DOI: 10.2428/ecea.2012.19(12)140 ECOL CHEM ENG A. 2012;19(12):1471-1484

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# APPLICATION OF SLOW-RELEASE FERTILIZERS IN GROWING MARGUERITE DAISY (*Argyranthemum frutescens*) Molimba® GROUP

## ZASTOSOWANIE NAWOZÓW O SPOWOLNIONYM DZIAŁANIU W UPRAWIE SREBRZENIA KRZEWIASTEGO (*Argyranthemum frutescens*) Z GRUPY Molimba

**Abstract:** The aim of the conducted studies was to evaluate the effect of the application of slow-release fertilizers Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) and Osmocote Exact Standard 3–4 M (16 : 11 : 11) on growth and flowering of 3 cultivars from Molimba® group of marguerite daisy (*Argyranthemum frutescens)*. The height of plants, the number of inflorescence buds, the number and diameter of anthodia were determined, together with the state of nutrition of these plants with macro- and microelements. As a result of the conducted experiments it was found that depending on the variety both the type and the rate of the applied fertilizer had an effect on plant height. The application of a slow-release fertilizer with the predominating content of nitrogen, *ie* Osmocote Exact Standard (16 : 11 : 11), as well as a higher rate of Osmocote Exact Hi-K (11 : 11 : 18) resulted in a stronger growth of plants. An exception in this respect was found in cv. 'Monroe Lemon Anemone'. In 'Mini White Double' and 'Monroe Lemon Anemone' flowering plants were produced as a result of higher rates of slow-release fertilizers. The type of fertilizer as well as its rate did not have a significant effect on the number of inflorescence buds or the diameter of anthodia. The cultivar had a significant modifying effect on the content of both macro- and microelements in plants. A significantly better nutrition of plants with phosphorus and iron was observed after the application of Osmocote Exact Standard 3–4 M (16 : 11 : 11) in comparison with Osmocote Exact Hi-K. Differences in the contents of the other macro- and microelements in plants recorded between the analyzed fertilizers were not significant. An increase in the rate of Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) had a significant effect on the state of nutrition of plants with potassium, manganese and zinc, while in case of Osmocote Exact Standard 3–4 M (16 : 11 : 11) it was for that of potassium and zinc. Taking into consideration the practical aspect, consisting in the simplification of cultivation methods under commercial production conditions as well as the quality of plants, and the ecological aspect (limitation of nutrient leaching outside the root zone of plants to groundwater, being hazardous to the natural environment), the tested slow-release fertilizers are suitable for the cultivation of marguerite daisy Molimba® group.

**Keywords:** slow release fertilizers, growth, plant nutrition, analysis of plants

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In recent years – due to their universal applications and very ornamental value--interest in the cultivation of bed plants has been increasing. Marguerite daisy is one such commercially available plant being in high demand. The rapid development of culture results in many new cultivars being offered every year, varying in their growth rates, colours, shapes and filling of anthodia. This provides an incentive for the undertaking of studies on optimization of their growing technology, focusing on plant nutrition, which is crucial for the production of good quality plants.

When growing many cultivars of marguerite daisy it is necessary to apply growth retardants in order to produce good quality plants [1]. In view of the increasing ecological restrictions it is attempted to reduce or eliminate the application of such substances. Growth of plants may be regulated, among other things, by appropriate plant nutrition, particularly with phosphorus [2].

The use of mixed slow-release fertilizers is an essential aspect in the simplification of cultivation methods [3] is of the opinion that balanced supply of nutrients during the whole growing period can be ensured by the use of slow-relase fertilizers. They are fertilizers, in which coatings exhibit properties determining the release of nutrients to the substrate. An example in this respect may be a resin coating of dicyclopentadiene copolymer with glyceride used in Osmocote Plus [4]. Typically the chemical composition of the coating is not disclosed as it is a business secret of the fertilizer manufacturer. The time and rate of nutrient release from slow-release fertilizers to a considerable degree is determined by temperature (the time of fertilizer activity is established for a temperature of 21 $^{o}$C), while it does not depend on substrate reaction/moisture content or microbiological activity of the root zone [5]. The coating itself is degraded as a result of biodegradation. What is important, a slow-release fertilizer provides a significant simplification of the production cycle – once applied, it should supply nutrients to plants throughout their entire vegetation period. Thanks to the above, fluctuations in substrate salinity, disadvantageous for plants, may be avoided and leaching of nutrients outside the root zone of plants to groundwater, being hazardous for the natural environment, may be reduced. Leaching of nutrients to groundwater is the primary cause of its contamination in areas of intensive horticultural use [6]. Optimization of nutrition in other species, as well as suitability of slow-release fertilizers in growing ornamental plants have been discussed in earlier studies [7–16].

Due to a lack of data in literature concerning fertilizer recommendations the aim of the conducted investigations was to evaluate the suitability of slow-release fertilizers Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) and Osmocote Exact Standard 3–4 M (16 : 11 : 11), applied at 2 rates in container growing of different cultivars of marguerite daisy (*Argyranthemum frutescens*) from Molimba® group.

## Material and methods

The studies was conducted at the Marcelin Experimental Station of the Poznan University of Life Sciences. Plants originating from Syngenta Seeds were planted to pots of 0.66 dm$^3$. Highmoor peat Klassman deacidified to pH 6.0 was used as a substrate. Slow-release fertilizers Osmocote Exact Hi-K 3–4 M (11 : 11 : 18 +

microelements) and Osmocote Exact Standard 3–4 M (16 : 11 : 11 + microelements) were added to the substrate. Each fertilizers was applied at two rates of 3 and 6 g · $dm^{-3}$. The experiments were conducted on three *Argyranthemum frutescens* Molimba® cultivars, *ie* 'Mini White Double' – with a compact habit, 'Monroe Lemon Anemone' – with a medium strong growth, and 'Maggy Pastel Yellow' – characterized by strong growth.

Biometric measurements were taken at the flowering phase of plants, concerning such traits as the height of plants, the number of inflorescence, the number of inflorescence buds and the diameter of inflorescence. Results of these measurements were statistically analyzed by the analysis of variance with the application of the Duncan test at the significance level $\alpha = 0.05$.

## Chemical analyses

On the day the experiment was completed leaf samples were collected from plants for chemical analyses. Leaves were dried at 45–50 $^{o}$C and then ground. In order to assay total forms of nitrogen, phosphorus, potassium, calcium, magnesium and sodium plant material was mineralized in concentrated sulfuric acid. Mineralization for assays of iron, manganese, zinc and copper was run using the wet method in a mixture of nitric(V) and chloric(VII) acids (3 : 1, v/v) [17]. After mineralization of plant material the following determinations were performed: N, total nitrogen using the distillation method according to Kjeldahl in a Parnas–Wagner apparatus; P, colorimetrically with ammonia molybdate; K, Ca, Mg, Na, Fe, Mn, Zn, and Cu using *atomic absorption spectroscopy* (AAS) (Carl Zeiss Jena). Results of chemical analyses of plants for their contents of macro- and microelements were analyzed statistically using the Duncan test, with inference at the significance level $\alpha = 0.05$.

## Results and discussion

### Growth and development of plants

The conducted statistical analysis showed a significant effect of the type and rate of fertilizer on plant height in all tested cultivars (Table 1). The application of a slow-release fertilizer with a predominant content of nitrogen Osmocote Exact Standard (16 : 11 : 11), as well as a higher rate of Osmocote Exact Hi-K (11 : 11 : 18) resulted in a stronger growth of plants. Cultivar 'Monroe Lemon Anemone' was an exception in this respect, in which taller plants were obtained only after the application of Osmocote Exact Hi-K (11 : 11 : 18) at 6 g · $dm^{-3}$. This confirms a previously stated trend for an improved growth of plants after the application of bigger rates of a slow-release fertilizer [12, 18].

In the other combinations in that cultivar no considerable effect on plant height was observed. Similar results were recorded in growing *Leucanthemum vulgare* [19] and larkspur [8]. In the other cultivars lower plants were produced under the influence of a lower rate of Osmocote Exact Hi-K (11 : 11 : 18).

Table 1

The effect of Osmocote fertilizers on the growth and flowering of marguerite daisy

| Fertilizer | Height of plants [cm] | | Number of inflorescences [quantity · plant$^{-1}$] | | Number of inflorescences buds [quantity · plant$^{-1}$] | | Diameter of inflorescences [cm] | |
|---|---|---|---|---|---|---|---|---|
| | Dose [g · dm$^{-3}$] | | Dose [g · dm$^{-3}$] | | Dose [g · dm$^{-3}$] | | Dose [g · dm$^{-3}$] | |
| | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 |
| Cultivar – Mini White Double | | | | | | | | |
| Osmocote Exact Hi-K (11 : 11 : 18) | 29.0a | 31.5b | 26.8a | 29.7b | 7.3ab | 7.5b | 3.2a | 2.9a |
| Osmocote Exact Standard (16 : 11 : 11) | 31.7b | 32.5b | 25.6a | 30.5b | 6.0a | 6.0a | 2.9a | 2.8a |
| Cultivar – Monroe Lemon Anemon | | | | | | | | |
| Osmocote Exact Hi-K (11 : 11 : 18) | 32.6a | 39.2b | 31.4a | 37.3b | 12.0b | 8.3ab | 3.0ab | 3.5b |
| Osmocote Exact Standard (16 : 11 : 11) | 31.4a | 31.3a | 31.5a | 38.6b | 8.1a | 10.3b | 2.8a | 3.4b |
| Cultivar – Maggy Pastel Yellow | | | | | | | | |
| Osmocote Exact Hi-K (11 : 11 : 18) | 40.6a | 48.5b | 10.5a | 11.4ab | 12.6bc | 11.1ab | 3.9ab | 4.0b |
| Osmocote Exact Standard (16 : 11 : 11) | 52.8c | 50.6bc | 11.2ab | 12.7b | 14.1c | 9.6a | 3.8ab | 3.6a |

An increase in fertilizer rates to 6 g · dm$^{-3}$ in case of both fertilizers resulted in the formation of higher numbers of flowers on plants. According to [9] the application of Osmocote Exact flowered of Easy Pot Freesia most abundantly, regardless to cultivar.

An identical effect was also found in case of increased rates of Osmocote Plus in larkspur and in large-flowered tickseed [8, 12]. Such a dependence was not recorded in cv. 'Maggy Pastel Yellow', in which the type of fertilizer or its rate did not influence flowering of plants.

In the conducted experiments the type of applied fertilizer or its rate did not have a significant effect on the number of inflorescence buds or the diameter of anthodia.

## Nutrient status of plants

Factors significantly modifying the state of nutrition in plants include among other things the cultivar, *ie* a genotype specific to a given cultivar [20–22], as well as applied fertilization [23–25]. The genotype of plants was a factor having a significant effect on plant nutrition with nitrogen (Table 2). The smallest mean content of this nutrient was found in cv. 'Maggy Pastel Yellow', while the highest in 'Mini White Double'. The state of nitrogen nutrition in case of marguerite daisy as expressed in the mean for the tested cultivars was not influenced by the type of applied fertilizer (means for both

Table 2

The effect of Osmocote fertilizers on the content of nitrogen and phosphorus in marguerite daisy leaves

| Dose (B) [g · dm$^{-3}$] | Fertilizer (A) | | | | | | | | Mean for B |
|---|---|---|---|---|---|---|---|---|---|
| | Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) (A1) | | | | Osmocote Exact Standard 3–4 M (16 : 11 : 11) (A2) | | | | |
| | Cultivar (C) | | | | | | | | |
| | 'Mini White Double' (C1) | 'Monroe Lemon Anemon' (C2) | 'Maggy Pastel Yellow' (C3) | Mean for A×B | 'Mini White Double' (C1) | 'Monroe Lemon Anemon' (C2) | 'Maggy Pastel Yellow' (C3) | Mean for A×B | |
| N [% in d.m.] | | | | | | | | | |
| 3 | 4.69 | 3.85 | 3.15 | 3.90a | 3.50 | 3.36 | 3.36 | 3.41a | 3.65a |
| 6 | 4.27 | 3.15 | 3.08 | 3.50a | 3.50 | 3.36 | 3.29 | 3.38a | 3.44a |
| Mean for A×C | 4.48a | 3.50b | 3.12c | | 3.50a | 3.36a | 3.33a | | |
| Mean for A | 3.70a | | | | 3.40a | | | | |
| Mean for C | C1 3.99a | | C2 3.43ab | | C3 3.22b | | | | |
| P [% in d.m.] | | | | | | | | | |
| 3 | 0.85 | 1.29 | 0.35 | 0.83a | 1.15 | 1.65 | 0.26 | 1.02a | 0.93a |
| 6 | 0.60 | 1.43 | 0.22 | 0.75a | 1.12 | 1.70 | 0.21 | 1.01a | 0.88a |
| Mean for A×C | 0.73b | 1.36a | 0.29c | | 1.14b | 1.68a | 0.24c | | |
| Mean for A | 0.79b | | | | 1.02a | | | | |
| Mean for C | C1 0.93b | | C2 1.52a | | | | C3 0.26c | | |

analyzed fertilizers were similar) or their rates. In most cases a trend was observed, although not confirmed statistically, for a reduction of nitrogen content in plants with an increase in the application of this nutrient in fertilization.

There are scarce studies in available literature concerning nutrition of marguerite daisy. A closely related species, coming from the same family, is *Dendranthema grandiflora* Tzvelev (syn. *Chrysanthemum* × *grandiflorum* (Ramat.) Kitam). There are several studies concerning the nutrition of chrysanthemums [21, 22, 26–28]. Nitrogen content in leaves, recorded in this study in all the tested cultivars, was lower than the contents reported for chrysanthemums [21], amounting to 4.86–5.21 % N.

Similarly as in case of nitrogen, a significant effect of cultivar was shown on the content of phosphorus in plants (Table 2). It was lowest in case of 'Maggy Pastel Yellow', while it was highest for 'Monroe Lemon Anemone'. The content of phosphorus in plants was significantly influenced also by the type of the applied fertilizer, with higher contents determined for Osmocote Exact Standard. Similarly as in case of nitrogen, a statistically unconfirmed trend could be observed for an improved state of nutrition of plants with phosphorus with an increase in the intensity of plant nutrition. For 'Mini White Double' and 'Monroe Lemon Anemone' phosphorus contents determined in plants were similar to those recorded in case of chrysanthemums [21].

The cultivar was a factor having a significant effect on the content of potassium in plants (Table 3). The highest amount of this nutrient, similarly as in case of nitrogen, was recorded in 'Mini White Double', while the amount was significantly lower in 'Maggy Pastel Yellow'.

This trend was confirmed for both tested fertilizers. The type of applied slow-release fertilizer was found to have no significant effect on the state of plant nutrition with potassium. However, as it was confirmed in case of Osmocote Exact Hi-K and Osmocote Exact Standard, an increase in the intensity of nutrition increased the content of potassium in plants. Potassium content in leaves of chrysanthemums ranged from 6.48 to 7.55 % K [21], which was consistent (except for 'Maggy Pastel Yellow') with contents determined in this study.

Similarly as in case of the previously discussed phosphorus and potassium, a significant effect of genetic traits of a given cultivar was found on the content of calcium in plants (Table 3). For both analyzed fertilizers it was highest in cv. 'Monroe Lemon Anemone', while it was lowest in 'Maggy Pastel Yellow'. Analyses showed no significant effect of the type of fertilizer or its rate on the mean content of this nutrient in plants. The above-mentioned authors [21], depending on the cultivar, recorded calcium content ranging from 2.63 to 3.10 % Ca, while in this study in cv. 'Monroe Lemon Anemone' its content was over 2-fold higher.

'Monroe Lemon Anemone' turned out to be a cultivar with a significantly highest content of magnesium, while it was lowest in 'Mini White Double' (Table 4).

Similarly as in case of calcium, the type of applied fertilizer and its rate were found to have no effect on significant changes in the state of magnesium nutrition in chrysanthemum. Similarly as in case of phosphorus, magnesium content determined in plants fell within a range of contents for this nutrient in chrysanthemums [21].

Table 3

The effect of Osmocote fertilizers on the content of potassium and calcium in marguerite daisy leaves

| Dose (B) [g · dm$^{-3}$] | Fertilizer (A) | | | | | | | | Mean for B |
|---|---|---|---|---|---|---|---|---|---|
| | Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) (A1) | | | | Osmocote Exact Standard 3–4 M (16 : 11 : 11) | | | | |
| | Cultivar (C) | | | | | | | | |
| | ‘Mini White Double’ (C1) | ‘Monroe Lemon Anemon’ (C2) | ‘Maggy Pastel Yellow’ (C3) | Mean for A×B | ‘Mini White Double’ (C1) | ‘Monroe Lemon Anemon’ (C2) | ‘Maggy Pastel Yellow’ (C3) | Mean for A×B | |
| K [% in d.m.] | | | | | | | | | |
| 3 | 7.91 | 7.07 | 4.32 | 6.43b | 7.51 | 5.80 | 4.52 | 5.94b | 6.19b |
| 6 | 8.23 | 8.38 | 6.17 | 7.59a | 7.62 | 7.64 | 5.52 | 6.93a | 7.26a |
| Mean for A×C | 8.07a | 7.73a | 5.25b | | 7.57a | 6.72a | 5.02b | | |
| Mean for A | 7.01a | | | | 6.44a | | | | |
| Mean for C | C1 7.82a | | C2 7.22a | | C3 5.13b | | | | |
| Ca [% in d.m.] | | | | | | | | | |
| 3 | 4.07 | 7.29 | 2.20 | 4.52a | 3.35 | 7.29 | 2.08 | 4.24a | 4.38a |
| 6 | 3.02 | 6.50 | 2.44 | 3.99a | 3.51 | 6.83 | 2.52 | 4.29a | 4.14a |
| Mean for A×C | 3.55b | 6.90a | 2.32c | | 3.43b | 7.06a | 2.30c | | |
| Mean for A | 4.25a | | | | 4.26a | | | | |
| Mean for C | C1 3.49b | | C2 6.98a | | C3 2.31c | | | | |

Table 4

The effect of Osmocote fertilizers on the content of magnesium and sodium in marguerite daisy leaves

| Dose (B) [g · dm$^{-3}$] | Fertilizer (A) | | | | | | | | Mean for B |
|---|---|---|---|---|---|---|---|---|---|
| | Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) (A1) | | | | Osmocote Exact Standard 3–4 M (16 : 11 : 11) | | | | |
| | Cultivar (C) | | | | | | | | |
| | 'Mini White Double' (C1) | 'Monroe Lemon Anemon' (C2) | 'Maggy Pastel Yellow' (C3) | Mean for A×B | 'Mini White Double' (C1) | 'Monroe Lemon Anemon' (C2) | 'Maggy Pastel Yellow' (C3) | Mean for AxB | |
| Mg [% in d.m.] | | | | | | | | | |
| 3 | 0.46 | 0.73 | 0.55 | 0.58a | 0.45 | 0.73 | 0.52 | 0.57a | 0.57a |
| 6 | 0.40 | 0.67 | 0.56 | 0.54a | 0.39 | 0.68 | 0.52 | 0.53a | 0.54a |
| Mean for A×C | 0.43c | 0.70a | 0.56b | | 0.42b | 0.71a | 0.52b | | |
| Mean for A | 0.56a | | | | 0.55a | | | | |
| Mean for C | C1 0.43b | | C2 0.70a | | C3 0.54a | | | | |
| Na [% in d.m.] | | | | | | | | | |
| 3 | 0.91 | 1.10 | 1.23 | 1.08a | 1.29 | 1.20 | 1.27 | 1.25a | 1.17a |
| 6 | 0.88 | 0.90 | 1.25 | 1.01a | 1.06 | 1.00 | 1.31 | 1.12a | 1.07a |
| Mean for A×C | 0.90b | 1.00b | 1.24a | | 1.18a | 1.10b | 1.29a | | |
| Mean for A | 1.05a | | | | 1.19a | | | | |
| Mean for C | C1 1.04b | | C2 1.05b | | C3 1.27a | | | | |

In the conducted experiments significant changes were shown in the content of sodium depending on the cultivar (Table 4). The lowest amount of this ion was found in 'Mini White Double', while it was highest in 'Maggy Pastel Yellow'. No significant effect of fertilizer rates or its type was observed on the content of sodium in plants. In turn, the contents of sodium as a ballast ion, not being a nutrient, were almost 10 times higher than those reported previously [21].

Specific genetic traits of tested cultivars turned out to a factor significantly modifying the content of metallic microelements such as iron, manganese, zinc and copper in plants. The highest amounts of iron and manganese were determined in 'Monroe Lemon Anemone', while the lowest amounts of these nutrients were recorded in 'Maggy Pastel Yellow' (Table 5).

The type of the applied fertilizer had a significant effect on iron content, at the same time having no modifying effect on the content of manganese in plants. For the mean of the tested combinations no significant effect of the rate of fertilizer was found for plant nutrition with iron and manganese. For iron a significant variation was observed between cultivars. Determined contents of this nutrient ranged in case of the 2 tested cultivars fell within the range given above, *ie* from 121.5 to 169.5 mg · $kg^{-1}$ d.m. [21, modif.]. In other studies [22] in chrysanthemum leaves the levels ranged from 69.17 to 193.07 mgFe · $kg^{-1}$ d.m.. Similar contents of this nutrient to those recorded in this study are reported in literature [26, 27]. The contents of manganese determined in plants in this study were markedly higher than the range of contents for this nutrient reported by Jerzy et al [21], amounting to 48.0–85.0 mg.

'Monroe Lemon Anemone' was a cultivar with significantly highest content of zinc, while it was lowest in 'Maggy Pastel Yellow' (Table 6). The above-mentioned dependence was found in case of both tested fertilizers. No effect of the type of fertilizer on the content of this nutrient in plants was observed, at the simultaneous positive effect of the applied rates. The content of zinc in plants increased significantly with an increase in the intensity of nutrition.

Similarly as in case of iron, manganese and zinc, a significant effect of specific cultivar traits was found on the content of copper in plants (Table 6). It was significantly highest in 'Maggy Pastel Yellow', while it was lower in case of the other cultivars. The type of applied fertilizer had no significant effect on the state of nutrition of plants with this microelement.

Adaptation of nutrition to species-specific or even cultivar-specific requirements is one of the factors influencing yielding of plants, both quantitatively and qualitatively. This may be provided by the determination of nutrients guide values (content of nutrients in plants), at which optimal yielding is achieved. Guide values are thus a valuable diagnostic tool in controlled plant nutrition. Their determination is particularly important in species with an increasing importance in commercial cultures, which group includes also marguerite daisy. Guide values for individual cultivars are as follows:

– 'Mini White Double' [in % d.m.]: N 3.50–4.27, P 0.60–1.12, K 7.62–8.23, Ca 3.02–3.51, Mg 0.42–0.43; [in mg · $kg^{-1}$ d.m.]: Fe 114.0–160.3, Mn 334.1–339.5, Zn 69.1–76.8, Cu 5.2–5.4,

Table 5

The effect of Osmocote fertilizers on the content of iron and manganese in marguerite daisy leaves

| Dose (B) [g · dm$^{-3}$] | Fertilizer (A) | | | | | | | | Mean for B |
|---|---|---|---|---|---|---|---|---|---|
| | Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) (A1) | | | | Osmocote Exact Standard 3–4 M (16 : 11 : 11) | | | | |
| | Cultivar (C) | | | | | | | | |
| | 'Mini White Double' (C1) | 'Monroe Lemon Anemon' (C2) | 'Maggy Pastel Yellow' (C3) | Mean for A×B | 'Mini White Double' (C1) | 'Monroe Lemon Anemon' (C2) | 'Maggy Pastel Yellow' (C3) | Mean for A×B | |
| Fe [mg · kg$^{-1}$] | | | | | | | | | |
| 3 | 153.1 | 221.7 | 130.6 | 168.5a | 154.0 | 280.4 | 120.1 | 184.8a | 176.7a |
| 6 | 74.9 | 351.7 | 125.1 | 183.9a | 166.5 | 318.9 | 132.4 | 205.9a | 194.9a |
| Mean for A×C | 114.0b | 286.7a | 127.9b | | 160.3b | 299.7a | 126.3b | | |
| Mean for A | 176.2a | | | | 195.4b | | | | |
| Mean for C | C1 137.1a | | C2 293.2b | | C3 127.1a | | | | |
| Mn [mg · kg$^{-1}$] | | | | | | | | | |
| 3 | 305.4 | 358.6 | 210.9 | 291.6b | 329.9 | 477.5 | 304.5 | 370.6a | 331.1a |
| 6 | 362.7 | 477.9 | 285.8 | 375.5a | 349.1 | 411.7 | 289.6 | 350.1a | 362.8a |
| Mean for A×C | 334.1b | 418.3a | 248.4c | | 339.5b | 444.6a | 297.1c | | |
| Mean for A | 333.6a | | | | 360.4a | | | | |
| Mean for C | C1 336.8b | | C2 431.4 a | | C3 272.7c | | | | |

Table 6

The effect of Osmocote fertilizers on the content of zinc and copper in marguerite daisy leaves

| Dose (B) [g · dm$^{-3}$] | Fertilizer (A) | | | | | | | | Mean for B |
|---|---|---|---|---|---|---|---|---|---|
| | Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) (A1) | | | | Osmocote Exact Standard 3–4 M (16 : 11 : 11) | | | | |
| | Cultivar (C) | | | | | | | | |
| | ‘Mini White Double’ (C1) | ‘Monroe Lemon Anemon’ (C2) | ‘Maggy Pastel Yellow’ (C3) | Mean for A×B | ‘Mini White Double’ (C1) | ‘Monroe Lemon Anemon’ (C2) | ‘Maggy Pastel Yellow’ (C3) | Mean for A×B | |
| Zn [mg · kg$^{-1}$] | | | | | | | | | |
| 3 | 70.1 | 68.2 | 22.8 | 53.7b | 76.7 | 87.9 | 6.6 | 57.1b | 55.4b |
| 6 | 68.0 | 113.2 | 31.0 | 70.7a | 76.8 | 109.1 | 30.8 | 72.2a | 71.5a |
| Mean for A×C | 69.1 | 90.7 | 26.9 | 62.2 | 76.8 | 98.5 | 18.7 | 69.1 | |
| Mean for A | 62.2a | | | | 64.7a | | | | |
| Mean for C | C1 72.9b | | C2 94.6a | | C3 22.8c | | | | |
| Cu [mg · kg$^{-1}$] | | | | | | | | | |
| 3 | 4.8 | 5.6 | 8.1 | 6.2a | 4.4 | 5.3 | 5.4 | 5.0a | 5.6a |
| 6 | 5.4 | 5.7 | 5.3 | 5.5a | 5.2 | 4.5 | 5.8 | 5.2a | 5.3a |
| Mean for A×C | 5.1b | 5.7b | 6.7a | | 4.8b | 4.9b | 5.6a | | |
| Mean for A | 5.8a | | | | 5.1a | | | | |
| Mean for C | C1 5.0b | | C2 5.3b | | C3 6.2a | | | | |

– 'Monroe Lemon Anemon' [n % d.m.]: N 3.15–3.36, P 1.43–1.70, K 7.64–8.38, Ca 6.50–6.83, Mg 0.70–0.71; [in mg · $kg^{-1}$ d.m.]: Fe 286.7–299.7, Mn 418.3–444.6, Zn 90.7–98.5, Cu 4.5–5.7,

– 'Maggy Pastel Yellow' [in % d.m.]: N 3.08–3.29, P 0.21–0.22, K 5.52–6.17, Ca 2.44–2.52, Mg 0.52–0.56; [in mg · $kg^{-1}$ d.m.]: Fe 126.3–127.9, Mn 248.4–297.1, Zn 18.7–26.9, Cu 5.3–5.8.

Taking into consideration the trend for the improvement of plant quality, expressed in their height as well as the number and diameter of flowers, in pot culture of different cultivars of marguerite daisy from Molimba® group the tested slow-release fertilizers Osmocote Exact Hi-K 3–4 M and Osmocote Exact Standard 3–4 M may be recommended at a rate of 6 g · $dm^{-3}$ substrate. Their use is advantageous due to the significant simplification of cultivation and a limitation of the potential environmental hazard as a result of drainage waters leaking to the soil.

## Conclusions

On the basis of conducted studies on the application of slow-release fertilizers Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) and Osmocote Exact Standard 3–4 M (16 : 11 : 11) in pot culture of Molimba® group marguerite daisy the following may be stated:

1. The application of slow-release fertilizer with the predominant content of nitrogen Osmocote Exact Standard (16 : 11 : 11), as well as a higher rate of Osmocote Exact Hi-K (11 : 11 : 18) resulted in a stronger growth of plants. 'Monroe Lemon Anemone' was an exception in this respect.

2. In cv. 'Mini White Double' and 'Monroe Lemon Anemone' more abundantly flowering plants were produced under the influence of higher rates of slow-release fertilizers.

3. The type of fertilizer, as well as its rate had no significant effect on the number of inflorescence buds or the diameter of anthodia.

4. The cultivar significantly modified the contents of both macro- and microelements in plants.

5. A significantly better nutrition of plants with phosphorus and iron was shown after the application of Osmocote Exact Standard 3–4 M (16 : 11 : 11). Differences in the contents of the other macro- and microelements in plants found between the tested fertilizers were non-significant.

6. An increase in the rates of Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) had a significant effect on the state of nutrition of plants with potassium, manganese and zinc, while in case of Osmocote Exact Standard 3–4 M (16 : 11 : 11) it was for potassium and zinc.

7. The following ranges of guide values, at which yielding of plants was most advantageous, are proposed for individual cultivars:

– 'Mini White Double' [in % d.m.]: N 3.50–4.27, P 0.60–1.12, K 7.62–8.23, Ca 3.02–3.51, Mg 0.42–0.43; [in mg · $kg^{-1}$ d.m.]: Fe 114.0–160.3, Mn 334.1–339.5, Zn 69.1–76.8, Cu 5.2–5.4,

– 'Monroe Lemon Anemone' [in % d.m.]: N 3.15–3.36, P 1.43–1.70, K 7.64–8.38, Ca 6.50–6.83, Mg 0.70–0.71; [in mg · $kg^{-1}$ d.m.]: Fe 286.7–299.7, Mn 418.3–444.6, Zn 90.7–98.5, Cu 4.5–5.7,

– 'Maggy Pastel Yellow' [in % d.m.]: N 3.08–3.29, P 0.21–0.22, K 5.52–6.17, Ca 2.44–2.52, Mg 0.52–0.56; [in mg · $kg^{-1}$ d.m.]: Fe 126.3–127.9, Mn 248.4–297.1, Zn 18.7–26.9, Cu 5.3–5.8.

8. Taking into consideration both the practical aspect, consisting in the simplification of cultivation methods in commercial production, and the quality of plants, and the ecological aspect, *ie* the potential reduction of nutrient leaching hazardous for the natural environment outside the root zone to groundwater, the tested slow-release fertilizers are suitable for the growing of Molimba® group marguerite daisy.

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## ZASTOSOWANIE NAWOZÓW O SPOWOLNIONYM DZIAŁANIU W UPRAWIE SREBRZENIA KRZEWIASTEGO (*Argyranthemum frutescens*) Z GRUPY Molimba

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**Abstrakt:** Celem przeprowadzonych badań była ocena wpływu stosowania nawozów o spowolnionym działaniu: Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) oraz Osmocote Exact Standard 3–4 M (16 : 11 : 11) na wzrost i kwitnienie 3 odmian srebrzenia krzewiastego (*Argyranthemum frutescens)* z grupy Molimba. Oceniano wysokość roślin, liczbę pąków kwiatostanowych, liczbę i średnicę koszyczków kwiatowych, a także stan odżywienia roślin makro i mikroelementami. W wyniku przeprowadzonego doświadczenia stwierdzono, że w zależności od odmiany zarówno typ, jak i dawka zastosowanego nawozu wpływała na wysokość roślin. Zastosowanie nawozu o spowolnionym działaniu z przewagą azotu Osmocote Exact Standard (16 : 11 : 11), a także wyższej dawki Osmocote Exact Hi-K (11 : 11 : 18) spowodowało silniejszy wzrost roślin. Wyjątek stanowiła odmiana 'Monroe Lemon Anemon'. U odmiany 'Mini White Double' i 'Monroe Lemon Anemon' obficiej kwitnące rośliny uzyskano pod wpływem wyższych dawek nawozów o spowolnionym działaniu. Typ nawozu, a także jego dawka nie miała istotnego wpływu na liczbę pąków kwiatostanowych, a także średnicę koszyczków kwiatowych. Odmiana istotnie modyfikowała zarówno zawartości makro, jak i mikroelementów w roślinach. Wykazano istotnie lepsze odżywienie roślin fosforem i żelazem po zastosowaniu Osmocote Exact Standard 3–4 M (16 : 11 : 11) w porównaniu z Osmocote Exact Hi-K. Różnice zawartości pozostałych makro i mikroelementów w roślinach występujące pomiędzy badanymi nawozami nie były istotne. Wzrost dawki nawozu Osmocote Exact Hi-K 3–4 M (11 : 11 : 18) wpływał istotnie na stan odżywienia roślin potasem, manganem i cynkiem – a w przypadku Osmocote Exact Standard 3–4 M (16 : 11 : 11) potasem i cynkiem. Biorąc pod uwagę aspekt praktyczny, polegający na uproszczeniu metod uprawy w warunkach produkcyjnych, jak również jakość roślin oraz aspekt proekologiczny – ograniczenia niebezpiecznego dla środowiska naturalnego wymywania składników pokarmowych poza strefę korzeniową roślin do wód gruntowych, badane nawozy wolnodziałające są przydatne do uprawy srebrzenia krzewiastego z grupy Molimba.

**Słowa kluczowe:** nawozy o spowolnionym działaniu, wzrost, stan odżywienia, analizy roślin