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THE APPLICATION OF PHOSPHATE GLASS IN THE PRODUCTION OF PEPPER (*Capsicum annuum L.)*

ABSTRACT

This paper presents the results of the application of phosphate glass with the addition of Fe, Mn, Zn and Cu in the production of *Capsicum annuum L*. pepper plants. This experiment was conducted in the greenhouse of the Faculty of Agriculture at the University of Belgrade and in the village of Slankamen during 2011. The pepper plants were grown in polystyrene containers and polypropylene pots. During the production of the plant seedlings the following glass treatment doses were used: 0, 1, 2, 3, 4 and 5 g/l. After transplanting in an open field (in Slankamen) the effect of the phosphate glass doses on the following properties of pepper plant development were examined: height, leaf number, weight of leaves, number of lateral branches, plant weight, weight and length of roots, number of fruits and weight and length of fruits.

The results of this research indicate that the use of phosphate glass in the production of pepper results in good plant development. The best effect of all of the examined parameters of pepper development was found in the phosphate glass dose of 3 g/l of substrate. The obtained results indicate a need for further research on the effect of phosphate glass in the production of different vegetable crops.

Keywords: phosphate glass, doses, plants, pepper

INTRODUCTION

The trend in modern agricultural production, as pointed out by Nikolić et al. (2011a, b) has been in the introduction of adequate eco-materials in order to achieve not only higher yields, but environmental protection as well.

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Research that has been conducted so far shows that glasses, due to their amorphous structures, have properties that make them promising candidates for materials that are capable of taking part in the biological processes of living organisms. Their chemical activity with regard to the processes occurring when in contact with various solutions is very helpful in the design and production of new materials that are effective in the development and growth of living organisms and environmental protection.

On the basis of these attributes, according to Tošić et al. (2002), new materials are currently being developed using glass for many varied purposes, including the nutrition of plants and animals, medicine and electronics. As pointed out by the abovementioned authors, the main advantage of glass is its flexibility to changes in chemical composition, which enables the introduction of new components, as well as a change in contents while designing the kinetics and mechanisms of the solution process. It is also very important to note that the pace of the separation of the components from these materials can be made equal to the pace of their consumption by plants and microorganisms, thus eliminating in entirety excess accumulation, or absence. These same authors state that the very solution of glass is a process that takes place in several phases, depending on its composition, the pH value of the solution, temperature and duration of the effect. This makes it possible to influence the total period of glass dissolution by either favouring or suppressing some of these phases. Furthermore, soil microflora and the root systems of the plants also influence the glasses' dissolution, when self-regulation of the solution process takes place. During the vegetation period of a plant, the components that disperse from the bioglass are intensively consumed, while the level around the glass particles themselves declines, which is why the movement force of the solution rises and the dissolution process intensifies. In a converse manner, upon completion of the vegetation period, the consumption of the separated components is reduced and their concentration around the glass particles rises, therefore the movement force of the solution decreases. This is why the process of glass dissolution in the soil slows down.

All of these factors point to the complex effects that many varied factors have on the significant variations in the solution of a glass of a specific composition. Because of this it is not necessary to add additional materials into the soil every year, thereby reducing the cultivation costs, soil contamination levels, etc. Furthermore, the wide range of changes in the possible composition of glass provides the opportunity for optimising the composition from the viewpoint of crop plants, soil properties and climatic conditions.

Taking into account the significance of vegetables in the human diet, the production volume that (as pointed out by Zečević et al. (2000)) is stable in Serbia when it comes to the area, the average yield and variety structure, and in order to follow the new trends in the production of safe food in terms of human health, the objective of this research was to consider the application of phosphate glass with additions (Fe, Mn, Zn, Cu) in the production of one of the most significant vegetable crops in our country – the pepper.

MATERIALS AND METHODS

The domestic pepper variety known locally as “župska rana” was used in this research. The pepper seedlings were produced in the greenhouse of the Faculty of Agriculture at the University of Belgrade. The seedling production was done in accordance with the *speedling system*, in polypropylene TEKU containers (size 144/4.5) in early February of 2011. For sowing, the commercial sowing substrate *Floragard B-fine* was used. Upon the appearance of the first two pairs of permanent leaves (4-5 weeks after sowing) the plants were planted into polypropylene TEKU round pots (pot system) (size 10.5 cm). The commercial substrate, *Floragard Medium Coarse*, was used for the transplanting and further cultivation of the seedling plants, with addition of glass of the following chemical composition: P_2O_5-68.14%, K_2O-21.92%, CaO-1.609%, MgO-1.409%, SiO_2-2.87%, ZnO-0.838%, CuO-0.899%, Fe_2O_3-1.707% and MnO-0.682%. The granulation was 0.5–1 mm and consisted of the following treatments (variations):

1. control: 0 g/l of substrate
2. 1 g/l of substrate
3. 2 g/l of substrate
4. 3 g/l of substrate
5. 4 g/l of substrate
6. 5 g/l of substrate

The initial seedlings chosen for transplantation into the pots were selected randomly, and the manual transplantation method was used. The plants were grown in their pots until the moment of sowing in the open field in Slankamen. The plants were transplanted on May 13, 2011. The transplantation was done according to the treatments of the glass doses applied during the period of production of the seedlings. Fifteen plants were transplanted for each of the different treatments (variants).

Following transplantation, during the vegetative period, only soil tillage and irrigation were used (of all standard agro-technical measures). During the fruit-bearing phase, the development of the pepper plants was tested against the following parameters: height (cm), number of leaves, weight of leaves (g), number of lateral branches, plant weight (g), root weight (g), root length (cm), number of fruits, length of fruit (cm) and fruit weight (g).

The data obtained were analysed using the statistical package, STATISTIKA 6. The results of this research were presented through the main indicators of descriptive statistics (variation interval, arithmetic mean and its standard error, median and coefficient of variation). For the homogenous samples ($c_v \leq 30\%$) the arithmetic mean was used as an average, and for the heterogeneous samples ($c_v \geq 30\%$) the median was used.

From the statistical standpoint, the hypothesis tested was that for each property of the plants analysed, the average values do not differ as a result of the application of different doses of phosphate glass. Testing the homogeneity of the variances in the treatment was done using the Levene's test. Depending on the results of the values of the coefficients of variation and the Levene's test, the hypothesis was tested using a parametric (ANOVA) or non-parametric (Kruskal-Wallis) variance analysis model. The individual comparisons of the two means were done on the basis of the results of the t-test or the Mann-Whitney U test.

RESULTS AND DISCUSSION

The application of phosphate glass had a statistically significant influence on the average pepper plant height (Tab. 1). The highest average pepper plant height (53.840 cm) was achieved with the application of the glass dose of 2 g/l. The average pepper plant heights achieved by the application of phosphate glass were lower than the average height (65-75 cm) which, as Zečević et al. (2000 and 2010) pointed out, characterizes this variety. The pepper plants had homogeneous heights in all samples but one ($c_v \leq 30\%$), so the median was taken as a more valid indicator of the average for that particular sample.

The number of leaves formed per plant ranged from a minimum of 96 to a maximum of 210. The highest average number of leaves (Tab. 1) was achieved by the application of the glass dose of 3 g/l (179.4). The application of phosphate glass had a statistically significant effect on the average number of leaves formed. The variances in the samples for this tested indicator of pepper plant development were homogeneous in all but one sample ($c_v \leq 30\%$), so the median was taken as a more valid indicator of the average for this particular sample.

The average weight of the leaves (Tab. 1) varied from 49 g in the control variant to 94.003 g in variant 4 (3 g/l) in which the highest number of leaves per plant was determined, and which was statistically significantly higher. The results of the average pepper plant leaves mass achieved (that Olutolaj and Makine (1994) noted) amounted to 60.84 g which only confirms the positive effect of the application of glass to this property of plant development tested. As the variances of samples for the mass of the leaves were heterogeneous in two samples ($c_v \geq 30\%$), the median was taken as a more valid indicator of the average.

The application of the phosphate glass had a statistically highly significant effect on the average number of lateral branches formed (Tab. 1). The highest average number of lateral branches (22.8) was formed by the pepper plants in the variant in which the glass dose applied was 3 g/l of substrate. The application of glass doses above 3 g/l resulted in a reduction of the average number of lateral branches on the pepper plants. The lowest number of lateral branches (7.0) was recorded in the control variant (no glass applied) and the highest (27.0) in variant 4 (3 g/l substrate). The results of the average number of lateral branches that Olutolaj and Makine (1994) described in their research was 10.2, which confirms, once again, the effect and justification for using phosphate glass in pepper production. The sample variances for this pepper plant development parameter were homogeneous in all of the samples ($c_v \leq 30\%$).

The application of phosphate glass had a statistically highly significant influence on the average pepper plant weight. Since the highest average number of lateral branches was achieved with the application of the glass dose of 3 g/l it is understandable that the highest average plant weight of 107.300 g was achieved for this same variant (Tab. 1). The median was used as a more valid indicator of the average, since the variance values for this indicator tested were heterogeneous in most of the samples (except one) ($c_v \geq 30\%$).

When it comes to the number of fruits formed per plant (Tab. 1) a major variation is noted, ranging from 0 (none) to 22. The average number of fruits formed varied from 3 in the variant where 2 g of glass/l of substrate was applied, to 7.4 in the variant with the maximum glass dose applied (5 g/l), and it was not statistically significant. In most of the samples the values for the number of fruits were heterogeneous ($c_v \geq 30\%$), so for these samples the median was taken as a more valid indicator of the average.

Although the average number of fruits formed per pepper plant was not statistically different when comparing treatments, the application of the glass had a statistically significant effect on the average length of the fruits, and a statistically highly significant effect on the average weight. The highest average length of the fruit was achieved in the variant without any glass applied (15.02 cm), and 13.145 cm was seen in variant 2 (1 g/l) and 12.510 cm in variant 4 (3 g/l) (Tab. 1). The highest average weight of the fruits (53.360 g and 51.100 g) was achieved in variants 2 and 1, respectively, and then in variant 4 (40.920 g). As before, for the quality indicator tested in which the values were heterogeneous, the median was taken as a more valid indicator of the average.

The application of phosphate glass had an effect on the average length and weight of the plant roots, but that effect was not statistically significant. The average pepper root length per plant (Tab. 1) ranged from 26.140 cm in the variant where the maximum glass dose (5 g/l) was applied, to 28.920 cm in the control variant (no glass). A small variation in the average pepper plant root length may be interpreted not only by the effects of the phosphate glass applied, but also by the favourable physicochemical properties of the soil itself (carbonated chernozem on loessial soil) on which the pepper was grown, which enabled good root development. The root length values were homogeneous in all samples ($c_v \leq 30\%$).

The average pepper plant root weight shows that the glass applied had a positive effect on the development of the root system. The highest average root weight per pepper plant (34.496 g) was achieved in variant 4 in which the applied glass dose amounted to 3 g/l of substrate. Furthermore, the average pepper root weight per plant achieved by the use of the maximum test dose of 5 g/l (29.963 g) was not statistically significantly different from the average root weight achieved with the application of the glass dose of 2 g/l (29.870 g). This result suggests that the application of higher doses of glass is not economically justified. For two samples in which the values for the root weight were heterogeneous ($c_v \geq 30\%$) the median was taken as a more valid indicator of the average.

Table 1. The basic statistical indicators for the examined parameters of *Capsicum annuum L.* pepper (župska rana) quality by using various treatment doses of phosphate glass.

Parameters tested	Dosage g/l	Interval of variation	$\bar{x}$ EMBED Equation.3 $\mp S_{\bar{x}}$ Arithmetic mean $\mp$ Standard error	M_e Median	C_v (%) Coefficient of variation
Plant height (cm)	0	40.700 - 50.100	44.280 ∓ 1.654	43.900	8.350
	1	5.800 - 51.100	40.460 ∓ 8.695	49.200	48.055
	2	50.100 - 59.200	53.840 ∓ 1.649	53.700	6.850
	3	47.200 - 55.500	51.140 ∓ 1.138	51.600	4.977
	4	45.200 - 35.400	50.540 ∓ 2.031	51.200	8.984
	5	51.00 - 58.100	53.680 ∓ 1.224	53.000	5.097
Number of leaves	0	96.00 - 130.00	115.400 ∓ 5.887	113.000	11.408
	1	89.00 - 197.00	133.300 ∓ 20.209	119.000	33.976
	2	113.00 - 193.00	159.200 ∓ 15.055	165.000	21.145
	3	136.00 - 210.00	179.400 ∓ 13.633	189.000	16.992
	4	121.00 - 161.00	139.400 ∓ 7.111	137.000	11.406
	5	129.00 - 184.00	158.600 ∓ 9.626	163.000	13.572
Weight of leaves (g)	0	38.853 - 66.414	49.000 ∓ 4.799	45.740	21.901
	1	43.467 - 98.759	63.908 ∓ 9.717	55.315	33.998
	2	55.710-118.821	76.374 ∓ 11.264	68.949	32.977
	3	71.518-115.126	94.003 ∓ 7.665	93.383	18.233
	4	64.132 - 97.047	76.794 ∓ 6.088	74.253	17.727
	5	73.507 - 94.387	81.116 ∓ 3.429	87.299	8.903
Number of lateral branches	0	7.000 - 13.000	9.200 ∓ 1.114	9.000	27.065
	1	8.000 - 17.000	12.400 ∓ 1.631	12.000	29.411
	2	14.000 - 18.000	15.200 ∓ 0.800	14.000	11.769
	3	17.000 -	22.800 ∓ 1.855	25.000	18.190

		27.000			
	4	14.000 - 17.000	15.200 ∓ 0.583	15.000	8.578
	5	12.000 - 16.000	15.200 ∓ 0.800	16.000	11.769
Plant weight (g)	0	22.16 - 54.18	39.777 ∓ 5.498	41.650	30.909
	1	33.32 - 97.69	52.107 ∓ 11.613	42.812	49.837
	2	53.82 - 118.73	81.301 ∓ 12.055	87.611	33.154
	3	58.66 - 162.80	105.811 ∓ 17.626	107.300	37.252
	4	40.88 - 103.27	69.173 ∓ 10.773	68.031	34.825
	5	6.97 - 10. 95	83.148 ∓ 5.957	81.802	16.021
Root weight (g)	0	15.56 - 32.18	21.448 ∓ 3.004	18.661	31.314
	1	18.40 - 30.83	23.167 ∓ 2.297	20.514	22.170
	2	24.51 - 45.10	29.870 ∓ 3.854	27.082	28.849
	3	1.23 - 40.34	27.467 ∓ 6.931	34.496	56.425
	4	20.46 - 31.87	27.145 ∓ 2.068	27.854	17.034
	5	24.19 - 35.58	29.963 ∓ 2.062	29.107	15.391
Root length (cm)	0	17.2 - 23.4	28.920 ∓ 1.006	29.700	7.776
	1	12.800 - 0.300	27.620 ∓ 1.788	26.300	14.476
	2	21.200 - 29.900	26.700 ∓ 1.531	27.200	12.819
	3	26.050 - 30.100	28.170 ∓ 0.834	29.000	6.622
	4	23.300 - 26.200	24.860 ∓ 0.533	24.600	4.798
	5	23.200 - 29.800	26.140 ∓ 1.309	25.300	11.198
Number of fruits	0	1.000 - 7.000	4.800 ∓ 1.020	5.000	47.507
	1	4.000 - 7.000	5.600 ∓ 0.510	6.000	20.360
	2	0.000 - 22.000	7.800 ∓ 3.992	3.000	114.455
	3	4.000 - 11.000	6.800 ∓ 1.356	5.000	44.605
	4	4.000 - 9.000	5.400 ∓ 0.980	4.000	40.572
	5	6.000 - 9.000	7.400 ∓ 0.600	8.000	18.130
Fruit length	0	11.600-	15.020 ∓ 1.409	13.800	20.972

(cm)		18.700			
	1	9.470-15.760	13.145 $\mp$ 1.444	15.370	24.562
	2	0.000-14.500	7.512 $\mp$ 2.589	5.600	77.067
	3	3.120-9.600	7.734 $\mp$ 1.170	8.530	33.840
	4	4.400-13.970	10.994 $\mp$ 1.728	12.510	35.140
	5	3.500-12.500	9.220 $\mp$ 1.660	11.300	40.250
Fruit weight (g)	0	42.685-104.489	63.615 $\mp$ 11.419	51.100	40.139
	1	19.530-71.680	50.028 $\mp$ 9.960	53.360	44.517
	2	0.000-75.560	21.868 $\mp$ 13.762	9.450	140.722
	3	2.940-26.080	19.418 $\mp$ 4.227	23.800	48.676
	4	6.900-56.390	35.428 $\mp$ 8.295	40.920	52.352
	5	4.510-25.000	15.136 $\mp$ 3.710	16.870	54.810

The results of the Levene’s test (Tab. 2) show that the variance of the samples of the weight of the leaves, the plant weight, the root weight, the root length, the fruit length and the fruit weight are homogeneous. For the height, the number of leaves, the number of lateral branches and the number of fruits, the variances of the samples are heterogeneous. Even after transformation, the values for the properties tested (the height, the number of leaves, the number of lateral branches and the number of fruits) remained heterogeneous, as well as the variances of the samples, therefore the significance of the differences of the average values was tested by the non-parametric Kruskal-Wallis test. The results of these tests show that the application of different doses of phosphate glass results in plant groups that are statistically significantly different by height, number of leaves and fruit length, and statistically highly significantly different when it comes to leaf weight, plant weight, the number of lateral branches formed and the fruit weight (Tab. 2). The phosphate glass application had no statistically significant effect on the number of fruits formed, the root weight or the fruit length.

The comparison of the average values of the two treatments for all of the tested parameters of pepper plant development was done on the basis of the Mann-Whitney U test (Tab. 3). The results of this test show that the application of phosphate glass into substrates has a statistically significant effect (increase) on the average pepper plant height. The application of the glass dose of 2 g/l has the most favourable effect on the average pepper plant height, which is also statistically significantly higher than the average height achieved in the control variant (no glass) and with the application of the lowest dose (1 g/l). The application of glass at 5 g/l of substrate is also statistically highly significant and statistically significantly increases the average pepper plant height when compared to the average heights achieved in the control variant and the variant with the lowest dose applied (variant 2) (Tab. 3). Since the application of this glass dose achieves an average plant height that is not statistically significantly different from the average plant height with the application of glass at 2 g/l of substrate, its application (5 g/l) is not economically justified.

The number of leaves per plant and their weight increases with phosphate glass use (Tab. 3). When it comes to the number of leaves, this increase is statistically significantly higher with the glass doses of 2 g/l, 4 g/l and 5 g/l of substrate, and statistically highly significantly higher with the application of the glass dose of 3 g/l of substrate. When it comes to the weight of the leaves, the application of phosphate glass at 2 g/l and 4 g/l has a statistically significant effect, and the application doses of 3 g/l and 5 g/l have a statistically highly significant effect on the increase in the average leaf weight. As there are no statistically significant differences between the doses of 3 g/l and 5 g/l when it comes to the average number and weight of the leaves, the application of the doses of phosphate glass higher than 3 g/l is not justified.

Table 2. The results of the Levene's variance homogeneity test and the analysis of variance for the application of phosphate glass on the *Capsicum annuum* pepper “župska rana”.

Tested parameters	Levene’s test		ANOVA		Kruskal-Wallis test	
	F	p	F	P	H	p
Plant height (cm)	4.193	0.007	2.012	0.113	15.064	0.010
Number of leaves	3.225	0.023	3.105	0.027	11.799	0.038
Leaves weight (g)	1.240	0.321	4.387	0.006	14.621	0.012
Number of lat. branches	2.948	0.033	13.575	0.000	19.348	0.002
Plant weight (g)	1.262	0.312	4.342	0.006	15.059	0.010
Root weight (g)	1.616	1.194	0.859	0.523	7.225	0.204
Root length (cm)	1.895	0.133	1.404	0.258	7.257	0.202
Number of fruits	6.429	0.001	0.427	0.825	3.798	0.579
Fruit length (cm)	1.275	0.307	3.075	0.028*	12.262	0.031
Fruit weight (g)	1.623	0.192	4.277	0.006	13.603	0.018

$p<0.05$ (*) the difference is significant
$p<0.01$(**) the difference is highly significant

The average number of lateral branches formed on the pepper plant is statistically highly significantly increasing with the application of the phosphate glass in the doses of 2 g/l, 3 g/l and 4 g/l, and statistically significantly increasing (5 g/l) when compared to the variant in which the glass is not applied (variant 1). The application dose of 3 g/l is not only statistically highly significant in increasing the average number of branches when compared to the control variant (no glass), but is also statistically highly significant in increasing the average number of branches when compared to the application of the two lower doses (1 g/l and 2 g/l). The application of the higher doses of phosphate glass (4 g/l and 5 g/l) is statistically significantly (4 g/l) and statistically highly significantly (5 g/l) different in reducing the average number of lateral branches when compared to the dose of 3 g/l of substrate.

Table 3. The levels of significance between the averages of the *Capsicum annuum L.* pepper plant "župska rana" on the basis of the Mann-Whitney U test.

Parameters tested	Treatments	2. 1 g/l	3. 2 g/l	4. 3 g/ l	5. 4 g/ l	6. 5g/l
Plant height (cm)	1. 0 g/l	0.347	0.012*	0.016*	0.028*	0.009**
	2. 1 g/l		0.028*	0.076	0.295	0.016*
	3. 2 g/l			0.347	0.465	0.917
	4. 3 g/ l				0.917	0.175
	5. 4 g/l					0.402
Number of leaves	1. 0 g/l	0.753	0.045*	0.009**	0.047*	0.016*
	2. 1 g/l		0.347	0.094	0.530	0.251
	3. 2 g/l			0.347	0.251	0.754
	4. 3 g/ l				0.059	0.251
	5. 4 g/l					0.142
Leaves weight (g)	1. 0 g/l	0.117	0.028*	0.009**	0.028*	0.009**
	2. 1 g/l		0.251	0.047*	0.251	0.117
	3. 2 g/l			0.175	0.602	0.175
	4. 3 g/ l				0.117	0.602
	5. 4 g/l					0.251
Number of lateral branches	1. 0 g/l	0.141	0.008**	0.009**	0.009**	0.013*
	2. 1 g/l		0.245	0.012*	0.246	0.195
	3. 2 g/l			0.015*	0.823	0.735
	4. 3 g/ l				0.011*	0.007**
	5. 4 g/l					0.737
Plant weight (g)	1. 0 g/l	0.602	0.016*	0.009**	0.076	0.009**
	2. 1 g/l		0.076	0.028*	0.175	0.076
	3. 2 g/l			0.347	0.347	0.917
	4. 3 g/ l				0.076	0.347
	5. 4g/l					0.175
Fruit length (cm)	1. 0 g/l	0.463	0.076	0.009**	0.175	0.016*
	2. 1 g/l		0.075	0.016*	0.346	0.172
	3. 2 g/l			0.917	0.465	0.753
	4. 3 g/ l				0.076	0.346
	5. 4 g/l					0.249
Fruit weight (g)	1. 0 g/l	0.465	0.076	0.009**	0.076	0.009**
	2. 1 g/l		0.117	0.076	0.347	0.028*
	3. 2 g/l			0.347	0.251	0.754
	4. 3 g/ l				0.076	0.402
	5. 4 g/l					0.076

The phosphate glass dose of 3 g/l also has the highest effect on the average pepper plant weight. The average plant weight obtained with the application of this dose is statistically highly significantly higher when compared to the values obtained in the control variant (no glass) and statistically significantly higher than the average weights obtained by the use of the lowest dose (1 g/l). The doses of glass applied above 3 g/l reduce the average pepper plant weight.

When it comes to the average length and average weight of the fruits, the highest values are obtained either without the application of glass or with the application of the lowest dose tested (1 g/l). The application of glass at 3 g/l (statistically highly significant) and 5 g/l (statistically significant) influences the reduction.

The glass application dose of 3 g/l has a statistically highly significant effect on the reductions of both the average weight and the average length of the fruits when compared to the average weights and lengths of fruit obtained in the variant where glass is not applied, and is statistically significantly reduced with the application of the lowest dose tested (1 g/l). The application of the dose of 5 g/l statistically significantly reduces the average length of the fruits and statistically highly significantly reduces the average fruit weight. With this dose, the average fruit weight achieved is also statistically significantly lower than the average weight of the fruits obtained by the application of the lowest glass dose (1 g/l). The results obtained may be explained by the fact that the higher dose of glass applied influences the vegetation yield, which has the effect of forming of a smaller number of fruits, and hence their smaller average length and average weight.

CONCLUSIONS

Based on the tested effects of the different doses of phosphate glass applied in the production of the pepper (*Capsicum annuum L.*) variety "župska rana", the following conclusions may be drawn:

- Extraordinary effect of the phosphate glass on all of the parameters of pepper plant development that were tested was confirmed.
- The application of phosphate glass in pepper production results in plants that are more well developed than plants produced without the application of the phosphate glass.
- The dose of phosphate glass at 3 g/l shows the most optimal production of pepper. The dose applied has had a highly significant effect on the increase in the average number of branches, the average plant weight, the average weight of the leaves and the number of leaves per plant. Furthermore, the glass dose of 3 g/l had a positive effect on the plant root weight.

The results obtained point to the need for further research on the effects of phosphate glass including a larger number of vegetable crops with the goal of determining not only the optimal application doses and achieving the maximum yields, but also in order to obtain food that is safe in terms of human health and environmental protection.

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MOGUĆNOST PRIMENE FOSFATNOG STAKLA U PROIZVODNJI PAPRIKE (*Capsicum annuum L.*)

SAŽETAK

U radu su prikazani rezultati istraživanja moguće primene fosfatnog stakla sa dodatkom Fe, Mn, Zn i Cu u proizvodnji paprike *Capsicum annuum L.* Istraživanja su sprovedena u stakleniku Poljoprivrednog fakulteta u Beogradu i u selu Slankamen tokom 2011. godine. Paprika je gajena iz rasada. Biljke-rasada proizvedene su po *speedling* i *pot systemu.* U toku proizvodnje rasada dodavano je ispitivano staklo u dozama: 0, 1, 2, 3, 4 i 5 g/l. Nakon rasađivanja na otvoreno polje (Slankamen), ispitivan je uticaj primenjenih doza fosfatnog stakla na sledeće osobine razvijenosti biljaka paprike: visinu, broj listova, masu listova, broj bočnih grana, masu stabla, masu i dužinu korena broj, dužinu i masu plodova.

Rezultati istraživanja ukazuju da se primenom fosfatnog stakla u proizvodnji paprike dobijaju biljke dobre razvijenosti. Najbolji efekat na ispitivane parametre razvijenosti biljaka paprike imala je doza fosfatnog stakla od 3g/l supstrata. Dobijeni rezultati takođe ukazuju i na potrebu daljeg istraživanja, kroz uključivanje većeg broja vrsta.

Ključne riječi: fosfatno staklo, doza, biljke, paprika