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Mini Review

Agrooter® - Skillful Natural Tubes to Enhance Soil Productivity and Manage Hydric Stress

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Abstract

Agrooter® is a Hungarian patent created by the first author, tested in several field experiments in Hungary and recently in some African countries. The point of the invention is that small tubes are mixed into the fertile soil, which keeps moisture or air in the soil, depending on their position. In the case of an entirely random distribution of the tubes within the soil, the tubes achieve both advantages. The point of this patent is the carefully designed size and amount of empty tubes fabricated from organic bio-degradable materials and micro-grinded specific minerals. Using these tubes in the plantations helps to avoid hydric stress and increases yield and improves quality. These small particles improve the water budget (significantly decreases water demand) and enhance the soil's porosity. After the description of the principle of the tubes, including the positive impact of the tubes on micro-biotic life in the soil, technical advice is also presented on the optimum amounts of mixing the tubes into the soil, and ways of planting are illustrated for plant seedlings and tree saplings. Finally, six different plants planted and observed in Hungary demonstrate the usefulness of these effects. The most common feature of these results is that significant improvements are obtained by using the Agrooter® compared to the traditional plantation by using a 50% smaller amount of irrigation water.

Introduction

Natural precipitation or regular irrigation, i.e. water, is essential to keep our plants alive. Water has three main functions:

a) solvent in the soil
b) source of hydrogen for photosynthesis,
c) evaporative cooling medium

These three functions are like the integrity of links in terms of the chain's strength. The aim of the present paper is to introduce a technical invention that substantially improves the hydrological features of agricultural soils. Before turning to it, summarize the efforts based on traditional farming practices.

Maintaining the optimal moisture level in the soil is of fundamental importance for plants' uninterrupted growth and development because it promotes healthy growth and development [1]. Heavy rains or prolonged dry periods significantly affect the soil moisture in the root zone, disrupting the normal water uptake of plants [2]. Preserving the activity of the root zone is a fundamental task for growers [3,4]. Plants absorb water from the soil through their roots. Adequate moisture levels tailored to the plant species ensure that plants receive sufficient water for their metabolic processes [5]. The soil moisture level is closely related to dissolved nutrients in the soil. Water acts as a solvent, aiding the absorption of nutrients available to the roots [6]. The moisture content of the soil is closely related to dissolved nutrients in the soil. Plants use water during photosynthesis to harness the energy of sunlight and produce glucose. Proper soil moisture allows for the efficient execution of photosynthesis [7]. Moisture contributes to the regulation of soil temperature. Moist soil heats up and cools down more slowly, helping plants cope with extreme temperature changes [8]. Adequate soil moisture is crucial for root development.

Roots have difficulty spreading in dry soil, while excessive moisture can cause damage [9]. Maintaining the proper soil moisture content can help prevent the proliferation of pathogens and fungal diseases in the soil, as specific pathogens thrive in a wet environment [10]. Therefore, a fundamental question arises: how can a favourable water supply and proper biological activity in the soil be improved and ensured? In recent years, biochar (BC) has become widespread for increasing crop yields due to its large specific surface area and strong adsorption properties [11-13]. Biochar is a product produced by pyrolysis of biomass at temperatures between 300 and 1000°C in a low-oxygen environment [14]. It is considered a significant advantage that it helps preserve and enhance soil microbiological activity [15], and biochar can also contain macronutrients such as nitrogen, phosphorus, and potassium [16,17]. Research results have confirmed that the addition of BC to the soil reduces soil evaporation, thus retaining more water in the root zone during dry periods [18].

Water scarcity and chronic drought negatively impact the state of the land and, therefore, agriculture, livestock production and food prices. Continued drought-induced soil compaction reduces the soil's capacity to absorb water (buffering capacity), forests and soil fertility, further compromising agricultural production and food security. Although the recent report of the Intergovernmental Panel on Climate Change [19] does not state that all weather and climate extremes become stronger and more frequent on our planet, there are many regions and extremes over the World, that have become more frequent and there are dangerous tendencies even in the averages. For example, according to global climate models, Fig. TS5 indicates that soil moisture content has become lower in many North and South African regions. A similar Figure

based on observation (Box TS.10, Figure 1) also indicates that drought frequency has increased in several regions of Africa. Still, their locations partly differ from those mentioned concerning projected soil moisture changes.

Food shortages are forcing people to migrate, increasing the population of urban slums but also increasing emigration. This correlation and possible migration mitigation by improving agriculture technology have recently been discussed [20,21]. The AGRO-HELP PROJECT is a pioneering initiative in this respect, initiated by the Hungarian Baptist Relief Service and the Hungarian Government's Hungary Helps programme, an international and global initiative to directly address the root causes of migration pressures, religious persecution and climate change exposure by supporting local farmers in their respective areas and thereby improving food supply. The model has been extended and successfully tested in the largest refugee camp of Kenya under the aegis of the local FAO resident. This project is primarily based on the vital invention called Agrooter®, so our engineering efforts may effectively influence this problem of humankind.

Methodology

Agrooter® is a multifunctional Hungarian innovation that helps the soils keep water and, as a by-product, increases porosity, i.e., it retains more air in the soil. Farmers in Hungary call it "*Gyökéritató*", meaning "make the roots drinking". Agrooter® is a hollow-structured tube (Figure 1) that supports root development in a moist and airy environment. The word Agrooter® is often used for the tube pieces added to the soil, but sometimes it also means the complete technology using these tubes.

Figure 1: Pieces of the tubes called Agrooter®.

Agrooter® is a mineral micro-granular powder containing only natural substances, micro and macro elements, stabilized with organic binders. Therefore, the rooting Agrooter® tubules provide nutrients for plants and soil life.

Typical ingredients are Dudarite, mined and milled in Hungary, and Alginite, which are used as soil conditioners in their own right. The binding agent of the product is Cellulose. The product's mechanism of action is as follows, greatly depending on the vertical position of the tube within the soil. If it is placed with its opening upwards in the soil (Figure 2a), part of the rain- or irrigation water- is trapped inside the tube. If the cell is standing with its opening downwards (Figure 2b) in the ground, it is aerating.

Both extreme positions help the soil avoid the below-listed problems of too much and too little moisture and air in the soil. In dry soil, plant roots have difficulty accessing nutrients. Even if it does get some, the plant uses it to grow its roots for survival. Plants find it difficult to feed in soil that is too wet and lacks air. Plants also suffer from a lack of air in soil that is too compacted and compacted, and water has difficulty finding its way through. In an airless soil environment, the habitat of microorganisms is limited, and their 'transformative' activity does not serve the plant.

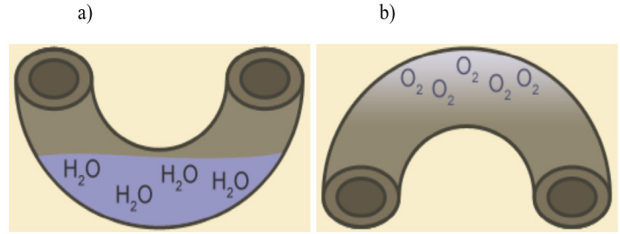

Figure 2: Schemes of retaining (a) water and (b) air oxygen in the two extremal positions taken in the soil.

A pivotal moment of using Agrooter® is the activation of microorganisms (bacteria, fungi) in the soil. The microorganisms living in the soil are "fed and watered", i.e. nourished and supplied with moisture. A loose, airy, moist, humid soil environment dramatically enhances the living conditions for microorganisms in the root environment of plants. This is why root fluff proliferates in Agrooter® tubes and colonies of microorganisms are formed.

At the same time, we know that roots have been shown to gravitate towards moisture. The uptake of nutrients through the root hairs embedded in water-holding tubules occurs precisely where soil life is most active. As a result, depending on the plant species, an efficient nutritional system for bacteria, fungi and plants to co-exist is established more quickly. The effect of Agrooter® lasts 1 to 3 years with a single application, depending on the crop and the application method, after which the product will break down and dissoluble in the soil. It is a certified product for organic farming.

It is essential to underline that Agrooter® is neither a substitute or replacement for irrigation, nor a fertilizer. However, it can reduce irrigation water requirements by up to 50% and eliminate hydric stress. Besides that, the use of Agrooter® traditional irrigation questions (when to irrigate, by which technology, how much to irrigate) becomes more complicated.

Preliminary Results

According to our business experience, Agrooter® has been widely used in Hungary for over twelve years [22]. At the same time, no systematic collection of the results achieved by using this technology has been performed. Therefore, we can present the results of six different plants according to the internet sources. Two garden flowers: French marigold *(Tagetes patula)* and begonia *(Begonia semperflorens)*; two vegetables, green pepper *(paprika, Capsicum annuum)* and tomato *(Solanum lycopersicum)*; finally, two fruits, grapevine *(Vitis vinifera)* and sour cherry *(Prunus cerasus)*.

The behaviour of the two flowers and the two vegetables is referred from an official certificate certified by the Agricultural Administration Office in Hungary [23]. Results for the grapevine are taken from the poster by Teszlák et al. [24], and those for sour cherry are read from the paper by Károly & Király [25].

For all the six investigated plants, it was found that the irrigation water demand was lower by 50 % in the experiments performed in the presence of Agrooter® compared to those in which the tubes were missing,

Regarding the first garden plant, the marigold, the number and size of the flowers became significantly larger compared to the control case. The same could be established about the area of leaves. In the case of begonia, several vegetative components of the plant body decreased, i.e., the height of the plants and the average number and area of the leaves. At the same time, generative components of the body increased, including the number and average size of the flower petals. For the green pepper, the yield, the

average number of paprika and their carbohydrate content increased. The average yield of tomatoes also increased, as did the leaf area and root mass. It is worth repeating that all the above differences, mostly in favour of the Agrooter® treatment, were achieved using a 50% lower amount of water than in the control cases. Concerning the grapevine experiments, they also contained half-dose treatments. Significant differences occurred only in the year's watering and re-watering periods. There were no significant differences among the treatments in the drought period of the year. In the case of shoot development, the Agrooter® treatment ensured faster shoot increase and faster biomass (i.e. root+shoot) growing development than in the control case.

In the case of sour cherry, the growth peculiarity of the trees (circuit of the trunk, the height of the tree and the number of the branches) were measured. The experiment aimed to determine whether it was possible to produce intense growth with biological products such as agrooter, organic manure and mycorrhizal fungi. Significant differences were found between the treated and control orchard in all measured parameters. In summary, we can establish that parallel to a 50% decrease in water demand, some features may be more advantageous than the control case. Similar experiments should be performed in much longer term than a single year or the 2-3 years life cycle of the tubes to obtain more unequivocal results.

Conclusion

The paper aimed to introduce the reader to the Hungarian innovation called Agrooter®. This is a product that, through its water retention, its tubular shape and the micro- and macro-elements that make up its material, can collectively and positively influence the factors that most affect plant life. In this way, it increases plants' shock tolerance, yield average, and growth rate and significantly speeds up their recovery.

In the Introduction, the importance of water is discussed, including several recent references from the scientific literature. Connected aspects of climate change and anti-migration effects of improving agriculture in those countries where lack of food supports migration are briefly mentioned. The longest chapter of the paper is Methodology, containing the fundamental aspects of the Agrooter®. The material of the tubes is a mineral micro-granular powder containing only natural substances, including micro and macro elements. So, tubes provide a source of nutrients not only for plants but also for soil life. A pivotal moment of using Agrooter® is the activation of soil microorganisms. The effect of Agrooter® lasts 1 to 3 years with a single application, after which the product will break down in the soil.

Besides that, recommended amounts of the tubes and traditional technology of plant seedlings and tree saplings are illustrated. The necessary steps before and after the planting actions are also included between these two aspects. Finally, the efficiency of the tubes is presented on six different plants; two are fruits, the other are vegetables, and the other are garden flowers. The most important finding in all the six different plants is that even parallel to 50% decrease of irrigation water demand, some features may have become more advantageous than in the control case.

We could provide our report in Short Communication only. To present more unequivocal results in a complete scientific paper, a much more comprehensive set of plants and a much longer term than a single year or the 2-3 years life cycle of the tubes would be needed.

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