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EFFECTS OF PRE-SOWING SEED TREATMENTS FOR IMPROVING GERMINATION AND THE GROWTH OF PEPPER AND TOMATO SEEDLINGS

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ABSTRACT

The aim of this study was to establish the effect of different seed treatments on germination, and the growth of the embryonic stem and the radicle of tomato and pepper varieties. Four treatments were used in the study: MIX [(Coveron + zinc (Zn 0.5%) + boron (B 0.025%)]; Coveron; zinc ($ZnSO_4$, Zn 0.5%) and boron (B 0.025%). The treatments were applied on seeds of following four pepper varieties: Šorokšari, Somborka, Kraljica, and Mirtima and three tomato varieties: Rio Grande, Saint Pierre, and Tomato apple of Novi Sad (Novosadski jabučar). Germination and the growth increase of both the embryonic stem (cm) and the radicle (cm) were observed in the germination cabinets and pots containing soil in two laboratories – locations. After the treatment applied to the pepper seeds and testing in the laboratory germination cabinet the following was established: i) the maximum increase in germination of 90% was when the MIX and Zn treatment was applied to seeds, ii) the growth increase of embryonic stems of 2.7 cm was recorded when the MIX treatment was applied, iii) the growth increase of radicles of 1.7 cm was gained when the Coveron and MIX treatment was applied. Tests performed in pots showed that Coveron was the most efficient treatment. Treatments on tomato seeds during the seed testing in the germination cabinet provided: vi) the germination increase of 13% with the MIX treatment, vii) the growth increase of the embryonic stem of 2.6 cm with the same treatment, vii) the growth increase of 1.7 cm of radicles. Coveron was the most efficient treatment in tests in pots.

Key words: coveron, seed quality, micronutrients, growth of embryonic stem and radicle

INTRODUCTION

In Serbia, pepper is grown on approximately 20 000 ha with the average yield of about 13 t/ha. The same area is cultivated with tomato and the average yield amounts to about 20 t/ha [Statistical Yearbook of Serbia 2018]. There is no official information on organic production of these species. However, it would be of high importance if these two vegetable species were organically grown on significantly greater areas [Özer 2018, Poštić et al. 2019]. The effect of such production on human health would be undoubtedly beneficial [Nicolopoulou-Stamati et al. 2016].

In order to reduce the use of conventional chemicals in the world, studies on the application of biostimuli and biological control of undesirable patho-

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gens have been performed [Harman 2000, Benítez et al. 2004].

According to Harman [2006], *Trichoderma* acts as a biocontrol agent from germination over the seedling initial growth. In such a way, it reduces the use of synthetic chemicals. *Trichoerma* strains exert biocontrol against other fungal pathogens, modify the environments, and induce plant defensive mechanisms or mechanisms such as mycoparasistism. All these mechanisms may act coordinately on the plant growth, activity of hydrolytic enzymes, antibiotics and increase the yield by approximately 30% [Benítez et al. 2004]. Based on the study carried out by Chen et al. [2017], *Glomus* sp. increased the embryonic stem and radicle biomass, contents of glycyrrhizic acid, liquiritin, isoliquiritin, and isoliquiritigenin in the main root, and improved the availability of Mg, Cu, Zn, and Mn.

Microelements, Zn and B are very important, whereby boron affects metabolic processes such as metabolism of nucleic acid, carbohydrates, proteins, indole-acetic acid, synthesis of cell walls, integrity and function of the membrane, and metabolism of phenols [Rehman et al. 2015, 2017, Havier et al. 2016]. It is functionally associated with one or more processes of calcium utilisation, cell division, water relations, and it is a catalyst for certain reactions [Tanaka and Fujiwara 2008].

Zinc is involved in physiological processes during the early seedling development, probably in the protein synthesis, membrane formation, cell elongation, resistance to abiotic stresses, as well as resistance to invasion of pathogens [Farooq et al. 2012, Mondal and Bose 2019].

Therefore, the goal of this study was to observe the effect of the following treatments applied to pepper and tomato seeds: i) MIX containing Coveron + boron + zinc; ii) Coveronom containing *Trichoderma atroviride* and *Glomus mosseae*, *G. intraradices*; iii) boron, iv) zinc, on germination and the early seedling growth in the germination cabinet and pots containing soil and to find out the optimal seed treatment for conventional and/or organic production of pepper and tomato. The results of the study could lead to the improvement of the organic production of both vegetables, pepper and tomato.

MATERIAL AND METHODS

Seeds of four pepper (*Capsicum annuum* L. ssp. *annuum*) varieties: Šorokšari, Somborka, Kraljica, Mirtima (factor A) and three tomato (*Lycopersicon esculentum* Mill.) varieties: Rio Grande, Saint Pierre, Novosadski jabučar (factor A) [the variety properties can be found on https://www.hoya-vs.com (HOYA SEEDS)] were treated woith the following (factor B): i) MIX – mixture of chemicals Coveron + zinc (0.5% Zn) + boron (0.025% B) – T1; ii) Coveron – commercial chemical containing *Trichoderma atroviride*, *Glomus mosseae*, *Glomus intraradices*) – T2; iii) zinc ($ZnSO_4$, 0.5% Zn) – T3; iv) boron (0.025% B) – T4. The obtained results were compared with the control variant T0 (no chemicals were used).

The analyses were preformed in the germination cabinets and pots containing soil in two laboratories-locations (factor C) in Belgrade: i) Topčider, Institute for Plant Protection and Environment and ii) Batajnica, National Reference Laboratory.

Following the seed treatments, the tests were performed on 4 × 00 seeds in the germination cabinet (temperature 20/30°C, 8 h in the light of 1520 lux and 16 h in the dark) and in pots containing soil in four replications. The agro-chemical properties of used soil were as follows: pH 7.2% (neutral reaction), humus 5.48% (well supplied), P_2O_5 29.06% (highly supplied), K_2O 22.65% (well supplied), N 0.24% (well supplied). The soil fertility was for growing both pepper and tomato. The soil fertility of was well suited for growing of both pepper and tomato. The soil properties were evaluated in the beginning of May, which is the sowing time of these species in the continental regions of the South-eastern Europe. Seed germination in the germination cabinet was read on the 14th day according to the ISTA Rules [2019], while seed germination in pots was determined on the 10th day. Seedlings (embryonic stem-ES and radicle-R) were measured during reading according to methods described in Stanisavljević et al. [2011]. The tetrazolium test was performed on non-germinated seeds to establish whether seeds were viable or non-viable [ISTA 2019].

The experimental design and statistical analysis: the three-factorial trial was set with the following factors: varieties, pre-sowing seed treatments, laboratory-location – according to 3 × 4 × 1 and 2 × 4 × 1

design for pepper and tomato, respectively. The effects of factors were evaluated by the analysis of variance (ANOVA; F test); the Tukey's Multiple Range Test ($p \leq 0.05$) and the coefficient of variation (CV%) were used to determine effects of means. Standard error of the mean (±SEM) was applied to estimate deviations from the mean. The arcsine transformation, $\sqrt{x}/100$, was applied to values expressed in percentages (germination). The coefficients of correlation (r) were calculated for the interrelationships between observed traits. Obtained values were statistically processed using the program *Minitab Inc.*, version 16.1.0, State College, Pennsylvania, USA, (free version).

RESULTS AND DISCUSSION

In order to maximise profits through maximising yields and minimising production costs during the chemisation of agriculture, various chemicals are often used starting from the application in seeds and seedlings over the production to the storage of finished products. This has undeniably contributed to achieving high yields and production efficiency, but also had adverse effects on the health of consumers of these products – people [Nicolopoulou-Stamati et al. 2016]. Considering all this, the agricultural science and practice try to establish biological control in all production segments [Jemiołkowska et al 2016, Majkowska et al. 2016], starting from reduction or avoidance of chemicals used in seeds and seedlings, especially of species that are consumed fresh, such as peppers and tomatoes [Özer 2018, Poštić et al. 2019].

The application of the F-test *showed that the laboratory-location did not significantly affect any of the traits of either observed species (Tab. 1). This was expected since germination locations were 10 km apart, while soil was divided into two samples (location I and location II). The same procedure was applied in germination cabinets. On the other hand, the effects of varieties, treatments and the variety × treatment interactions on germination, growth of embryonic stem and radicle were significant in both testing variants – in germination cabinets and pots containing soil for both species, pepper and tomato (Tab. 1).

Pepper seed. Seed testing performed for all varieties in the germination cabinet show that the choice of the optimal treatment (T1 or T4 – 90% G could increase germination by 6% (T0 – 84% G). However,

Table 1. Results of analysis of variance (ANOVA) for germination (G), growth of embryonic stem (ES) and radicle (R). Sources of: varieties (A), seed treatments (B), laboratory-location (C) after pepper and tomato seed testing in germination cabinets and pots containing soil

Species	Factor	df[1]	Tests in germination cabinets			Tests in pots containing soil		
			G (%)	ES (cm)	R (cm)	G (%)	ES (cm)	R (cm)
Pepper	A	3	**	*	*	***	*	***
	B	4	**	*	**	**	*	*
	C	1	ns	ns	ns	ns	ns	ns
	A × B	12	*	*	*	*	*	*
	A × C	3	ns	ns	ns	ns	ns	ns
	B × C	4	ns	ns	ns	ns	ns	ns
Tomato	A	2	***	*	*	***	*	**
	B	4	**	*	**	***	*	***
	C	1	ns	ns	ns	ns	ns	ns
	A × B	8	*	*	*	**	*	*
	A × C	2	ns	ns	ns	ns	ns	ns
	B × C	4	ns	ns	ns	ns	ns	ns

F test, statistical significance levels: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, ns – not significant ($p \geq 0.05$)
[1] df – degree of freedom

the highest increase in germination (9%) was achieved by the application of the treatments T3 (Zn) and T1 (MIX) in the variety Miritima, but these two treatments applied to the variety Šorokšari had the lowest effect – the increase in comparison to control T0 was 1% and 2%, respectively (Tab. 2). On the other hand, the most efficient treatments (T1 and T2) in pots resulted in germination higher by 10% in relation to the treatment T0. The most efficient treatments over varieties were as follows: T2 for Šorokšari (germination higher by 13%); T1 (MIX) for Somborka (germination higher by 8%); T1 and T2 for Kraljica (germination higher by 11%), T4 for Mirtima (germination higher by 11%). Coveron was the most stable treatment in which varieties expressed the lowest (CV = 2.95), i.e. the highest variability (CV = 5.72) for germination in the germination cabinet, i.e. control, respectively. The treatment B and Coveron were the most stable treatments for varieties tested in pots containing soil (CV = 7.80 and CV = 8.47, respectively), and the highest for varieties treated with Zn (CV = 9.72).

The highest increase in the embryonic stem growth of 1.8 cm was achieved in the germination cabinet by the application of treatments T1 and T2. The treatment T2 was the most efficient treatment in pots containing soil (the average increase amounted to 0.9 cm for all varieties). The most efficient treatments in the germination cabinet were T1 in variety Mirtima and T2 in the varieties Šorokšari and Somborka, while these two treatments were equally efficient in the variety Kraljica. In seeds testing in pots containing soil, the treatment T2 was the most efficient for the embryonic stem growth, while effects of treatments T3 and T4 varied over varieties (Tab. 2).

The application of the treatment T2 – Coveron was the most efficient in all varieties regarding the embryonic stem growth in both, the germination cabinets and pots, but it did not statistically significantly ($p \geq 0.05$) affected the radicle growth in relation to the treatment T1 (MIX). Varieties differently responded to treatments T3 and T4, which is supported by a significant ($p \leq 0.05$) variety × treatment interaction (Tab. 1). Generally, the treatment T3 had the lowest effect on the radicle growth in all varieties – 0.5 cm and 1.1 cm in the germination cabinet and pots, respectively Generally, the treatment T3 had the lower effect on the radicle growth in all varieties – 0.5 cm and 1.1 cm in the germination cabinet and pots, respectively in comparison with the most efficient treatment T2 (Coveron). Moreover, the treatment T3 significantly ($p \leq 0.05$) affected a higher radicle growth in all varieties in the germination cabinet and pots in relation to the control treatment T0 (Tab. 2).

Tomato seed. All treatments had significant ($p \leq 0.05$) effect on the germination increase in all varieties in the variant with the germination cabinet in relation to the control treatment T0. Differences among treatments were not significant in any of the varieties, while the average for all varieties was uniform (T1 G 86%, T2, T3, T4 G each 85%). MIX was the most stable treatment, in which varieties expressed the lowest variability for germination in the germination cabinet (CV = 6.38) and the highest for control (CV = 10.7), while Rio Grande was the most stable variety (CV = 3.38), whose variability depended on a treatment. Germination read in pots was generally and expectedly lower than the one read in the germination cabinet. The treatment T3 in pots was the least efficient, but it was not significantly lower than treatments T1 and T4 in varieties Rio Grande and Saint Pierre. The effect of the treatment T3 on germination of the variety Saint Pierre was higher than effects of the treatment T1, hence the variety × treatment interaction was also higher (Tabs 1 and 3). The lowest (CV = 3.89), i.e. highest (CV = 8.65) variability in germination in the pot variant was determined in control T0, i.e. T4, respectively. Depending on the treatment, the variety Saint Pierre with the lowest variability was the most stable (CV = 5.45), while the variety Rio Grande with the highest variability was the least stable (CV = 11.3).

All treatments applied to tomato seeds resulted in a higher embryonic stem than in control (T0). The average embryonic stem length of all varieties was mostly affected by Coveron (T2) in both variants in the germination cabinet (7.5 cm) and pots (3.7 cm), thus the stem was length by 2 cm (germination cabinet) and 1.1 cm (pots) than in control. In the variant with the germination cabinet, the difference among treatments T1 to T4 in the variety Novosadski Jabučar was not significant (height in T3 was 6 cm, while it was 6.2 cm in T1 and T2). On the other hand, in all varieties in the variant with pots and two remaining variants with the germination cabinet, the significant ($p \leq 0.05$)

Table 2. Effects of applied pre-sowing treatments on seed germination and seedling growth of pepper

Tested	Treatment	Variety				$\bar{X}$	CV (%)
		Šorokšari	Somborka	Kraljica	Mirtima		
results obtained in germination cabinets							
Germination (%)	control – T0	85 ±0.72 b AB	80 ±0.66 b B	90 ±0.59 b A	80 ±0.46 b B	84	5.72
	MIX – T1	87 ±0.77 ab B	88 ±0.76 a A	95 ±0.66 a A	89 ±0.70 a B	90	4.00
	Coveron – T2	89 ±0.83 a AB	87 ±0.79 a A	93 ±0.71 ab A	88 ±0.63 a B	89	2.95
	Zn – T3	86 ±0.79 ab B	86 ±0.59 ab A	94 ±0.59 ab A	89 ±0.36 a AB	89	4.25
	B – T4	90 ±0.76 a AB	88 ±0.71 a B	95 ±0.62 a A	88 ±0.55 a B	90	3.70
	$\bar{X}$	87	86	93	87	–	–
	CV %	2.37	3.90	2.22	4.42	–	–
Embryonic stem (cm)	control – T0	2.9 ±0.31 b AB	3.6 ±0.52 c A	2.1 ±0.42 c B	3.2 ±0.42 c A	3.0	21.5
	MIX – T1	3.7 ±0.29 a C	5.0 ±0.48 a A	4.5 ±0.36 a B	5.9 ±0.51 a A	4.8	19.3
	Coveron – T2	3.9 ±0.51 a C	5.1 ±0.39 a A	4.5±0.51 a B	5.8 ±0.37 a A	4.8	16.9
	Zn – T3	3.7 ±0.33 aB	4.4 ±0.55 b A	4.1 ±0.44 b B	4.8 ±0.56 b A	4.3	10.9
	B – T4	3.6 ±0.45 abC	4.4 ±0.51 b A	4.0 ±0.38 b B	4.6 ±0.33 b A	4.2	10.7
	$\bar{X}$	3.6	4.5	3.8	4.9	–	–
	CV %	10.8	13.3	26.0	22.5	–	–
Radicle (cm)	control – T0	2.6 ±0.43 c C	2.6 ±0.42 c C	3.2 ±0.32 c B	3.8 ±0.36 b A	3.1	18.8
	MIX – T1	3.5 ±0.41 ab B	3.4 ±0.36 a B	4.9 ±0.36 a A	5.1 ±0.52 a A	4.2	21.3
	Coveron – T2	3.8 ±0.55 a B	3.5 ±0.29 a B	4.9 ±0.51 a A	5.2 ±0.63 a A	4.4	19.0
	Zn – T3	3.4 ±0.48 ab A	3.0 ±0.44 b B	4.3 ±0.48 ab A	4.9 ±0.43 a A	3.9	22.1
	B – T4	3.1 ±0.57 b C	3.1 ±0.19 ab C	4.2 ±0.29 b B	5.0 ±0.29 a A	3.9	24.0
	$\bar{X}$	3.3	3.1	4.3	4.8	–	–
	CV %	13.9	11.4	16.2	11.9	–	–
results obtained in pots							
Germination (%)	control – T0	61±0.49 b B	64 ±0.43 c AB	75 ±0.53 c A	68 ±0.41 c AB	67	9.04
	MIX – T1	72 ±0.41 a C	72 ±0.40 a C	86 ±0.39 a A	78 ±0.49 ab B	77	8.61
	Coveron – T2	74 ±0.26 a AB	71 ±0.56 a B	86 ±0.43 a A	76 ±0.56 b AB	77	8.47
	Zn – T3	65 ±0.51 ab B	68 ±0.33 b B	79 ±0.48 b A	78 ±0.63 ab A	73	9.72
	B – T4	70 ±0.63 a B	69 ±0.39 b B	80 ±0.52 b A	79 ±0.42 a A	75	7.80
	$\bar{X}$	68	69	81	76	–	–
	CV %	7.78	4.53	5.87	5.93	–	–
Embryonic stem (cm)	control – T0	1.3 ±0.49 c A	1.3 ±0.42 c A	1.5 ±0.43 b A	1.3 ±0.48 c A	1.4	7.41
	MIX – T1	1.9 ±0.41 ab B	1.9 ±0.19 b B	2.5 ±0.49 a A	2.2 ±0.42 ab AB	2.1	13.5
	Coveron – T2	2.1 ±0.29 a B	2.2 ±0.26 a B	2.6 ±0.19 a A	2.4 ±0.33 a AB	2.3	9.54
	Zn – T3	1.6 ±0.33 b C	1.9 ±0.44 b B	2.3 ±0.39 a A	1.9 ±0.53 b B	1.9	14.9
	B – T4	1.8 ±0.44 ab B	2.0 ±0.52 ab B	2.4 ±0.51 a A	2.0 ±0.39 ab B	2.1	12.3
	$\bar{X}$	1.7	1.9	2.3	2.0	–	–
	CV %	17.5	18.1	19.4	21.2	–	–
Radicle (cm)	control – T0	3.2 ±0.36 c A	3.0 ±0.43 d AB	2.8 ±0.30 c AB	1.8 ±0.71 c B	2.7	23.0
	MIX – T1	4.6 ±0.53 a B	4.6 ±0.25 ab B	5.1 ±0.39 ab A	3.3 ±0.39 a C	4.4	17.5
	Coveron – T2	4.8 ±0.44 a C	5.2 ±0.39 a B	5.7 ±0.26 a A	3.6 ±0.33 a D	4.8	18.6
	Zn – T3	3.9 ±0.31 b B	3.8 ±0.63 c B	4.3 ±0.63 b A	2.8 ±0.53 b C	3.7	17.2
	B – T4	4.2 ±0.26 ab B	4.2 ±0.45 bc B	4.6 ±0.26 b A	2.5 ±0.23 b C	3.9	24.2
	$\bar{X}$	4.1	4.2	4.5	2.8	–	–
	CV %	15.2	19.9	24.2	25.1	–	–

Different small letters means significant effect ($p \leq 0.05$; Tukey's Multiple Range test) for the column; different capital letters means significant effect ($p \leq 0.05$; Tukey's Multiple Range test) for the row.
Values are mean ±standard error of the mean

Table 3. Results of pre-sowing treatments applied to tomato seeds

Tested	Treatment	Variety			$\overline{X}$	CV (%)
		Rio Grande	Saint Pierre	Novosadski Jabučar		
results obtained in germination cabinets						
Germination (%)	control – T0	82 ±0.52 b A	67 ±0.78 b B	80 ±0.55 b A	76	10.7
	MIX – T1	89 ±0.72 a A	80 ±0.45 a B	90 ±0.78 a A	86	6.38
	Coveron – T2	88 ±0.22 a A	77 ±0.65 a B	89 ±0.19 a A	85	7.86
	Zn – T3	89 ±0.23 a A	77 ±0.32 a A	88 ±0.23 a A	85	7.86
	B – T4	88 ±0.43 a A	78 ±0.22 a B	89 ±0.36 a A	85	7.16
	$\overline{X}$	87	76	87	–	–
	CV %	3.38	6.69	4.69	–	–
Embryonic stem (cm)	control – T0	7.0 ±0.23 c A	5.3 ±0.09 c B	4.2 ±0.33 b C	5.5	25.6
	MIX – T1	8.0 ±0.56 a A	7.9 ±0.21 b A	6.2 ±0.08 a B	7.4	16.7
	Coveron – T2	7.9 ±0.19 a B	8.3 ±0.16 ab A	6.2 ±0.24 a C	7.5	14.9
	Zn – T3	7.6 ±0.38 ab B	8.3 ±0.34 ab A	6.0 ±0.16 a C	7.3	16.2
	B – T4	7.4 ±0.11 b B	8.5 ±0.35 a A	6.1 ±0.11 a C	7.3	16.4
	$\overline{X}$	7.6	7.7	5.7	–	–
	CV %	5.31	17.5	15.1	–	–
Radicle (cm)	control – T0	4.0 ±0.23 c A	3.5 ±0.19 c B	3.4 ±0.39 c B	3.6	8.85
	MIX – T1	5.1 ±0.22 a A	4.1 ±0.26 b B	4.8 ±0.56 ab A	4.7	11.0
	Coveron – T2	5.2 ±0.46 a A	4.5 ±0.25 a B	5.1 ±0.23 a A	4.9	7.67
	Zn – T3	4.6 ±0.45 b A	3.9 ±0.46 b B	4.7 ±0.09 b A	4.4	9.91
	B – T4	4.5 ±0.51 b AB	4.0 ±0.36 b B	4.9 ±0.23 ab A	4.5	10.1
	$\overline{X}$	4.7	4.0	4.6	–	–
	CV %	10.4	9.01	14.8	–	–
results obtained in pots						
Germination (%)	control – T0	69 ±0.45 c B	70 ±0.92 b A	65 ±0.48 c B	68	3.89
	MIX – T1	88 ±0.55 ab A	77 ±0.88 a C	83 ±0.45 a B	83	6.66
	Coveron – T2	93 ±0.42 a A	80 ±0.67 a B	83 ±0.72 a B	85	7.98
	Zn –T3	87 ±0.87 b A	79 ±0.40 a B	78 ±0.87 b B	81	6.07
	B – T4	92 ±0.69 ab A	80 ±0.69 a B	79 ±0.88 ab B	84	8.65
	$\overline{X}$	86	77	78	–	–
	CV %	11.3	5.45	9.54	–	–
Embryonic stem (cm)	control – T0	1.9 ±0.44 c C	3.5 ±0.56 c A	2.3 ±0.56 c B	2.6	32.4
	MIX – T1	2.4 ±0.65 a C	4.6 ±0.77 a A	3.7 ±0.84 ab B	3.6	31.0
	Coveron – T2	2.4 ±0.45 a C	4.8 ±0.92 a A	3.9 ±0.66 a B	3.7	32.8
	Zn – T3	2.2 ±0.86 b C	4.2 ±0.66 b A	2.9 ±0.80 b B	3.1	32.7
	B – T4	2.3 ±0.63 ab C	4.1 ±0.26 b A	3.1 ±0.54 b B	3.2	28.5
	$\overline{X}$	2.2	4.2	3.2	–	–
	CV %	9.26	11.9	20.2	–	–
Radicle (cm)	control – T0	3.6 ±0.78 c A	2.0 ±0.77 c B	2.5 ±0.61 c B	2.7	30.3
	MIX – T1	5.7 ±0.97 ab A	2.6 ±0.78 ab C	4.7 ±0.98 ab B	4.3	36.5
	Coveron – T2	6.3 ±0.45 a A	2.7 ±0.57 a C	4.9 ±0.45 a B	4.6	39.2
	Zn – T3	5.8 ±0.92 a A	2.4 ±0.62 b C	3.8 ±0.66 b B	4.0	42.7
	B – T4	4.8 ±0.63 b A	2.6 ±0.62 ab C	3.5 ±0.63 b B	3.6	30.4
	$\overline{X}$	5.2	2.3	3.9	–	–
	CV %	20.3	11.4	25.0	–	–

Different small letters mean significant effect ($p \leq 0.05$; Tukey's Multiple Range test) for the column; different capital letters mean significant effect ($p \leq 0.05$; Tukey's Multiple Range test) for the row.
Values are mean ±standard error of the mean

difference was determined over treatments (T1 to T4). The choice of the variety-related treatment could additionally affect the increase in the embryonic stem (Tabs 1 and 3).

After germination in the germination cabinet, the treatment with Coveron (T2) had the strongest effect on the tomato radicle growth. This growth was greater by 1.3, 0.5, 0.4 and 0.2 cm in comparison with the treatments T0, T3, T4 and T1, respectively. The same effect was determined after germination in the ports – the seedling radicle growth was greater by 1.9, 1.0, 0.6 and 0.3 than in seedlings in treatments T0, T4, T3 and T1, respectively (the average of all varieties). With the exception of Coveron, the following treatments had the most efficient impact on the radicle growth of varieties germinated in the germination cabinet: T1 for Rio Grande and Saint Pierre and T4 for. Novosadski Jabučar. The most efficient treatment for the radicle growth in the pot variant was T3 for Rio Grande, T1 and T4 for Saint Pierre and T1 for Novosadski Jabučar (Tab. 3). Thus, the selection of treatments T1, T3 and T4 significantly improved the radicle growth in varieties germinated in both the germination cabinet and the pots.

The highest positive correlation (r; $p \leq 0.001$) was determined between germination and the embryonic stem growth of pepper and germination and the radicle growth of tomato obtained in the germination cabinet and pots. Differences determined for the radicle growth in pepper and the embryonic stem growth in tomato were positive but not significant regardless variant (germination cabinet vs. pots) – Table 4.

According to Poštić et el. [2019], the *Trichoderma* + *Glomus* combination increased pepper seed germination in the two-year period by 4–6% (first year) and by 3–4% (second year), but also a single application of *Glomus* can affect the increase of biomass of radicles and embryonic stems [Chen et al. 2017].

Trichoderma and/or *Glomus* have developed multiple mechanisms that lead to the increase in plant resistance to diseases, root growth and development and root morphology [Vinale et al. 2008]. *Trihoderma* provides production of indole 3-acetic acid – IAA in plants and thus facilitates the development and revives of the root system of various plant species. Moreover, *Trihoderma* can reduce the seed infection [Morales and Stall 2004, Gravel et al. 2007]. According to Asaduzzaman et al. [2010] and Mastouri [2010] the application of selected *Trihoderma* strains to pepper and tomato seeds can result in the significant increase in germination and the seedling growth. All these mechanisms of action explain the increase in germination and the growth of the embryonic stem and particularly of the radicle, which supports our results (Tabs 2 and 3). Micronutrients can be applied to the soil, leaves and seeds and the impact of micronutrient seed priming is the best option, because their application is easy, it is the most efficient method of the application with a high effects on germination and seedling growth in the initial stage of development [Farooq et al. 2012, Mondal and Bose 2019].

Zn and B affect the cell division, protein synthesis, cell membranes, which result in the growth increase of the root and the embryonic stem [Tanaka and Fujiwara 2008]. According to Rehman et al. [2012], the seed treatment with Zn together with mycorrhizal fungi improves the efficiency of individual treatments (Zn, mycorrhizal fungi). This was also shown in our

Table 4. Coefficients of simple correlations (r) among observed traits of varieties developed in the germination cabinet and pots: pepper (n = 20) and tomato (n = 15)

Species	Traits		
	G (%)	ES (cm)	R (cm)
Pepper	0.858^{***}	0.662^{***}	0.062^{ns}
Tomato	0.616^{***}	0.291^{ns}	0.810^{***}

*** significant (F tests at the $p \leq 0.001$ level of significance); ns – not significant (F tests at the $p \geq 0.05$ level of significance)

experiments with pepper and tomato seeds tested in the germination cabinet (Tabs 2 and 3). Increased germination and a greater seedling growth rate are the result of the B treatment that accelerated the cell division. This was confirmed in the following species: turnip *(Brassica rapa* L.), sunflower *(Helianthus annuus* L.), soybean, sugar beet *(Beta vulgaris* L.), alfalfa *(Medicago sativa* L.), wheat (*Triticum* sp.), barley (*Hordeum vulgare* L) [Shorrocks 1997].

Impacts of Zn and B on the initial seedling growth is obvious [Farooq et al. 2012, Mondal and Bose 2019]. Thus, the application of ZnO (0.75 g) in chilli affected the increase in germination, radicle length and embryonic stem length by 4%, 0.45 cm and 0.09 cm, respectively [Afrayeem and Chaurasia 2017].

On the other hand, the application of Zn and B to seeds of *Stylosanthes* sp. cv. 'Campo Grande' (*Stylosanthes capitata*/macrocephala) had an adverse effect on germination [Xavier et al 2016]. Furthermore, treatments with microelements did not result in the increase in rice seed germination [Tavares et al. 2013]. Wheat seed priming with zinc can have a positive or a negative effect on the seedling growth, depending on the form of its application ($ZnSO_4$ or $ZnCl_2$) and its concentration [Rehman et al. 2015].

Dill (*Anethum graveolens* L.) seed priming with B in the concentration of 1% increased germination by 6.5%, while the concentration of 2% reduced germination by 5% in comparison with the control, Mirshekari [2012]. According to Geetha et al. [2018] the increase in germination, radicle length and embryonic stem of sunflower seeds ranged from 13.1 to 0.9, 2.84 to 0.07 cm and 0.7 cm to a negative effect (growth lower by 4.3 cm than in control), respectively, depending on the form and the concentration of the B application.

Hence, the effect *trihoderma, glomus,* micronutrients or and their mixture depended on a plant species, and other circumstances, indicating the complexity of the action of microelements on seed germination and the initial growth of seedlings.

CONCLUSION

The treatments applied to pepper and tomato seeds can significantly increase germination and the growth of embryonic stems and radicles. Depending on whether we want organic production with the biological preparation, Coneron (*Trichoderma atroviride*, *Glomus mosseae*, *Glomus intraradices*) or conventional production with the application of microelements (zinc, boron or Coveron + zinc + boron) to seeds prior to sowing, the choice of the variety according to the treatment can additionally improve germination and the initial growth of pepper and tomato seedlings.

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