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The Effect of Ammonium Carbonate Fertilizers on the Biological Activity of Soil

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Abstract: The influence of Ammonium Carbonate Compounds (ACC) and their combination with biologically active substances (VIDAKSes) on microorganism development in rhisospheric soil of agricultural plants as well as enzyme and aminoacid accumulation were studied ander the field and vegetative house. The results of this research were compared with ammonium nitrate application. It was found out that the use of ACC and VIDAKSes induces the development of asporogenic organotrophic microorganisms and nitrogen-fixing bacteria in the root system of the plants contributing to a decreased nitrification activity. The new agrochemicals increase the soil enzyme activity as well as the aminoacid content in most cases.

Key words: mineral fertilizers, microorganisms, enzymes, aminoacids.

Introduction

The use of new mineral fertilizers-ammonium carbonate compounds (ACC) means creating the ecologically safe soil protecting technology. Chemically, ACC are known to be a mixture of ammonium hydrocarbonate (NH_4HCO_3) and ammonium carbonate (NH_4CO_3). They compose 17% of nitrogen (N) and 50% of CO_2. Thus, ACC are considered to be complex nitric carbonate fertilizers.

Specialists (Veshitsky and Levchuk, 1995) proved that power consumption per nitrogen unit during ACC production is practically twice the less than that in the case of ammonium nitrate or carbamide. The same applies to VIDAKS preparations created in Scientific Engineering Centre AKSO of NAS in Ukraine on the base of ACC with the addition of the biologically active substances such as ivin (VIDAKSi) and sodium-humate (VIDAKS s-h). Besides, when compared to ammonium nitrate, the use of ACC was found to contribute to the growing quantity of the movable phosphate forms in the soil, which improves mineral supply of the agricultural plants (Nosko et al., 1998).

The results of the research of many years testify the efficiency of ACC used not only for planting winter wheat, maize, sugar beet and vegetables (Kravchuk, 1998, Ruban and Storchak, 1998), but also for planting soya beans, red clover and rye grass (Datsenko et a., 1998, Volkogon and Dulnev, 1998). Most of the scientists demonstrated that in combination with potassium fertilizers, ACC efficiency is much higher than that with ammonium nitrate.

Such an impact of ACC is explained by the fact that ACC contain nitrogen in the form that is easily assimilated by the plants so that this combination of fertilizers enables a better use of the plant potential.

It is evident that while being put in the soil, ACC influence microflora whose activity is connected to transforming biogenic elements, and producing, and utilizing biologically active substances.

The data obtained demonstrate a direct and indirect influence of ACC on the soil microorganisms. The direct effect of these compounds can be explained by the fact that they are an accessible source of nitrogen and carbon to many microorganisms including diazotrophic bacteria. In addition, it was demonstrated (Andreyuk et al., 1998) that ACC reinforce the plant root system development leading to an increase in exudates penetrating the soil, the last factor being of great importance to the supply of microflora.

Materials and Methods

The effect of ACC fertilizers on the biological activity of grey podzolic soil was studied under field and vegetative house conditions. The soil samples for the analyses were taken during different stages of agricultural plant development. The action of ACC was compared to that of ammonium nitrate used in the same amount.

The quantity of microorganisms was determined by the method of soil suspension inoculation of solid nutrient media, for organotrophic bacteria meat peptone agar, - for streptomycetes starh ammonia agar, for micromycetes, Chapek medium (pH 5.8), for nitrifying bacteria Vinogradsky medium, for prototrophic bacteria, Krasilnakov medium, for oligoazotrophic microbes, Ashbey medium, for anaerobic nitrogen-fixing microbes, Yemtsev medium (methods, 1991) for associated fixators - Debereiner medium in Kaseros modification. Nitrification activity was defined by the increase of the soil nitrates content after composting the soil with nitrification substrate, i.e.

intensity of sodium phenolphtalein phosphate in acid, neutral and alkaline media (Dubovenko, 1960). Catalase activity was defined by decomposition intensity of hydrogen peroxide (Kaznelson and Yershov, 1958). Aminoacid content was studied by application method (Methods, 1991). Microbe quantity was determined in CFU (Colony Forming Units) per one gram of dry soil. Average data are given in tables and figures.

Results and discussion

In the experiment with maize it was stated that mineral nitrogen fertilizers increased the development of organotrophic asporogenous microorganisms. In the case of ammonium sulphate, their quantity was 2.1 times higher than that with control. In the cases with ammonium nitrate and ACC, these were 2.7 and 3.6 times higher, respectively (tab.1.). Microbiological growing life activity can be proved by the lowering ratio of sporeforming to asporogenous bacteria.

The best results were obtained in variants with ACC and ammonium nitrate. The qunatity of streptomycetes almost did not change under the impact of fertilizers but the number of micromycetes was the highest in the case of ammonium nitrate.

Tab.1. Composition of Microbial Associations under Applying Different Mineral fertilizers

Research Variant	Organotrophic Bacteria			Streptomycetes $10^6 g^{-1}$	Micromycetes $10^3 g^{-1}$
	Asporogenous $10^6 g^{-1}$	Sporeforming 10^6	% of asporogenous		
Control	42	0.88	2.1	0.10	8
Ammonium Nitrate (N_{90})*	115	0.35	0.3	0.13	16
Ammonium Sulphate (N_{90})	90	0.55	0.6	0.008	10
ACC (N_{90})	164	0.65	0.003	0.20	12

* all nitric fertilizers were put into the soil against the background P60 k60

The use of mineral fertilizers increased the development of microorganisms of eutrophic block, first of all those using organic and mineral forms of nitrogen (Fig.1). The quantity of denitrifying and oligotrophic microorganisms grew also higher. The quantity of nitrifying bacteria increased 3.1-3.7 times compared to the control. At the same time, this quantity decreased 3.3 times when ACC was applied.

Nitrification activity with the use of ACC was nearly twice lower than that in the variant with ammonium nitrate and 1.2 times lower than that in the control. Suppression of nitrifying bacteria development and their activity in the

result of an increasing CO_2 content released by fertilizer decomposition. The lower level of nitrification prevents soil pollution, soil waters and vegetation with nitrates.

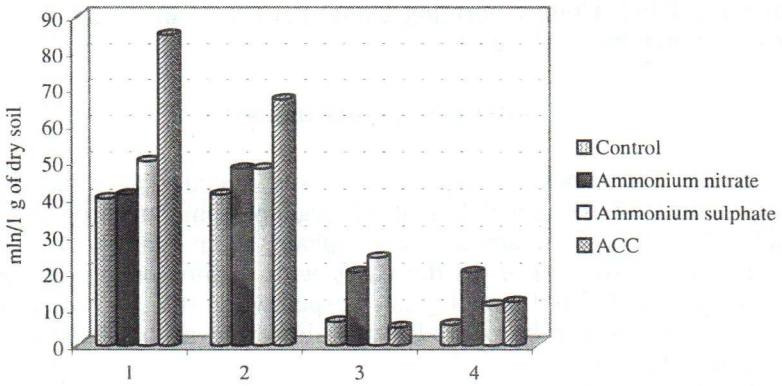

Fig.1 The Influence of Nitrogen Fertilizers (N_{90} against the background $P_{60}0K_{60}$) on the Quantity of Bacteria Transforming Nitric compounds, 1-organotrophic microorganisms, 2-those assimilating nitric nitrogen, 3 nitrifying bacteria, 4- denitrifying bacteria

The results of studying the influence of different nitrogen fertilizers on the microflora of maize rhizospheric soil (tab.2) point to the advantages of using new agrochemical compounds in relation to the traditional ones. During the research period, the variant with ACC shows that there were 18% more oligoazotrophic bacteria and 123% more anaerobic nitrogen-fixing microorganisms than being in the variant with ammonium nitrate. VIDAKSes put into the soil contributed to the increase in nitrogen-fixing microorganisms development in relation to not only ammonium nitrate but to ACC, as well. Carbamide was found to weaken prototrophic microorganism development to a certain extent.

Positive influence of ACC and VIDAKSes on nitrogen-fixing micro-organisms in maize rhizospheric soil enabled conditions improving biological nitrogen fixing on the whole.

The positive influence of complex ammonium carbonate fertilizers on the development and activity of agrarian useful microflora in maize rhizospheric soil led to the increase in fertility and improvement in vegetation production quality. The use of ammonium nitrate has raised green mass production of maize (depending on fertilizer dose), 7.6-28.6% of grain, 11.9-14.4%. The application of ACC has raised green mass by 13.7-37.9%, 14.2-18.5% grain.

VIDAKS s-h application resulted in obtaining of 18.7-53.7% green matter 15.5-21.4% for the grain.

The vegetation production attained by the use of the new fertilizers had 8-11% more of dry matter content and basically lower one (1.4-2.2 times) of the nitrates.

Tab.2. Quantity of Microorganisms in Maize Rhisosphere Soil*

Nitrogen fertilizer, N_{45}	Prototrophic microbes, $10^6 g^{-1}$	Oligoazotrophic microbes, $10^6 g^{-1}$	Nitrogen-fixing bacteria		
			Azotobacter, % of owergrown lumps	Associative, $10^3 g^{-1}$	Anaerobic $10^6 g^{-1}$
Ammonium Nitrate	1.9	10.7	55.3	40.7	5.5
Carbamide	1.4	12.6	52.7	46.5	2.1
ACC	2.3	12.7	55.3	41.5	12.3
VIDAKS-i	1.6	11.5	69.3	55.6	19.6
VIDAKS-s-h	1.8	13.8	68.0	57.4	11.7

*As shown in tab.1. and 3, all the nitrogen fertilizers were put against the background $P_{30}K_{30}$.

It is known that soil always has enzyme hydrolases, oxydoreductases, syntetases, etc. phosphatases and catalases play an important role in forming soil biological potential. Phosphatases (acid, neutral and alkaline) catalyse hydrolasis of phosphoric organic compounds with unorganic ion release.

Catalase takes part in the decomposition of hydrogen peroxide formed as a result of oxidation-reduction processes in living organisms and in the soil, as well.

Therefore, we came to conclusion that (tab.3.) in the experiment with *Promopsis infermis* Leiss , the total phosphatase activity of rhisospheric soil with the use of ammonium nitrate and ACC was 20 and 30%, respectively, higher than that in the control group. In the experiment with alfalfa using VIDAKS s-h, phosphatase activity was the highest and exceeded the data with ammonium nitrate used by 28.5%. The intensification of rhisosphere soil catalase activity under the effect of new agrochemicals and especially of VIDAKS s-h was essential only in the experiments with maize and *Promopsis infermis* Leiss. However, basiaclly, the results showed no differences with alfalfa.

Tab.3. Influence of Different Nitrogen Mineral Fertilizers on Rhizospheric Soil Enzyme Activity

Nitrogen fertilizers, N_{45}	Rhizospheric Soil		
	Maize	*Promopsis infermis*	Alfalfa
Total phosphatase activity (mg phenolphtalein · 10^{-1} g of the soil)			
Control	2.43	10.31	7.61
Ammonium nitrate	2.62	12.48	7.01
ACC	2.36	13.20	7.27
VIDAKS s-h	2.38	10.58	9.00
Catalase activity (ml 0.1 N $KMnO_4$· 10^{-1} g of the soil)			
Control	22.9	56.4	50.9
Ammonium nitrate	28.1	51.7	48.5
ACC	30.4	53.2	44.6
VIDAKS s-h	38.7	53.8	48.7

Soil biological potential depends to a great extent on the level of free aminoacid accumulation. It is considered one of the links in nitrogen circulation. Changes in the quantity and composition of aminoacids indicate microbiological and biochemical processes in the soil. These processes increase soil fertility and yield of the agricultural vegetation.

The introduction of nitrogen mineral fertilizers into the soil has increased the content of aminoacids in rhizospheric soil of cultivated plants (Fig.2). In the experiments with maize, the best results were obtained in the variant with VIDAKS s-h and in those with *Promopsis infermis* and alfalfa in the variant with ACC. The figures look higher than those in the control group by some 19, 20 and 80%, respectively.

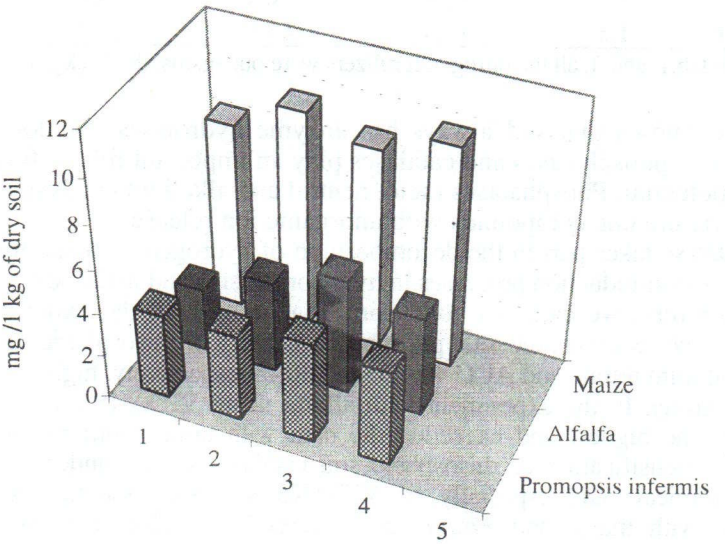

Fig.2. Accumulation of Free Aminoacids in Rhisospheric Soil. 1 - Control, 2-Ammonium nitrate, 3- ACC, 4-VIDAKS s-h

The new fertilizers contributed to the increase in alfalfa green mass yield by 15.7-18.3%, Promopsis infermis by 4.2 to 7.6%, as well as to an increase in the plant root mass by 20/5-34.8%, and to that of the root active absorbing surface 42-80%. When compared to the traditionally used ammonium nitrate, the impact felt on the root systems obviously improved the mineral supply of plants provided more organic substances in the soil upper layer, being an important factor of humus conservation and of soil fertility renewal.

Thus, when compared to ammonium nitrate, the new agrochemicals (ACC and VIDAKSes) were found to have a more positive effect on the formation of the useful microbial associations in the rhizospheric soil of agricultural plants, then in the increase of soil enzyme activity and free aminoacid content. All these factors led to the growth of the agricultural vegetation production, to a better vegetation quality and a more stable humus content in the soil.

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EFEKAT ĐUBRIVA NA BAZI AMONIJUM KARBONATA NA BIOLOŠKU AKTIVNOST ZEMLJIŠTA

- originalni naučni rad-

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U radu su ispitivani uticaji đubriva na bazi jedinjenja amonijum karbonata (ACC) i njihovih kombinacija sa biološki aktivnim substancama (VIDAKSes) na razvoj mikroorganizama u rizosfernom zemljištu poljoprivrednih kultura, kao i akumulacija enzima i amino-kiselina u njima gajenih na otvorenom polju i u stakleniku. Rezultati istraživanja su upoređeni sa rezultatima dobijenim primenom amonijum nitrata. Ustanovljeno je da primena ACC i VIDAKSes-a aktivira razvoj asporogenskih organotrofskih mikroorganizama kao i azotofiksirajućih bakterija u korenovom sistemu biljaka, kao i smanjenje nitrifikacione aktivnosti zemljišta. Nova agrohemijska sredstva povećavaju enzimsku aktivnost kao i sadržaj amino kiselina u većini slučajeva.