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STUDY ON THE EFFICIENCY OF BIOFERTILIZERS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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Abstract: Sustainable agriculture is an action with a long–term aim that seeks to overcome the problems and restrictions faced by conventional agriculture, society in general, in order to ensure economic viability, the good state of the environment, the acceptance by society of agricultural production systems. This system of sustainable agriculture requires economically viable technologies over a long period of time, with high harvests, obtained at lower costs. Sustainable development combines the demands of the present without compromising the ability of future generations to meet their own needs. Among the materials used in agriculture, fertilizer is the most widely used. Each type of fertilizer, chemical or organic, has its advantages and disadvantages. These advantages must be integrated in order to achieve optimal performance by each type of fertilizer and to achieve a balanced nutrient management for crop growth. Biofertilizers differ from chemical and organic fertilizers in that they do not directly supply nutrients to crops, and they are crops of special bacteria and fungi. The production technology for biofertilizers is simple, and the cost of use is low compared with chemical fertilizers for plants.

Keywords: durable agriculture, agrochemical, biofertilizers, soil fertility

INTRODUCTION

Sustainable agriculture involves healthy food for consumers at balanced prices, respect for the environment, attention to animals, viable economic methods, a contribution to the beautification of landscapes, protection of precious ecosystems and biodiversity *(Vanghele N. et al., 2019)*. Sustainable agriculture has as exact objectives the production of food in sufficient quantities and quality, the conservation of natural resources (products obtained from nature must return in different forms to nature), landscape management, etc *(Anghel M.G. et al., 2017)*.

This system of sustainable agriculture requires economically viable technologies over a long period of time, with high harvests, obtained at lower costs. In order to be sustainable and viable a system must meet the following conditions:

- maintenance and improvement of the physical environment and resistance to external pressures or strong disturbances;
- satisfying the society's requirements in food products;
- ensuring the economic and social well–being of agricultural producers

Sustainable agriculture, with all the substantial contributions to social progress, is still far from what means a sustainable development, which means not only a fixed state in harmony with nature but, rather, a development in a dynamic process, in accordance with modern ecological principles, by which the use of resources, the direction of investments, the orientation of the development of technologies and institutional changes are made taking into account the requirements, both current and future of society's progress *(Ahlem Z. and Hammas M. A., 2017)*.

This type of agriculture, sustainable, is an integrated system of plant and animal production practices with a specific local application which, in the long term, achieves:

- meeting the requirements of food and fiber;
- improving the quality of the environment and the resource base;
- maximum efficient use of non–renewable resources;
- improving the quality of life and the whole of society.

In the modern ecological concept, alternative agriculture is the strategy, and sustainable agriculture is the goal, while soil quality is the role and position of the link, constituting the key to agricultural sustainability *(Chand S. et el., 2006)*.

Sustainable agriculture is an action with a long–term aim that seeks to overcome the problems and restrictions faced by conventional agriculture, society in general, in order to ensure economic viability, the good state of the environment, the acceptance by society of agricultural production systems *(Ramakrishnan B. et al., 2021)*.

The concept of sustainable agriculture is based on achieving optimal yields of inclusive economic efficiency and ensuring ecological balance. Hence the need to integrate agricultural policy into environmental policy *(Petre A. et al., 2019)*.

In order to achieve the objective of harmonising the development of agriculture with the environment, an

integrated approach is needed both to considerations relating to the development of agriculture and to ensuring environmental protection *(Willer H. and Sahota A., 2020)*.

Among the materials used in agriculture, fertilizer is the most widely used. Each type of fertilizer, chemical or organic, has its advantages and disadvantages. These advantages must be integrated in order to achieve optimal performance by each type of fertilizer and to achieve a balanced nutrient management for crop growth *(Micu A. et al., 2017)*. Based on the production process, it can be roughly classified into three types: chemical, organic and biofertilizing.

ORGANIC FERTILIZERS. ADVANTAGES AND DISADVANTAGES OF USING ORGANIC FERTILIZERS

Advantages of using organic fertilizers:

- Nutrient intake is more balanced, which helps maintain plant health;
- They increase the biological activity of the soil, which improves the mobilization of nutrients from organic and chemical sources and the decomposition of toxic substances;
- They increase the colonization of mycorrhizae, which improves the supply of P;
- They increase the growth of roots due to a better structure of soil;

Disadvantages of using organic fertilizers:

- They are relatively low in nutrient content, so a larger volume is needed to provide enough nutrients for crop growth;
- The rate of release of nutrients is too slow to meet the requirements of crops in a short time, therefore, a certain nutrient deficiency may occur;

CHEMICAL FERTILIZERS. ADVANTAGES AND DISADVANTAGES OF USING CHEMICAL FERTILIZERS

Advantages of using chemical fertilizers:

- Nutrients are soluble and immediately available to plants; therefore, the effect is usually direct and fast;
- The price is lower and more competitive than organic fertilizer, which makes it more acceptable and often applied by users;
- They are quite high in nutrient content; only relatively small amounts are needed for growing crops;

Disadvantages of using chemical fertilizers:

- Over–application can have negative effects, such as leaching, pollution water resources, the destruction of microorganisms and friendly insects, the susceptibility of crops to the attack of diseases, acidification or alkalization of the soil or the reduction of soil fertility – thus causing irreparable damage to the general system;
- Overeating N leads to softening of plant tissue, resulting in plants that are more susceptible to diseases and pests (Bokhtiar S.M. and Sakurai K., 2005).

THE ROLE OF BIOFERTILIZERS IN CROP PRODUCTION

Soil microorganisms play a significant role in regulating the dynamics of the decomposition of organic matter and the availability of plant nutrients such as N, P and S. It is well recognized that microbial inoculants are an important component of the integrated nutrient management that lead to sustainable agriculture. In addition, microbial inoculants can be used as an economic factor to increase crop productivity; doses of fertilizers can be reduced and more nutrients can be harvested from the soil (*Laza E. A. et al., 2021*).

The biofertilizer is defined as a substance containing live microorganisms and is known to help expand the root system and better seed germination. A healthy plant usually has a healthy rhizosphere, which should be dominated by beneficial microbes *(Chen J. H., 2006)*.

Inoculation of biofertilizers

Biofertilizers are generally applied to soil, seeds or seedlings, with or without a specific carrier for microorganisms, for example, peat, compost or stickers. Regardless of the methods, the number of cells reaching the soil from commercial products is less than the existing number of microorganisms in the soil or rhizosphere; it is unlikely that these added cells will have a beneficial impact on the plant, unless there is a lot of application. In addition, the population of the introduced microorganisms will decrease and be eliminated in a very short time, often days or weeks. The formulation of inoculums, the method of application and storage of the product are all essential for the success of a biological product. Short shelf life, lack of adequate transport materials, susceptibility to high temperatures, transport and storage problems are biofertilyzing blockages that still need to be solved in order to obtain effective inoculated ions *(Young C.C. et al., 2004)*.

Inoculation of seeds

Seed inoculation uses a specific microbe strain that can grow in association with plant roots; soil conditions must be favorable for the inoculants to work well. Selected strains of N–fixing Rhizobium bacteria have proven to be effective as seed inoculants for legumes *(Kaur K. et al., 2005)*.

Seed treatment can be done with any of two or more bacteria without antagonistic effect. In the case of seed treatment with Rhizobium, Azotobacter, Azospirillum together with PSB, the seeds must first be covered with Rhizobium or Azotobacter or Azospirillum. Where each seed has a layer of the abovementioned bacteria, the PSB inoculant must be treated on the outer layer of the seed. This method will provide a maximum population of each bacterium to generate better results *(Young C.C. et al., 2003)*.

MATERIALS AND METHODS

Examples of microorganisms used as biofertilizers and their roles:

- Azotobacters and azospirillum. These are free living bacteria that fix atmospheric nitrogen in grain crops without symbiosis and do not need a specific host plant. They can fix 15– 20 kg/ha N per year. Azotobacter sp. can also produce antifungal compounds to fight many plant pathogens (Kunda B. S. and Gaur A. C., 1984). They also increase germination and vigor in young plants, which leads to improved crop stands (Joergensen R. G. et al., 2019).
- Solubilizing bacteria in phosphate (PSB). In conditions of acidic or calcareous soil, large amounts of phosphorus are fixed in the soil, but are not available for plants. Phosphobacterins, mainly bacteria and fungi, can make insoluble phosphorus available to the plant. The solubilization effect of phosphobacterins is generally due to the production of organic acacids that lower the pH of the soil and cause the dissolution of phosphate–related forms. It is reported that the PSB culture has increased the yield to 200–500 kg/ha and thus can save 30 to 50 kg of superphosphate (Sundara B. et al., 2002).
- Plant growth that promotes rhizosis (PGPR). PGPR is a wide variety of bacteria in the soil that, when grown in combination with a host plant, lead to stimulation of host growth. PGPR modes include fixing N2, increasing the availability of nutrients in the rhizosphere, positively influencing root growth and morphology, and promoting other beneficial plant symbiosis – the microbe (Dutta S. et al., 2003). Some researches have indicated that PGPR will often have several modes of action. Some researchers found that a combination of the mycorrhizal shrub mushroom Glomus aggregatum, PGPR Bacillus polymyxa and Azospirillum brasilense maximized biomass and the P content of palmarosa aromatic grass (Cymbopogon martinii) when grown with an insoluble inorganic phosphate *(Young C.C. et al., 2003)*.

In this research, we applied two biofertilizers to cultures located within experimental lots, which can be found at the National Institute of Research and Development for Machinery and Installations For Agriculture and Food Industry – INMA Bucharest, in 2021.

The products used in this research were *Cystium–k* and *Ficosagro,* biofertilizers obtained in Spain from algae. *Cystium–k* is a liquid bio stimulant made from Macrocystis pyrifera seaweed, with high polysaccharides content. Its main functions are: Contribution of alginates and polysaccharides and fertilization support.

We apply foliar, in vegetative growth periods by spraying. Some benefits:

- Prompts the natural defences of the crop into action;
- Improves crop yields;
- Increases cell multiplication and differentiation in the early stages of growth;

FICOSAGRO

This product aids the development and strength of plants by enriching the biological potential of the soil. Its application areas including agriculture, horticulture, and turf fields for sports use.

Is it composed from Lactic acid bacteria (Lactobacilus plantarum) and Fungus and yeasts (Saccharomyces c.). We applied this product foliar.

- Crops of strawberries, tomatoes and cucumbers are placed in protected areas, cherries and blueberries are placed in unprotected areas. The first application of biofertilizers was on April, foliar. It was foreseen a control lot for each crop, with an area of 1/2 of the surface on which the biofertilizers were applied. The crops to which they have been applied, the areas on which they have been applied and the doses of biofertilizers used are listed below:
- Strawberries 50 sqm: Cystium–k, 15ml; Ficosagro, 75 ml
- Tomatoes 100 sqm: Cystium–k, 30ml; Ficosagro, 100 ml
- Cucumbers 50 sqm: Cystium–k, 15 ml; Ficosagro, 50 ml
- Cherries 25 sqm: Cystium–k, 5 ml; Ficosagro, 50 ml
- Blueberries 25 sqm: Cystium–k, 10 ml; Ficosagro, 25 ml

Below are some images from the application time.

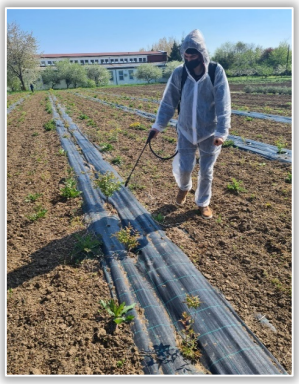

Figure 1 – Application on blueberries;

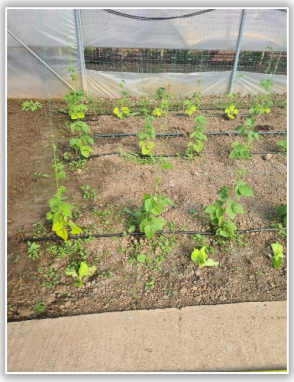

Figure 2 – Application on cucumber

- At an interval of about 30 days, in May, we still used Cystium–k and Ficosagro products, we applied them foliar. The control lots for crops were observed, in the area of 1/2 of the areas on which we applied. The crops to which they have been applied, the areas on which they have been applied and the doses of biofertilizers used have been the same as in the first case of application. Below are some images from the application time (Figure 3 and 4).
- In June, at an interval of about 30 days, using Cystium–k and Ficosagro products, we applied them foliar. The control lots for crops were observed, in the area of 1/2 of the areas on which we applied. The crops to which they have been applied, the areas on which they have been applied and the doses of biofertilizers used have been

the same as in the first and second application. Below are some images from the application time (Figures 5 and 6).

Figure 3 – Application on cherries;

Figure 4 – Application on blueberries

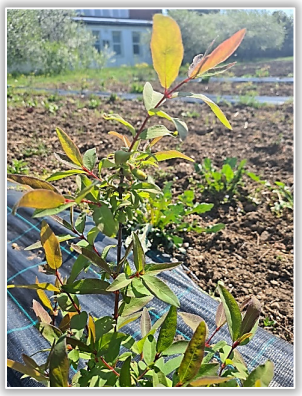

Figure 5 – Application on blueberries;

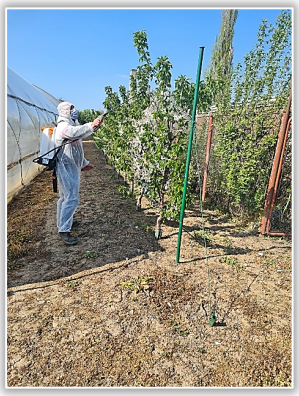

Figure 6 – Application on cherries;

RESULTS

We left a control lot for each crop. Please note that strawberries, tomatoes and cucumbers are placed in protected areas, cherries and blueberries are placed in non–protected areas.

In this research, we found an increase in the size of the fruits in the plants where we used the biofertilizing products mentioned between 5 – 10% compared to the control groups, an increase in the foliar mass and more vigorous roots, at the same time the plants being less attacked by diseases and pests. We found that Ficosagro aids the development and strength of plants by enriching the biological potential of the soil. Is it composed from Lactic acid bacteria (Lactobacilus plantarum) and Fungus and yeasts (Saccharomyces c.). It speeds up the decomposition of organic matter, it is rich in microorganisms that aid the recovery of microflora and microfauna in the soil, helping in their regeneration.

We use also Cystium–k, foliar, a liquid bio stimulant made from Macrocystis pyrifera seaweed, with high polysaccharides content. We found the development of axillary branching, foliar mass and photosynthetic capacity, and increases root hairiness.

For optimal plant growth, nutrients must be available in sufficient and balanced quantities. Soils contain natural reserves of plant nutrients, but these reserves are mostly in forms unavailable to plants and only a small part has been released each year through biological activity or chemical processes. This release is too slow to compensate for the elimination of nutrients through agricultural production and meet crop requirements. Therefore, fertilizers are designed to supplement the nutrients present in the soil. The use of chemical fertilizers, organic fertilizers or biofertilizer has its advantages and disadvantages in the context of nutrient supply, crop growth and the quality of the environment. The advantages must be integrated into the sauna in order to make the optimal use of each type of fertilizer and to achieve a balanced nutrient management for crop growth. Below are some images from the application time.

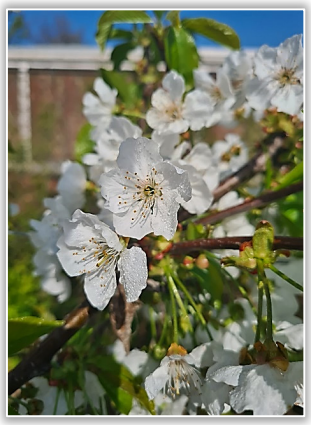

Figure 7 – Application on strawberries; Figure 8 – Application on cherries;

CONCLUSIONS

The intensive system of modern agriculture requires an intense energy flow, it has also put into circulation the solar energy previously accumulated in the form of fossil fuel, has generalized the use of mechanical energy in the processing of soil and chemical energy (fertilizers, pesticides) to increase fertility and productivity. In this way, the plant–soil system came out of the sub influence of natural regularity and became dependent on the energy intake from outside. As a consequence, it is not possible to ensure the maintenance of the physico–chemical balance in a long time, which leads to degradation *(Chand S. et el., 2006)*.

As a result of exaggerated chemistry, involutional processes occur, the microbial life of the soil disappears, structural destabilization occurs, the decomposition of organomineral complexes occurs. In order to be able to occur, in order to maintain the fertility of the soil, it is necessary to continue to apply chemical fertilizers, which brings the soil to intoxication, and the degradation can only be avoided.

Sustainable agriculture requires economically viable technologies over a long period of time, with high harvests, obtained with lower costs. Any agricultural

system must have long–term and high productivity, which is conditioned not only by the quality of the resource base, but also by the social and economic framework. Therefore, the sustainability of agricultural production systems, has a physical and a socio–economic dimension. More specifically, in order to be sustainable and viable, a system must meet the following conditions:

- maintenance and improvement of the physical environment and resistance to external pressures or strong disturbances;
- satisfying the society's requirements in food products;
- ensuring the economic and social well–being of agricultural producers (*Chandran, S. et al., 2018*).

In this research of using biofertilizers Cistium–k and Ficosagro, made in Spain, from algae.

We found that Ficosagro aids the development and strength of plants by enriching the biological potential of the soil. Its application areas including agriculture, horticulture, and turf fields for sports use.

Is it composed from Lactic acid bacteria (Lactobacilus plantarum) and Fungus and yeasts (Saccharomyces c.) The most important benefits are: speeds up the decomposition of organic matter, it is rich in microorganisms that aid the recovery of microflora and microfauna in the soil, helping in their regeneration; improves the absorption of nutrients through the crops root system, helps unblock and absorb nutrients such as nitrogen and phosphorus, improves crop yields. We applied this product foliar.

Cystium–k is a liquid bio stimulant made from Macrocystis pyrifera seaweed, with high polysaccharides content. Its main functions are:

- contribution of alginates and polysaccharides and
- fertilization support

The most important benefits are: prompts the natural defences of the crop into action, improves crop yields, increases cell multiplication and differentiation in the early stages of growth, promotes the development of axillary branching, foliar mass and photosynthetic capacity, and increases root hairiness.

Methods of application was foliar: apply in vegetative growth periods by spraying.

During this research, we found an increase in the size of the fruits in the plants where we used the biofertilizing products mentioned between 5–10% compared to the control groups, an increase in the foliar mass and more vigorous roots, at the same time the plants being less attacked by diseases and pests. We recommend continuing the study.

Effective management of plant nutrition should ensure improved and sustainable agricultural production and protect the environment. Chemical, organic or microbial fertilizer has its advantages and disadvantages in terms of nutrient supply, soil quality and crop growth. Developing an appropriate nutrient management system that integrates the use of these three types of fertilizers can be a challenge to achieve the objective of sustainable agriculture; however, much research is still needed.

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