MINERAL NUTRITION OF CHAMOMILE (CHAMOMILLA RECUTITA (L.) K.

A. Nikolova and K. Kozhuharova
Department of Botany
Higher Institute of Agriculture
12 Mendeleev str., 4000 Plovdiv
Bulgaria

V.D. Zheljazkov (Jeliazkov) and
L.E. Craker
Department of Plant and Soil Sciences
12 A Stockbridge Hall
University of Massachusetts
Amherst, MA 01003, U.S.A.

Keywords: Chamomile, Asteraceae, Compositae, fertilizers, nutrients, essential oil

Abstract

In field and pot experiments, we studied the effect of different nutrients (N, P, K, S, Ca and Mg) on the qualitative and quantitative characters of the Bulgarian cultivar Lazur from chamomile (Chamomilla recutita (L.) K).

In the pot experiments, the optimal ratio between the macronutrients in the nutrient solution for achieving best quantitative results in chamomile cv Lazur was N:P:K = 40:28:32%, while the optimal ratio between the other elements was K:Ca:Mg = 40:38:22%; Nitrogen and potassium increased the yields, while phosphorus increased the essential oil content. Calcium was also found to be important for high yields and dry matter content in the herba. Sulfur and phosphorus increased inflorescence weight and essential oil content in them.

In field experiments the highest yields of inflorescence and oil were achieved when the ratio between the major nutrients N:P:K was 1:1:1 (in 120 kg/ha active ingredients).

Differences in the nutrient regimes induced some alterations in the essential oil quality. The (-)-α- bisabolol content was increased by elevated phosphorus levels, while higher content of magnesium in the solution sharply decreased its content. Hamazulene content in the oil was found to be a relatively more stable characteristic and was not affected greatly by variation of the tested nutrients in the solution.

1. Introduction

Chamomile is a widely grown aromatic crop in Bulgaria. However, there are very few investigations on the mineral nutrition of this crop, besides most of them have been conducted with older cultivars and there is no information on nutrient requirements of cv Lazur which is a tetraploid high-yielding Bulgarian cultivar (Zheljazkov et al., 1996). There is significant variation in the content of different compounds in the chamomile essential oil from different origin (Stanev et al., 1996). Some investigations have shown relationship between chamazulene content in the oil and the morphological features of chamomile (Popova and Peneva, 1987; Peneva, 1986). On the basis of results from other performed with the same species but different cultivar and in different environment, (Dovjak, 1988; Dragland et al., 1996; Emongor and Cheweya, 1992; Emongor et al., 1990; Fernandez et al., 1993; Letchamo, 1992; Letchamo et al., 1993; Meawad et al., 1984) we made up our aim to investigate the effect of different nutrient elements on qualitative and quantitative characters of Bulgarian cv Lazur for the agroecological conditions of Bulgaria.
2. Materials and Methods

As a experimental material we used Bulgarian cultivar Lazur from chamomile (Chamomilla recutita (L.) K.). Experiments were conducted in the experimental field of the Research Institute for Roses, Aromatic and Medicinal Plants in Kazanlik, Bulgaria. In three year field experiments (by using block design in four replications and size of the experimental plot 10 m$^2$), we investigated the effect of nitrogen, phosphorus and potassium in 15 variants (active ingredients in kg/ha): (1) Control (non-fertilized); (2) K$_{120}$; (3) P$_{120}$; (4) P$_{120}$K$_{120}$; (5) N$_{120}$; (6) N$_{120}$K$_{120}$; (7) N$_{120}$P$_{120}$; (8) N$_{120}$P$_{120}$K$_{120}$; (9) N$_{30}$P$_{60}$K$_{120}$; (10) N$_{90}$P$_{60}$K$_{60}$; (11) N$_{60}$P$_{30}$K$_{60}$; (12) N$_{60}$P$_{90}$K$_{60}$; (13) N$_{60}$P$_{60}$K$_{30}$; (14) N$_{60}$P$_{60}$K$_{90}$; and (15) N$_{60}$P$_{60}$K$_{60}$. Chamomile was sown at the beginning of October, with sowing rate 3 kg/ha, at 0.7 m interrow space which ensure around 160 plants/m$^2$. During the vegetation period, we used the standard agronomic practices for growing of chamomile. Experiments were conducted without watering. Fertilizers were applied before the sowing, with the main soil cultivation. We grew chamomile as a one year crop, which is typical for the region. The concentration of N, P, and K in the soil was as follows: nitrogen 20-25 mg/kg in the soil layer 0-20 cm and 17-22 mg/kg in the soil layer 20-40 cm; phosphorus: 18.5-35 mg/100 soil in the soil layer 0-20 cm and 14.1-23.8 mg/100 g soil in the layer 20-40 cm; potassium: 20.8-32.8 mg/100 g soil in the layer 0-20 cm and 18.1-35 mg/100 g in the layer 20-40 cm. The soil in the experimental plot had a humus content 2.04, and pH 5.6.

Pot experiments were conducted by using the method of Homes for systematization of the variants (the studied nutrient in the solution was in higher concentration, while the other nutrients were in a concentration optimal for the normal plant growth and development). According to this method, the ions of the studied element consist of 60% of the amount of other cautions or anions in the solution. Plants were grown in 7 L pots filled with inert substrate. The nutrient solution we used was replaced every three days. In this experiment we examined the effect of N, S, P, K, Ca and Mg ions on chamomile. The essential oil distillation was performed by using Clevenger apparatuses with 50 g samples for 12 hours. GC analysis of the oils from field and pot experiments were conducted on Pye Unicam 204, equipped with a Flame Ionization Detector (FID) and a Carbowax 20 m capillary column, applying hydrogen as a carrier gas.

3. Results and Discussion

Results from the pot experiment (average for 2 years) have shown that plants were higher in the variants with N or K as predominant elements and shorter in the variants with S or P as predominant elements in the nutrient solution (Figure 1). Similar tendency was shown by measuring the dry matter content of the plants. More sensitive index to different element concentration in the solution seems to be the yield of fresh inflorescence per plant. Higher concentration of N, K or Ca ions in the solution increased inflorescence yield per plant in comparison with higher concentration of S, P or Mg (where the yields were the lowest). It is well known that different macro and micronutrients have different effect on chamomile yields (Dovjak, 1988; Dragland et al., 1996; Emongor and Cheweya, 1992; Letchamo, 1992; Letchamo et al., 1993). The effect of a particular ion in the solution depends on the background levels of other ions, on the cultivar/variety used, on the age of the plant, water supply, temperature, light etc. We believe that conclusions from a particular experiment are relevant only within a given cultivar or origin and the given environment and they can hardly be applied to the species itself and to other growth conditions.
Concentration of some of the main chemical compounds in the oil have also been influenced by different concentration of nutrient elements (Figure 2). The positive effect of the tested nutrients as predominant elements in the nutrient solution on the content of the main chemical compounds was as follows: For bisabolol: $P > K > S > N > Ca > Mg$. For bisabolol oxide A: $Mg > Ca > Ca = N >> S = P$; For bisabolol oxide B: $N = Ca >> P = K = Mg = S$. For farnesene: $S = N = P -> Mg = K = Ca$.

Results from the field experiment (average for 3 years) have shown that the tested levels of fertilizer application did not significantly changed plant height relative to the unfertilized control, which do not comply with other findings (Letchamo, 1993). The application of $P_{120}$ kg/ha alone decreased the number of inflorescence per plant while the application of $N_{120}$, $P_{120}$, $K_{120}$ and in the variant with application of $N_{90}$, $P_{60}$, $K_{60}$ increased the value of this index relative to the control. Obviously, most pronounced effect in this respect has nitrogen but only if it is combined with the other two major nutrients – potassium and phosphorus. In all the variants, (except variant 2, 3 and 12), the yields of fresh material were increased by 10 to 32% relative to the unfertilized control. The highest yield was obtained with the highest fertilizer application ($N_{120}$, $P_{120}$ and $K_{120}$). The application of phosphorus and potassium alone did not increase fresh material yields. In all variants except in the variant with $P_{120}$, yields of essential oil were increased by 8–92% relative to the untreated control. The highest oil yields were obtained in variants 8, 14 and 15. Yields of dry inflorescence (except in variants 2 and 3, potassium or phosphorus alone) were increased by 27–80% relative to the unfertilized control. The highest yields were obtained in variant 8 ($N_{120}P_{120}, K_{120}$) and in variant 6 ($N_{120}, K_{120}$).

Gas chromatography analysis of the essential oil from different variants have shown that different combinations and levels of fertilizer application did not cause significant changes in the content of the main chemical compounds: farnesene (with values 6–9.6%), bisabolol oxide B (18.3–21.3%), bisabolol oxide A (19.3–25%), chamazulene (with values between 15.2–17.8%) and bisabolol (with values between 11.7–14.6%), although other authors reported changes in oil quality due to fertilizers (3, 4, 6, 7). All the values of farnesene, bisabolol oxide B, bisabolol, bisabolol oxide A and chamazulene were within the normal values for these compounds in the essential oil of cv Lazur (Stanev et al., 1996).

4. References


Figure 1 - Plant height (cm), dry matter content (%) and yield of fresh inflorescence per plant (g/plant) as depending on the predominant nutrient element in the solution.

Figure 2 - Main chemical compounds in the oil as depending on the predominant nutrient element in the solution.
Figure 3 - Plant height (cm) and number of fluorescences as depending on the rate of fertilizer application.

Levels of fertilizer application, element in kg/ha

Figure 4 - Yield of fresh material (t/ha), essential oil yield (kg/ha) and dry inflorescence yield (t/ha) as depending on the rate of fertilizer application.

Levels of fertilizer application, kg/ha