Mechanisms of EM-1 Effect on the Growth and Development of Plants and its Application in Agricultural Production

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Abstract: *EM-1 application in plant cultivation (floriculture, gardening etc.) causes acceleration of development and increased growth in plants. The principal factors determining these processes are as follows: increase of seed germination, improvement of root system formation, stimulation of photosynthetic ability of plants with increase of chlorophyll and protein formation, rise of antioxidant ability of plants and so on. These and other processes provide the increase of plant growth and development, and of cropping power. The EM-1 effect on harvest quality is another important aspect. It has been found that the EM-1 application promotes the accumulation in grain of a number of important constituents for man and animals, irreplaceable and replaceable amino acids which are necessary for synthesis of protein, hormones and other biologically active compounds. No less important is the EM-1 effect on the content of important chemical elements (P, Ca, S, Mn, Mg etc.) and microelements (Cr, Ni etc.) in grain. The positive effect of EM-1 on the content of lipids, carbohydrates and gluten in grain has been shown. The first data have been obtained on the EM-1 effect on Cs-137 and Sr-90 radionuclides transfer from soil to plants. This is important for agricultural production on territories polluted with radionuclides as a result of Chernobyl NPP accident.*

Introduction

At present, we possess considerable material about the efficiency of EM-1 application in plant cultivation and animal husbandry (Higa (1996), Jonglaekha et al. (1993), Zacharia (1993), Shin et al. (1993)). The scale of application of Effective Microorganisms widens every year. There are tendencies, on the one hand, of increase of number of articles revealing the basic mechanisms and processes of such efficient preparation (Piyadasa et al. (1993), Hussain et al. (1993)) and, on the other hand, of broadening of fields of its application.

Such activities are carried out in the Republic of Belarus too. The main tasks of them are the next:

1. To assess the efficiency of EM-1 application in plant cultivation in geoclimatic conditions of Belarus with local soil possibilities.
2. To reveal the factors and processes which are the basis of effects in agriculture. This is relevant for developing the strategy of purposeful use of different qualities of EM-1.
3. To study the EM-1 effect on the quality of agricultural produce.
4. To determine the possibility of EM-1 application in agricultural areas polluted with radionuclides as a result of Chernobyl NPP accident. This purpose is of special significance not only for Belarus but also for other countries, because the frequency of nuclear incidents is still quite high in the past years.

Materials and Methods

The assessment of efficiency of EM-1 application and the study of mechanisms of EM-1 influence on growth and development processes were carried out both in experimental conditions (phytotrone, Biological Experimental Station and Botanical Garden of the National Academy of Sciences of Belarus) and in field conditions: in economies of Minsk region of Belarus.

The plant germination, root system state, plant growth and development, yield and quality of grain were assessed. Different schemes of EM-1 introduction were used: before sowing, during and after sowing. Various doses of preparation were introduced and juxtaposed with the indices of plant development on different stages of its growth.

In the study of processes which are the basis of EM-1 action mechanisms, great attention was paid to the state of plant photosynthetic ability. The contents of chlorophyll and protein were determined with that end of view. Taking into account that these indices depend on enzymatic activity, the activities of chlorophyllase and ATPase were studied. The antioxidant ability of plants was assessed through the peroxidase activity.

In order to evaluate the quality of agricultural produce, the weight of grains was measured as well as the content of protein, fats, carbohydrates, amino acids, chemical elements and microelements in them.

In order to determine the possibility of EM-1 use on radiocontaminated territories, the Cs-137 and Sr-90 accumulation in plants was assessed as well as the coefficients of radionuclide transfer from soil to plants. The model experiments with radiocontaminated soil were held, and the experiments in field conditions in 30-km zone (evacuation zone) adjacent to Chernobyl NPP.

The Cesium-137 and Strontium-90 contents in soil and plants were determined by the methods of spectrometry and radiochemical analysis.

The principal types of study were carried out with oats (Gramineae) and soya bean (Leguminosae).

Results and Discussion

The study of EM-1 effect on plant germination showed that the EM-1 introduction into soil caused rise of germination by 20-25 per cent and more as compared with control both in oats and in soya bean. Along with the germination rise, the improvement of root system took place. The example of lemon was the most obvious: the rooting of cuttings increased under the EM-1 action by 10 per cent, and the length of root was 12.2 ± 0.7 cm whereas it was 9.6 ± 0.4 cm without EM-1 introduction ($P<0.05$).

The analysis of results of different schemes of EM-1 application shows that in case it is not possible to apply EM-1 several times, the best effect is reached at its introduction during sowing. Sufficiently high results can be reached only at triple EM-1 introduction: during sowing, after plant sprouting and before the blooming or earing phase.

The dosage of EM-1 application is also important in obtaining a positive effect. The positive effect is observed already at relatively small application doses: 0.3-0.5

ml/m^2. The stable result is reached at the introduction of 10.0 ml/m^2 into soil. The further increase of dosage provides the positive effect, however the efficiency does not increase. So, the increase of dosage up to 20.0 ml/m^2 did not increase the growth and development of plants, and in number of cases the decrease of EM-1 effect was observed. At the introduction of doses higher than 20 ml/m^2, the low effect was observed more frequently than at lower doses. Note that the efficiency of introduced preparation can be connected with type of soil and its physico-chemical characteristics.

The EM-1 application leads to the increase of formation of chlorophyll (green pigment of plants, which participates in the absorption of solar energy and its transformation into the energy of chemical relations of organic compounds of plants) in oats and soya. This increase up to 30 percent takes place on all phases of development and has its peak at the 10.0 ml/m^2 dosage of introduction.

The rise of protein content in plants takes place simultaneously with the increase of chlorophyll content. It is more significant in oats (up to 30 percent) and less in soya bean. This can be connected with the fact that soya bean contains more protein than oats, and therefore the increase is less evident.

The activity of chlorophyllase - enzyme participating in the regulation of chlorophyll content in plants - is still on the same level. The tendency is even observed to decrease its content. This fact can be considered as positive because chlorophyllase influences, as a rule, the processes of chlorophyll splitting.

Peroxidase is the enzyme which catalyzes oxidation processes in cells participating in plant respiration and carries out the defense function in plant organisms. Its activity increases almost at two times and this increase takes place all stages of plant development.

The EM-1 effect on the content of Cs-137 and Sr-90 in plants can be characterized as the increase of transfer of Cs-137 into plants and decrease of that of Sr-90. EM-1 exerts different influences on different soil substances (organic and inorganic). And cesium and strontium in their turn have different relations with soil substances. Cesium-137 and Strontium-90 are long-living radionuclides (the half-decay period is about 30 years) and they determine now the radiation situation after the Chernobyl accident. This situation will last for tens of years.

Important is that the Sr-90 transfer into plants decreases. In the last period, Sr-90 is transforming itself into the form which is biologically accessible to plants and thus causes the radioactive pollution of agricultural crops.

Along with the effect on growth and development of plants, it is very important to assess the EM-1 effect on the quality of agricultural produce. With that end in view, the contents of protein, fats, carbohydrates, micro-elements and amino acids in grain were measured. These substances are important both for plant growth and development and for its benefit for man and animals. The results obtained indicate, firstly, the expressed effect of EM-1 on protein content in plants and, secondly, the accumulation in grain of amino acids and chemical elements under the action of EM-1 important for living organisms.

In conclusion, we must say that plant development is provided by many factors. The energy of solar light is among them in combination with carbon dioxide entering from air and organic and mineral substances entering through the root system. Due to the function of photosynthetic apparatus of cells, they transform into necessary plant organism substances responsible for plastic processes, energy supply, antioxidant function, chlorophyll, ATP, protein, antioxidant system and so on. All these are regulated by enzymes: chlorophyllase, ATPase, peroxidase and others. The radioactive substances, including those released into the atmosphere at normal functioning of atomic stations, nuclear industries, lead to the disturbance of those processes. Application of EM-1 acts in the direction contrary to irradiation: activates the synthesis of chlorophyll, protein and enzymes participating in their formation, increases the antioxidant protection of plants and the resistance of plants to injuring factors. The effect of EM-1 and EMX application is determined in many by its dosage and scheme. And small doses can turn out more to be efficient than big ones. This is the principle. Besides, EM-1 acts on the level of soil, influencing the state of organic and mineral fertilizers including the radionuclides behaviour.

Conclusion The positive effect of EM-1 on plant growth and development is shown as well as the effect on seed quality. The last is connected with activation of photosynthetic processes and improvement of chemical composition (proteins, fats, carbohydrates, amino acids, microelements and so on) of grain.

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