EFFICACY OF EM-PREPARATION USED FOR OPTIMIZATION OF EGGPLANTS NUTRITION

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The use of EM-technology (soil tillage, treatment of seeds, seedlings and plants during the growing season with EM- preparation) on the left-bank Forest-Steppe zone of Ukraine under irrigation results in improvement of eggplant marketable yield on 2.6 t/ha or 18 % as comparing to control, increase of nutrients content and reduction of nitrate levels in fetus. Application of EM-technology ensures profit of 4.2 thousand UAH/ha, profitability within 92 % and has bioenergetic efficiency factor 2.99.

Keywords: *eggplant, EM-technology, productivity, product quality, economic and bioenergetic efficiency.*

Nowadays, the demand for environmentally friendly products, grown using “organic” technologies is increasing dramatically. There is a number of biological preparations In Ukraine used for protection of vegetables, including eggplant, from the major pests (Colorado potato beetle) and diseases (late blight). Cultivation of eggplant using “organic” technologies requires certain environmentally friendly means for optimization of plant nutrition. There are number of works done on optimization of eggplant nutrition in different soil and climatic conditions performed by D. Aliyev (Azerbaijan), V. S. Vadyana (Georgia), Ye. I. Tkalova (Moldova), E. V. Agafonof, A. N. Bogachev, A. J. Chernov, B. S. Barskiy (Russia), V. A. Babich and R. F. Nedbal (Ukraine, Steppe zone) [1–6]. But in most cases they have studied the effectiveness of mineral and organic- mineral fertilizer systems. One of the important ways to improve eggplant nutrition in “organic” agriculture is utilization of organic fertilizers, but their amount is limited due to the sharp decrease of livestock in Ukraine. The real and promising way of improving the nutrition of plants is the use of microbial preparations that can enhance nitrogen fixation processes in rhizosphere, increase the mobility of phosphorus, potassium and other elements compounds, cause increased soil mineral weathering processes and, in general, promote intensive development of the plants.

The research was aimed to develop an optimization system for eggplant nutrition for growing in “organic” conditions.

Materials and methods. The study was conducted in the laboratory of agricultural chemistry and analytical measurements of Institute of Vegetables and Melons Growing NAAS during 2010–2012 on typical chernozem, low humuc and heavily loamy soil according to the recommendations and guidelines for agricultural chemistry and vegetable growing. Eggplant of Almaz variety was grown under the commonly used technologies for steppe Ukraine using sprinkler irrigation method.

The efficiency of microbial preparation “Baikal EM-1Y” (EM-preparation) that includes a vast variety of useful microorganisms – *Lactococcus lactis*, *Lactobacillus casei*, *Saccharomyces cerevisiae* and *Rhodopseudomonas palustris* was studied. Microbial preparation “Baikal EM-1U” was used in accordance to the following scheme: 1) before greenhouse sowing eggplant seeds were soaked in the preparation

suspension – 1 l/t (1 ml/kg), dilution 1:1000; 2) week before planting – 50 l/ha, dilution 1:100; 3) seedlings spraying in greenhouse (three times); 4) plants spraying during the growing season – 20 l/ha, dilution 1:500, during 3 plant growth stages – enduring, start of flowering and fruiting. Rates of EM solution were as following: 400 l/ha – for soil treatment and 200 l/ha – for foliar application.

Besides the EM-applications we included control variant and two other options: mineral fertilizers ($N_{140}P_{120}K_{90}$) and organic- mineral fertilizers (compost 40 t/ha + $N_{60}P_{60}K_{60}$) into the experiment.

The general plot area was 31.5 sq.m (5 m x 6.3 m), record – 19.6 sq.m (4 m x 4.9 m), repetition – four-fold, location sites - one layer, in system.

Results and discussion. The increase of nitrate nitrogen contents in the plow layer of soil was observed during two years of research in variants where the fertilizers and EM-product were used. Thus, in the stage of active growth of control plants the nitrate nitrogen content in the plow layer of soil was 70.9 mg / kg, in variants with fertilizers – 108.1–133.9 mg/kg, in variants with EM-preparation – 131.1 mg/kg dry soil. Gradually, the content of nitrate nitrogen in the plow layer of soil in all experimental variants was decreasing, due to its utilization by plants and migration within the soil profile. Still, in variants with fertilizers application, its values were higher than in control. In flowering stage the content of nitrate nitrogen in the soil under the different fertilization systems was 69.3–89.3 mg/kg (without fertilizers – 51.7 mg/kg), while at fruiting stage – 46.2–76.4 mg/kg (36.9 mg/kg dry soil in control). At the end of the growing season nitrate nitrogen content in the soil in variants with EM technology application was reduced to the control level (34.7 mg/kg). Thus, microbial preparations had actively mobilized soil nitrogen during the initial stages of plant growth, which resulted in shortage of nitrogen for eggplants nutrition during the fruiting stages in variants with EM technology use.

The content of mobilized phosphorus in arable soil layer can be significantly affected only by the application of fertilizers. The highest content of mobile phosphorus in the soil was observed in the variants with organic-mineral fertilizers: active growth stage – 117 mg/kg dry soil (without fertilizer – 101 mg/kg), flowering stage – 169 mg/kg (control – 156 mg/kg), early fruiting stage – 108 mg/kg (control of 88 mg/kg). Mobilized phosphorous content in the soil in variants with EM-product application was at the same level as in control – 81–96 mg/kg dry soil.

The content of exchangeable potassium in the plow layer of soil was also significantly dependents on the application of organic and mineral fertilizers. In variants with EM-preparation the potassium content had gradually decreased from 184 mg/kg dry soil in the active stage of plant growth to 125 mg/kg dry soil in fruiting stage, which is, more likely, due to the active utilization of mobile compounds of given element for eggplant nutrition.

It was established that the application of fertilizers had reduced the number of rhizosphere fungi in soil, especially in the first half of the eggplant growing season. Thus, during the stage of active plants growth the number of *Micromycetes* in control was 23.03 million/g dry soil, at application of fertilizers – 18.87–19.83 m/g dry soil and at in variants with EM-preparation use – 20.17 million/g dry soil. During the flowering stage the number of CFU of fungin in control variant 13.97 million/g dry soil, in variants with fertilizers application – 11.53–15.60 m/g dry soil, and in variants with EM-preparation – 19.0 million/g dry soil. At a later period, the number of fungi

in the rhizosphere soil in variants with fertilization and application of EM-preparations was 12.37–17.48 m/g dry soil while in control there number was 11.47 million/g dry soil.

It was noticed that the number of phosphorous mobilizing microorganisms had increased in the variants with organic and mineral fertilizers. Thus, in stage of active eggplants growth this indicator in control variant was 0.28 million/g dry soil, while in variants with fertilizer application – 0.56–0.68 m/g dry soil, and 0.44 million/g dry soil – in variants with EM-preparation use. The number of phosphorous mobilizing bacteria during the flowering and fruiting stages under different fertilization systems had not changed.

Application of fertilizers had increased the number cellulose destructing microorganisms, especially in variants with organo-mineral fertilization system. The number of cellulose destructing bacteria had varied during the eggplant ontogenesis and had ranged from 11.5 to 24.2 thousand/g dry soil (in control – 5.4–11.5 thousand/g dry soil). Both EM technology and fertilization had not influenced significantly on this indicator.

Fertilizers application had affect the growth of bacteria of nitrogen cycle in different ways (Table 1). Thus, during the initial stages of eggplant development the largest number of diazotrophs was observed in control variant (14.26 thousand/g dry soil), whereas fertilizers and microbial preparation had decreased this number to 8.53–14.10 thousand/g dry soil. The number of nitrogen fixing bacteria during the flowering stage had increased in the variants with fertilizers application, especially in the one with compost (40 t/ha + N₆₀P₆₀K₆₀) and use of EM technology (74.13–76.7 thousand/g dry soil).

It was established that during active growth and flowering stages the number of microorganisms that metabolize mineral nitrogen in the rhizosphere soil had significantly increased comparing to control in the variants with organic-mineral fertilizers (31.2–34.7 m/g dry soil). The same tendency was also observed at fruiting stage but in the variants with EM product application (14.21 m/g dry soil).

The largest number of microorganisms that mainly assimilate organic nitrogen during the active growth stage was observed in control variants (25.0 million/g dry soil) and in variant with 40 t/ha compost + N₆₀P₆₀K₆₀ (16.23 m/g dry soil). During the flowering stage, the largest number of microorganisms of this group was found in the rhizosphere soil of eggplants in variant with EM technology (31.4 million/g dry soil). This tendency had persisted during fruiting stage. Thus, the number of microorganisms that mainly assimilate organic forms of nitrogen in variants with EM technology was 42.07 million/g dry soil, while in rhizosphere soil of eggplants in variant with the application of organic and mineral fertilizers – 10.32–13.23 m/g dry soil.

Fertilization had caused increase of the mineralization coefficient (due to the growth of microorganisms that assimilate mineral forms of nitrogen). The most intensive increment of this indicator was in the variants with N₁₄₀P₁₂₀K₉₀ and 40 t/ha compost + N₆₀P₆₀K₆₀. Application of EM-preparation had no significant effect on the variation of mineralization coefficient.

It should be noted that no changes of potential nitrogen fixation activity was observed in the variants with application of mineral and joint organic-mineral fertilizers. Application of EM preparation had ensured the growth of this indicator

during the flowering and fruiting stages – 70.1 C₂H₄/g dry soil per h and 42.68 C₂H₂/g dry soil per h., respectively.

TABLE 1. Effect of fertilizers and EM preparation on the development of microorganisms of nitrogen cycle in rhizosphere soil of eggplants.

Variants	Nitrogen fixing bacteria, thsd/g dry soil	Microorganisms, cultivated on SAA, mln/g dry soil	Microorganisms, cultivated on MPA mln/g dry soil	Mineralization ratio	Potential activity of nitrogen fixation nmol C ₂ H ₄ /g dry soil per hour	Potential activity of denitrification nmol N ₂ O/g dry soil per hour
Active growth stage						
Control	14,26	30,57	25,0	1,22	71,4	18,29
N ₁₄₀ P ₁₂₀ K ₉₀	8,53	23,03	5,7	4,04	24,6	23,34
Compost 40 t/ha + N ₆₀ P ₆₀ K ₆₀	14,1	34,73	16,23	2,14	73,5	25,18
EM-preparation	12,6	15,87	6,27	2,03	65,4	42,88
LSD ₀₅	1,34	1,77	1,12		2,3	1,56
Flowering stage						
Control	61,3	10,6	14,07	0,75	63,2	24,52
N ₁₄₀ P ₁₂₀ K ₉₀	58,07	17,6	16,67	1,06	64,1	27,59
Compost 40 t/ha + N ₆₀ P ₆₀ K ₆₀	74,13	31,2	18,8	1,66	66,6	32,06
EM-preparation	76,7	14,1	31,4	0,45	70,1	57,05
LSD ₀₅	1,2	1,25	2,01		3,4	2,03
Fruiting stage						
Control	14,32	7,12	9,97	0,71	27,95	9,31
N ₁₄₀ P ₁₂₀ K ₉₀	15,07	11,29	10,32	1,09	29,41	11,35
Compost 40 t/ha + N ₆₀ P ₆₀ K ₆₀	12,60	13,33	13,23	1,01	35,17	10,92
EM-preparation	13,90	14,21	42,07	0,34	42,68	10,05
LSD ₀₅	1,44	1,05	1,11		2,65	1,54

*) – microorganisms that mainly assimilate mineral nitrogen

**) – microorganisms that mainly assimilate organic nitrogen

It was established that the application of fertilizers and microbial preparations promotes increment of potential denitrification activity in rhizosphere soil of plants. During the active plant growth stage in variants with fertilization and EM preparation, the potential denitrification activity was 23.34–42.88 nmol N₂O/g dry soil per h., during flowering stage – 27.59–57.05 nmol N₂O/g dry soil per h, during the fruiting stage – 10.05–11.35 nmol N₂O/g dry soil per h.

It was shown that application of organic and mineral fertilizers had ensured an yield increase of marketable eggplant on 5.2–6.3 t/ha or 36.6–44.4 % if comparing to the yield values in control variants – 14.2 t/ha (Table 2). Use of EM-preparation had caused productivity growth of eggplant up to 2.6 t/ha or 18.3 % if comparing to control.

TABLE 2. Productivity of eggplants under the influence of microbial preparation and fertilizers (mean data for 2010–2012).

Variants	Marketable products yield, t/ha				Increment, t/ha	Marketability, %
	2010	2011	2012	Mean value		
Control	13,6	7,5	21,6	14,2	-	93,8
N ₁₄₀ P ₁₂₀ K ₉₀	17,9	12,7	30,9	20,5	6,3	96,8
Compost 40 t/ha + N ₆₀ P ₆₀ K ₆₀	16,9	10,9	30,5	19,4	5,2	96,5
EM-preparation	14,2	9,9	26,4	16,8	2,6	94,5
LSD ₀₅	1,6	2,8	2,5			

Eggplant marketability in variants with fertilizers and microbial preparation use had ranged within the 94.5–96.8%, which was slightly higher than in control variant – 93.8 %.

It was established that investigated technological factors had affected biochemical indices of eggplants (Table 3). The tendency of dry matter content increase in fruits was observed in variants with EM technology – 9.75 % versus 9.42 % in control. The same relations were observed for sugar content increase in eggplants in variant with N₁₄₀P₁₂₀K₉₀ application and use EM technology (2.82 and 2.86 %, respectively). Ascorbic acid content in the variants with fertilizers application and use of microbial preparation were slightly lower if comparing to the control variant. Use of EM-preparation had promoted reduction of nitrate levels in fruits. Thus, nitrate contents in fruits in variants with EM technology was 123 mg/kg, while in variants with fertilizers application – 195 mg/kg green weight.

TABLE 3. Effect of microbial preparation and fertilizers on biochemical indices of eggplant fruits (mean data for 2010–2012).

Variants	Content			
	Dry matter, %	Sugar, %	Ascorbic acid, mg/100 g	Nitrates, mg/kg green weight
Control	9,42	2,61	2,32	154
N ₁₄₀ P ₁₂₀ K ₉₀	8,94	2,82	2,02	195
Compost 40 t/ha + N ₆₀ P ₆₀ K ₆₀	8,83	2,64	1,51	207
EM-preparation	9,75	2,86	2,06	123
LSD ₀₅				300

Use of EM preparation in eggplant growing technologies is cost-effective and quite profitable (Table 4). EM technology returns are equal to 4.21 UAH/ha, leveling with the profit of fertilizers use – 4.46 UAH/ha. Due to the low expenditure costs of microbial preparation use the production costs of eggplants are relatively low (0.78 UAH/kg), with the highest profitability – 91.9 %. In terms of bioenergy effectiveness the use of EM preparation concede fertilizers application but still is significantly higher than the control variant values.

TABLE 4. Economic and bioenergetic efficiency of EM preparation use in the growing technologies of eggplants

Variants	Profit, thousand UAH/ha	Profit from preparation and fertilizers application, thousand UAH/ha	Full costs of 1 kg of output	Production profitability, %	Bioenergetics efficiency coefficient
Control	7,86	-	0,95	58,5	2,59
N ₁₄₀ P ₁₂₀ K ₉₀	12,32	4,46	0,90	66,8	3,18
Compost 40 t/ha + N ₆₀ P ₆₀ K ₆₀	10,36	2,50	0,96	55,3	3,13
EM-preparation	12,07	4,21	0,78	91,9	2,99

Summarizing, the use of EM-preparation had improved nitrogen nutrition of eggplants, especially in the initial periods of their growth. EM technology had no effect on the content of mobilized phosphorus and potassium in the soil. It had ensured certain positive changes in the microbiological community of rhizosphere soil of eggplants: increase of phosphorous mobilizing bacteria number during the stage of active growth of plants, the number of nitrogen fixing bacteria during the flowering stage and the potential nitrogen fixation activity.

Application of EM-preparation improves the yield of marketable products of eggplant up to 2.6 t/ha or 18.3 % comparing to control, which had not significantly conceded to the application of mineral and organic-mineral fertilizers.

EM technology has a positive impact on the nutritional content of eggplant fruits: higher dry matter content and total sugar and lower nitrate levels.

Application of EM product ensures 4.21 UAH/ha returns. While its production costs are only 0.78 UAH/kg the product profitability is 91.9 %, with the rate of bioenergetic efficiency – 2.99.