BIOPREPARATIONS FOR THE PRODUCTION OF ENVIRONMENTALLY SAFE FOOD – Part I

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Abstract: Russian biopreparations cover almost all aspects of the problem of growing plants. The history of development and implementation of industrial large-scale production of biopreparations in Russia goes back more than 40 years. Biopreparations have a purposeful action and are divided into the following main types: bioinsecticides, biofungicides, biofertilizers, immunomodulators and regulators of plant growth and development, as well as land-fertilizing biopreparations. The variety of Russian biopreparations can fully ensure the implementation of the potential varietal properties of agricultural plants, minimize damage from adverse weather conditions, reduce the cost of chemicals, restore soil humus and obtain environmentally friendly food.

Keywords: biotechnology, biopreparations, plants, ecology, biofungicides, growth biostimulators, bioinsecticides, industrial production.

INTRODUCTION

Providing the population with ecologically safe food products is a national task for any country. This is connected with the unprecedented pollution of soil, air and drinking water with chemicals and wastes from enterprises.

New terms appeared in the world nowadays: "organic farming, organic food products". They mean production of products without use of chemical pesticides.

Vegetables and cereals are among main food products. The volume growth of the vegetables produced in Russia is 12% in two years [1]. Consumption of vegetables and fruits is a prevention of such terrible diseases as cancer, asthma, heart attack. It reduces the risk of heart attack by 43%, lung cancer by 50%, liver cancer - up to 50%, uterus cancer - up to 30%.

Potatoes and grains have the highest volume of production among agricultural products in Russia. Previously, each introduced kg of mineral fertilizers gave 28 kg of yield increase, currently it gives only 5 kg. The effectiveness has been significantly reduced by suppressing the beneficial microflora of soil, resulting in its obvious degradation. For example, the straw that remains in the fields doesn't naturally decompose. At the same time, it is shown that the use of microorganisms for soil and plant cultivation can give from 50 to 300 kg of nitrogen per hectare, which is equivalent to 1 ton of mineral fertilizers.

Therefore, it is extremely important to use the results of innovative agrotechnological development that can solve such problems as increasing the productivity of agricultural plants, improving the quality and safety of products, as well as preserving and restoring of soil fertility.

What can biotechnologists offer right now to help the agriculture? Years of scientific and industrial experience in the sphere of industrial development of biopreparations for agriculture can assure that complex method of using the biopreparations, specifically the

System of biofertilizers, biofungicides and bioinsecticides, fertilizing biopreparations, biofertilizers and immunomodulators, is capable to give the necessary protection, increase drought resistance, provide a yield increase up to 28%, obtain a high-quality crop with minimal chemistry use, reduce the maturation period by 1.5-2 weeks, increase the quality indicators: starch, vitamins, gluten, oil, dry substances, organic acids, energy value and other indicators. As the result, it can give the consumer an environmentally friendly high-quality product.

MATERIALS AND METHODS

The following biopreparations were used during the study:

BICOL – bioinsecticide, produced according to the unified author's technology based on the polycomponent nutrient medium (PCM) and bacteria *Bac. Thuringiensis* ssp. *Thuringiensis* strain 98 in apparatus $V=63\text{ m}^3$. This biopharmaceutical is made in the form of a dry wettable powder with a viable spore titer of 609 spores/g and the biological activity of $LC_{50} = 10.1 \cdot 10^6$ spores/ml for larvae of the second-generation gypsy moth [2]. BICOL effectiveness was determined in the field on various insects using standard and ultra-small-volume sprayers in accordance with generally accepted conditions for the use of biopreparations with a flow rate 0.28 to 1.2 kg/ha.

LUTAN – complex biofungicide, also produced according to the author's technology based on several strains of *Trichoderma* fungi. It is a broad-spectrum biofungicide for different phytopathogens, and it contains 3 to 5 different active components. LUTAN was produced in apparatus $V = 1.5\text{ m}^3$ and 10 L in the form of a liquid suspension concentrate. Biofungicide was used against various diseases of the following plants: apple, cabbage, beet, cucumber, tomato, grapes, and flowers in a dose of 0.5 to 1.5 liters per 1 hectare by spraying with a working suspension. The efficiency analysis was carried out by standard methods.

NIKFAN - liquid biofertilizer, also produced according to the author's technology based on endophytic fungi, in a form of a liquid concentrate in apparatus V=10 L [2]. This preparation contained active metabolites of the culture-producer: auxins and cytokinins phytohormones, precursors of phytohormones, active microelements, humic and fulvic acids, potassium, silicon and components of the commodity form: stabilizer, antibacterial component, perfume. NIKFAN was used in the form of a working suspension with a dose of 1-2 ml per 1 hectare, as well as a concentrated working suspension with a dose of 0.4 liters per 1 hectare as a sheet dressing and 0.8% suspension for seed treatment before sowing.

The efficiency of biopreparations was verified according to the following indicators: the number of fruits, the weight of the fruit, the maturation period, the color intensity of the leaves, the content in the leaves of chlorophyll, and also according to the concentration of vitamins, energy value and other indicators in the case of fodder corn.

RESULTS AND DISCUSSION

The main effects of implementation of innovative agrotechnological developments:

- Increase of productivity of agricultural plants;
- Improving of the quality of products;
- Improving of safety items;
- Conservation and restoration of soil fertility;
- Production of environmentally safe food.

At the same time, the content of toxins, the infection with phytopathogens and harmful insects are minimized. The above effects can be achieved only through the application of a systematic approach consisting of the use of biopreparations: bioinsecticides, biofungicides and biofertilizers. This system should also include the right crop rotation, high-quality seeds, use of siderate-plants, use of specific biologies: nitrogen fixers and phosphomobilizing preparations, as well as special means - traps from harmful insects. All of the above components of the System provide the required effects, revitalize the soil microflora and restore soil humus.

The use of biopreparations makes it possible to use food in 3-5 days after treatment. It is proved that biological products not only don't affect the taste, color and nutritional value of products, but also increase the content of vitamins and mineral components.

For a long period of industrial production of CPP (crop protection product) biopreparations (from 1972, when maximum productivity of Russian factories reached 11,000 tons of CPP biopreparations in the form of dry wettable powders per year in 1982, to the present day) the high efficacy of biologies and their ecological safety was proved.

The BICOL bioinsecticide contains a spore-crystalline complex as an active principle and an exotoxin, produced by bacterial cells. The main difference between bioinsecticides and chemicals is that they are developed on the basis of microorganisms taken from nature, they have high selectivity of action and they are harmless to humans, animals and useful insects. The effectiveness of protection reaches 80-97%. For example, BICOL protects beets, carrots, cabbage and other vegetables from a complex of leaf-eating caterpillars: celery looper, white butterfly, meadow moth, with a concentration of 4-5 g of the preparation per 1 liter. To protect apples, pears, cherries, plums against the apple moth caterpillars, leafworm, moth, hawthorn, American white butterfly, silkworm and other insects, the biopreparation is used in a concentration of 5-7 g/L. BICOL is effective against leaf rollers caterpillars, melonworm, moth, leaf gall midges, spider mites at a concentration of 8 g per liter. It is also effective against pests of medicinal herbs. BICOL is a splendid protection of cucumbers, flowers and peppers in greenhouses from spider mite [2].

Biofungicides are able to suppress fungal and bacterial infections and are mainly produced from microorganisms derived from natural objects, often these are soil inhabitants. Among the most common producers of biofungicides are fungi of the genus *Trichoderma*, bacteria *Bac. Subtilis*, *Pseudomonas*, *Azomonas agilis*, *Azotobacter*. Biofungicides made from bacterial strains of *Bac.subtilis* are well known as a good source of antibiotics and enzymes that also have high efficiency. Some preparations are made from *Pseudomonas aureofaciens* and *fluorescens*, which are known for a long time as producers of antibiotics and biologically active substances, capable to inhibit phytopathogens and to stimulate plant growth. *Pseudomonas*, in contrast to bacilli, have an even faster growth rate and, as a rule, can accumulate up to 10^{12} cells per ml in the culture liquid after 10-15 hours of growth. Fungal preparations are usually based on the use of saprophytic fungi of the genus *Trichoderma*. *Trichoderma* now has 88 different species and is characterized by an exceptionally rich composition of metabolites. Fungi of the genus *trichoderma* are natural antagonists living in the soil. Biologically active compounds of *trichoderma* include a variety of **antibiotics**: gliotoxin, viridine, trichoviridine, dermatin, cyclosporine, trichopolin A and B, **volatiles**: carbon dioxide, ethanol, volatile antibiotics, **enzymes**: cellulolytic enzymes, chitinase, helicase, amylase, catalase, pentonase. In addition to these substances, *trichoderma* secretes hormone-like substances - growth stimulators. Biopreparations have a complex effect on the plant: protective properties, stimulating properties, as well as destructors of stubble residues.

They effectively protect seeds, plants and tubers from rot caused by various phytopathogenic fungi: *Fusarium*, *Alternaria*, *Rhoma*, *Ascochuta*, *Verticillium*, *Rhizocini*, *Sclerotinia*, *Botrytis*, *Septoria* etc., which can cause the formation of gray and white rot, root rot, powdery mildew, late blight, mildew, oidium, scab and other plant diseases during growth in the field, as well as during long-term storage of products. The use of LUTAN biofungicide in our work has shown that it has very high fungicidal activity and not only protects plants from a wide range of fungal infections, but also increases the yield of cucumbers by 0.5-3.0 kg/m², cereals by 15-30%, cabbage and other vegetables by 40% [3].

Biofungicides based on *Trichoderma*, are able to work also at low temperatures, effectively protecting vegetables during their long-term storage at +2 + 3°C.

The most important direction is the production of biofertilizers with evident signs of growth stimulant and immunomodulator. An example of such biopharmaceutical is Biofertilizer NIKFAN.

This biopharmaceutical, produced on the basis of endo- and ectophytic fungi, living as a natural microflora in living plants, is a producer of a highly effective biopharmaceutical with a complex of various properties useful for plants [3]. It is the source of a whole complex of biologically active substances: vitamins, microelements, enzymes, amino acids, natural phytohormones: auxins, cytokinins, potassium, silicon, humic and fulvic acids. This is due to its polyfunctionality.

Main effects:

- Increase in root formation;
- Increased germination of seeds and tubers;

- Intensification of nitrogen fixation, photosynthesis;

- Increase of plant immunity, frost resistance and drought resistance;

- Increased resistance to fungal diseases;

- Improving the growth of rootstock and graft;

- Increase in the consumer properties of plants (increase of the gluten content of grain, technological properties of fiber, sugar content);

- Increase in the growth of shoots, bushiness, decrease in the lag in the ovaries.

High efficiency of NIKFAN on various plants is shown: wheat, barley, oats, corn, rapeseed, soy, rice, vegetables, fruit trees, grapes, berry crops, ornamental plants in different countries: Russia, Colombia, India, China, Bulgaria, Zambia, Lithuania.

One of the main effects is a significant increase in root formation, which, together with other effects, leads to an increase in yields and a shortening of maturation periods by 1.5 to 2 weeks, as well as to an increase in plant resistance to adverse weather conditions, significant (by 20-60%) increase in yield, acceleration of the growth and development of plants, improvement of the quality characteristics of plants: gluten, starch, vitamins, microelements. Tests in greenhouses showed an increase in the yield of cucumber by 38-51% [4, 5, 6]. Fodder corn showed a significant increase in sugar by 36%, protein by 26%, and carotene by 2.7 times (Table 1). The study of the content of selenium in the processed beet showed (Table 2) a significant increase in this most important index. The results of implementation of the NIKFAN biopreparation for cereals are presented in Table 3.

Table 1. Nutrient content of green mass of maize after application of fertilizer NIKFAN

№	Items	Experiment versions		
		Control (without treatment)	1ml of NIKFAN (seed treatment)	Increase, %
1	Green mass, kg % rel. to the control	1422 -	1755	123
2	Dry matter, kg % rel. to the control	262 -	357	136
3	Crude protein, kg % rel. to the control	28,5 -	36,0	126
4	Crude fat, kg % rel. to the control	5,48 -	7,58	138
5	Raw fiber, kg % rel. to the control	55,7 -	78,2	140
6	Nitrogen-free extractive substances, kg	144	201	39,5
	% rel. to the control:	-		
	including starch kg	19,6	27,7	141
	% rel. to the control	-		
	Sugar, kg	49,7	67,9	136
	% rel. to the control	-		
7	B-carotene, g % to the control	3,79 -	10,4	275
8	Gross energy, MJ / kg	3,18	3,54	11,3

Table 2. Influence of the biopharmaceutical NIKFAN on the intensity of beet growth (research in All-Russian Research Institute of Selection and Seed Vegetable Crops)

Item	Study	Control
Average weight of plant root, g	0.93	0.20
Average weight of leaves, g	3.0	0.93
Plant leaf area, mm ²	57.6	41.7
Selenium content, µg/kg:		
In root crops	460	not determined
In leaves	216	196

Table 3. Results of NIKFAN testing on cereals, Krasnodar Territory

Grain crops	Area, hectares	Application rate, ml/ha	Productivity, Centner/ha
WINTER WHEAT			
Winter wheat, "Vita", LLC Agricultural company "Kolos", Kalininsky district	40.0	1.5 ml together with herbicides 1.0 ml by terrestrial method together with fungicides (aero spraying)	73.7 Addition to the crop 18.1 % Gluten 26%
	80.0	Control	62.4
Winter wheat, "Pamyat", Agricultural company "Selhoz-Contract"	25.0	1.5 ml together with fungicides and 1.0 ml by terrestrial method together with herbicides	58.9 Addition to the crop 31.7 % Gluten 25%
	25.0	Control	44.7
WINTER BARLEY			
Winter barley, "Kondrat" Agricultural company "Kolos"	40.0	1.5 ml together with herbicides by ground method	57.7 Addition to the crop 5.9 %
	100.0	Control	54.5
SUGAR BEET			
Sugar beet, "Atamansha" Agricultural company "Kolos", Kalininski district, 2009	40	1.5 ml, by aviation method	478 Centner/ha, Addition to the crop 11.6 %
	68	Control	428 Centner/ha
SUNFLOWER			
Sunflower, hybrid A-83, Agricultural company "Kolos", Kalininski district, 2009	40	1.5 ml, by aviation method	38.2 Centner/ha Addition to the crop 8.2 %
	220	Control	35.3 Centner/ha

The effectiveness of biopreparations LUTAN and NIKFAN is presented in photos on Fig. 1-6.

The efficiency of biopreparation Lutan

(Trichoderma)

Efficacy of the biofungicide LUTAN

Fig. 1. Efficiency of LUTAN on carrots, bulbs of tulips and lilies

The infestation of Apple trees *Venturia inaequalis*

Apple-tree, brown rust

Apple-trees after treatment with biofungicide

Fig. 2. Efficiency of LUTAN on apple trees against scab

Roots of lilac seedlings
Control Experiment

Cucumber fruits, China
Experiment Control

Fig. 3. Effectiveness of NIKFAN on lilac and cucumber seedlings

Saplings of Apple trees, Krasnodar nursery (age 1 year)
Control Experiment

Shoots of rice in Colombia
Control Experiment

Apple seedlings, Krasnodar nursery, (one-year-olds)
Control Experiment

Rice sprouts in Colombia
Control Experiment

Fig. 4. Efficiency of NIKFAN on apple and rice seedlings

control experiment

Strawberry, Lenin farm, Moscow Oblast, 2011

Cucumbers, treatment by NIKFAN

Fig. 5. Effectiveness of NIKFAN on strawberry and cucumber seedlings in the greenhouse

Effectiveness of NIKFAN on soybean
cultures in laboratory conditions
Control Experiment

Soya, Ulyanovsk, Agricultural Academy
Control Experiment

Fig. 6. Effectiveness of NIKFAN on soybean underground seedlings and soybean seedlings

CONCLUSION

It is shown that biological products are the basis of agrotechnology, which presupposes the production of ecologically safe food products. Each of them is able to protect plants from sucking and gnawing insects and phytopathogens, increase

immunity, enable the plant to realize its varietal properties. In addition, fruits, root crops, grain reach higher quality and grade. Thus, the content of sugar increases by 2-3%, protein by 5%, fiber by 2%, starch by 10%, gluten by 22%, maturation time decreases by 1.5 weeks, resistance to diseases improves 87%.

REFERENCES

1. Nugmanova, T.A., Use of biological products for obtaining environmentally friendly food. Collection of works of the Russian Academy of Natural Sciences, "Unconventional natural resources, innovative technologies and products", No 23, 2016, 103-107.
2. Nugmanova, T.A., Unified Technology of Biological Toxins as the Basis for the Industrial Production of Effective Bacterial Insecticides. Doctor of Technical Sciences Thesis, Moscow, 1992. 389.
3. Nugmanova, T.A., Biopreparations - products of microbiological synthesis for the production of ecologically safe food products: technology, advantages, perspectives, Ecological Aspects of the Life of Man, Animals and Plants, Publishing House "Belgorod" 2017, 45-76.
4. Chistyakova, L.A., Petra, I.K., Nugmanova, T.A., Grushina, O.A., Imbiya A.M., Nikfan: Protection and Harvesting // Potatoes and vegetables, 2016, No.11, pp. 20-21
5. Chistyakova, L.A., Nugmanova, T.A., Growth regulators on cucumber. Potatoes and vegetables, 2016, No.8, 14.
6. Nugmanova, T.A., Bioinsecticides, biofungicides and biostimulants. Role in vegetable growing and potato growing, Potatoes and vegetables, 2017, No. 6, pp. 2-4.
7. Nugmanova, T.A., Grushina, O.A., Sorokopudov, V.N., The use of biologics for crop production, International scientific journal "Successes of Modern Science", No. 10, Volume 5, 2016, pp. 128-131.

БИОПРЕПАРАТИ ЗА ПРОИЗВОДСТВО НА ЕКОЛОГИЧНО БЕЗОПАСНИ ХРАНИ - Част I

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Резюме: Руските биопрепарати обхващат почти всички аспекти и проблеми свързани с отглеждането на растения. Историята на разработването и внедряването на промишлено мащабно производство на биопрепарати в Русия датира повече от 40 години. Биопрепаратите имат целенасочено действие и са разделени на следните основни типове: биоинсектициди, биофунгициди, биостимулатори, имуномодулатори и регулатори на растежа и развитието на растенията, както и биопрепарати за наторяване на земята. Разнообразието от руски биопрепарати може да осигури напълно реализацията на потенциалните сортови свойства на селскостопанските растения, да сведе до минимум щетите от неблагоприятни климатични условия, да намали разходите за химикали, да възстанови почвения хумус и да получи екологично чиста храна.

Ключови думи: биотехнологии, биопрепарати, растения, екология, биофунгициди, растежни биостимулатори, биоинсектициди, промишлено производство

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