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THE EFFECT OF DIVERSE FERTILIZERS ON THE QUALITY OF *BEGONIA SEMPERFLORENS* LINK. ET OTTO.

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ABSTRACT

This research was carried out to analyze the effect of diverse types of fertilizers and concentrations on the morphological features of *Begonia semperflorens* Link. et Otto., as well as to determine the most appropriate concentration of fertilizer to obtain the highest plant quality. Different types of liquid fertilizers and concentrations were used in this experiment - Agrosal with NPK 10-5-5 + microelements (0.2%; 0.3%; 0.4%), Agrosal with NPK 7-1-5 + microelements (0.2%; 0.3%; 0.4%) and Agrosal with NPK 12-5-7 + microelements (0.2%; 0.3%; 0.4%). For measurement, 30 plants were used per treatment, three months after planting into plastic containers. The following biometric parameters were analyzed: plant height (mm), number of leaves, number of branches, and number of inflorescences. Measurements of biometric parameters showed that the liquid mineral fertilizer Agrosal with NPK 12-5-7 + microelements and a concentration of 0.4% showed the highest average number of branches and number of inflorescences. Agrosal with NPK 12-5-7 + microelements and concentration of 0.3% showed the highest average height of plant and Agrosal with NPK 7-1-5 + microelements and concentration of 0.2% showed the highest average number of leaves. Agrosal with NPK 12-5-7 + microelements and a concentration of 0.4% can be recommended in practice.

Key words: biometric parameters, concentration, morphological features, plants.

INTRODUCTION

Begonia semperflorens Link. et Otto. belongs to the Begoniaceae family. There are more than 1000 species in the *Begonia* L. genus, native to tropical and subtropical parts of both hemispheres (Hadzi Pecova, 2017). *Begonia semperflorens* Link. et Otto. finds wide application and is massively used as an annual flower crop. It can be grown in the sun, but it also blooms beautifully in shady positions. *Begonia semperflorens* Link et Otto. is one of the most popular flower crops for arranging flower beds, and compared to other types of begonias, it is produced the most. *Begonia semperflorens* Link et Otto. originates from Brazil, and was brought to Europe in the 19th century (Hadzi Pecova, 2017). It grows from 20 to 35 cm. The leaves are asymmetrical. *Begonia semperflorens* Link et Otto. has small and numerous flowers of white, pink or red color, placed on short stalks. It blooms continuously from May until the appearance of the first frost (Nikolova, 1999). Plants are propagated by seed. The seeds are sown in December, in greenhouses, in boxes or containers. A temperature of 20 to 25 ºC is required for seed germination and sprouting. After germination, the temperature is maintained at 15-16 ºC. Begonia seeds are very small and therefore require two pickings (Hadzi Pecova, 2017). Any delay, even that of 2-3 days, can have a negative effect on development because the plants will overgrow and become elongated (Hadžiabulić, 2010). After the appearance of the first leaf, they are planted in boxes or containers at a distance of 3 to 4 cm. The second picking is done when the first real petals appear, in pots with a diameter of 6 to 7 cm (Hadzi Pecova, 2017). The starting pH of the substrate should be 5.5-6.0 (Hamrick, 2003). In order to obtain high quality seedlings, it is necessary to use substrates, which are on the market of many different qualities, which is important to be known when choosing (Todorović, 2019). For optimum growth of the young transplanted seedlings, a 22/18 ºC day/night temperature is recommended for 2 weeks, after which time, the temperature can be lowered to 16 ºC nights and 19 ºC days (Dole & Wilkins, 1999). In the production of flower seedlings, the dose of fertilizer application must be in accordance with the size of the container, the stage of plant development and the pH values of the substrate (Vujošević, 2015). It should be fertilized at every other watering with 150-200 ppm of NPK 15-0-15, alternating with NPK 20-10-20. To harden the plants, nitrogen levels should be reduced a few weeks before sale (Hamrick, 2003). Potted plants are fertilized weekly during maintenance with complex NPK fertilizer (20-20-20) in a concentration of 0.5 to 1 g per liter of water (Karasek, 2007). Outdoor planting is carried out after the danger of winter and spring frosts has ended (usually after May 15) (Đurovka et al., 2006). Depending on the variety and the arrangement of the green areas, they are planted at a distance of 10-20 cm (Šilianova, 2005). According to Lin et al. (2011), salicylic acid pretreatments with satisfactory concentrations between 25 to 400 μM proved to enhance outdoor heat tolerance in *Begonia semperflorens*.

The specificity of seedling production, especially in protected areas where a large number of horticultural plants are often grown in different conditions, often of different geographical origin, imposes the need to provide these plants with climatic and optimal conditions in terms of nutrition, whether in the germination, in seedling period or further development. This goal is achieved by growing plants in substrates or soil mixtures adapted to the requirements of plants at certain stages of development (Karasek, 2002).

This research was carried out to analyse the effect of diverse fertilizers on the quality of *Begonia semperflorens* Link. et Otto., as well as to decide what is the most appropriate concentration of fertiliser for highest quality of *Begonia semperflorens* Link. et Otto.

MATERIALS AND METHODS

The experiment was conducted in the greenhouse of the farm "Flower-Garden" in the village of Vladevci, near by the city Strumica, Republic of North Macedonia. The experiment was conducted on *Begonia semperflorens* Link. et Otto.. The substrate used for the production of *Begonia semperflorens* Link. et Otto. is known as "Poinsetia". The structure of the substrate "Poinsetia" is as follows: 65% white peat, 30% black peat and 5% perlite. Different types of liquid fertilizers and concentrations were used in this experiment - Agrosal with NPK 10-5-5 + microelements (0.2%; 0.3%; 0.4% concentration), Agrosal with NPK 7-1-5 + microelements (0.2%; 0.3%; 0.4% concentration) and Agrosal with NPK 12-5-7 + microelements (0.2%; 0.3%; 0.4% concentration). Seedlings of *Begonia semperflorens* Link. et Otto. were produced from seeds in containers. Planting of seedlings is done manually, from containers in pots. Each plant was individually removed from the cells and planted in pots with a diameter of 10.5 cm. The pots are pre-filled with a substrate "Poinsetia". Immediately after planting, each pot was watered with 100 ml of water. The experiment contained nine treatments. Every treatment consisted of 30 plants or a total of 270 plants in the experiment. Fertilization was started when the seedlings developed 4 to 5 leaves. For each variant, a solution was made of the appropriate fertilizers with an appropriate concentration, and from this quantity, with a measuring cup, each pot of the variant was filled with 100 ml of solution. Fertilization was done once a week. If

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necessary, the seedlings were irrigated with water in the amount of 100 ml in each pot. Types of fertilizers, their concentrations and solution are shown in Table 1.

Table 1. Types of fertilizers, their concentrations, solution and number of plants

Treatment	Type of fertilizer	Concentration	Solution	Number of plants
Treatment I	Agrosal 10-5-5 + M.E.	0.2%	3 ml / 1.5 l	30
Treatment II	Agrosal 10-5-5 + M.E.	0.3 %	4.5 ml / 1.5 l	30
Treatment III	Agrosal 10-5-5 + M.E.	0.4 %	6 ml / 1.5 l	30
Treatment IV	Agrosal 7-1-5 + M.E.	0.2%	3 ml / 1.5 l	30
Treatment V	Agrosal 7-1-5 + M.E.	0.3 %	4.5 ml / 1.5 l	30
Treatment VI	Agrosal 7-1-5 + M.E.	0.4 %	6 ml / 1.5 l	30
Treatment VII	Agrosal 12-5-7 + M.E.	0.2%	3 ml / 1.5 l	30
Treatment VIII	Agrosal 12-5-7 + M.E.	0.3 %	4.5 ml / 1.5 l	30
Treatment IX	Agrosal 12-5-7 + M.E.	0.4 %	6 ml / 1.5 l	30

30 plants of each treatment were measured, four months after planting the seedlings in pots. The following biometric parameters were analyzed: plant height (mm), number of leaves, number of branches and number of inflorescences. The obtained results were statistically processed according to the method of analysis of variance and test with LSD (Least Significant Difference) test.

RESULTS AND DISCUSSION

The highest average value for the plants' height (242 mm) was reached in the plants from Treatment VIII. Treatment II and Treatment III showed the same average value for the plants' height (200 mm). The lowest average value for the plants' height (186 mm) was obtained in the Treatment VI. Plants from Treatment II had the most heterogeneous height (CV 22.91%) (Table 2). According to Kessler et al. (1991), the greatest final leaf area and plant height occurred after 2 weeks of 125 $\mu mol \cdot s^{-1} \cdot m^{-2}$ metal-halide supplemental irradiance in the greenhouse.

Table 2. Height of plants (mm)

Treatment	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Interval of Variation (min-max)
I	196	24.08	12.29	170-220
II	200	45.83	22.91	150-230
III	200	7.07	3.54	190-210
IV	208	19.24	9.25	180-230
V	202	13.04	6.45	190-220
VI	186	15.17	8.15	170-210
VII	222	22.80	10.27	200-250
VIII	242	16.43	6.79	220-260
IX	214	13.42	6.27	200-230

Treatments I, II, III, V and VIII showed significant statistical difference at a level of 0.05 compared with Treatment VII. Treatments IV and IX showed significant statistical difference at a level of 0.05 compared with Treatment VI. Between Treatments VIII and IX there was statistically significant difference at a level of 0.05. The height of plants from Treatments I, II, III, IV, V and VI showed significant statistical difference at a level of 0.01 compared with the height of plants from the Treatment VIII. Between Treatments VI and VII there was statistically significant difference at a level of 0.01 (Table 3).

Table 3. Height of plants (mm) – Comparison between treatments

Treatment	Comparison with Treat. I	Comparison with Treat. II	Comparison with Treat.III	Comparison with Treat.IV	Comparison with Treat. V	Comparison with Treat.VI	Comparison with Treat.VII	Comparison with Treat.VIII	Comparison with Treat.IX
I	Treat.I	-4	-4	-12	-6	10	-26	-46	-18
II	4	Treat.II	0	-8	-2	14	-22	-42	-14
III	4	0	Treat.III	-8	-2	14	-22	-42	-14
IV	12	8	8	Treat. IV	6	22	-14	-34	-6
V	6	2	2	-6	Treat.V	16	-20	-40	-12
VI	-10	-14	-14	-22	-16	Treat.VI	-36	-56	-28
VII	26	22	22	14	20	36	Treat.VII	-20	8
VIII	46	42	42	34	40	56	20	Treat.VIII	28
IX	18	14	14	6	12	28	-8	-28	Treat.IX

LSD 0.05 =19.62*

LSD 0.01 =29.04**

The number of leaves was largest in Treatment IV with 42 leaves. Treatments VII, VIII and IX showed the same average value for the number of leaves (40 leaves). The lowest number of leaves had plants of Treatment II, with an average value of 33 leaves. The most heterogeneous coefficient of variation had plants from Treatment II with CV 27.22% (Table 4).

Table 4. Number of leaves

Treatment	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Interval of Variation (min-max)
I	34	5.68	16.91	27-42
II	33	8.93	27.22	24-45
III	39	7.43	18.95	30-47
IV	42	8.38	19.77	30-52
V	38	6.62	17.60	29-47
VI	41	5.37	13.22	35-47
VII	40	4.72	11.69	33-45
VIII	40	1.14	2.88	38-41
IX	40	4.83	12.19	32-45

Plants from the Treatment I and Treatment II, showed significant statistical difference at a level of 0.05 in the number of leaves compared with plants of Treatment IV. The number of leaves from Treatment II showed a significant statistical difference at a level of 0.05 compared with the number of leaves from Treatment VI (Table 5).

The highest average number of branches (14 branches) was obtained in plants from Treatment IX. Treatments VI, VII and VIII showed the same average value for the number of branches (13 branches). Plants from the Treatment II had the lowest values, with an average value of 8 branches. Plants from Treatment II had the most heterogeneous number of branches (CV 18.05%) (Table 6).

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Table 5. Number of leaves – Comparison between treatments

Treatment	Comparison with Treat. I	Comparison with Treat. II	Comparison with Treat.III	Comparison with Treat.IV	Comparison with Treat.V	Comparison with Treat.VI	Comparison with Treat.VII	Comparison with Treat.VIII	Comparison with Treat.IX
I	Treat.I	1	-5	-8	-4	-7	-6	-6	-6
II	-1	Treat.II	-6	-9	-5	-8	-7	-7	-7
III	5	6	Treat.III	-3	1	-2	-1	-1	-1
IV	8	9	3	Treat. IV	4	1	2	2	2
V	4	5	-1	-4	Treat.V	-3	-2	-2	-2
VI	7	8	2	-1	3	Treat.VI	1	1	1
VII	6	7	1	-2	2	-1	Treat.VII	0	0
VIII	6	7	1	-2	2	-1	0	Treat.VIII	0
IX	6	7	1	-2	2	-1	0	0	Treat.IX

LSD 0.05 =7.76*

LSD 0.01 =11.48**

Table 6. Number of branches

Treatment	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Interval of Variation (min-max)
I	9	1.10	12.45	7-10
II	8	1.52	18.05	7-10
III	10	0.89	8.73	10-12
IV	12	1.87	15.59	10-14
V	11	1.64	14.67	10-13
VI	13	1.82	14.53	10-15
VII	13	0.45	3.49	12-13
VIII	13	0.45	3.49	12-13
IX	14	0.89	6.75	12-16

Treatments II and IV showed significant statistical difference at a level of 0.05 compared with Treatment III. The number of branches in plants from Treatments I, VI, VII and VIII showed significant statistical difference at a level of 0.05 compared with the number of branches from plants of the Treatment V. Treatment IV showed significant statistical difference at a level of 0.05 compared with Treatment IX. Treatments IV, VI, VII, VIII and IX showed significant statistical difference at a level of 0.01 compared with Treatment I. Treatments IV, V, VI, VII, VIII and IX showed significant statistical difference at a level of 0.01 compared with Treatment II. Treatments VI, VII, VIII and IX showed significant statistical difference at a level of 0.01 compared with Treatment III. Between Treatments V and IX there was statistically significant difference at a level of 0.01 (Table 7).

The highest average value for the number of inflorescences was obtained in the plants from Treatment IX (13 inflorescences). Treatments I and V showed the same average value for the number of inflorescences (9 inflorescences), Treatments IV and VI (11 inflorescences) and Treatments VII and VIII (12 inflorescences). The lowest average value for the number of inflorescences (7 inflorescences) was obtained in Treatment II. Plants from Treatment IV had the most heterogeneous number of inflorescences (CV 26.34%) (Table 8).

Table 7. Number of branches – Comparison between treatments

Treatment	Comparison with Treat. I	Comparison with Treat. II	Comparison with Treat.III	Comparison with Treat.IV	Comparison with Treat.V	Comparison with Treat.VI	Comparison with Treat.VII	Comparison with Treat.VIII	Comparison with Treat.IX
I	Treat.I	1	-1	-3	-2	-4	-4	-4	-5
II	-1	Treat.II	-2	-4	-3	-5	-5	-5	-6
III	1	2	Treat.III	-2	-1	-3	-3	-3	-4
IV	3	4	2	Treat. IV	1	-1	-1	-1	-2
V	2	3	1	-1	Treat.V	-2	-2	-2	-3
VI	4	5	3	1	2	Treat.VI	0	0	-1
VII	4	5	3	1	2	0	Treat.VII	0	-1
VIII	4	5	3	1	2	0	0	Treat.VIII	-1
IX	5	6	4	2	3	1	1	1	Treat.IX

LSD 0.05 = 1.52*

LSD 0.01 = 2.25**

Table 8. Number of inflorescences

Treatment	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Interval of Variation (min-max)
I	9	1.10	12.45	7-10
II	7	0.55	7.40	7-8
III	10	1.82	18.92	7-12
IV	11	2.95	26.34	7-14
V	9	1.14	12.13	8-11
VI	11	2.28	21.11	7-13
VII	12	0.55	4.42	12-13
VIII	12	0.89	7.21	11-13
IX	13	1.64	12.84	10-14

The number of inflorescences from Treatments II, IV, VI, VII, VIII and IX showed significant statistical difference at a level of 0.01 compared with the number of inflorescences from the Treatment I. Treatments III, IV, V, VI, VII, VIII and IX showed significant statistical difference at a level of 0.01 compared with Treatment II. Treatments VII, VIII and IX showed significant statistical difference at a level of 0.01 compared with Treatment III. Treatments V and IX showed significant statistical difference at a level of 0.01 compared with Treatment IV. Treatments VI, VII, VIII and IX showed significant statistical difference at a level of 0.01 compared with Treatment V. Between Treatments VI and IX there was statistically significant difference at a level of 0.01 (Table 9). According to Vujošević et al. (2007), application of natural bio-stimulant (33% essence of wetland weeds of *Laminaria sp.* in the ratio 2 ml/l of water) and slow-release fertilizer (NPK in the proportion 15:9:9 + MgO + Me, in the ratio 1.2 g/l of substrate) in the course of further production of saplings of *Begonia semperflorens* does not have statistically significant influence upon the average values of the stalk weight, average number of blossoms and average number of sprouts.

Table 9. Number of inflorescences– Comparison between treatments

Treatment	Comparison with Treat. I	Comparison with Treat. II	Comparison with Treat.III	Comparison with Treat.IV	Comparison with Treat.V	Comparison with Treat.VI	Comparison with Treat.VII	Comparison with Treat.VIII	Comparison with Treat.IX
I	Treat.I	2	-1	-2	0	-2	-3	-3	-4
II	-2	Treat.II	-3	-4	-2	-4	-5	-5	-6
III	1	3	Treat.III	-1	1	-1	-2	-2	-3
IV	2	4	1	Treat. IV	2	0	-1	-1	-2
V	0	2	-1	-2	Treat.V	-2	-3	-3	-4
VI	2	4	1	0	2	Treat.VI	-1	-1	-2
VII	3	5	2	1	3	1	Treat.VII	0	-1
VIII	3	5	2	1	3	1	0	Treat.VIII	-1
IX	4	6	3	2	4	2	1	1	Treat.IX

LSD 0.05 = 1.07*
LSD 0.01 = 1.59**

CONCLUSIONS

Based on the analyzes of the statistical data acquired by measuring the morphological characteristics of *Begonia semperflorens* Link. et Otto., the liquid mineral fertilizer Agrosal with NPK 12-5-7 + microelements and concentration of 0.4% is more appropriate compared to the other analyzed fertilizers. Treatment with liquid mineral fertilizer Agrosal with NPK 12-5-7 + microelements and a concentration of 0.4% showed the highest average number of branches and the average number of inflorescences. Treatment with Agrosal with NPK 12-5-7 + microelements and concentration of 0.3% showed the highest average height of the plant and Treatment with Agrosal with NPK 7-1-5 + microelements and concentration of 0.2% showed the highest average number of leaves. For better quality of *Begonia semperflorens* Link. et Otto., the liquid mineral fertilizer Agrosal with NPK 12-5-7 + microelements and a concentration of 0.4% can be recommended.

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