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Research Article

Reaction of Chamomile to Organic Fertilisation

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Abstract
The increasing and growing interest in chamomile essential oil is leading to a rise in cultivated areas outside of Europe. Currently, the amount of produced chamomile flowers and essential oil cannot meet market needs. The reason for this is the lack of good and sustainable agricultural practices. This study aims to determine how fertilisation with organic fertilisers Bioazoto N12® and Plonar Active® affects the quantitative and qualitative indicators of the chamomile variety Lazur. The field trial was set up in the region of Stambolovo (41.767°N 25.65°E) over a period of three years (2023-2025). The experiment was arranged based on the randomised complete block design in three replications and an individual plot size of 25m^2. Two organic fertilisers have been included in the study: Bioazoto N12® at a rate of 400 kg ha^{-1} and Plonar Active® in a dose of 120 kg ha-^{1}. The products have been applied in the autumn before the main soil tillage. The results indicated that the organic product Plonar Active® positively influenced the agricultural performance of chamomile and achieved the highest yields of fresh flowers and essential oil. Moreover, the product stimulated the synthesis of β-farnesene, chamazulene, α-bisabolol, α-bisabolol oxide A, and α-bisabolol oxide B. These findings allow the organic fertilisers Plonar Active® to be recommended for sustainable chamomile production.

Keywords: hamazulene, chamomile, organic fertilisation.

Introduction

Chamomile (*Matricaria chamomilla* L.) is a well-known medicinal plant species from the Asteraceae family native to southern and eastern Europe, as Hungary is the biggest producer on a European scale [1]. Pamukov and Achtardziev [2] reported that chamomile is included in the pharmacopoeia of 26 different countries. Although chamomile is native to Europe, nowadays it is also grown in Asia, North Africa, North America and other parts of the world [3]. It is part of traditional homoeopathic medicinal preparations [4, 5]. As a medicine, chamomile is used for flatulence, colic, and fever attacks [6]. The flowers contain 0.2 to 1.9% essential oil [5], which has various applications. Chamomile is mainly used as an anti-inflammatory and antiseptic agent, as well as a spasmolytic and mild sudorific [7]. Orally, it is primarily consumed as an infusion for stomach disorders and slow digestive function. The tea is highly effective, but less commonly used for urinary tract inflammation and painful menstruation [1]. In powdered form, chamomile could be applied to slow-healing wounds, skin eruptions, inflammations of the mouth, throat, eyes, and infections as herpes zoster [8]. In addition to having antibacterial and fungicidal properties, the oil is used as a mild sedative and to aid digestion [9]. Besides its significant importance for the pharmaceutical industry, the oil is widely used in perfumery, cosmetics, aromatherapy, and the food industry [10]. Due to the chamazulene content in the essential oil extracted from the flowers, *Matricaria chamomilla* L. is used in various products such as perfumery, cosmetic creams, hair products, skin lotions, toothpaste, and also in fine liqueurs [11]. The dried chamomile flowers are also highly sought

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after for use in herbal tea, baby massage oil, for stimulating gastric secretion, and for treating coughs and colds. Chamomile herbal tea has been proven to eliminate colic in infants [12]. The aforementioned advantages and versatile applications of chamomile determine its high economic value, as well as the demand for the raw material in several European countries. The relentless and growing interest in chamomile essential oil is leading to an increase in cultivated areas outside of Europe in some Asian countries, such as India and Pakistan [1]. Currently, the amount of produced chamomile flowers and essential oil cannot meet market needs. The reason for this is the lack of good and sustainable agricultural practices. Today, production costs are rising due to higher prices for fertilisers and plant health products. Excessive and intensive use of fertilisers not only poses a risk to health and the environment but also increases production costs. The use of organic fertilisers would help support the resilience of ecosystems. This study aims to determine how fertilisation with organic fertilisers Bioazoto N12® and Plonar Active® affects the quantitative and qualitative indicators of the chamomile variety Lazur.

Material and methods

Experimental setup

The field trial was set up in the region of Stambolovo (41.767°N 25.65°E) over a period of three years (2023-2025) with the chamomile variety Lazur. The experiment was arranged based on the randomised complete block design in three replications and an individual plot size of 25m^2. Sowing was carried out in September after wheat as a predecessor. Two organic ffertilisers have been included in the study: Bioazoto N12® (hydrolysed animal hide 20% w/w, total nitrogen 12%, organic nitrogen 12%, total phosphorus pentoxide 8%, organic carbon 40%, magnesium, Iron, pH 6.0) at a rate of 400 kg ha^{-1} and Plonar Active® (65% humic acids, 35% organic matter, 3.5% P, 6.5% K, 9% Ca, Mg, S, 31 mg/kg B, 9 mg/kg Cu, 980 mg/kg Fe, 34 mg/kg Mn, 1.8 mg/kg Mo, 43 mg/kg Zn) in a dose of 120 kg ha^{-1}. The products have been applied in the autumn before the main soil tillage. After sowing, the area was harrowed. Weed control was carried out mechanically. The following parameters have been recorded: plant height (cm), number of flowers/plant, fresh flowers yield (kg ha^{-1}), dry flower yield (kg ha^{-1}), essential oil content (%) and oil yield (kg ha^{-1}). Essential oil yield (kg ha^{-1}) was determined by multiplying the dry biomass yield from flowers by the oil content (%) (Upadhyay et al., 2016). The collected dry flowers were stored in a cool and dry environment. The oil was extracted through hydrodistillation using a Clevenger-type apparatus. The chamomile oil's chemical composition was analysed using a Hewlett-Packard 6890 gas chromatograph with an autosampler. Helium served as the carrier gas at a flow rate of 40 cm/s and a pressure of 11.7 psi at °C, with a constant flow of 2.5 mL/min. The injection involved a split ratio of 60:1 with a volume of 0.5 µL, and the inlet temperature was maintained at 220 °c. The oven started at 60 °C for 1 minute, then increased at 10 °C/min to 250 °c. The column used was HP-INNOWAX (cross-linked polyethene glycol), measuring 30 m × 0.32 mm with a film thickness of 0.5 µm. The flame ionisation detector was operated at 275 °c.

Soil and climatic conditions

The soil cover of the region is represented by cinnamon forest soils, some of which are deeply eroded. They have a calcareous base and are characterised by a shallow profile, low thickness, and dense structure. In terms of mechanical composition, they range from light to heavy clay and with humus content between 2 and 4%. The soil profile is shallow: 60-70 cm. The humus-accumulative horizon is relatively well developed. In terms of climate, Stambolovo falls within the South Bulgarian climate region, specifically in the Eastern Rhodope climate area, which is influenced by the warm Mediterranean influence. It is expressed primarily in the higher average annual temperatures and the more sensitive shift of the main precipitation minima and maxima. The average annual air temperature of the plain and lowland areas varies from 12.2 to 12.8^{0}C, and for the Eastern. The main precipitation maximum is observed in the winter months (Figure 1).

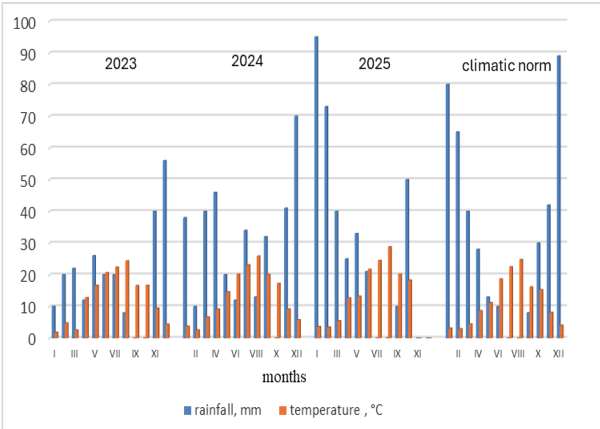

Figure 1. Climate data during the study period.

Data Analysis

The results from three separate tests were averaged and presented as mean ± SD. These means were compared using one-way analysis of variance (ANOVA). Treatment differences were analysed with Duncan's Multiple Range Test at a significance level of 0.05. Correlation analysis was applied to calculate the relationships between the studied traits. The statistical analysis was conducted using SPSS and XLSTAT Version 2016.02.

Results and discussion

The height of the plants varied widely under the influence of applied organic fertilisation. The shortest plants were recorded in 2025, when the average height in the control variants was 28 cm. As a result of fertilisation with Plonar Active ®, the average height during the same period increased by up to 67%. In the first year, the highest average values of the indicator were recorded, with a maximum of 48 cm again observed in the variant treated with Plonar Active ® (Table 1). It should be noted that, as a result of the application of Plonar Active ®, the height of the plants didn't vary widely under the influence of contrasting climatic conditions. The favourable conditions over the past year had contributed to the formation of more branches, a higher yield of dry flowers, and a greater content of essential oil. On average, during the period, fertilisation with Bioazoto N12® promoted the formation of 20% more branches compared to the control variants. With the same treatment, the increase in dry flower yield was from 2.45 to 2.97 Mg ha^{-1}, resulting in an average accumulation of 20% more essential oil compared to the unfertilised variants. As a result of fertilisation with Plonar Active ®, the branching of the plants increased on average by up to 35% over the period, which contributed to higher productivity. The content of essential oil changed dynamically, ranging from 0.71% by the control to 0.95% by the variant fertilised with Plonar Active ®.

Table 1. Chamomile biometrical traits

Treatment	Year	Plant height (cm)	Nr of branches/plant	Dry flower yield (Mg ha^{-1})	Oil yield kg ha^{-1}	essential oil content (%)
Control	2023	28^{a}	19.83^{a}	2.15^{a}	19.31^{a}	0.71^{a}
	2024	32^{a}	22.17^{a}	2.48^{a}	25.03^{b}	0.75^{a}
	2025	36^{b}	23.43^{b}	2.73^{b}	32.42^{c}	0.82^{a}
Bioazoto N12®	2023	35^{b}	23.80^{b}	2.38^{a}	28.18^{b}	0.78^{a}
	2024	38^{b}	26.41^{b}	2.82^{b}	29.03^{b}	0.83^{b}
	2025	45^{d}	28.10^{c}	3.18^{d}	38.30^{d}	0.89^{b}
Plonar Active ®	2023	41^{c}	27.20^{c}	2.65^{b}	36.20^{d}	0.83^{b}
	2024	43^{c}	29.32^{e}	2.96^{c}	38.70^{d}	0.90^{b}
	2025	41^{c}	32.10^{f}	3.30^{d}	41.12^{e}	0.95^{c}

**Means within columns followed by different lowercase letters are significantly different (P<0.05)*

Table 2. Correlation coefficient values

Parameters	Plant height	Nr of branches/plant	Dry flower yield (Mg ha^{-1})	Oil yield kg ha^{-1}	essential oil content (%)
Plant height	1	0.491	0.105	0.384	0.311
Nr of branches/plant		1	0.91*	0.93*	0.97*
Dry flower yield (Mg ha-1)			1	0.898*	0.962*
Oil yield kg ha-1				1	0.956*
essential oil content (%)					1

**significance level alpha =0.05.*

The correlation analysis indicated a significant and strong correlation between the number of branches per plant and the dry flower yield, as well as between the number of branches per plant and the essential oil yield and essential oil content. The essential oil content was strongly related to traits as the dry flower yield and the essential oil yield. There was no significant correlation between the plant height and the other examined traits (Table 2).

While the effect of phosphorus and potassium on fresh flower yields and essential oil yields was unpronounced, the nitrogen significantly improved the chamomile productivity [1]. Ammonium sulfate applied in a dose of 40 kg ha^{-1} could significantly increase the yields, but in the meantime decreased the essential oil content in the flowers [13]. The same authors stated that the application of organic matter improved the whole crop performance through an increase in the humus content. Farmyard manure applied at a rate of 15-25 t ha^{-1} before transplanting proved to be beneficial for the medicinal plants [14]. El-Hamidi et al [15] obtained the highest yield after distributing nitrogen and phosphorus in a ratio of 2:2. The author noted that a higher level of N caused a significant decrease in the chamazulen percentage. In the study of Singh [14], chamomile reacted very positively to N and P fertilisation. According to Misra et al [10], the optimum doses of N and P fertilisers varied between 50-60 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1}. Nitrogen could positively affect the contents of α-bisabolol and chamazulene, but could significantly decrease the contents of bisabolol oxides A and B in the essential oil [16]. In the study of El-Hamidi et al [15], nitrogen fertilisation resulted in increased essential oil yields in both varieties included in the experiment. On lime soils, magnesium, cobalt and borax sulfates improved the productivity of chamomile [17]. Koeurik and Dovjak [25] reported an increase in dry matter as a result of the combined application of boron and molybdenum. According to Hadi et al [18], vermicompost applied in a dose of 20t ha^{-1} achieved the best quantitative and qualitative flower yield and chamomile essential oil composition.

Table 3. Chemical composition of chamomile essential oil

Compound	RT (min)[a]	%[b]		
		Control	Bioazoto N12®	Plonar Active ®
α- pinene	27.14	0.5	0.6	0.5
camphene	28.11	13.20	14.08	14.67
β-pinene	30.22	0.78	0.83	0.82
sabinene	30.54	0.92	0.88	0.92
camphor	34.12	0.76	0.82	0.89
β-ocimene	34.25	0.83	0.95	1.20
terpinene-4-ol	47.19	1.87	2.10	2.08
borneol	47.65	3.20	3.45	3.94
germacrene-D	66.83	3.85	4.23	4.61
β-farnesene	84.20	6.40	7.72	8.30
α-bisabololoxide B	85.32	8.34	9.45	10.12
α-bisabolol	85.15	38.25	42.18	43.30
chamazulene	87.08	17.60	17.66	18.20
α-bisabololoxide A	88.10	2.55	2.93	3.02

[a] Retention time.
[b] Relative proportions of the essential oil constituents.

The analysis of the essential oil indicated that the applied products had a beneficial effect on the composition of chamomile essential oil, and the values of the main components, such as β-farnesene, chamazulene, α-bisabolol, α-bisabolol oxide A, and α-bisabolol oxide B, increased as a result of the applied organic fertilisation (Table 3). As a result of treatment with Plonar Active®, all the main components reached their highest values as follows:β-farnesene-8.30%, α-bisabololoxide B-10.12%, α-bisabolol-43.30%, chamazulene-18.20% and α-bisabololoxide A-3.02%. The present findings are in line with the observations of other authors. The main constituents identified in the chamomile flower belong to the group of sesquiterpene derivatives [1]. According to the literature, the principal components of the essential oil are: (E)-β-farnesene (4.9–8.1%), terpene alcohol (farnesol), chamazulene (2.3–10.9%), α-bisabolol (4.8–11.3%), and α-bisabolol oxides A (25.5–28.7%) and α-bisabolol oxides B (12.2–30.9%) [10, 19], as α-bisabolol and chamazulene were reported as more useful than the others. The chemical composition of the essential oil could vary depending on the growth stage and harvest time. For example, Arak [20] observed the maximum quantity of α-bisabolol and α-bisabolol oxides A and B at the full blooming stage. During drying, the flowers continued to accumulate essential oils, and for this reason, Franz [21] recommended harvest at the earliest flowering phase. The author noted that the oil content was lowest in decaying heads and highest one week after the flower initiation. Moreover, chamazulene and bisabolol oxide content increased from the bud to the fully developed flower bud phase. In the study by Hendawy and Khalid [22], the different levels of liquid compost not only increased the essential oil content but also improved the flower head characteristics, as well as the composition of the essential oil. According to Singh et al. [1], humic substances and composts could positively influence the growth, flowering and essential oil yield of chamomile. The same authors stated that the secondary metabolites of chamomile were affected by organic fertilisation, which led to beneficial changes in the concentration and quality of their ingredients such as essential oil, alkaloids, glycosides and steroids. The product Plonar Active®, which is based on humic acids, managed to stimulate not only the vegetative growth of chamomile, but also to improve the quality of its essential oil. In the study of Juárez et al. [23], the humic substances improved the agronomic performance of chamomile. Application of compost could enhance plant growth, development, flower productivity and essential oil quality [24].

Conclusions

The product Plonar Active® positively influenced the agricultural performance of chamomile and achieved the highest yields of fresh flowers and essential oil. Moreover, the product stimulated the synthesis of β-farnesene, chamazulene, α-bisabolol, α-bisabolol oxide A, and α-bisabolol oxide B. These findings allow the organic fertilisers Plonar Active® to be recommended for sustainable chamomile production.

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