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# CAN WOOD ASH AND BIO-FERTILIZER PLAY A ROLE IN ORGANIC AGRICULTURE?

## MOGU LI DRVNI PEPEO I BIOGNOJIVO BITI ZNAČAJNI U EKOLOŠKOJ POLJOPRIVREDI?

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ABSTRACT

It is known that intensive land use in agriculture causes acidification of soils due to harvest or leaching of cations. Wood ash is recommended instead of lime for improving acidic soils. The main objective of this study was to test the potential of wood ash to feed back the cations into the soils without risk of toxicity, and to examine the impact of bio fertilizer Phylazonit MC®.

Corn (*Zea mays L.*) and cucumber (*Cucumis sativus L.*) seeds were grown in nutrient solution under controlled environmental conditions. The elements content was measured with ICP. The release of organic acids was examined by the root-disc-method and the amounts of organic acids were measured with HPLC.

The use of living bacteria (bio-fertilizer Phylazonit MC) accelerates mineralization of organic residues in soil, therefore makes the nutrients more available. At the same time due to effect of living bacteria from bio-fertilizer, the uptake of heavy metals decreases.

An application of Phylazonit was offered under heavy metal contaminated circumstances. According to our experiments bio fertilizers and wood ash can be effective tools in organic agriculture.

Key words: wood ash, bio-fertilizer, soil pH.

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SAŽETAK

Poznato je da zbog iznošenja i ispiranja kationa, intenzivno korištenje tla u poljoprivredi uzrokuje zakiseljavanje. Za popravak tla, uz vapno preporuća se i drvni pepeo. Svrha provedenog ispitivanja bila je testiranje potencijala drvnog pepela za povrat kationa u tlo bez porasta toksičnosti tla, te ispitivanje učinka biofertilizatora Phylazonita MC®.

Kukuruz (*Zea mays L.*) i krastavci (*Cucumis sativus L.*) uzgajani su u hranjivoj otopini u kontroliranim uvjetima. Promjene sadržaja elemenata u otopini kontrolirane su pomoću ICP. Otpuštanje organskih kiselina mjereno je korijen-disk metodom pomoću HPLC-a. Korištenje preparata sa živim bakterijama (biognojivo Phylazonit MC) ubrzalo je mineralizaciju organskih ostataka i učinilo hraniva dostupnijim biljci. Istovremeno, zahvaljujući živim bakterijama iz biognojiva, usvajanje teških metala se smanjilo. Stoga se primjena Phylazonita preporuča u uvjetima jakog zagađenja teškim metalima. Na temelju provedenog pokusa može se zaključiti da biognojivo i drvni pepeo mogu biti učinkovito oruđe ekološke poljoprivrede.

Ključne riječi: drvni pepeo, biognojivo, kiselost tla.

## INTRODUCTION

It is a constant challenge to minimize the use of chemicals in agriculture. The intensive land use, including the artificial N-fertilizers, in agriculture causes the acidification of soils due to the harvest or leaching of cations. An advantage of using organics, where practical, is that nutrients are liberated slowly as the microbes mineralise the organic materials. Thus there is low risk for fertilizer burn on plants and less risk for environmental problems due to runoff and leaching. Soil microbes are of great importance in cycling nutrients such as carbon (C), nitrogen (N), phosphorus (P), and sulphur (S). Not only do they control the forms of these elements (e.g. specialized soil bacteria convert ammonium N ($NH_4^+$) to nitrate $NO_3^-$) they can regulate the quantities of N available to plants. Beside their effects on the availability of nutrients the bacterial soil life prevents the uptake of several harmful ions. The most important limiting factor for microbial growth in soil (assuming moisture is adequate) is the abundance of available organic carbon sources. To increase microbial activity in a soil one must make the environment optimal, or at least more favourable, in terms of aeration, moisture, and pH, and above all provide the organic substrates needed to fuel the population.

There is tight connection among the soil fertility, soil pH and soil microbial life. Plant growth and soil microbial activity are strongly affected by soil acidity, resulting in reduced crop yields. The indirect effect of soil acidity on the presence and availability of toxic ions, such as aluminium, manganese, or other heavy metals, are generally more important to crop production than the direct effect of acidity on the plants. Some nutrients will be less available in acidic soil circumstances, while others become more available thanks to their increased solubility on lowering pH. Impacts of soil acidification can be; decreased number and activity of useful soil organisms, deficiency of magnesium, calcium may occur, phosphorus may become less available, the solubility of several heavy metals may reach toxic levels, increasing uptake of heavy metals by crop plants may cause serious health problems to animals and humans. Thus the maintenance of the quality of our soils, including their pH, can be the most important task of organic farming, and sustainable agriculture.

Besides lime wood ash can be one of the most effective sources to provide the sustainability of intensive land use (1). To provide the sustainable soil quality, the buffer capacity of soils, it is necessary to complete the soils with minerals. Fertilization with wood ash reduced acidity of humus layer, even after 23 years, with wood ash treatments of 2,5 and 5 tons per hectare, the soil pH values were respectively 0.3 and 0.9 units higher than of the control (3). Although wood contains cations in favourable amounts and all the cations originate from plant materials, the use of ash can be limited because of the potential risk associated with its cadmium (Cd) content (1-30 $mgkg^{-1}$). In agriculture, wood ash is usually allowed for use as fertilizer when its Cd content is below 3 $mgkg^{-1}$. The availability of phosphorus was better using wood ash instead of lime (4). Higher oil contents of oil rapeseeds were observed in experiments, on former forest soil, where the pH was below 6.0, and wood ash was applied (1).

The main objectives of our study were to test if wood ash (as heavy metal containing industrial by product) had the potential for feeding the cations back into the soil without risk of toxicity, and to examine the impact of bio fertilizer Phylazonit MC® as the potential tool to reduce the risk in agricultural production.

## MATERIALS AND METHODS

Corn (*Zea mays L. cvs. Norma SC*) and cucumber (*Cucumis sativus L. cv. Rajnai fürtös*) seeds were used in the experiments. The seeds were germinated on moistened filter paper at 25 °C. The seedlings were then transferred to a continuously aerated nutrient solution of the following composition: 2.0 mM $Ca(NO_3)_2$, 0.7 mM $K_2SO_4$, 0.5 mM $MgSO_4$, 0.1 mM $KH_2PO_4$, 0.1 mM KCl, 1μM $H_3BO_3$, 1μM $MnSO_4$, 0.25 μM $CuSO_4$, 0.01 μM $(NH_4)_6Mo_7O_{24}$. In case of dicot cucumber the $H_3BO_3$ concentrations were 10μM. Iron was added to the nutrient solution as Fe-EDTA in a concentration of $10^{-4}$M. The wood-ash was added to the nutrient solution as powder in the amount of $1gL^{-1}$ and as a soluble part of 1 g wood ash. The bio fertilizer Phylazonit MC® was added to the nutrient solution in amounts of 1 $mlL^{-1}$. When Al treatment was used, the concentration of Al was $10^{-4}$M. The Phylazonit MC® contained living bacteria as follows: *Bacillus megatherium var. Phosphaticum*, as phosphorus mobilizing bacteria in conc. of 1-2 x $10^8 cm^{-3}$, and *Azotobacter chroococcum* as free living $N_2$ fixing bacteria, in conc. of 1-2 x $10^9 cm^{-3}$.

The seedlings were grown under controlled environmental conditions (light/dark regime 10/14 h at 24/20 °C, relative humidity 65-70% and a photosynthetic photon flux 390 $mEm^{-2}s^{-1}$ at plant height. The elements contents were measured with ICP. The release of organic acids was examined by using the root-disc-method and the amounts of organic acids were measured with HPLC.

## RESULTS

It has been proved that heavy metal originating in wood ash bound to the organic matter in the soil, and their availability dramatically decreases. The contents and the solubility of different elements in ash were measured under different pH values. The results are shown in Table 1.

**Table 1. Different elements contents in washing solution and in wood ash**

| Some elements contents in wood ash in $mgKg^{-1}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ca | Cd | Cu | Fe | Mg | Mn | P | Al |
| | 343070 ±7725 | 3,3 ±0,07 | 97,7 ±2,9 | 4235 ±217 | 19378 ±527 | 11870 ±411 | 34042 ±4750 | 4018 ±150 |
| Some elements contents in buffer solution after 8 hours shaking in $mgL^{-1}$ | | | | | | | | |
| pH:5 | 6,71 ±1,63 | <0,001 | 0,085 ±0,001 | 0,009 ±0,001 | 0,34 ±0,03 | 0,02 ±0,004 | 86,96 ±18,5 | 0,193 ±0,08 |
| pH:6 | 3,08 ±1,01 | <0,001 | 0,035 ±0,004 | 0,005 ±0,001 | 0,22 ±0,01 | 0,01 ±0,001 | 178,3 ±37,0 | 3,48 ±1,28 |
| pH:7 | 1,39 ±0,04 | <0,001 | 0,015 ±0,01 | 0,004 ±0,001 | 0,20 ±0,01 | 0,01 ±0,001 | 396,0 ±75,0 | 6,8 ±1,65 |

As Table 1 shows, several elements contents are extremely high in the sample. The concentrations of micronutrients are in optimum amounts in ash, so ash is considered to be a micronutrient-fertilizer. By feeding these micro-, and macronutrients back to the soils the acidification can be retarded. Besides its nutritional effect, lime can be substituted with wood ash because of its high calcium contents.

Each form of wood ash had a strong increasing effect on the pH value. By the end of the test period the roots of cucumber plants compensated for the pH by their proton and organic acids releases. Due to this acidification effect by the roots, the uptake of most nutrients increases, and as a consequence, the dry matter accumulation increases. The treatment with wood ash had an effect on the root formation of corn seedlings (Figure 1*)*. The control (4) nutrient solution contained half amounts of nutrients, therefore deficiency symptoms could be seen, while the treated (6) nutrient solution was completed with wood ash of $1gL^{-1}$. The root development of the treated seedlings was more intensive, the total amounts of root dry matter were almost doubled, and as a consequence, the growth of shoots also increased.

Serious effects on root morphology were observed when the nutrient solution was completed with wood ash with or without bio fertilizer. The corn seedlings grown on nutrient solution containing half amounts of nutrients showed nutrient-deficiency symptoms, these symptoms were reduced when the nutrient solution was completed with wood ash. Wood ash and the bio fertilizer had a well visible co-effect. There are no deficiency symptoms observed, and the wood ash solution applied in a 10 $mlL^{-1}$ concentration together with bio fertilizer had an advantageous effect on shoot and root development. (Figures 1-2.) The effects depend on the concentrations of wood ash. The bio-fertilizer can moderate the changes in pH, but this effect is limited. It seems arguable, that sufficient soil life is needed to use wood ash in agriculture. The effect of wood ash on the pH and the moderation effect of bio fertilizer can be seen in Table 2. The moderation effect of bio fertilizer on pH is well visible. The effects of applied treatments on dry matter accumulation can be seen in Table 3. The treatments started when the seedlings were one week old. The decrease of dry matter accumulation is strongly retarded by the application of wood ash in both plants, although cucumber is much more sensitive. The bio fertilizer could moderate the decrease of dry matter accumulation on a lower level in comparison to the control.


*Figure 1. Maize seedlings grown on nutrient solution (4:50% nutrients content in solution 6: No. 4. is completed with 1mlL$^{-1}$ wood ash solution)*

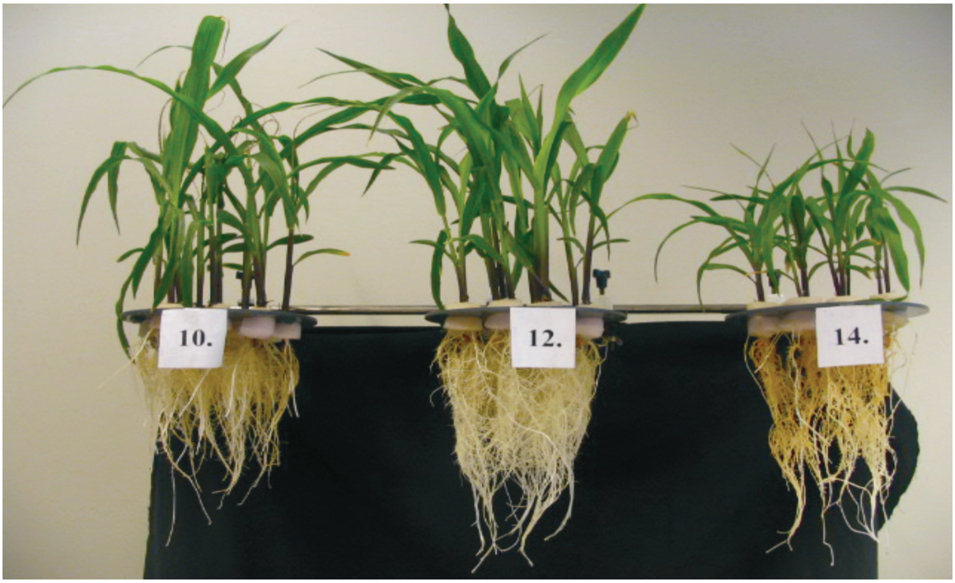


*Figure 2. Maize seedlings grown on nutrient solution completed with 1mlL$^{-1}$ biofertilizer and wood ash solution. (10:1mlL$^{-1}$, 12:10mlL$^{-1}$, 14:100mlL$^{-1}$)*

**Table 2. Effects of wood ash and bio fertilizer Phylazonit MC on pH of nutrient solution of cucumber seedlings**

| Treatments | **0 day** | **2 nd day** | **4th day** | **6th day** |
|---|---|---|---|---|
| Control | 6,81±0,59 | 6,72±0,41 | 6,49±0,38 | 7,05±0,13 |
| Bio fertilizer 1 $mlL^{-1}$ | 7,64±2,50 | 6,92±0,21 | 6,88±0,04 | 7,16±0,37 |
| 1 $gL^{-1}$ wood ash | 10,82±0,61 | 9,91±0,40 | 9,09±0,63 | 9,09±0,28 |
| 1 $gL^{-1}$ w. ash+Biof. 1 $mlL^{-1}$ | 10,76±0,64 | 9,73±0,18 | 8,72±0,33 | 7,87±0,32 |

**Table 3. Dry matter accumulation in shoots and roots of maize and cucumber seedlings 4 days after treatment (gdm.$plant^{-1}$)**

| Treatments | shoot maize | root maize | shoot cuc. | root cuc. |
|---|---|---|---|---|
| Control | 4,0277±0,387 | 1,2663±0,098 | 8,581±1,127 | 1,728±0,114 |
| Biofertilzer 1 $mlL^{-1}$ | 4,5947±0,279 | 1,1932±0,067 | 7,955±1,093 | 1,961±0,125 |
| 1 $gL^{-1}$ wood ash | 2,6168±0,410 | 1,2270±0,102 | 1,008±0,089 | 0,333±0,027 |
| 1 $gL^{-1}$ w. ash + Biof. 1 $mlL^{-1}$ | 3,0174±0,312 | 1,2412±0,091 | 2,165±0,651 | 0,880±0,131 |

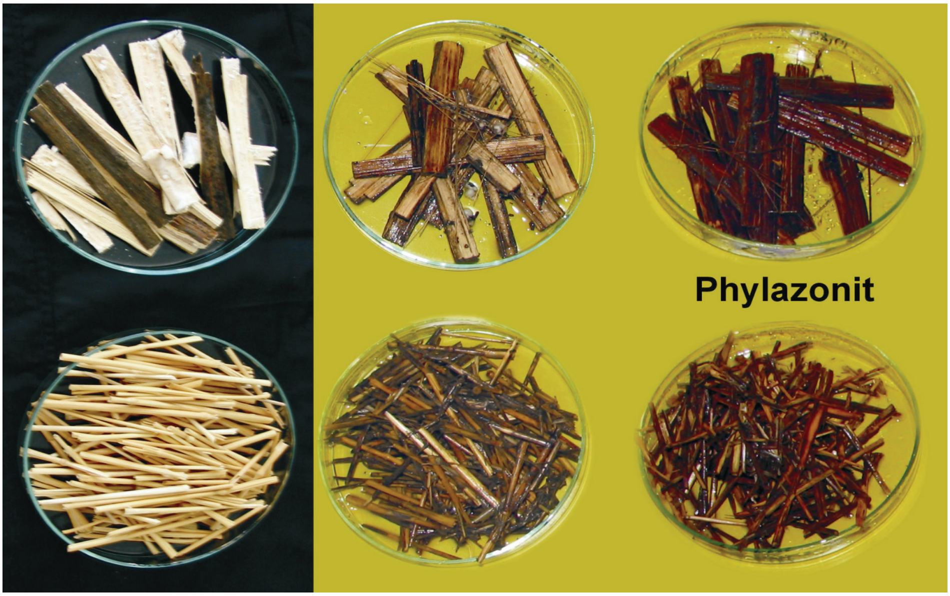


*Figure 3. Sunflower and wheat stems before and after two weeks of Phylazonit treatment*

We suppose that this retardation in dry matter accumulation is in close connection with the increasing pH values.

The effect of Phylazonit MC on mineralization of wheat (W) and sunflower (S) stem was also examined. The results can be seen in Figure 3, and Table 4-5.

**Table 4. The available N-P-K concentrations in the surface-soil of wheat and sunflower stems, with and without Phylazonit MC® treatments. The running time of exp. was 2 weeks. (n=4; ±se)**

| treatments | $P_2O_5$ mgkg$^{-1}$ | $K_2O$ mgkg$^{-1}$ | N % |
|---|---|---|---|
| Wheat control | 228,8±14 | 315,1±23 | 0,162±0,01 |
| Wheat + Phylazonit | 249,9±9 | 352,4±19 | 0,173±0,02 |
| Sunflower control | 278,8±11 | 346,6±15 | 0,158±0,01 |
| Sunflower+Phylazonit | 309,5±21 | 403,6±31 | 0,175±0,03 |
| Control (bulk soil) | 230,1±17 | 267,8±17 | 0,168±0,04 |

**Table 5. The effect of treatment on mineralization of wheat (W) and sunflower (S) stems. The running time of exp. was 2 weeks. (n=4; ±se)**

| dry matter (g) | | | | |
|---|---|---|---|---|
| treatments | | | | |
| Time | W (control) | W+Phylazonit | S (control) | S+Phylazonit |
| Before the exp. | 11,09±1,2 | 10,98±0,9 | 15,27±1,7 | 15,13±2,1 |
| End of the exp. | 8,40±0,9 | 7,11±1,3 | 12,15±0,8 | 10,00±0,6 |
| Loss of weight% | 24,25 | 35,24 | 20,43 | 33,9 |

As can be seen, the break down of organic matter was more intensive, when living bacteria was applied. We consider this effect is very important, while the mineralization plays a significant role in the maintenance of sustainable soil life and quality.

The acidification of soils seems to be the crucial problem in agriculture and forestry. As a consequence the uptake of heavy metals by the roots increases. The accumulation of aluminium causes the roots to die. This can be the main reason for the damage of European forests and is a limiting factor in agricultural production. The Phylazonit moderated the toxic effect of aluminium in our experiment, as can be seen in Figure 4.

The aluminium retarded the growth of corn seedlings in the applied concentration, but this effect was moderated when bio-fertilizer was applied. We suppose, that the organic acids, released by the bacteria form complexes with Al, and with other heavy metals in our other experiments.

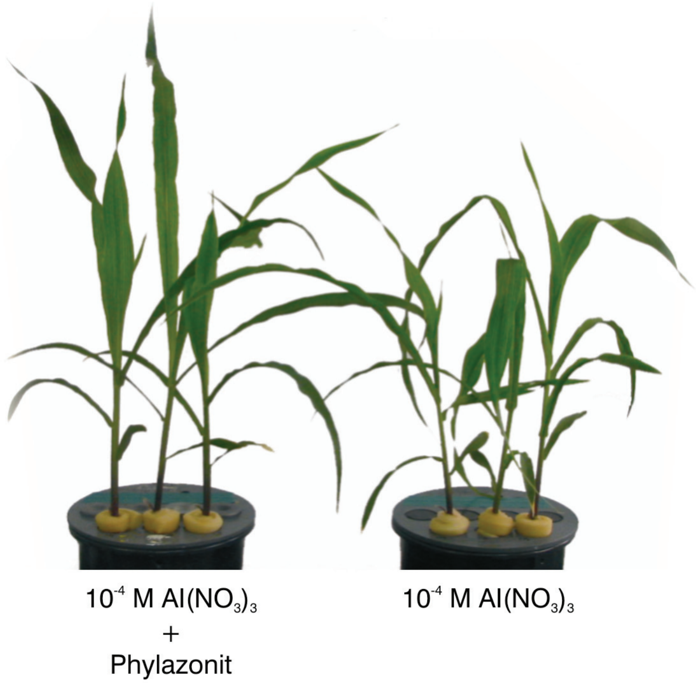


*Figure 4. Corn seedlings grown on nutrient solution complemented with Al ($10^{-4}$M $Al(NO_3)_2$ and Phylazonit MC 1mlL$^{-1}$.*

CONCLUSIONS

The use of wood ash is recommended instead of lime for improving acidic soils, as is proved by the evidence of its pH increasing effect. Wood ash contains several micronutrients in an optimum composition for forestry and agricultural plants. The use of bio fertilizers and wood as (specially on acidic soil) is recommended in bio-production. It seems arguable, that sufficient soil life is needed to use wood ash in agriculture. The use of living bacteria containing bio-fertilizer Phylazonit MC accelerates the mineralization of organic residue in soils, therefore makes the nutrients more available. Using living bacteria containing bio-fertilizer, the uptake of heavy metals decreases, therefore the application of Phylazonit is offered under heavy metal contaminated circumstances as well. By our experiments bio fertilizers and wood ash can be effective tools organic agriculture.

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