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The Effect of Using Effective Microorganisms on the Changes in the Chemical Composition of Spring Wheat

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ABSTRACT

The world's noticeable population growth is associated with an increased demand for agricultural products. The search for new solutions to increase crop productivity while ensuring environmental stability is becoming a key role. One such method is the use of the biopreparations containing Effective Microorganisms. EM consist of about 80 species of selected aerobic and anaerobic microorganisms, which have the ability to restore the biological balance. Professor Teruo Higa of Ryukyus University in Okinawa is the creator of Effective Microorganisms. When added to agricultural ecosystems they stimulate plant growth, improve the condition of soils affected by excessive use of chemical fertilizers allowing insoluble forms of elements to be transformed into plant-available forms and protect them from certain diseases and pests. This solution is an ecological alternative to conventional technologies and does not further pollute the ecosystem, which is crucial. Organic fertilizers in the form of EMs are made using live microorganisms they do not only deliver nutrients to the soil but also allow inactive ones to become available. With improved nutrient uptake and protection from soil pathogens, plants develop and grow better for improved yields. They contain organic matter and one or more biologically active organic compounds (amino acids, vitamins) as well as macro- and microelements that stimulate plant growth and development. They provide plants with essential substances, which are naturally synthesized in many complex biochemical processes, causing energy savings that can be used for other transformations in the plant.

Keywords: effective microorganisms, macronutrients, micronutrients, wheat.

INTRODUCTION

In recent years, there has been a noticeable focus on the state of the environment. This occurs due to unconscious disturbances of biological homeostasis by human activities [Pniewska, 2015; Pitzalis, 2020; Szymanek et al., 2020]. According to Janas [2009], it is possible to reduce the amount of chemicals used with the help of a microbial preparation, with Effective Microorganisms, which is increasingly popular in Poland and in the world (Western Europe, Japan, USA, Brazil) [Piotrowska and Boruszko, 2021; Kosicka et al., 2015; Lamparski et al., 2018]. The Effective Microorganisms technology was invented by Professor Teruo Higa from the Ryukyus Agricultural University in Okinawa, Japan [Boruszko, 2019; Prisa, 2020; Tommonaro et al., 2021].

The natural environment is changing due to anthropogenic activities and the development of new technologies. A way to restore balance in the natural environment is to reduce conventional agriculture in favor of organic farming based on the use of natural and organic fertilizers and exclude the use of chemical inputs [Gao, 2020; Auriga, 2021; Shin et al., 2017]. In organic farms, soil microorganisms play an important role which affects the processes of mineralization of organic carbon, humification of organic matter and making nutrients more readily available to plants [Sosnowski et al., 2017; Czopek et al., 2018; Li et al., 2020].

In literature one can find a number of pieces of information about the positive effect of Effective Microorganisms on the volume and quality of crop yield. The use of Effective Microorganisms in crop cultivation improves seed germination, increases the efficiency of thephotosynthetic process, improves the activity of enzymes as well as reduces the occurrence of diseases and pathogens [Domenico, 2019; Joshi et al., 2014; Panisson at al., 2021]. The plants treated with EM will have increased biomass and greater resistance to external factors and attack by pathogens. Talaat [2014] believes that crop biomass yield will increase after the application of Effective Microorganisms [Pniewska, 2015].

Biopreparations with Effective Microorganisms are recommended to improve soil fertility and fertility, increase biological activity of soil, improve the process of germination, rooting, flowering as well as to improve fruit quality [Pszczółkowski, 2017; Prisa, 2021]. The formulations, depending on the needs, can be applied to the soil, as plant sprays or in the form of seed dressings. In environmental protection they can help reduce the use of artificial fertilizers. The Institute of Plant Protection in 2011 conducted the research which showed that the application of EM preparations caused an increase in the fresh and dry mass of herbs and had an influence on the higher content of essential oils [Małuszyńska et al., 2011].

The experiment was conducted because of the wide application of Effective Microorganisms in agriculture. The aim of the study was to determine the effect of dressing and watering seeds with the EM Naturally Active preparation on the higher contents of macro- and microelements in plants.

MATERIALS AND METHODS

The study was carried out in 2021 in the Departmental Chemical Laboratory of the Faculty of Construction and Environmental Sciences of the Bialystok University of Technology. The material for analysis consisted of indicator plants in the form of week-old spring wheat seedlings of the FEELING variety, which were treated with the EM Naturally Active preparation. This preparation consists of lactic acid bacteria (*Lactobacillus casei, Streptococcus lactis*), yeasts (*Candidia utilis, Sacharomyces albus*), photosynthesizing bacteria (*Rhodopseudomonas palustrus, Rhodobacter spae*), mold fungi (*Aspergillus oryzae, Mucor hiemalis*), Azotobacter and Actinomycetes (*Streptomyces griseus, Streptomyces albus*) [Iriti et al., 2019]. Greenland Technologia EM Sp. z o.o. is the exclusive licensee of EMRO Japan for Poland and Central and Eastern Europe and is responsible for the production and sales of products based on the original Japanese EM technology. The EM Naturally Active preparation has been registered as an organic fertilizer by the decision of the Minister of Agriculture and Rural Development No. 281/11 dated March 31, 2011.

In the first study, the plants that grew from grains treated with concentrations of 0.1%, 1%, 5% of EM Naturally Active for 30 min, 1h, and 3h were used for analysis (Fig. 1). In the second study, the plants that were watered according to their needs with six different concentrations (0.5%, 1%, 5%, 15%, 30%, 50%) of EM Naturally Active (Fig. 2) solution throughout the experiment were used for analysis [Faltyn and Miszkieło, 2008].

The content of the studied elements was determined using atomic absorption spectrometry (ASA), which is an analytical technique that allows determination of chemical elements such as: Cu, Zn, Fe, Mn, Na, Ca, Mg and K in samples.

The content of metals in plants was determined after microwave mineralization in nitric acid (V) and perhydrol. Before each series of determinations, at least five calibration solutions were prepared from the standard solution of the element, covering the concentration range to be determined. For each element, a calibration curve was plotted with the concentration readings of the calibration solutions. During the analysis of the samples, the blank solution and the test sample solution were sucked successively into the flame and the absorbance value of a given element was measured. The element concentration corresponding to the absorbance values of the test sample was read from the plotted calibration curve.

Experimental setup:

- Object 1 − week-old seedlings untreated with EM Naturally Active;
- Object 2 − week-old seedlings after seed dressing for 30 minutes with 0.1% EM Naturally Active solution;
- Object 3 − week-old seedlings after seed dressing for 30 minutes with a solution of 1% EM Naturally Active;
- Object 4 − week-old seedlings after seed dressing for 30 minutes with 5% EM Naturally Active solution;

- Object 5 − week-old seedlings after seed dressing for 1h with 0.1% EM Naturally Active solution;
- Object 6 − week-old seedlings after seed dressing for 1h with 1% EM Naturally Active solution;
- Object 7 − week-old seedlings after seed dressing for 1h with 5% EM Naturally Active solution;
- Object 8 − week-old seedlings after seed dressing for 3 hours with 0.1% EM Naturally Active solution;
- Object 9 − week-old seedlings after seed dressing for 3 hours with a solution of 1% EM Naturally Active;
- Object 10 − week-old seedlings after seed dressing for 3 hours with 5% EM Naturally Active solution;
- Object A − week-old seedlings after watering the grain with water;
- Object B − week-old seedlings after watering with 0.5% Naturally Active EM solution;
- Object C − week-old seedlings after watering with 1% Naturally Active EM solution;
- Object D − week-old seedlings after watering with 5% Naturally Active EM solution;
- Object E − week-old seedlings after watering with 15% Naturally Active EM solution;
- Object F − week-old seedlings and seeds that did not germinate after watering with 30% Naturally Active EM solution;
- Object G − week-old seedlings and seeds that did not germinate after watering with 50% Naturally Active EM solution.

RESULTS AND DISSCUSION

Comprehensive seed dressing contributed to, an increase of copper and calcium contents in wheat in all research objects. Compared to the wheat that was not treated with EM Naturally Active before sowing, the highest increase in the concentration of Cu in the seedling occurred in

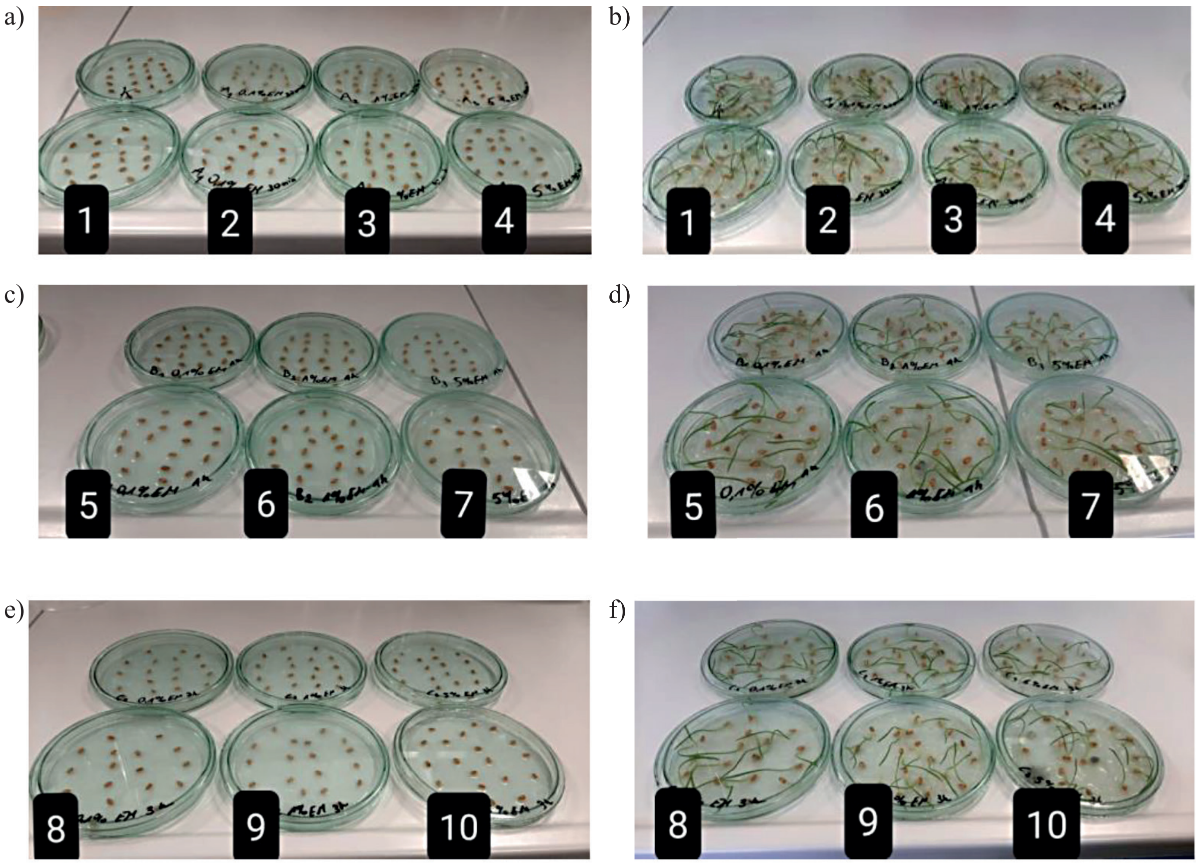

Figure 1. Petri dishes: (a) first day after dressing grain with objects 1, 2, 3, 4, (b) seventh day after dressing grain with objects 1, 2, 3, 4, (c) first day after dressing grain with objects 5, 6, 7, (d) seventh day after dressing grain with objects 5, 6, 7, (e) first day after dressing grain with objects 8, 9, 10, (f) seventh day after dressing grain with objects 8, 9, 10

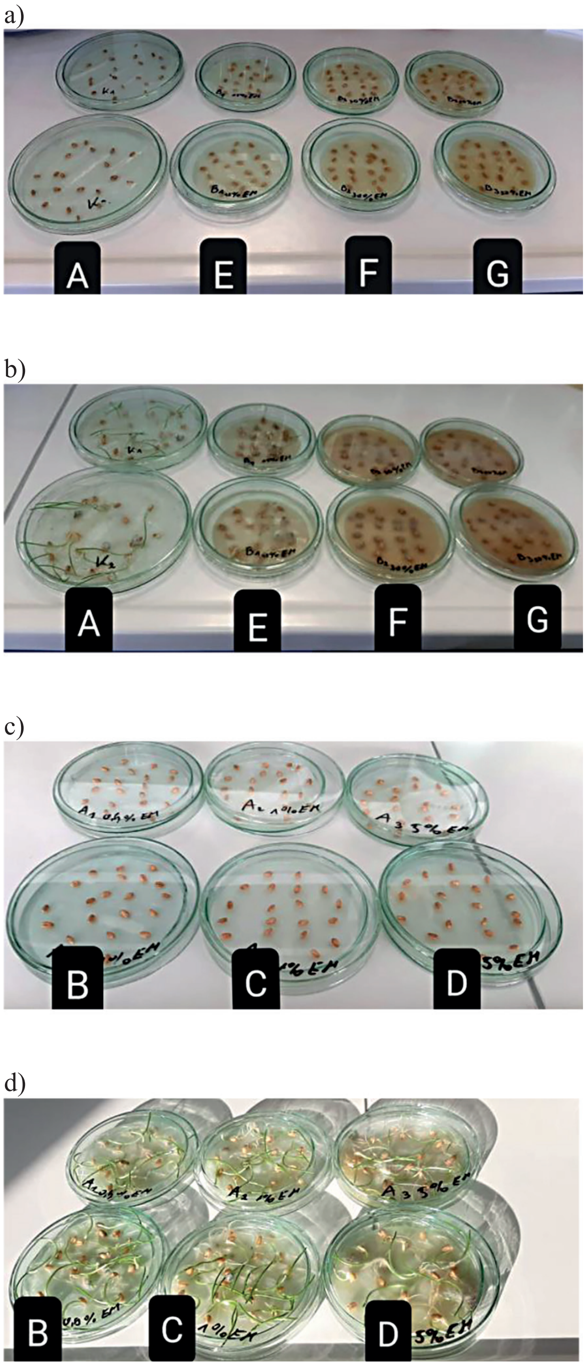

Figure 2. Petri dishes: (a) first day after grain watering with objects A, E, F, G, (b) seventh day after grain watering with objects A, E, F, G, (c) first day after grain watering with subjects B, C, D, (d) seventh day after grain watering with objects B, C,D

object 8, where the grain was treated for 3h with a 0.1% solution of EM Naturally Active and was 71.7% higher than in the control. The lowest increase in the Ca content in the seedlings occurred in the case of object 2 after dressing the grain for 30 min with 0.1% EM Naturally Active solution and was 16.2% greater than the control object. The highest accumulation of Ca was recorded in object 10 after dressing the seeds for 3h with 5% EM Naturally Active solution and it was 65% more than the control object (Table 1).

The average zinc content in research samples treated with EM Natural Active was higher by 9.9% than that in the control sample. Treatment with EM Natural Active did not affect the increase of iron content in the research samples. The content of this element decreased and fluctuated within 15.7-0.3% in relation to the control object.

Increases in the manganese and sodium contents were observed only in the case of object 5 after dressing grain for 1h with 0.1% solution of EM Naturally Active by 4.8% in relation to the control object. Decreases in the manganese and sodium contents were observed in the remaining test samples.

The uptake of Mg, and to a lesser extent of K, increased after the application of the EM Naturally Active preparation for seed dressing. Of all the research objects, object 9 was characterized by the highest percentage of Mg and K uptake. The 85.1% higher content of magnesium and potassium in the 52.1% plant was found to be related to the content of these elements in the control, which was not treated with EM Naturally Active. Decreases in the content of Mg and K were recorded only in the case of the object 10 in which the grain was treated for 3h with 5% solution of EM Naturally Active and it amounted for Mg to 0.5% and for K to 1.6%.

In the cases of five elements (copper, zinc, calcium, magnesium and potassium) out of eight determined, increases in their content were found in the wheat seedlings treated with Effective Microorganisms.

Analysis of Figure 3 shows that with the increase of grain dressing time, the amount of Cu in the plant increases to the greatest extent 4.4–71.5% with respect to the control object. Increasing the efficiency of nutrient uptake and assimilation from microbially enriched organic manure will help to reduce the use of mineral fertilizers and other chemical crop inputs [Das et al., 2014].

Application of EM preparation at 1% concentration for 3h to seed treatment has a beneficial effect on the increase of Zn, Ca, Mg and K in the plant (Fig. 4). Plants optimally supplied with macro- and micronutrients are characterized by proper structure, better health and thus higher yield [Piwowar, 2021].

The results of the study showed that the application of 5% EM solution to seed dressing

Table 1. Changes in metal content in the samples after treatment of grain with EM

Object	Metals							
	Cu	Zn	Fe	Mn	Na	Ca	Mg	K
	[mg/kg]						[mg/g]	
1	2.220	15.223	16.558	13.155	6.578	24.455	1.243	3.197
2	2.318↑	15.785↑	13.955	12.320	6.160	28.423↑	1.281↑	3.229↑
3	2.689↑	13.253	14.400	12.843	6.421	35.163↑	1.393↑	3.361↑
4	2.805↑	21.668↑	15.005	12.153	6.076	38.365↑	1.526↑	3.489↑
5	2.843↑	14.173	14.710	13.783↑	6.891↑	35.343↑	1.301↑	3.364↑
6	3.210↑	13.695	15.908	12.260	6.130	33.273↑	1.531↑	3.501↑
7	3.775↑	15.160	16.508	10.658	5.329	38.408↑	1.431↑	3.779↑
8	3.813↑	21.400↑	15.700	12.708	6.354	33.228↑	1.510↑	3.636↑
9	3.705↑	19.435↑	14.440	12.260	6.130	35.770↑	2.301↑	4.864↑
10	3.635↑	16.060↑	16.113	12.498	6.249	40.335↑	1.237	3.147

Legend: – lowest value; – highest; ↑ – value higher than control.

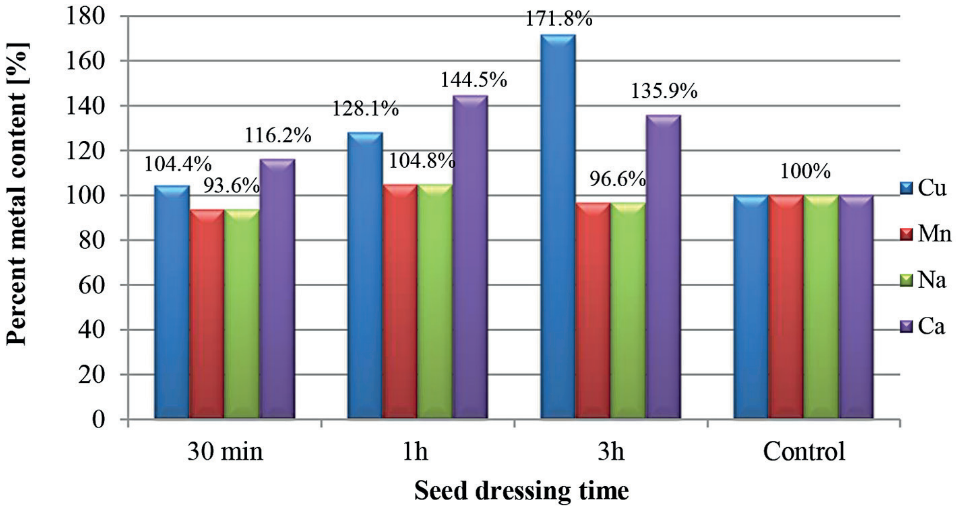

Figure 3. Percentage dependence of increase/decrease in selected micro- and macroelements after treatment with 0.1% EM solution at 30 min, 1h and 3h compared to the control

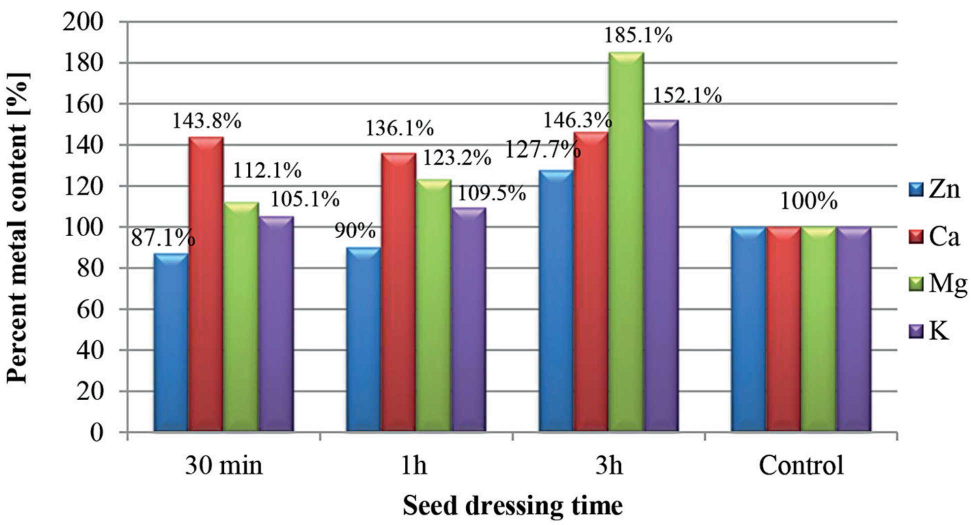

Figure 4. Percentage dependence of increase/decrease in selected micro- and macronutrients after treatment with 1% EM solution at 30 min, 1h and 3h compared to the control sample

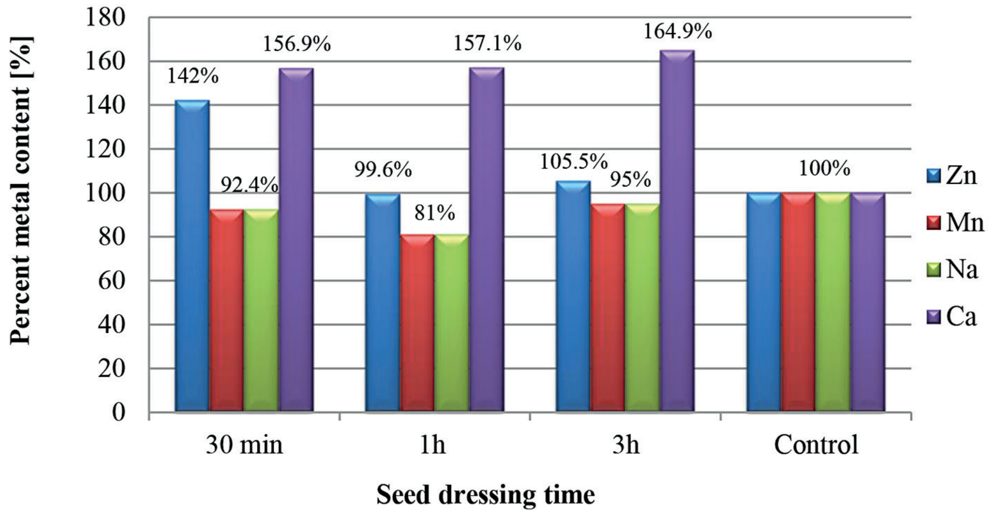

Figure 5. Percentage dependence of increase/decrease in selected micro- and macroelements after treatment with 5% EM solution at 30 min, 1h and 3h, relative to the control sample

contributes to the greatest increase in the calcium content in the objects treated with 5% EM solution at 30 min, 1h, 3h varied on average 156.9–164.9% with respect to the control object. In other elements, the metal content varied in quantity with respect to the control (Fig. 5).

On the basis of the analyses of EM watering, different contents of micro and macronutrients were found between the control and research samples. Higher concentrations of Cu, Mn, Na, Ca, Mg and K were recorded in most of the research samples compared to the control sample. Significantly lower contents of Cu, Zn, Fe, Mn, Na, Mg and K were recorded in site G relative to the control (Table 2).

The lowest contents of five elements (Cu, Zn, Fe, Mn, Na) out of eight were recorded in trial F in which 30% solution of EM Naturally Active was used for watering in relation to control trial.

The highest values of Fe, Mn, Na, Mg, and K were found in trial D in which a 5% solution of EM Naturally Active was used for watering compared to the other trials.

Watering with EM Naturally Active does not increase the content of Zn and Fe. The samples watered with EM Naturally Active solution number B, C and D showed higher contents of six elements with respect to the control.

Using both methods of dressing and watering the grain there will be an increase in the content of Mg, Cu and K in relation to the control trial in which no EM preparation was used. The highest increase of Mg was observed when grain was treated with 1% EM preparation for 1h and the content of this element was 85.1% higher than in the control sample. In comparison, application of the method with watering with 1% EM preparation will result in an increase in the amount of Mg by only 6.8% with respect to the control (Fig. 6).

Treating the seeds with 1% EM for 1 h resulted in 85.1–52.1% higher Mg, Cu and K

Table 2. Changes in metal content after grain watering with EM preparation

Object	Metals							
	Cu	Zn	Fe	Mn	Na	Ca	Mg	K
	[mg/kg]						[mg/g]	
A	3.508	25.613	18.683	11.263	5.631	33.718	1.261	3.158
B	3.995↑	21.713	16.905	13.128↑	6.564↑	41.910↑	1.379↑	3.865↑
C	3.773↑	15.815	16.680	12.723↑	6.361↑	39.753↑	1.347↑	4.394↑
D	3.673↑	14.405	17.468	14.563↑	7.281↑	39.070↑	1.446↑	4.972↑
E	3.548↑	12.810	17.218	11.398↑	5.699↑	32.973	1.337↑	4.466↑
F	2.525	8.555	11.950	8.348	4.174	34.158↑	1.087	2.767
G	3.275	8.763	14.773	9.885	4.943	46.208↑	0.945	2.142

Legend: yellow – lowest value; blue – highest; ↑ – value higher than control.

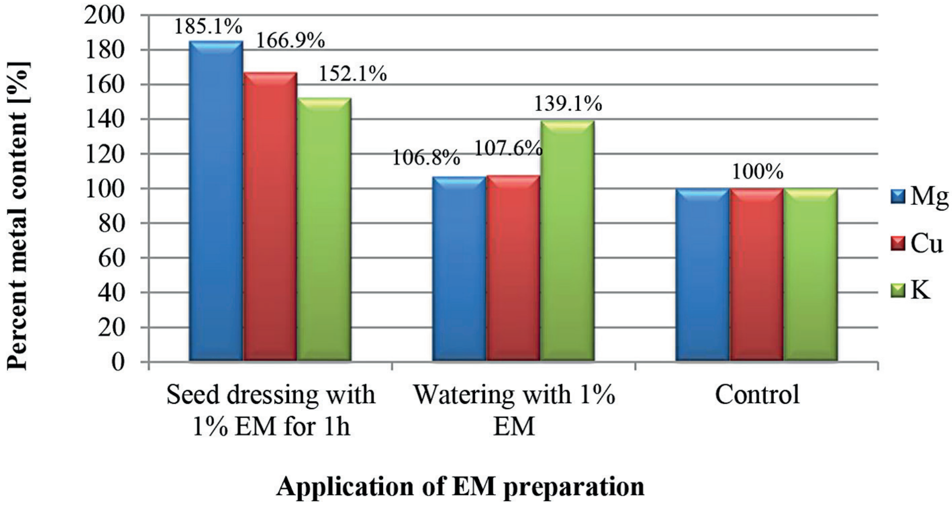

Figure 6. Effect of treating with 1% EM for 3h and watering with 5% EM on the increase of Cu, Mg, Ca content in plants

contents with respect to the control. Slightly less effective, was the watering with 1% EM preparation in which 39.1–6.8% higher contents of Mg, Cu and K were obtained in relation to the control sample.

CONCLUSIONS

Experimental results show that seed dressing with EM Naturally Active containing beneficial microorganisms has a favorable effect on the amount of micro and macro elements in plants. This makes the plant more valuable from the consumer's point of view. The highest levels of micro- and macro-elements were recorded when the seeds were treated with the optimal EM concentration of 1%.

The use of the EM preparation as a seed watering additive had a less effective effect on the increase of micro- and macronutrients in plants as opposed to the dressing method. Irrigation with excessive a concentration of the EM preparation has a growth-limiting effect and thus reduces the accumulation of copper, zinc, iron, manganese, sodium, magnesium and potassium in the plant.

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