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OPTIMIZATION OF COMPOSITION OF COMPLEX BIOPREPARATIONS FOR PLANTS YIELD INCREASING

The aim of work is to develop new complex biopreparations with growth-promoting, protective and immunomodulating properties. The modeling of complexes was carried out on the base of biopreparations Bactogen and MaxImmun, coniferous extract, minor-nutrient complex. Eleven treatment options were tested. We've selected the most effective sets of biopreparations with plant's growth stimulating and systemic resistance induction properties ("MaxImmun + coniferous extract") and protective properties ("Bactogen + coniferous extract"). Statistical analysis of the results allowed to prove their effectiveness. Using of complex biopreparations will reduce the pesticidal load on agrobiocenoses.

Целью работы является разработка новых комплексных биопрепаратов, обладающих стимулирующими, защитными и иммуномодулирующими свойствами. Моделирование комплексов проводилось на основе биопрепаратов Бактоген и МаксИммун, хвойного экстракта, минорно-питательного комплекса. Было протестировано одиннадцать вариантов лечения. Подобраны наиболее эффективные наборы биопрепаратов со свойствами стимуляции роста растений и индукции системной резистентности («МаксИммун + хвойный экстракт») и защитными свойствами («Бактоген + хвойный экстракт»). Статистический анализ результатов позволил доказать их эффективность. Использование комплексных биопрепаратов снизит пестицидную нагрузку на агробиоценозы.

Keywords: yield; organic farming; pesticides; biological preparation; alternaria desiase; plant growth stimulation; plant protection; induction of systemic plant resistance.

Ключевые слова: урожайность; органическое земледелие; пестициды; биопрепараты; альтернариоз; стимуляция роста растений; защита растений; индукция системной устойчивости растений.

The organic farming is one of the world trends and is practiced in 172 countries of the world. In more than 88 countries, national laws on organic agriculture are in force, and the market for organic products is growing. Agriculture is one of the leading sectors of the economy of the Republic of Belarus. The strategic objectives of the economic development of the republic include a gradual transition to a "green economy", the development of organic agriculture (Decree of the Council of Ministers of the Republic of Belarus dated December 21, 2016 No. 1061). The urgency of solving this problem is associated with the excessive use of chemically synthesized substances in agriculture, which, on the one hand, provide an increase in yield, and, on the other hand, lead to an increase in pesticidal load, deterioration of human health and environmental situation (Decree of the Council of Ministers of the Republic of Belarus dated March 11, 2016 No. 196).

It is necessary to search the ways and means of increasing plant productivity, which reduce risks and help reduce environmental pollution. Using of biopreparation based on cultures of microorganisms, which are environmentally friendly is the alternative way. The antagonist bacteria that are part of the biopreperetion are natural inhabitants of the rhizosphere and plant phylosphere,

do not change the composition of agrobiocenoses [1]. The relevance of the use of biopreperetions in crop production is primarily associated with the need to ensure environmental safety and competitiveness of agricultural products.

The Republic of Belarus, like many other countries, has a national legislative and scientific-production base for the development of organic agriculture and the biologization of agriculture (the Law of the Republic of Belarus "On the Production and Circulation of Organic Products"; the state standard "Organic Production"). The purpose of the research is to develop new complex biopreparations and to study their growth-promoting, protective and immunomodulating properties, in order to increase plant's yield and to protect.

The objects of research are watercress (*Lepidum sativum* L.) varieties "Zvychainy" and rape plants *(Brassica napus)* varieties "Zorny". Using the example of watercress, we studied the growth-promoting properties of complex biopreparations, because this plant has a short period of technical ripeness. This allows us to quickly evaluate the results. By the example of rape we evaluated the growth-promoting, immunomodulatory and protective properties, because this plant is a model object in biology. We have modeled 6 variants of complex biopreparations based on biopreparation Bactogen and Max Immune growth regulator using coniferous extract and minor nutrient complex according to the scheme: "biopreparation + coniferous extract", "biopreparation + minor nutrient complex" and "biopreparation + coniferous extract + minor nutrient complex". Antagonistic activity was assessed by the plate method.

Results

1. We have developed 6 variants of complex biological products based on biopreparation Bactogen and Max Immun plant growth regulator, coniferous extract and minor nutrient complex.
2. The complex "MaxImmun + coniferous extract" has the maximum growth-promoting effect in relation to watercress and rape plants (table 1).

Table 1. Information about the average values and errors of the average values of the measured parameters of watercress plants

Processing option	The average value and the standard error of the mean			
	seedling length, mm	root length, mm	Wet weigt of 10 seedling, mg	Dry weigt of 10 seedling, mg
Control	4,96±2,55	23,38±2,23	288,09±6,66	13,13±0,59
Bactogen (B)	54,86±2,54*	27,09±2,5*	323,8±6,86*	15,2±0,62*
MaxImmun (MI)	61,09±3,19*	29,72±2,35*	364,14±9,25*	16,6±1,12*
Caniferous extract (CE)	47,98±2,39*	23,01±2,125	290,61±7,79	13,84±0,44*
Minor nutrient complex (MNC)	49,28±2,69*	24,04±2,28	294,2±7,00	13,86±0,69*
B + CE	56,53±2,63*	27,84±2,61*	373,19±8,51*	17,93±1,08*
B + MNC	58,2±2,24*	28,26±2,46*	343,78±5,57*	16,75±0,93*
B + CE + MNC	54,4±3,37*	26,22±2,27*	325,35±7,08*	15,95±0,3*
MI + CE	63,3±3,16*	31,99±2,6*	405,94±12,27*	19,21±1,33*
MI + MNC	64,43±2,85*	32,66±2,91*	375,59±7,29*	17,99±0,52*
MI + CE + MNC	61,75±2,34*	30,27±2,4*	364,83±7,62*	17,71±0,27*
* - statistically significant differences compared with control when $p<0,05$				

3. The most pronounced antagonistic properties are demonstrated by the complex “Bactogen + coniferous extract” (table 2).
4. Immunomodulating properties are most pronounced in the complex "MaxImmun + coniferous extract“ (table 2).
5. Recommendations on the practical use of complex biological products have been developed. They include: information on the composition, purpose, methods of their use, safety requirements.

Table 2. Information on the antagonistic and immunomodulating properties of complex biopreparations

Processing option	Protective properties		Immunomodulating properties	
	The degree of spreading of the disease, %	The degree of development of the disease, points	The degree of spreading of the disease, %	The degree of development of the disease, points
Control	96,06±3,26	3,84±0,13	93,59±3,35	3,76±0,1
Bactogen (B)	66,13±2,43*	1,47±0,07*	69,24±2,01*	1,37±0,03*
MaxImmun (MI)	72,81±2,6*	1,53±0,03*	61,25±1,34*	1,13±0,05*
Caniferous extract (CE)	77,8±3,03*	2,27±0,05*	84,85±3,0*	2,05±0,1*
Minor nutrient complex (MNC)	91,86±0,52*	3,49±0,03*	93,54±0,22	3,66±0,04*
B + CE	56,48±2,54*	0,97±0,04*	61,43±2,24*	1,08±0,03*
B + MNC	68,9±1,82*	1,51±0,01*	69,76±1,39*	1,38±0,07*
B + CE + MNC	58,24±2,6*	1,08±0,07*	60,54±2,36*	1,05±0,03*
MI + CE	67,19±2,18*	1,23±0,03*	46,41±2,6*	0,86±0,03*
MI + MNC	76,35±1,86*	1,5±0,07*	61,56±1,29*	1,1±0,03*
MI + CE + MNC	69,99±1,8*	1,33±0,02*	45,21±3,46*	0,77±0,02*
* - - statistically significant differences compared with control when $p<0,05$				

Growth-promoting, antagonistic and immunomodulating properties of the developed complex biopreparations have been studied and characterized. This may be the basis for the creation of new complex biopreparations with the properties of biofungicide and regulator of plant growth with the functions of an immunomodulator, followed by their introduction into production and agricultural practice. The research prospects is to study of the antagonistic properties of the developed complex biopreparation in relation to phytopathogenic bacteria, the induction of systemic resistance to various biotic and abiotic factors in a wide range of crops.

The modeling of complexes was carried out on the base of biopreparations Bactogen and MaxImmun, coniferous extract, minor-nutrient complex. Eleven treatment options were tested. We’ve selected the most effective sets of biopreparations with plant’s growth stimulating and systemic resistance induction properties (“MaxImmun + coniferous extract”) and protective properties (“Bactogen + coniferous extract”). Statistical analysis of the results allowed to prove their effectiveness. Using of complex biopreparations will reduce the pesticidal load on agrobiocenoses.

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