INFLUENCE OF ORGANIC AND CHEMICAL FERTILIZATION ON THE YIELD OF FLOWERS, CONTENTS AND COMPOSITION OF ESSENTIAL OIL OF (Chamomilla recutita (L.) Rauschert)

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Abstract

A field experiment was conducted with chamomile (Chamomilla recutita [L.] Rauschert), in an area of the Olericulture and Medicinal Plants of the Horticulture Department at UNESP – Jaboticabal Campus, with the aim to evaluate the influence of organic and chemical fertilization on the yield of flowers, and content and composition of the essential oil of chamomile. The experimental design for the yield of flowers consisted of randomized blocks with 7 treatments and 4 replications, for the analysis of the contents and composition of the oil, the completely randomized block was used and for analysis of the correlation between harvesting and treatment, the split-plot design into randomized blocks was used. The treatments tested were: no fertilization, green manure (Mucuna aterrima + Crotalaria spectabilis), green manure (“plant cocktail”), organic fertilizer (farmyard manure), N as urea, N as ammonium sulphate, NPK with N supplement as ammonium sulphate.

There was no influence of the treatments on the yield of flowers nor on the essential oil content; on the other hand both characteristics did show significant differences in harvesting times (Tukey 5%). The main yield was 885.90 kg/ha dry flowers and the mean oil content was 0.86%. The green manure treatment (M. aterrima + C. spectabilis) showed a higher percentage of chamazulene content, with a highly significant difference in harvesting times (Tukey 1%). The α-bisabolol percentages did not evidence significant differences between treatments. However, among harvesting times, there was a variation. A negative correlation was verified between the chamazulene and α-bisabolol percentages; the first increasing – from 21.02 to 36.17% - and the latter decreasing – from 14.12 to 8.72 % - from the first to the sixth harvest. The observed mean content of chamazulene was 14.64 % and α-bisabolol was 16.72 %.

1. Introduction

According to an estimate by the World health Organization (WHO), approximately 80% of the world population use popular medicine in dealing with their primary health care (Farnsworth et al. 1986). Chamomile (Chamomilla recutita (L.) Rauschert) is one of the plants selected by CEME (Central de Medicamentos – Medicine Central) and by the Phytotherapy Project of SUDS – (Secretaria de Saúde do Paraná – Paraná State Department of Health), BR (Perozin, 1989). It is the medicinal plant with the largest planted area and the highest level of involvement from small rural producers in the country. The county of Mandirituba-PR is the largest producer with a planted area of 300 ha and a yield of 150 t dried product. There are approximately 200 producers in activity (Corrêa Júnior & Taniguchi, 1992).
No studies on the economic dimension of chamomile in Brazil have been found, in particular any that made reference to the effects of organic material and other sources of nutrients on the yield. Studies undertaken by several researchers (Chandra & Kappor, 1971; Kocurik, 1979; Dovjak & Andracik, 1986; Johri et al. 1991; Rubio, 1992), have shown that phosphorus and potassium do not increase the biomass yield, nor bring any benefit to the yield of essential oil, and that nitrogen is the nutrient with the highest level of influence on the yield of essential oil – with an increase of up to 29.1% (El-Hamidi et al. 1965) – and on the yield of flowers.

This experiment targeted the evaluation of the influence of organic and chemical fertilization on the yield of flowers, the content and composition of essential oil of the crop grown in Mandirituba (Corrêa Júnior, 1995).

2. Material and methods

The area where the experiment was carried out is located in the experimental area of the Department of Horticulture-UNESP, Jaboticabal-SP-BR (21°15'22" latitude South, 48°18'58" longitude West, 595 meters above sea level). Köppen classifies the climate as CWA, subtropical with relatively dry winters. The average annual rainfall is 1400 mm. The average annual temperature is approximately 22°C. The soil used is classified as “latossolo roxo”, series Jaboticabal. The soil analysis was performed in the Soil Fertility laboratory of FCAVJ/UNESP. The soil in the experimental area presents the following physical characteristics: clay = 54%; silt = 25%; sand = 21% and chemical characteristics: pH - 5.5, P = 85 mg/ml; M = 3.5%; K = 0.5 meq/100ml; Ca = 3.8 meq/100ml; Mg = 1.5 meq/100ml; H+Al = 3.4 meq/100ml; SB = 5.87 meq/100ml.

The experiment was carried out in the period of February to November 1993 in the field. The chemical analyses were performed from November 1993 to March 1994 in the laboratory of the Pharmacy College – Araraquara Campus/UNESP.

The experimental design was random blocks with 4 repetitions. The treatments tested were: T0: witness (absence of fertilization), T1: green manure with Mucuna aterrima + Croataria spectabilis, T2: green manure with a plant cocktail developed by Estância Demétria – Botucatu, SP, by Piemonte Peña (1992), T3: farmyard manure (dairy cattle) 40 t/ha, T4: 80 kg/ha of N in the form of urea, 50 kg/ha at planting time + 30 kg/ha in top-dressing, T5: 80 kg/ha of N in the form of ammonium sulphate, 50 kg/ha at planting +30 kg/ha in top-dressing, T6: NPK to the amount of 34.4 kg/ha of N, 120.4 kg/ha of P2O5 and 68.8 kg/ha of K2O, equal to 860.0 kg/ha from the formulation 4-14-8 and 30 kg/ha of N in the form of ammonium sulphate, in top-dressing. Each plot consisted of a 1.0 x 4.0 m bed. Yield data for biomass were subjected to analysis of variance in random blocks design; the data on yield and composition of essential oil, in a completely randomized design. The harvest of flowers was performed 6 times, in eight-day intervals. The data relative to each harvest were correlated to the treatments using an experimental design in random blocks with split-plot, considering the harvests as factors and the fertilization treatments as sub-factors.

For this experiment the seedlings were produced in greenhouse. Sowing, carried out on April 22nd, was on Styrofoam trays with 264 alveolus, using as substrate compost to which vermiculite was added, using the equivalent of 2 kg/ha of seeds. On March 21st, the seedlings (average height 8-19 cm) were transplanted to the experimental area in a spacing grid of 25 x 30cm.

The spreading of the green manure for the treatment with black mucuna and crotalária took place on February 16th. The spacing used for crotalária followed the recommendation of Baltazar et al. (1992). The spacing for black mucuna followed the recommendation of Monegat (1991) and Baltazar et al. (1992).
The plots with the “Cocktail” were seeded on February 16th, complying to Piamonte Peña’s (1992) recommendation with later incorporation of the green mass.

The farmyard manure (dairy cattle) was applied and incorporated to the soil through rotating hoe, in dose of 16 kg/ha, what is equivalent to 40 t/ha. Incorporation was carried out 30 days before the seedlings were transplanted.

The chemical fertilizers were placed in open furrows 5 cm to the side of the sowing lines at an average depth of 10 cm, covered with soil and immediately irrigated.

The area of the experiment was irrigated by sprinklers, undesirable plants/weeds were kept under control by manual hoeing between the lines and hand weeding in the lines. 45 days after the transplantation, at the onset of the flowers, N fertilization in top-dressing was performed.

Harvest of the flowers began 3 months after transplantation. A total of 6 harvests, at an average interval of 8 days, were performed. The harvests were performed manually with the help of a flower collector. The produce was cleaned, removing impurities and keeping the peduncle with a maximum length of 4 mm. They were dried in the shade in cardboard paper tray-type boxes, for an average 4 days, till reaching humidity levels of 8-10%. The essential oil was extracted by steam distillation in extraction equipment of the CLEVENGER type. Analysis of the composition of the essential oil was performed in gaseous phase chromatograph of Instrumentos C.G. Ltda. Model 3357 equipped with flame ionizing detectors, using Nitrogen SS at a pressure of 20 to 40 lbs/in² as carrier. This device is linked to a model 300, Instrumentos C.G. Ltda. recorder/integrator/processor.

3. Results and discussion

3.1. Yield of flowers

There were no significant differences between the treatments (T0 = 56.45; T1 = 68.37; T2 = 56.65, T3 = 63.65, T4 = 54.27, T5 = 68.12, T6 = 51.36 at g/4 m²) what probably is a consequence of the high fertility of the soil where the experiment was carried out. The absence of effect from the fertilization on the yield is in accordance with Sváb et al. (1967), Dovjak & Andrasic (1987), Rubio (1992). Other authors (Schilcher, 1987; Galombosi et al., 1991) agreed that other environmental and genetic factors have more influence on the yield of flowers than the factor of soil fertility, though chamomile responds to nitrogen fertilization.

Significant differences were noted among the harvests, with the best results obtained on the 3rd (70.26 g/4 m²), 4th (84.97 g/4 m²), 5th (89.95 g/4 m²), and the worst on the 1st (15.24 g/4 m²), 2nd (50.55 g/4 m²) and 6th (43.35 g/4 m²) harvests. This trend is in agreement with the results obtained by Saleh (1993) and Letchamo & Marquard (1993). Based on this data, we suggest the harvest should be performed, at the maximum, in three times.

Average yield of the treatments was of 885.90 kg/ha, about 77.16 % above the Brazilian average (500 kg/ha). This level of productivity falls within the world average (Schilcher, 1987).

The ratio fresh/dry weight of the flowers, on average, was 22.04%. The final level of humidity of the flowers was approximately 10%.

3.2 Content of essential oil

There was no effect of the treatments in the content of the essential oil of chamomile; there was also no significant interaction between harvest and treatment (T0 = 0.82; T1 =
0.88; T2 = 0.87; T3 = 0.88; T4 = 0.86; T5 = 0.84; T6 = 0.83). Several authors have already mentioned the absence of effect from the various types of fertilization in the yield of essential oil (Sváb, 1967; Kocúrik, 1979; Dovjak, 1987; Dovjak & Andrascik, 1987; Dovjak, 1988; Rubio, 1992).

According to Schilcher (1987), excess of nitrogen causes a delay in flowering and this reflects indirectly on the production of essential oil. Other authors have noticed an increase in oil content when fertilized with N and/or NK (El-Hamidi, 1965; Chandra & Kappor, 1971; Madueño Box, 1973; Dovjak & Andrascik, 1986; Johri et al. 1991; Emongoe & Chweya, 1992).

As far as harvests, it was observed that the first four presented higher percentage levels of essential oil content, respectively; 0.90%, 0.97%, 0.94% and 0.96%. There was a significant decrease in the last two harvests, respectively; 0.67% and 0.70%, what had already been observed by Chandra & Kappor (1971), Saleh (1973), Krstic-Pavlovic & Dzamic (1984), Schilcher (1987) and Letchamo & Marquard (1993).

In comparing the average percentage level of essential oil extracted from the samples collected in the experimental area (0.86%) and that obtained from samples collected in the area of Mandirituba-PR (0.84%), no significant differences were found, and they were 0.43% superior to those found by Donalisio (1985) and 0.60% superior to those found by Schilcher (1987), as well as superior to the 0.40% recommended by the Farmacopéia Brasileira (1977). These percentage values are also above the world average (0.70%) (Costa, 1986), however below those which are cultivated, or those which have object of improvement, such as the tetraploids, which present yields above 1.0% (Gasic et al. 1986, Galambosi et al. 1991, Salamon, 1992).

3.3 Composition of the essential oil

A significant difference was noted in the composition of the oil among the different treatments; the green manure treatment (Mucuna aterrima and Crotalaria spectabilis) presented the highest ratio of chamazulene in the essential oil and the treatment with organic fertilizer (farmyard manure), the lowest. The other treatments did not differ from each other (T0 = 26.97, T1 = 27.78, T2 = 27.01, T3 = 26.77, T4 = 26.93, T5 = 27.28, T6 = 27.39). It was observed that the treatments, in which chemical fertilizers were used, did not differ from each other, what is in accordance with Dovjak (1988). However, Mostafà et al. (1983) and Emongor & Chweya (1992) verified an increase in the amount of chamazulene when chamomile had been chemically fertilized, in particular when N fertilizers were used.

In relation to α-bisabolol there were no significant differences among the treatments, what is in accordance with what Kocúrik (1979), and Dovjak & Andrascik (1987) observed, while differing from Emongor & Chweya, (1992), who noted an increase in the percentage of α-bisabolol resulting from N fertilization.

Regarding the harvests, it was observed (illustration 1) that the 6th was the one presenting the highest percentage of chamazulene (36.17%), being markedly different from the others; followed by the 5th (30.49%) and the 4th (28.98%) which differ from each other and from the rest; and the 3rd (23.07%) and the 2nd (23.23%) that do not differ from each other, but do from the others; and the 1st (21.02%), different from the others, what is in accordance with what Letchamo & Marquard (1993) found. However, results obtained by Sváb (1967), Saleh (1973) and Galambosi et al. (1991) did not show significant differences between the harvests in relation to the chamazulene percentage. Over the harvests (figure 1) a statistically superior percentage of α-bisabolol was found on the 1st (14.12%); followed by the 2nd (12.09%) and 3rd (12.96%) which did not differ from each other, but did from the rest; the 4th (9.82%) and 5th (9.34%) differing from
each other and the rest; and the 6th (8.72%) was the one which presented the smallest percentage, differing from all the others. A decreasing trend in the amount of α-bisabolol was noticed from the 1st to the 6th harvest (figure 1) contrary to what was evidenced for chamazulene.

This trend, increase of chamazulene and decrease of α-bisabolol over the harvests, is confirmed by a significant negative correlation ($R^2 = 0.90$) between chamazulene and α-bisabolol. Due to the results obtained in this project and also by Letchamo & Marquard (1993), we would like to suggest that producers separate the produce by harvest and market them according to the specific needs of their clients. When the interest of the chamomile user is concentrated on chamazulene, option should be made for the last harvests; and when the area of interest is α-bisabolol, the first ones.

A difference was observed in the chamomile grown in the experimental area (27.16% and 11.12%, chamazulene and α-bisabolol, respectively) and that grown in the Mandirituba-PR unit (35.03% and 7.13%), both in chamazulene and α-bisabolol, despite the same crop origin. These differences are even more marked when these are compared with the one analyzed by Schilcher (1987), of 1.91% and 16.05%. We attributed these quantitative differences in the percentage of content of chamazulene and α-bisabolol to the differences in the climate of the two cultivation sites, more specifically to the temperature range. However, there was no change in the chemical composition (Chemotype), that is, in the genetic features in whatever site of cultivation, what is in accordance with what was observed by Franz et al. (1986); Gasic et al. (1986); Schilcher (1987); Gasic (1989); Galambosi et al. (1991), Mano & Bichi (1991), Salamon (1992).

Considering that the world average chamazulene percentage in essential oil of chamazulene is 17% (Costa, 1986), the percentage of chamazulene found in the analysis of both situations: experimental area with 27.17% and Mandirituba-PR with 35.02%, is well above it.

The percentage of α-bisabolol found in this project was 11.12% in the experimental area and 7.13% in the samples from Mandirituba-PR, below the chemotype (D) proposed by Schilcher (1987) who observed 16.05%. This clearly indicates a need for further studies. As far as the percentage of α-bisabolol in the essential oil of chamomile, no world average reference was found, but if compared to the average of the papers consulted, which is 16.72%, it was observed that in both growing environments it was below the average.

4. Acknowledgement

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5. References


Figure 1 – Essential oil composition of chamomile (*Chamomilla recutita* [L.] Rauschert); ratio between α-bisabolol and chamazulene. Araquara/Jaboticabal-SP, Brazil, 1994.