THE EFFECT OF HYDROABSORBENT ON SELECTED SOIL BIOLOGICAL AND BIOCHEMICAL CHARACTERISTICS AND ITS POSSIBLE USE IN REVITALIZATION

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Abstract

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A limiting factor in large areas in the world is water. This problem can also be met with at sites after gravel and sand mining the soil might suffer from a lack of water, organic matter and nutrients following recultivation. This problem can be solved during revegetation by the addition of hydrogels – hydroabsorbents. One hydroabsorbent is TerraCottem, a mixture of more than twenty components as hydroabsorbent, nutritive, root growing activators, carrier material, all assisting the plant growth processes in a synergic way. Hydroabsorbents can play an important role not only in germination and growth rate but could effect soil properties including those of a biological and biochemical nature. These properties were of interest during small parcel research with a mixture of grasses + clover in different variations of application, namely, with hydroabsorbents and a control without hydrogel. During three years of research statistical differences were described between plots with hydroabsorbent application and the control in all the studied parameters: CO_2 production, cellulose decomposition and chosen enzymes activities (phosphatase, dehydrogenase, protease and urease). These studied soil biological and biochemical parameters are connected with other soil properties which were influenced by hydroabsorbent application and previously described in the scientific literature.

Key words: soil, hydrogel, hydroabsorbent, biological and biochemical properties, enzymes, CO_2 production, cellulose decomposition

Introduction

A limiting factor in plant growth in large areas is water. Questions concerning desertification are widely discussed because as much as 60 percent of agricultural soils in non-humid areas in the world is affected by desertification (Šarapatka et al., 2002). This problem can also be met, for example, at sites following gravel and sand exploitation, where soils selected for recultivation suffer from a lack of water, organic matter and nutrients. At many places problems were solved using an artificial product (hydrogels) the use of which would take on the role of compost and clay and improve soil properties by vegetation treatment of the sites. Hydrogels could be used in revegetation projects, as well as perennial, and annual establishment and production. Hydrogels have the potential to have a large number of benefits on the landscape (Peterson, 2002). Hydrogels have been used to establish tree seedling and transplants in the arid regions of Africa and Australia to increase plant survival (Specht, Harvey-Jones, 2000; Save et al., 1995), they can aid in decreasing erosion, thus reducing nutrient and sediment losses to sensitive environments, and adsorb nutrients for slow release (Peterson, 2002).

The use of hydrogels will become more important over time, especially in places with reduced water availability. Three classes of hydrogels are commonly used and are classified as natural, semi-synthetic, or synthetic polymers (Mikkelsen,1994). Natural polymers are starch based polysacharides commonly derived from crops, semi-synthetic polymers are initially derived from cellulose and then combined with forms of petrochemicals and finally, synthetic hydrogels.

One of the hydroabsorbents is TerraCottem, a mixture of more than twenty components, all assisting the plant growth processes in a synergetic way (Dewever, Ottevaere, 2003). After years of rigorous testing and research Dr. W. van Cotthem and his team from the University of Ghent developed the product which has been called TerraCottem. This product contains a mixture of different organic hydroabsorbent polymers as components which absorb and store rain or irrigation water that is normally lost (the dry form before swelling and gel particles after swelling is shown in Fig. 1) and also absorb organic and mineral nutrients increasing the ecological and efficient use of fertilizers. TerraCottem also contains soluble and slow release mineral fertilizers, synthetic organic fertilizers, root growth activators and carrier materials.

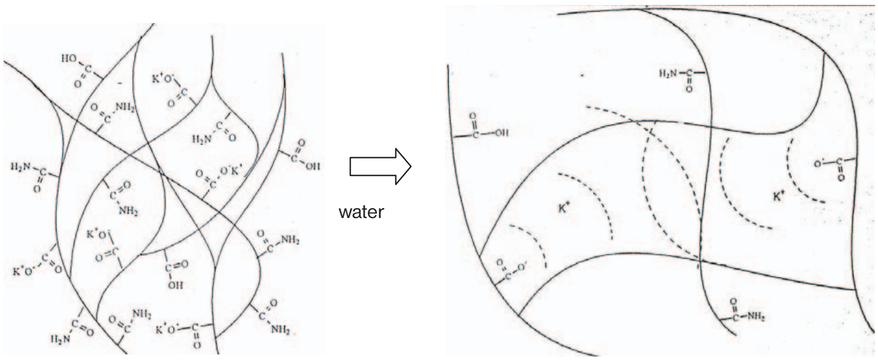

Fig. 1. Principles of absorption – granules before swelling and gel particles after swelling.

Hydroabsorbents can play an important role in germination rates because of increasing water availability, especially in arid and semi arid environments (Woodhouse, Johnson, 1991). Odell et al. (1992) also found that tomato responded with faster germination after hydrogel was incorporated. Research in Sudan (Callaghan et al., 1988) shows that added hydrogels significantly increased the survival rate of the germinated trees. Some research studies also showed that hydrogels can potentially damage seeds by providing too much water (Baxter, Waters, 1986). Transpiration of plants can be affected by the use of hydrogels since these potentially increase water availability. Specht and Harvey-Jones (2000) described an increase in overall water uptake and stomata activity increase in studied plants and hydrogel also can reduce the effects of salts in the soil matrix (El Sayed et al., 1991). Johnson and Hummel (1985) described the way in which the addition of hydrogels to soil could decrease the amounts of mycorrhizal root associations. Nitrogen fixing microbes can also benefit from hydrogel applications (Kohls et al., 1999).

More research was done with the production and survival rate of plants. When Eucalyptus was planted in sandy soil in the absence of irrigation, the survival rate of trees doubled compared with trials with no hydrogel amendment (Callaghan et al., 1989) The hydrogel could also prolong water availability for plant use when irrigation was stopped (Huttermann et al., 1999). The incorporation of hydrogels into sand media for tomato, lettuce, radish and wheat increased dry weight and increased the time from irrigation stop to wilting (Henderson, Hensley, 1986; Johnson, Leah, 1990). Salaš (2002) also described the use of hydroabsorbent in substrates for ornamental tree species. In Belgium, Dewever and Ottevaere (2003) studied the effect of TerraCottem on growth at the Experimental Station for Ornamental Plants. The application of this hydroabsorbent had an effect on water use, fresh and dry weight biomass production and water use efficiency. Salaš (2002) demonstrated that hydroabsorbents do not completely substitute for an irrigation system, but they are very effective instruments limiting daily plant stress thanks to its stabilisation of water circulation.

In our experiment we concentrated on the effect of TerraCottem on soil biological and biochemical properties. In the scientific literature data exists on the effect of hydrogel application to water holding capacity (Huttermann et al., 1999), water percolation (Rubio et al., 1989), decrease in soil erosion (Zhang, Miller, 1996; Lentz, Sojka, 1994), reduction in the overall bulk density by expanding the soil (Al-Harbi et al., 1999), reduction in soil salinity (Malik, Letey, 1991), and pH buffering effect, among others. Compared with the data about the effect on plant production there are few data about the effect of hydroabsorbent application on the soil biological and biochemical properties.

The aim of our research is to explain the influence of hydroabsorbent (hydrogel) application on the soil biological and biochemical characteristics.

Material and method

The research was conducted in the Písek cadastre (Hradec Králové district, the Czech Republic). The experimental parcels were set up on flat recultivated site with sandy soil. The parcels are of rectangular shape with dimensions 8.5x1.6 m, orientated with their longer side towards north–south. The parcels were separated by sidewalks without vegetation, on the northern and southern side 1 m wide and between each other 0.2 m wide.

A total of 6 parcels were set up with addition of hydroabsorbent Terracottem and 6 parcels without hydroabsorbent – as a control. All the parcels were sown with a special sowing machine for setting out experiments with a mixture of grasses and clover. To eliminate as much as possible any environmental effects, the soil samples were always collected from inside 4 parcels by means of a needle probe. The same method was used on both the experimental and control plots. Samples of soil for biochemical activity of enzymes were collected 12 times in 2000–2004.

Soil biological and biochemical methods used:

Phosphatase activity

Tabatabai and Bremner method (1969) was used with the application p-nitrophenyl phosphate as the substrate. The p-nitrophenol released by phosphomonoesterase activity was determined spectrophorometrically.

Dehydrogenase activity

Soil samples were suspended in a triphenyltetrazolium chloride solution and incubated. The triphenyl formazan produced was extracted and measured photometrically (Ross, 1970).

Protease activity

The methodology described by Ladd and Butler (1972) was used with the application of casein as the substrate. Aromatic acids react in the alkaline solution with the phenol reagent and form blue complex which is determined spectrophorometrically.

Urease activity

The soil samples were incubated with urea solution as a substrate and released ammonium was determined volumetrically (Tabatabai, Bremner, 1972).

Decomposition intensity of the model cellulose

The intensity of the cellulose decomposition was determined according to the mass difference of the model cellulose before and after exposure in the soil.

The distribution CO_2 from the soil in natural conditions

The CO_2 from the soil is absorbed by the granules of soda lime; the differences in weight show the quantity of CO_2 produced.

Results and discussion

The evaluation of the selected soil biological and biochemical characteristics were based on the presumption that the TerraCottem application to the extreme sandy soil during the restoration of sites after gravel mining has the effect not only of increasing the capacity of sandy soil to retain and provide water and nutrients and has positive benefits on plant growth and other effects described in the introduction but it also improves soil biological activity.

In our three years of research statistical differences were described between plots with hydroabsorbent application and control in all studied parameters. Results of CO_2 production and cellulose decomposition are described in Figs. 2 and 3, differences in enzymes activities are shown in Fig. 4.

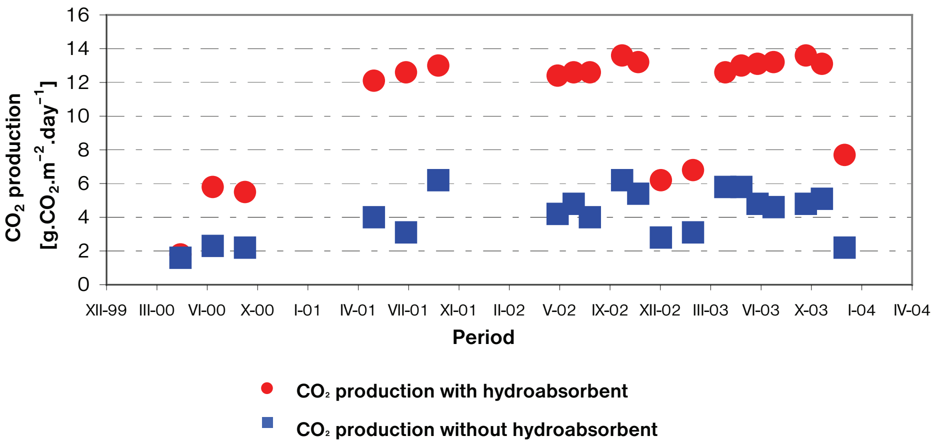

Fig. 2. The distribution of CO_2 from the soil.

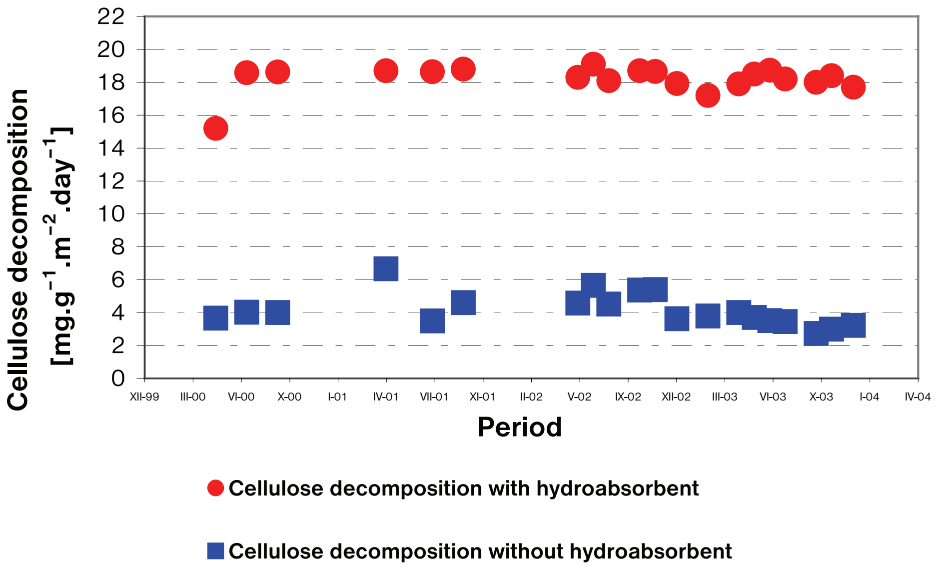

Fig. 3. Cellulose decomposition.

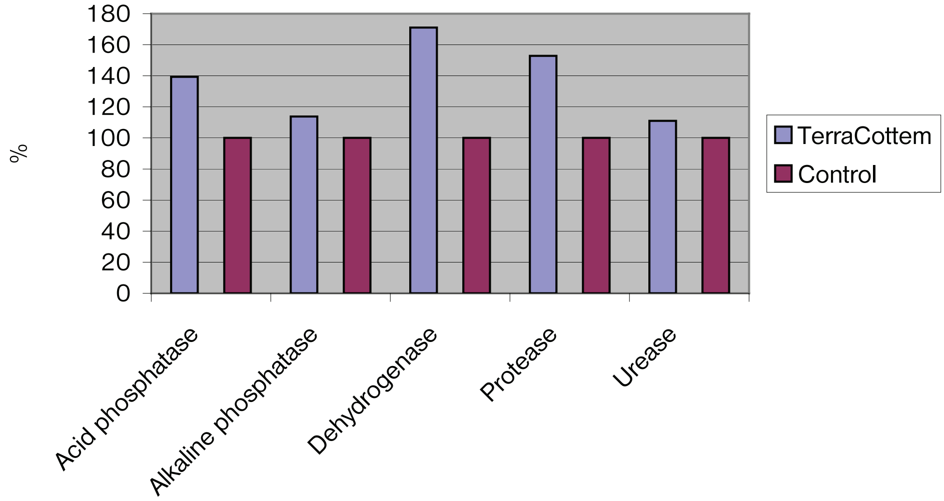

Fig. 4. Differences in enzyme activities in variants with and without TerraCottem.

The studied soil biological and biochemical parameters are connected with other soil properties. Soil microorganisms can be sensitive biological markers and can be used to assess disturbed or degradated soils, or on the other hand, soil quality or health. These parameters are influenced by many factors, e.g. soil moisture, temperature, aeration, pH, organic matter quality and quantity, the presence of inhibitors and activators.

Enzyme activity is a good index of soil quality or changes because it is closely related to important soil quality parameters and can begin to change much sooner than other properties (Dick et al., 1996). The studied soil biological and biochemical parameters are possitively affected by changing soil physical and chemical properties, e.g. the addition of hydrogels to sandy soils can change the water holding capacity to that of silty clay or loam (Huttermann et al., 1999) and influence infiltration rates, density and soil structure (Helalia, Letey, 1988), and reduce the negative effect of nutrient losses which available for plant growth.

The effect for soil biological properties can also be indirectly influenced by germination and growth rate (Henderson, Hensley, 1986; Johnson, Leah, 1990; Dewever, Ottevaere, 2003 and others) and by the highest input of organic matter to the soil. Soil organic matter is one of the important factors in soil enzyme activity (Šarapatka, 2003 and others). The production of the grass + clover mixture in our experiment was also higher on those plots with hydroabsorbent application, but is not the topic of this paper.

Conclusion

Hydrogels have a large number of documented benefits in the landscape. In the scientific literature the effects in decreasing erosion, sediment and nutrient losses reduction to sensitive environments. Hydroabsorbents are used with success in greenhouse and container field production in horticulture, in ecological restoration projects in arid regions of the world. In our conditions, the use of hydrogels in recultivation projects on degradated sites (for example after mining) where there are commonly difficulties with revegetation because of extreme soil characteristics with lack of water, organic matter, nutrients and where there are considerable losses of plants and consequently economic losses. Research on hydro-absorbent application also requires study of the duration of its effect on soil and plants. Its use in agriculture and field horticulture also requires detailed economic evaluation and the calculation of final products.

Translated by the authors

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Šarapatka B., Rak L., Bubeníková I.: **Vliv použití hydroabsorbentů na vybrané biologické a biochemické charakteristiky půd.**

Limitujícím faktorem pro organismy v řadě oblastí světa je voda. S tím se můžeme setkat i u nás například na extrémně písčitých stanovištích, rekultivovaných po těžbě štěrkopísku. Tento problém může být zmírněn při výsadbě vegetace aplikací hydrogelů – hydroabsorbentů. Jedním z nich je TerraCottem – směs více než 20 složek, jako je např. hydroabsorbent, živiny, aktivátory růstu, všechny působící synergicky při růstu rostlin. Hydroabsorbent nemá pouze pozitivní vliv na klíčení a růst rostlin, ale může ovlivňovat i půdní vlastnosti včetně biologických a biochemických. Tyto vlastnosti byly v našem zájmu během maloparcelkového výzkumu s jetelotravní směskou ve variantách s aplikací hydroabsorbentu a bez jeho použití jako kontroly. Během sledování byl popsán pozitivní vliv aplikace TerraCottemu na půdní dýchání, rozklad celulózy a na aktivitu vybraných půdních enzymů (fosfatázy, dehydrogenáza, proteáza a ureáza). Tyto charakteristiky jsou v úzkém vztahu k dalším půdním vlastnostem, jejichž změny jsou po aplikaci hydroabsorbentů popisovány ve vědecké literatuře.