herb dry matter (the foliage stem with the inflorescences) per pot.

The field experiment was set up on October 2, 2008 at the Experiment Station at Mochełek, of the University of Technology and Life Sciences in Bydgoszcz. It was set as a two-factor experiment, in split-plot design in four replications. The first factor involved chamomile cultivars, 'Mastar' and 'Dukat', and the second one: the application or non-application of Asahi SL biostimulant. The selection of the agent for the field experiments was made based on the pot experiments results. The experiment was set up in the field from which soil was earlier sampled for the pots. The sowing rate for 'Mastar' was 2 kg ha^{-1}, for 'Dukat' 2.5 kg ha^{-1}, the row spacing 20 cm. No mineral fertilisation was applied. Asahi SL was applied on May 17, 2009 (initial stage of generative stem formation) and on May 29, 2009 (initial flowering stage), each time at the dose recommended by the manufacturer, at the concentration of 0.1%; each plot (10 m^2) was provided with 0.5 dm^3 of water. The plants were collected on June 8, 2009. The following traits were determined: the plant height (mean for 10 plants), number of inflorescences per stem (mean of 20 stems) and the dry matter yield of inflorescences (per 1 m^2) and herb (the foliage stem with inflorescences). Herb was dried at the temperature of 30^oC. The analyses determining the essential oil content were performed using the water vapour distillation method using the Deryng apparatus [9].

The results were exposed to the analysis of variance and the differences were verified with the Tukey test at the significance level of P=0.05. The calculations were performed using the statistics ANALWAR-5.2.FR software.

The weather conditions from sowing to harvest are given in Table 2. In autumn the chamomile plants were exposed to very good emergence conditions and initial development in autumn. Winter, with exception of January, was relatively mild. From the beginning of April to the end of the second decade of May only minimum rainfall was reported. Abundant rainfall occurred only in last days of May. The air temperature in April was 2.5 ^oC higher than the long-term temperature.

Table 2.

Weather conditions in the growing period of chamomile as compared with the long-term report by the Mochełek Experiment Station

month	October	November	December	January	February	March	April	May
total rainfall [mm]								
2008/2009	80.0	19.4	24.8	14.2	19.4	43.7	0.4	85.3
long term	31.9	31.8	31.7	24.4	19.1	24.3	28.0	41.7
average daily temperature (°C)								
2008/2009	8.4	4.3	0.2	–3.3	–0.9	2.4	9.8	12.3
long term	8.2	3.0	–0.5	–2.2	–1.5	1.9	7.3	12.8

RESULTS

Pot experiment

Plants of the tetraploid cultivar 'Dukat' were higher, as compared with plants of the diploid cv. 'Mastar', which was statistically confirmed in the 2006 series (tab. 3). There was a different reaction of the cultivars to the biostimulants applied. The autumn-sown 'Dukat' plants were significantly higher when no preparation was applied or when Asahi was sprayed. The spring-sown 'Dukat' plants were significantly higher when Bio-Algeen S-90 was used. There was noted no significant increase in the cv. 'Mastar' plant height as a result of the agents used.

Table 3.

Chamomile plant height prior to harvest (cm) in the pot experiment

sowing time	cultivar	preparation				mean
		control	Asahi SL	Bio-Algeen S-90	Ekolist P	
autumn 2006	Mastar	28.2	27.8	28.8	26.6	27.9
	Dukat	32.2	31.3	28.7	28.1	30.1
	mean for preparation	30.2	29.6	28.8	27.4	29.0
	LSD for cultivar – 2.00; LSD for preparation – n.s.; LSD for interaction 2.65					
spring 2007 and 2008	Mastar	28.9	28.1	26.1	27.9	27.8
	Dukat	29.3	27.1	31.5	27.7	28.9
	preparation mean	29.1	27.6	28.8	27.8	28.3
	LSD for cultivar – n.s.; LSD for preparation – n.s.; LSD for interaction 2.79					

The flowering of autumn-sown chamomile was much more abundant than that of the spring-sown chamomile (tab. 4). In the series of experiments plants of 'Mastar' set up in autumn produced more inflorescences then plants of 'Dukat'. Both cultivars produced the greatest number of inflorescences when Ekolist was applied, and 'Dukat' – also when Asahi SL was used.

In the spring-sowing series dates, more abundant flowering of 'Dukat' plants was reported (tab. 4). 'Dukat' produced higher number of inflorescences followed with the application of Asahi SL and Bio-Algeen S-90 than in the control or after the application of Ekolist P.

Table 4

Number of inflorescences per pot – pot experiment

sowing time	cultivar	preparation				mean for cultivar
		control	Asahi SL	Bio-Algeen S-90	Ekolist P	
Autumn 2006	Mastar	171.0	168.0	176.0	206.0	180.3
	Dukat	111.0	151.0	117.0	151.0	132.5
	mean for preparation	141.0	159.5	146.5	178.5	156.4
	LSD for cultivar – 15.55; LSD for preparation – 28.51; LSD for interaction - 32.01					
Spring 2007 and 2008	Mastar	34.5	34.5	35.0	39.0	35.8
	Dukat	43.5	47.5	46.5	40.0	44.4
	mean for preparation	39.0	41.0	40.8	39.5	40.1
	LSD for cultivar – 7.83; LSD for preparation – n.s.; LSD for interaction - 2.91					

Spring sowing, there was reported a higher yield of herb from the 'Dukat' plants than from 'Mastar' plants (tab. 5). Similar trend was also observed in 2006 series (autumn sowing). The plants from both sowing dates similarly responded to the preparations; as compared with the control treatments, there was recorded an increase in the herb yield following the application of Asahi, especially in spring experiments since the increase in yield accounted for 9%. The application of Bio-Algeen S-90 (autumn and spring series), and in autumn sowing – also Ekolist, however, resulted in a decrease in the herb yield. In fact, the cultivars did not differ in their reaction to the agents used, with exception for a decrease in herb yield due to the application of Bio-Algeen S-90 in 'Dukat' plants (autumn and spring series).

Table 5.

Dry matter of herb (g per pot) – pot experiment

sowing time	cultivar	preparation				mean for cultivar
		control	Asahi SL	Bio-Algeen S-90	Ekolist P	
Autumn 2006	Mastar	23.7	24.7	24.0	25.8	24.6
	Dukat	27.5	27.9	21.3	24.1	25.2
	mean for preparation	25.6	26.3	22.7	25.0	24.9
	LSD for cultivar – n.s.; LSD for preparation - 1.23; LSD for interaction – 5.13					
Spring 2007 and 2008	Mastar	6.18	6.57	5.11	5.62	5.87
	Dukat	6.97	7.77	6.10	6.02	6.72
	mean for preparation	6.58	7.17	5.61	5.82	6.29
	LSD for cultivar – 0.812; LSD for preparation – 0.451; LSD for interaction – n.s.					

Field experiment

In field experiment only selected, based on the pot experiments, Asahi SL biostimulant was applied. The results of the field experiment; considerably, although not completely, coincided with the results reported in the pot experiments (tab. 6). The 'Mastar' plants were higher and set more inflorescences than the 'Dukat' plants. They also contained more essential oil in the inflorescences. Nevertheless, higher yield of herb was harvested from the tetraploid cv. 'Dukat' than from the diploid cv. 'Mastar'. Similarly the content of essential oil in the the herb of 'Dukat' plants was significantly higher than in 'Mastar' herb.

Following the application of Asahi SL, there was reported a significant increase in the plant height (tab. 6). As for the other morphological characters, only a tendency to an increase in their value as affected by the biostimulant was reported. The effect of Asahi SL on the content of essential oil neither in inflorescences nor in the herb of both chamomile cultivars was reported. Yet an effect of interaction of the experimental factors was recorded. As affected by Asahi SL, there was identified an increase in the yield of dry matter of 'Dukat' herb. However, no such reaction was reported for 'Mastar'.

Table 6.

Reaction of chamomile cultivars to the application of Asahi SL biostimulant in the field experiment

character	Control			Asahi SL			mean for cultivar	
	Mastar	Dukat	Mean	Mastar	Dukat	Mean	Mastar	Dukat
plant height [cm]	58.0	55.5	56.8	59.5	58.2	58.9	58.8	56.9
LSD for cultivar - 1.75; LSD for biostimulant - 1.51; LSD for interaction – n.s.								
number of inflorescences per stem	4.5	3.7	4.1	4.0	3.8	3.9	4.25	3.85
LSD for cultivar - 0.35 LSD for biostimulant – n.s.; LSD for interaction – n.s.								
yield of inflorescences [g·m^{-2} d.m.]	38.5	36.7	37.6	38.7	42.1	40.4	38.6	39.4
LSD for cultivar - n.s. ; LSD for biostimulant - n.s.; LSD for interaction – n.s.								
yield of herb (t·ha^{-1} d.m.)	3.66	3.92	3.79	3.67	4.11	3.89	3.67	4.02
LSD for cultivar – 0.324; LSD for biostimulant – n.s.; LSD for interaction – 0.179								
content of essential oil in inflorescences [% d.m.]	0.50	0.45	0.48	0.50	0.46	0.48	0.50	0.46
LSD for cultivar - 0.031; LSD for biostimulant - n.s.; LSD for interaction – n.s.								
content of essential oil in herb [% d.m.]	0.15	0.19	0.17	0.14	0.19	0.17	0.15	0.19
LSD for cultivar – 0.025; LSD for biostimulant – n.s.; LSD for interaction – n.s.								

DISCUSSION

The highest chamomile inflorescence and herb yields are reported on medium-compact soils of controlled air-water relations, rich in calcium and other basic nutrients. Agricultural crops, however, are often exposed to stress conditions independent from farmer, e.g. long-lasting high air and soil drought. In practise, agrotechnical guidelines are often disregarded, including delayed sowing and fertilisation negligence. In such conditions the application of biostimulants in agricultural crops, in general, enhances yield to some extent [3]. Yet, a positive effect of foliar fertilisation with microelements and nitrogen is often seen when the plant cannot, e.g. due to water deficit, uptake the nutrients using the root system.

The biostimulants and microelement fertiliser applied in present research resulted in significant, although not spectacular effects which could have been due to severe conditions the chamomile plants were exposed to. In the pot and field experiments the growth and development of chamomile coincided with high air temperature and, as a result, soil drought for a quite long time. Of all the agents used, Asahi SL was the only one which increased the chamomile herb yield. However, the problem of a decrease in dry matter yield of herb following the application of Ekolist and Bio-Algeen S-90 in the pot experiment seems to be difficult to account for.

Kołodziej [7, 8] clearly reported more favourable effects of the application of

Asahi SL growing peppermint and golden rod, nevertheless, the temperature and humidity were more favourable to the development of plants. Developing crop tolerance, including medicinal plants, to semi-drought in Poland is extremely essential. Thus, the breeding work to obtain cultivars resistant to water deficit [10, 11], but also research into the application of agrotechnical treatments alleviating the effects of unfavourable environmental factors is also important.

A part of the working hypothesis assuming that the plants of a varied morphological structure would also demonstrate a different reaction to the foliar treatments applied was shown to be verified as considerably true. In general, the plants of 'Dukat', tetraploid cultivar, compared with plants of the diploid cultivar 'Mastar' set lower number of inflorescences. However, it was visually determined that the foliage was more abundant and the plant habit – spreading more, which must have resulted in a greater possibility of the foliar-applied agents uptake.

The content of essential oil in chamomile plants depends on three groups of factors: genotype, weather and agrotechnical factors [12-14]. In present research the essential oil content was determined only in the field experiment series in which cultivar-specific differences were shown. However, there was shown no effect of the application of Asahi SL on the essential oil accumulation, whereas Šalamon [15] pointed to the fact that growth regulators affect not only the plant growth and an increase in the flower number but also the content of essential oil in chamomile plants, yet noted that the costs of the application of those agents are greater than the production effects.

CONCLUSIONS

1. Under long-lasting high air temperature and water deficit in the soil the application of Asahi SL biostimulant increased the herb yield of the chamomile cultivar 'Dukat'.
2. No benefits were observed for application of the microelement fertilizer Ekolist P or the biostimulant Bio-Algeen S-90 to both chamomile cultivars grown under stress conditions.
3. The plants of the tetraploid cultivar 'Dukat', produced higher yield of herb with higher essential oil content in the herb than the plants of the diploid cultivar 'Mastar'. Nevertheless, flowering of 'Mastar' plants was more abundant and the plants contained more essential oil in inflorescences.

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REAKCJA ODMIAN RUMIANKU POSPOLITEGO (*CHAMOMILLA RECUTITA* L. RAUSCHERT) NA STOSOWANIE BIOSTYMULATORÓW I NAWOŻENIA DOLISTNEGO

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S t r e s z c z e n i e

W trzech seriach doświadczeń wazonowych (2006–2008) badano reakcję dwóch odmian rumianku pospolitego (*Chamomilla recutita* L. Rauschert) – diploidalnej 'Mastar' i tetraploidalnej 'Dukat' – na stosowanie biostymulatorów Asahi SL i Bio-Algeen S-90 oraz nawozu mikroelementowego Ekolist P. Badania prowadzono w warunkach stresu wywołanego wysoką temperaturą powietrza i niską wilgotnością gleby. Według wyników doświadczeń wazonowych jedynie stosowanie preparatu Asahi SL wpłynęło na przyrost plonów suchej masy ziela rumianku. Działanie Asahi SL przetestowano w doświadczeniu polowym (2008/2009), gdzie także uzyskano zwiększenie plonu ziela, ale tylko roślin odmiany 'Dukat'. Rośliny odmiany 'Dukat' wydały wyższe plony suchej masy ziela, o większej zawartości olejku w zielu niż rośliny odmiany 'Mastar', ale rośliny odmiany 'Mastar' kwitły obficiej i zawierały więcej olejku w kwiatostanach. Nie stwierdzono przydatności biostymulatora Bio-Algeen S-90 i nawozu mikroelementowego Ekolistu P dla rumianku uprawianego w warunkach niedoboru wilgotności i wysokich temperatur.

Słowa kluczowe: Asahi, Bio-Algeen, Ekolist, odmiana diploidalna, odmiana tetraploidalna, ziele rumianku