Prospects of Utilizing Effective Microorganisms (EM-1 and EMX) in the Liquidation of Nuclear Accident Consequences

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Introduction

The scope of co-operation with EMRO and Okinawa Agricultural University is wide, however, three items need attention.

1. Effects of EM-1 application on plant growing and possible mechanisms of EM-1 action.
2. EM-1 application in animal husbandry and its action in organisms.
3. Revealing the possibility of EM-1 and EMX application at the Chernobyl accident and liquidation of consequences of nuclear incidents.

A great amount of data on EM-1 and EMX application in agricultural production is gathered presently. Such data appeared also in Belarus in the last 1.5 years. This paper highlights them including floriculture. But another question is also important: what is the cause of positive results obtained in the production increase ?

Effect on Plants

The EM-1 effect on plant germination is the first stage to consider. This is one of the principal factors of increased production.

The principal attention is focussed in this presentation on two plants; oats (Gramineae) and soybean (Leguminosae). The ways of soil inoculation were different namely three times one month before planting, during planting and after planting. The best effect on oats and soybean germination was obtained during and after planting yielding approximately a 30 percent increase.

In the second lemon cutting plantings, important factor influencing production was, state of the root system. In this example besides 15-20 percent and more increase of rooting, increase in number of shoots, height of plants and the increase of root system development takes place with EM-1 application. The length of root increases almost 10 percent at the soil inoculation with EM-1. The growth of oats and soybean too accelerates, especially of oats. The bushiness increases in soybean.

The most important factor determining the productivity is the state of photosynthetic apparatus of plants and, in particular, the level of chlorophyll formation. Under the action of EM-1 the growth of chlorophyll formation takes place. With EM-1 application, the chlorophyll increase up to two times in soybean and oats.

The activation of plastic processes takes place in plants in parallel with this process. This is manifested by the increase of protein formation. This increase under the influence of EM-1 was more significant in oats than in soybean. Such a result probably, is connected only with that experiment, when the optimum conditions were created. It is necessary to take into account that on the whole in soybean more protein was formed than in oats.

Beside the search for the most efficient scheme of EM-1 introduction into soil, the volume of the introduced preparation is also of great importance. With this aim four principal doses of EM-1 introduction into soil were tested. They were 0.3, 0.6, 3.0 and 30.0 ml of starting concentration for 1.0 m^2 in three portions. Small doses of EM-1 turned out to be the most efficient. The maximum effect both for oats and for soybean was reached at the introduction of 0.3 ml/m^2. The increase of introduced preparation volume did not lead to the increase of chlorophyll content. The most significant increase was obtained at the highest dose of introduced EM-1 – 30.0 ml/m^2. The same “dose-effect” dependence was found concerning the protein content in plants. The best effect relating to oats was obtained at the lowest EM-1 dose of 0.3 ml/m^2. Relating to soybean, these differences were not so significant.

These processes would not be possible without the enzymes activation in plants. Therefore special attention was paid on the second stage to the state of enzymatic systems of plants under the EM-1 influence. It was found that the EM-1 introduction leads to the activation of ATPase which

promotes ARP (the principal energy source in plants) fission with release of orthophosphate necessary for exchange processes including plastic ones with protein, mentioned above. A dose of 0.6-3.0 ml/m^2 introduced preparation was optimum both for oats and for soybean.
The activity of chlorophyllase (another enzyme participating in photosynthetic processes and regulating the level of chlorophyll content through the fission of its increased content) tends to decrease. This is observed both in oats and in soybean. The most considerable decrease of chlorophyllase activity takes place on the introduction of 0.6-3.0 ml/m^2 of preparation into soil.
It is necessary to fix attention on the EM-1 effect on peroxidase activity in plants. This enzyme activates the oxidation processes in cells of living organisms and takes part in the provision of protective functions, leading to the destruction of hydroperoxides which form in plants, and other underoxidized toxic products. As shown with other indices of growth and development of plants, the EM-1 introduction leads to the increase of peroxidase activity in plants. The most significant increase takes place at 0.3-3.0 ml/m^2 doses of introduced preparation. This index decreases at higher doses – 30.0 ml/m^2.
Consequently, the EM-1 use leads to the increase in germination and development of plants. This is associated with the activation of photosynthetic processes in plants as well as their protective function. Finally, it not only increases the plant's productivity but also increases its resistance.

Effects on Livestock

Another task concerning this study was the influence of EM-1 application in animal husbandry. Of two results the influence of EM-1 application in swine production and poultry breeding, is discussed first.
The EM-1 application in swine fattening was begun from 4-months age in the form of bokashi. The starting daily gain in swine group without EM-1 was higher. At the end of second month, both groups became equal. After 3 months of EM-1 application, the average daily gain of pigs became 250 g (or 1.5 times) higher than it was without EM-1. After 4 months and 5 months, this index decreased although it was still quite high.
EM-1 was added to the forage of broilers from 10 days age. The weight of broilers in the control group was somewhat higher at the beginning, however, after 30 days, the experimental group overtook the weight of the group without EM-1. After 50 days, the difference was 150 g.
It was interesting to clear the period of EM-1 application after which the maximum effect is reached. The maximum gain of broilers is observed after 20 days of EM-1 administration. They remain at this level during the following 20 days and further tends to decrease like in pigs.
Questions arise as to how does such EM-1 action impress on the organism and what is the reason for this gain. From the results two possibilities are suggested. EM-1 effects on muscular protein content and – as the faster growth of birds took place – state of calcium – phosphorus exchange. Many functions in the organism are connected with this exchange, in particular, the growth and development of bone tissue.
The EM-1 application in broilers leads to the rise of protein content, first of all in red and white muscles, providing good gain of broilers. The protein content in liver does not change. Its content in spleen increases slightly. This indicates that the spleen is sensitive to EM-1. It is important to stress that the nucleic acids content (RNA and DNA, which are responsible for genetical state and heredity) does not change.
Taking into account the good growth of broilers it was necessary to study the state of calcium-phosphorus exchange. The EM-1 administration did not change the calcium content in blood serum and led to the increase of phosphorus content. The acid-alkaline balance did not change and the protein content in blood serum increased like in muscles.
Analysis of calcium content in bones of broilers showed a decrease accompanied by the increase of phosphorus content. This conditions the decrease of Ca/P ratio in bones. The data obtained can be interpreted so that the bone formation accelerates under the EM-1 action. However the calcium receipt with the ration is not sufficient for quickly growing broilers. Consequently, we can get even

better results with addition of calcium salts into the ration. This is very important for laying hens too. We plan to deal with this problem jointly with EMRO in future.
The EM-1 application in animal husbandry and poultry breeding increases thereby the productivity and favorably influences a number of exchange processes. In separate cases, the optimization of ration can lead to the strengthening of positive results of EM-1 application.

EM on Irradiation Catastrophies

The study of possibility of use of Effective Microorganisms in mitigation of the Chernobyl catastrophic consequences proceeded by in two ways; firstly, EM-1 introduction into soil for decreasing the radio-nuclides transfer into vegetable production and, consequently, decreasing the dose commitments; secondly, EMX application as radio-protective mean at the organism irradiation.
First Way: The EM-1 introduction into soil as expected did not lead to the decrease of Cesium – 137 transfer from soil to plants, on the contrary: it increased. The highest effect was reached at lower dosage of EM-1 introduction into soil. Such regularities were observed both in Gramineae and in Leguminosae. It is necessary just to note that Cesium – 137 and Strontium – 90 are long-living radio-nuclides and determine the radiation situation.
Concerning the EM-1 effect on Strontium-90, another dependence is observed; EM-1 introduction causes, as a rule, the decrease of strontium transfer from soil to plants and accumulation in them. This effect is not so clear and needs to be studied further.
The question arises: what is the cause of such EM-1 effects ?
In case of Cesium it is known that up to 90-95 percent remain bound with organic and mineral substances of soil. The EM-1 introduction causes the rise of free and easily accessible Cesium forms and decrease of number of its bound forms for plants.
Relating to strontium, other changes are observed. In contrast to cesium, it has transformed up to 50 percent and more into free state and is easily absorbed by plants. The EM-1 introduction leads to lowering of free forms of strontium and its fixation in soil in the form of bound, fixed compounds. A number of factors influence these processes and new experiments and analyses are necessary.
Thus the EM-1 introduction into the radio-contaminated soil influences differently the state of radio-nuclides in it. This determines the possibility of EM-1 effect on radio-nuclides transfer from soil to plants, their inclusion into food chains, accumulation in human organism and formation of dose commitments for people.
Secondly: EMX application as radio-protector, i.e. radio-protective mean, much work was carried out here, when the primary positive results were obtained, because the dosage and the scheme of EMX application was not known. The radio-protective effect will be confirmed in this presentation with the establishment of two EMX properties: antioxidant and immunocorrecting.
It is known that the organism exposure leads to the activation of peroxidation system with formation of hyperoxides and decrease of antioxidant system function. In given case, the acute gamma-irradiation of animals was accompanied by the accumulation in blood of malonic dialdehide, one of principal products of lipid peroxidation. Simultaneously, the decrease of blood antioxidant activity was observed. The EMX application after the irradiation (2.5 ml/100 g of weight) prevented the malonic dialdehide accumulation in blood and decrease of antioxidant activity of blood. The two fold increase of EMX dosage did not strengthen the effect. This indicates the importance of selecting the optimum EMX dose, as with EM-1.
Even better results were obtained at chronic irradiation. The activity in blood erythrocytes of suproxide dismutase – one of the principal enzymes of antioxidant protection – decreases after the chronic irradiation, like the antioxidant activity of blood. Use of EMX during the irradiation normalized the level of superoxide dismutase activity. The effect of EMX use in 9 ml/100 g dosage was more significant than in 13 ml/100 g dosage.
The activity of catalase – second enzyme of organism antioxidant system – did not decrease during the first month after irradiation. However it became higher at EMX introduction than it was before

the irradiation. This can be interpreted as protective reaction of organism.
The same results were obtained in the conditions of animals confined within the 30-km zone, where they underwent chronic irradiation. The irradiation of the organism, the rise of hydroperoxides was observed as well as the lowering of the antioxidant system in the organism.
It is important to stress here that there were no considerable differences in the normalization of indices in EMX doses 45.0 and 125 ml/100 g in a month, Besides, EM-1 application in 45 ml/100 g dose in a month gave the same results as EMX application.
The analogous normalizing effect of EM-1 and EMX at the stay of animals in 30-km zone was also discovered regarding the change of catalase activity in blood erythrocytes and antioxidant activity in blood.
Another important item was that in the experiments on chronic irradiation of animals and the confinement of animals in 30-km zone, the decrease of mass of the spleen was found (one of principal organs in immunogenesis). The application of EMX protected the mass of spleen from decrease at the irradiation.
Taking this into account, attempts to protect the immune system on the conditions of irradiation was undertaken this year. The receptor, activation and proliferative properties of blood lymphocytes were studied. The confinement of animals in the zone conditioned the rise of proliferative ability of lymphocytes. Use of EMX in a bigger dose and EM-1 as well decreased this effect stimulated by the irradiation. The state of function of T-and B-cellular receptors decreases at chronic irradiation. Application of EMX in a bigger dose as well as of EM-1 caused protective effect. Similar data were obtained regarding the functional state of receptors to interleukin-2, when we could decrease the injuring action of radiation using EMX and EM-1. One more conclusion from the data of studied indices that EM-1 does not yield to EMX by the efficiency in the effect on immune system state. Thereby EMX and EM-1 have the radio-protective effect, activating the system of antioxidant protection and possessing immunocorrecting action.

Conclusion

The life and development of plants is determined by many factors. The energy of solar light is among them in complex with carbon dioxide entering from air and organic and mineral substances entering through the root system. Due to the function of photosynthetic apparatus of cell, they turn into the necessary plant organism substances responsible for plastic processes, energy supply, antioxidant function etc. chlorophyll, ARP, protein, antioxidant system and so on. All this is 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. This is marked with corresponding pointers. 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. Small doses can turn out more efficient than big ones. Besides, EM-1 acts on the level of soil, influencing the state of organic and mineral fertilizers including the radio-nuclides behaviour. However these processes are not studied yet, and this is a task.