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EFFECT OF NATURAL BIO-STIMULANT AND SLOW-RELEASE FERTILIZERS IN COMMERCIAL PRODUCTION OF BEGONIA SAPLING (*Begonia semperflorens*)

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Abstract: The present research in the study of the effect of application of natural bio-stimulants and slow-release fertilisers on commercial production of begonia (*Begonia semperflorens*) saplings. Two types of containers were deployed in the production process, whereas the results of the experimental research showed that the application of both slow-release fertilizers and natural bio-stimulants in further production is only justifiable in cases when largevolume containers are deployed in commercial production of sapling. The application of those significantly influences the increase in stalk weight, number of sprouts and number of blossoms. The application of natural bio-stimulants may be justifiable with the saplings that have previously been produced in smaller containers, since they have auspicious effect upon development of the root, i.e. upon its length.

Key words: begonia, sapling, container, bio-stimulant, slow-release fertilizer.

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Introduction

Begonia semperflorens – begonia, belongs to the group of annual flower plants. In our climate conditions begonia comes into flower during the period from the beginning of May till the late autumn, which ranges it into the group of our most wanted seasonal flowers. This flower species is characterized by a rather long period of vegetation, and therefore its production usually commences during the winter season. The glasshouses or plastic hothouses of glasshouse type are required for successful cultivation of this breed of flowers. Majority of our flower growers perform the process of flower sapling production in superseeded or improvised facilities deploying the outdated technologies, hence as a result many problems occur during the production process, and the products of inadequate quality appear in the market.

Previous practices in production of flower saplings indicate insufficient awareness of the intensive production systems and of the advantages they offer. The contemporary sapling production, besides deployment of diverse container production systems (Marković et al., 1992) is also based upon the application of various bio-stimulants and slow-release fertilizers (Hanić, 2000., Beatović et al., 2006).

The aim of this research study is to gain insight into the effects of application of natural bio-stimulants and slow-release fertilizers on state-of-art commercial production of begonia saplings.

Materials and Methods

The experiment was prepared and conducted at the Belgrade Faculty of Agriculture greenhouse. The annual flowers species *Begonia semperflorens – President* were the subject of the experiment. The experiment was conducted in two phases.

In the first phase, sowing of the seeds was performed, i.e. production of begonia saplings, in two containers: type I, containing 144 cells or 870 plants/m^2, and type II, containing 230 cells or 1640 plants/m^2, planted into the ready-made commercial substrate for seeding. As soon as the plants formed two pairs of permanent leaves, transplantation of the saplings into the 9cm flowerpots containing the convenient substrate (*Floragard*) was performed, and the experiment entered its second phase in which the impact of natural bio-stimulants and slow-release fertilizers was conducted through the following treatments:

1. convenient substrate – control group
2. convenient substrate + natural 'bio-stimulant' (33% essence of wetland weeds of *Laminaria sp.* family) in the ratio 2 ml/l of water
3. convenient substrate + slow-release fertilizer NPK (in the proportion 15:9:9 + MgO + Me) in the ratio 1.2 g/l of substrate.

The natural bio-stimulant was used once a week when watering the plants, dosed in 2 ml/l of water till the emergence of first sprouts. The slow-release fertilizer was added to the substrate prior to filling the flowerpots. Production of the sapling was conducted with implementation of the state-of-art cultivating technologies and with day-to-day control, and monitoring of all relevant parameters meant to provide successful cultivation (day and night temperature levels, relative air humidity, humidity of the substrate).

Concurrently with emergence of first flower sprouts the analysis of all parameters relevant to the quality of begonia sapling was performed, such as: stalk weight (g), root length (cm), root weight (g), number of blossoms and number of flower sprouts.

The analysis of the data obtained through the experiment and evaluation of their significance was performed by variance analysis and LSD test upon the relevant data, these being converted beforehand since the provisons of parametric testing had not been attained with the original values, and the nonparametric testing was not developed for the purpose of bi-factorial experimental plans. The homogeneousness of the data within the samples and the homogeneousness of the variances for the property *stalk weight* was attained by *logX* transformation, and $\sqrt{x+1}$ transformation for the property *number of blossoms*. The homogeneousness of the variances and decrease of the variable quotient was attained by $\frac{1}{\sqrt{x+1}}$ transformation for the property *number of sprouts*. Heterogeneousness of the variances for the root property was not decreased, but homogeneousness of the *root length* values was obtained by *logX* transformation and homogeneousness of the data for the *root weight* was increased by *log(X+1)* transformation.

Results and Arguments

As for the examined property *root length*, the lowest variability was established in the control variant of the saplings produced in both container types (Table 1.) In the variant with the slow-release fertilizer the lowest variability was distinguished by the property *stalk weight*.

In the case of bio-stimulants application the most homogeneous property was the *stalk weight* of the plants previously produced in the type I container, and the *root length* with the plants previously produced in the type II containers (Table 1.). As for the plants produced in the second type of containers prior to transplantation, the property with highest variability in all examined variants was the *number of sprouts*. The property with highest variability with the plants produced in the larger containers (type I) prior to transplantation was the *number of blossoms* in the control variant, *root weight* and *number of sprouts* in the variant with bio-stimulant, and the *number of sprouts* in the variant with the slow-release fertilizer. The analysed parameter *number of sprouts* demonstrated the highest variability quotient.

T a b. 1. - Basic indicators of descriptive statistics for the examined begonia sapling quality parameters

Container type	Treatments	Sapling Quality Indicators	Arithmetic Mean	Standard Error	Minimum	Maximum	Standard Deviation	Variability Quotient for the Transformation Data
I.	Control	Stalk weight (g)	18.13	1.76	6.97	41.50	8.63	15.72
		Root length (cm)	9.70	0.49	5.60	14.20	2.41	11.48
		Root weight (g)	2.78	0.23	0.87	4.62	1.11	24.62
		Number of blossoms	1.38	0.28	0.00	4.00	1.38	29.48
		Number of sprouts	2.79	0.43	1.00	9.00	2.11	22.01
	Bio-stimulant	Stalk weight (g)	23.52	5.35	6.62	102.00	22.04	18.11
		Root length (cm)	8.22	0.92	1.80	15.60	3.81	28.80
		Root weight (g)	3.21	0.56	0.22	8.95	2.33	45.83
		Number of blossoms	1.65	0.36	0.00	5.00	1.50	30.47
		Number of sprouts	6.00	0.92	0.00	11.00	3.79	43.69
	Fertilizer	Stalk weight (g)	24.48	1.47	9.42	38.16	7.21	10.50
		Root length (cm)	9.27	0.65	4.00	16.90	3.19	15.81
		Root weight (g)	3.43	0.27	1.61	5.81	1.32	21.04
		Number of blossoms	2.21	0.34	0.00	5.00	1.67	28.60
		Number of sprouts	7.00	0.80	0.00	14.00	3.90	47.77
II.	Control	Stalk weight (g)	13.37	0.99	4.75	25.27	5.54	17.93
		Root length (cm)	8.18	0.38	4.50	13.50	2.11	12.60
		Root weight (g)	2.27	0.20	0.60	4.58	1.11	30.28
		Number of blossoms	0.43	0.18	0.00	4.00	1.01	29.13
		Number of sprouts	5.53	0.50	0.00	14.00	2.71	32.34
	Bio-stimulant	Stalk weight (g)	16.12	1.07	4.54	25.04	5.87	16.22
		Root length (cm)	9.62	0.53	3.50	14.0	2.91	15.58
		Root weight (g)	2.08	0.16	0.34	3.35	0.86	29.46
		Number of blossoms	0.67	0.18	0.00	3.00	0.96	27.22
		Number of sprouts	7.37	0.78	0.00	16.0	4.26	45.30
	Fertilizer	Stalk weight (g)	13.03	0.87	4.69	21.10	4.62	16.06
		Root length (cm)	4.11	0.23	2.20	6.40	1.22	22.58
		Root weight (g)	0.75	0.07	0.23	1.58	0.36	37.28
		Number of blossoms	0.57	0.17	0.00	4.00	0.92	25.94
		Number of sprouts	7.29	0.88	0.00	15.00	4.68	48.60

Homogeneousness of the variances of the samples analysed was examined by the following tests: *Hartley*, *Cochran*, *Bartlett* and *Levenes*. The results of these tests indicate that it may be assumed that the variances are homogeneous with the properties stalk weight, *number of sprouts* and *number of blossoms*, and that they are not homogeneous with the properties *root length* and *root weight* (Table 2.).

T a b. 2. - Results of homogeneousness tests

Sapling Quality Indicators	Tests					
	Hartley F-max	Cochran C	Bartlett χ^2	P	Levenes F	Levenes P
Stalk weight	2.39	0.23	4.09	0.54	1.25	0.29
Root length	4.90	0.41	18.95	0.00	3.18	0.00
Root weight	8.48	0.43	25.60	0.00	4.40	0.00
Number of blossoms	2.45	0.24	9.23	0.10	2.90	0.01
Number of sprouts	2.85	0.22	10.49	0.06	1.47	0.20

According to Cross (1996), the selection of the appropriate container is a crucial factor for successful production of flower saplings in general and therefore of begonia saplings as well. The results obtained by multivariate variance analysis (MANOVA) given in the Table 3. below indicate that the properties *stalk weight*, *root weight*, *root length* and *number of blossoms* depend of the selected volume of the container to be used for the production with a very high level of statistical significance, while the property *number of blossoms* does not.

T a b. 3. - Results of bi-factorial experiment variance analysis (MANOVA)

Sources of Variables	Sapling Quality Indicators									
	Stalk weight		Root length		Root weight		Number of blossoms		Number of sprouts	
	F	P	F	P	F	P	F	P	F	P
container	26.01**	0.00	18.83**	0.00	55.39**	0.00	34.92**	0.00	3.72	0.06
treatment	2.16	0.11	18.55**	0.00	5.86**	0.00	2.01	0.13	2.518	0.08
interaction	4.77**	0.00	27.52**	0.00	18.64**	0.00	0.95	0.38	2.11	0.12

$p<0.05$ - statistically significant differences
$p<0.01$ - statistically very significant differences

From the data given in the Table 3., it may also be noticed that application of natural bio-stimulants and slow-release fertilizers in the course of further production of sapling does not have statistically significant influence upon the average values of the *stalk weight*, average *number of blossoms* and average *number of sprouts*, while it does have statistically very significant influence over the average *root length* and average *root weight*.

Interaction of the container – treatment factors (Table 3.) has statistically very significant influence on the *stalk weight*, average *root length* and average *root weight*.

The number of levels of analysed factors taken into account, the individual LSD test was applied upon the treatments and the interaction of container – treatment factors (Table 4.).

T a b. 4. - Results of significance levels of the LSD test of begonia sapling quality indicators for the treatments factor

Treatments	Sapling Quality Indicators														
	Stalk weight			Root length			Root weight			Number of blossoms			Number of sprouts		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	-	0.195	0.041*	-	0.38	0.00**	-	0.723	0.00**	-	0.26	0.04*	-	0.06	0.04*
2	-	-	0.486	-	-	0.00**	-	-	0.00**	-	-	0.40	-	-	0.91
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The application of the natural bio-stimulants does not have statistically significant influence on the increase of average values of the monitored properties as against the values of the control sample.

The average *root length* decreases at statistically very significant rate with the application of slow-release fertilizers, and the average *root weight* increases as against the values of the control sample and the variant with natural bio-stimulants applied.

The average *number of blossoms* and average *number of sprouts* obtained through the application of slow-release fertilizers (Table 4.) is higher with statistically higher significance than the average number of blossoms obtained in the control sample.

By examining the interaction significance level by LSD test (Table 5.) the conclusion was reached for the analysed parameter *stalk weight.*

The application of slow-release fertilizers is only justifiable in the case of larger containers (type I) used beforehand in the production of the begonia saplings, since the average *stalk weight* (24.48 g) increases with very high statistical significance as against the control sample (18.13 g) and with some statistical significance as against the application of bio-stimulants (23.52 g), whose data are concurrent with the data obtained by the researches of Marschner (1995) and Belger (1989).

The application of natural bio-stimulants influences increase of average *stalk weight* of the plants, notwithstanding the type of the container selected for the production of sapling, but this increase is not statistically significant (Table 5.). In the case of bio-stimulants applied on plants previously produced in the smaller containers (type II), similar average *stalk weight* is obtained as with the plants produced in the larger container of the control variant.

T a b. 5. - Results of significance levels of the LSD test for the interaction of container – treatments factors for the *stalk weight*

Container type	Treatments	Container type					
		I			II		
		Treatments			Treatments		
		control	bio-stimulant	fertilizer	control	bio-stimulant	fertilizer
I	control		0.85	0.00**	0.01*	0.387	0.01*
	bio-stimulant			0.01*	0.01*	0.032*	0.01*
	fertilizer				0.00**	0.00**	0.00**
II	control					0.07	0.956
	bio-stimulant						0.07
	fertilizer						

The application of slow-release fertilizers on begonia saplings previously produced in the small containers (type II) has statistically very significant influence on decrease of both average *root length* and average *root weight* as well (Table 6. and 7.), while upon the begonia saplings previously produced in the large containers (type I) it has no influence at all.

T a b. 6. - Results of LSD test for the interaction of container – treatments factors for *root length*

Container type	Treatments	Container type					
		I			II		
		Treatments			Treatments		
		control	bio-stimulant	fertilizer	control	bio-stimulant	fertilizer
I	control		0.01*	0.48	0.07	0.75	0.00**
	bio-stimulant			0.08	0.38	0.02*	0.00**
	fertilizer				0.28	0.66	0.00**
II	control					0.11	0.00**
	bio-stimulant						0.00**
	fertilizer						

T a b. 7. - Results of LSD test for the interaction of container – treatments factors for *root weight*

Container type	Treatments	Container type					
		I			II		
		Treatments			Treatments		
		control	bio-stimulant	fertilizer	control	bio-stimulant	fertilizer
I	control		0.99	0.11	0.09	0.03*	0.00**
	bio-stimulant			0.14	0.13	0.049*	0.00**
	fertilizer				0.00**	0.00**	0.00**
II	control					0.58	0.00**
	bio-stimulant						0.00**
	fertilizer						

Furthermore, the application of natural bio-stimulants on the begonia saplings previously produced in the small containers (type II) does not cause statistically significant increase of average *root length* and average *root weight* as against the control sample values. By their application approximately the same root length is obtained as in the control variant of plants in whose production large containers (type I) have been used.

The average *number of blossoms* and average *number of sprouts* formed with the begonia saplings previously produced in the small containers (type II) does not change statistically significant by, despile the application of bio-stimulants or slow-release fertilizers (Table 8. and 9.). The average *number of blossoms* is increased with high level of statistical significance if the sapling is produced beforehand in the large containers (type I), whose data are concurrent with the data reported by the researches of B e l g e r (1989).

T a b. 8. - Results of LSD test for the interaction of container – treatments factors for *number of blossoms*

Container type	Treatments	Container type					
		I			II		
		Treatments			Treatments		
		control	bio-stimulant	fertilizer	control	bio-stimulant	fertilizer
I	control		0.52	0.03*	0.00**	0.03*	0.01*
	bio-stimulant			0.19	0.00**	0.00**	0.00**
	fertilizer				0.00**	0.00**	0.00**
II	control					0.34	0.53
	bio-stimulant						0.75
	fertilizer						

The *number of sprouts* formed is increased with very high level of statistical significance due to the application of slow-release fertilizers on the sapling of begonia previously produced in the large containers (Table 9.).

T a b. 9. - Results of LSD test for the interaction of container – treatments factors for *number of sprouts*

Container type	Treatments	Container type					
		I			II		
		Treatments			Treatments		
		control	bio-stimulant	fertilizer	control	bio-stimulant	fertilizer
I	control		0.05	0.00**	0.00**	0.00**	0.00**
	bio-stimulant			0.58	0.67	0.40	0.68
	fertilizer				0.87	0.76	0.86
II	control					0.62	0.98
	bio-stimulant						0.62
	fertilizer						

Conclusion

On the basis of the research results obtained, the following conclusions may be established:

- adequate selection of containers used in the production of the begonia sapling represents the core condition of successful production of high quality sapling. Advantage should be given to larger containers for seeding, i.e. production of sapling;
- the effect of application of slow-release fertilizers and natural bio-stimulants in the course of further production of begonia sapling is directly dependent on the volume of containers used beforehand in the production of the sapling;
- the use of larger containers in the production of the sapling produces positive effects of the application of slow-release fertilizers on the examined parameters of the sapling quality, these parameters being *stalk weight*, *number of sprouts* and *number of blossoms*;
- by the application of natural bio-stimulants positive effect is attained only on the *root length* of the saplings produced beforehand in the small containers, so the average root length of these may reach the average root length of the plants produced in the large containers.

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UTICAJ PRIRODNIH BIOSTIMULATORA I SPORORAZLAGAJUĆIH DJUBRIVA U KOMERCIJALNOJ PROIZVODNJI RASADA BEGONIJA (*Begonia semperflorens*)

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Rezime

U radu je ispitivan uticaj primene prirodnih biostimulatora i spororazlagajućih djubriva u komercijalnoj proizvodnji rasada begonija (*Begonia semperflorens*).Za proizvodnju rasada korišćeno je dva tipa kontejnera a dobijeni rezultati eksperimentalnih istraživanja pokazali su da je primena i spororazlagajućih đubriva i prirodnih biostimulatora u toku dalje proizvodnje , opravdana samo u slučaju kada se za proizvodnju rasada koriste veći kontejnerima. Njihovom primenom utiče se značajno na povećanje nadzemne mase, broja pupoljaka i broja cvetova. Primena prirodnih biostimulatora može biti opravdana i kod proizvodnje rasada u manjim kontejnerima jer povoljno utiče na razvoj korena tj. njegovu dužinu.

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Projekat TR-6900B: Primena spororazlagajućih djubriva i prirodnih biostimulatora u komercijalnoj proizvodnji rasada cveća, lekovitog, aromatičnog i začinskog bilja.. Sredstva za realizaciju Projekta obezbedilo Ministarstvo nauke i životne sredine Republike Srbije