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Fungicidal and growth-stimulating effect of microbial preparations on hop plants yield

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Cultivation of plant products using organic technology is becoming widespread. In our opinion, the technology of protection of hops from pests should be improved. The harmful effect of pests, diseases, and weeds should be limited by biological factors. Favorable phytosanitary conditions of agrocoenoses of hops plantations should be achieved using agrotechnical, biological, chemical, and other methods that require thorough study. The developed system of protection of hops against root rot is based on biological features of mycoses, the introduction of varieties with the lowest degree of affection by pathogens of fungal etiology, application of optimal tillage and fertilization systems, terms of pesticide treatments, and technological operations of plant care and plant growth, rational use of effective mixtures of biological preparations and plant growth regulators. Environmentally friendly protection of hops against root rot involves complex treatment of the main rhizome with one of the biological preparations after spring pruning. The possible preparations are Mikosan N, liquid (10.0 l/ha); Avatar Zakhyst, liquid (2.0 l/ha); Psevdobakteryn-2, liquid (3.0 l/ha); Agat 25-K (100 g per 10 liters of water), or Khetomic, powder (40 g per 10 liters of water) together with the sodium salt of carboxymethylcellulose (NaCMC) in the amount of 200 g per 10 liters of suspension. The preparations are applied by watering the parent of hops or adding dry crystals of superabsorbent Teravet T-400 to the pits with an application rate of 7.5 g per rhizome. The proposed measures make it possible to maintain the yield of hops cones at the level of 0.08–0.25 t/ha, or 10–30%, increase the content of alpha-acids, and increase the content of alpha-acids and increase alpha acid content by 0.2–0.3%.

Keywords: pathogens of hops root diseases, biological preparations, protection system.

Introduction

Many domestic and foreign scientists, in particular I. M. Demchak, S. V. Dovgan, S. V. Retman, S. M. Babych, G. P. Kozak, T. I. Guk, L. Korsten, W. Elmer, J. R. Lamichhane, and others, addressed the problems of crop protection (Kramarets & Matsiakh, 2017).

Some theoretical aspects of solving environmentally friendly production problems, particularly agricultural ones, are covered in V. P. Fedorenko, A. N. Tkalenko, V. P. Konverskaya V. N. Fursov, V. S. Shelestova, M. M. Padia, O. I. Goncharenko, and other researchers. According to scientists, the transition of production technologies from intensive to environmentally friendly ones will contribute to environmental and economic problems in agriculture and improve the quality of people's life (Fedorenko et al., 2009; Fursov, 2001).

Ukraine has a favorable geographical location and favorable soil and climatic conditions for hops cultivation and sale. The production areas of hops plantations are concentrated in the Polissia and Forest-Steppe zones, characterized by sufficient moisture for the crop under climate change conditions, and are most suitable for growing aromatic types of hops. Due to this fact, Ukraine can develop the industrial complex of hops growing, grow a sufficient amount of hops raw materials of excellent quality to meet its own needs, and boost export potential (Pryimachuk et al., 2016).

Hops have been grown in the same place for more than 15-20 years; it is significantly damaged by various pests and diseases every year. A single crop, lack of crop rotation, a large amount of annually applied organic and mineral fertilizers create conditions for the formation of a special agrocoenosis of soil entomofauna (Venher et al., 2004).

Hops plants are significantly damaged by diseases that annually reduce the yields and deteriorate the quality of cones, weaken plants, cause death, and cause death. Thus, according to A. A. Yachevsky, V. M. Venher, O. I. Tymoshchuk, L. A. Sydorzhevska, hops are affected by about 50 species of pathogens, which include fungi, bacteria, and viruses. 8–10 species cause the most damage to hops plants; they include powdery mildew, fusariosis, winter scald, leaf spot, verticillium wilt, false powdery mildew, or downy mildew (Venher et al., 2014).

To get complete high-quality hops yields, it is necessary to ensure reliable protection of plants from pests and diseases continually. For this purpose, an integrated protection system is applied. This is a rational combination of all measures that are part of an obligatory agricultural complex with additional measures to protect pests and diseases. Such a system makes it possible to reduce the harmfulness of pests and diseases as much as possible, to increase yields and their quality at the minimum (optimal) costs per unit of additional products obtained. Annual intensive application of chemicals on hops, especially against multivoltine species, such as alfalfa weevil, red spider, hops aphid, leads to accelerating the selection of resistant races and forces to increase the rate of use of preparations and alternate them (Venher et al., 2007).

Therefore, the study's purpose was to develop a system of measures to control the biotic potential of root rot in the agrocoenosis of hops plantations based on reducing the pesticide load. The susceptibility of hops varieties to phytopathogenic affection was established under treatment with complex microbiological preparations; the effectiveness was also determined.

Materials and methods

The study was carried out during 2016–2020 in the experimental hops plantation No. 221 of the Institute for Agriculture of Polissia NAAS (Zhytomyr) using a knapsack-motor sprayer, chemical and biological insecticides under the exceedance of ETH of pests according to the experimental schemes. The height of hops plants was 4.0–7.0 m. Studied the species Humulus lupulus. The total area of the experiment is 1 ha, the accounting area is 150 m^2. The drugs were applied to the soil from the 3rd decade of April to the 1st decade of May.

The development of environmentally friendly systems to protect hop rhizomes was carried out on the varieties Zagrava, Ruslan, Ksanta, and Slovyanka. The scheme of planting is 3.0 × 1.0. The bush formation type is V-shaped, with two stems for two supports (13–14 thousand pieces/ha). The experiment was repeated four times, and the placement was randomized along the designed rows of hops. A suspension of tested preparations was prepared for the treatment of hops parents. The preparations included Agat-25 K, Khetomic, and Mikosan-N. The sodium salt of carboxymethylcellulose (Na CMC) was added to this suspension in 200 g per 10 l of suspension. The solution was applied immediately after pruning the hops parents by watering them and then covering them with soil (Boucias & Pendland, 2008). Following the task, it was planned to conduct the study to establish the effect of microbial preparations on hops' growth and development and their resistance to pathogens of root diseases.

A sampling of soil, determining, recording, and cultivating phytopathogens was carried out according to conventional methods. The antibiotic activity of fungal cultures was determined by diffusion into the agar. During the identification of fungi, the determinants of fungi described by V. I. Bilay, M. M. Pidoplichko, and T. S. Kyrylenko were used (Bilay, 1977; Pidoplichko, 1977). Records of hops plant diseases were carried out according to the testing and application of pesticides (Trybel et al., 2001).

Solutions of preparations were applied in the spring immediately after pruning the parent by adding superabsorbent and watering the main rhizome with working solutions of preparations and covering with soil. The rate of application of working fluid of preparations per parent was one liter.

The assessment of hops parents' condition on the degree of affection of plants by root rot pathogens and the percentage of their spread was performed before the introduction of preparations and repeated in autumn, after harvest (Volkodav, 2003).

During the experiment, the date of emergence of seedlings, the height of hops stems before and after putting them on support, the number of spike-shaped shoots (primary infection of powdery mildew), yield, and alpha-acid content was noted. The number of spike-shaped shoots was determined in the period from emergence to hops seedlings to framing (DSTU 4810-2: 2007). For this purpose, 5 plants in a row were inspected in 10 equidistant places, and the number of shoots with deformed (thickening, shortened internodes, small light green twisted leaves, dark gray mold with a purple tinge) spike-shaped shoots and the number of such shoots on the bush was counted.

Results

In Zhytomyr oblast, out of 115 hectares of investigated hops plantations, signs of root rot on the underground part of hops plants were detected in 44.9%, which indicates a high extension of diseases. We found that the average point of affection of underground parts of hops by root rot pathogens was 2.12. From 2450 hops plants, 1160 had signs of affection of the underground part with root rot pathogens. From them, 577 were with a 1 point of affection, 291 plants had 2-3 points, 168 plants had 4-5 points, 91 had 6-7 points, and 33 had 809 points. Analysis of samples taken from the rhizosphere of hops plants showed that the pathogenic complex includes *Fusarium oxysporum* (Schlecht.) Snyd. et Hans., *F. oxysporum* var. orthoceras (Appl. et Wr.) Bilai, *Verticillium albo-atrum* Reinke et Berth., *Plenodomus humuli* Kuzn, *Alternaria alternata* (Fr.) Keissler, *Alternaria* sp. and *Cladosporium* spp.

Mycological analysis of plating of soil samples taken between rows and from the rhizosphere of hops plants showed that the number of colony-forming units (CFU) of fungi was 331–442 thousand in 1 g of rhizosphere soil and 255 thousand in soil between rows.

Representatives of the genus Fusarium were the most common in the soil between rows and in the rhizosphere of hops plants; they accounted for 31–55% of the total number of fungi (Fig. 1).

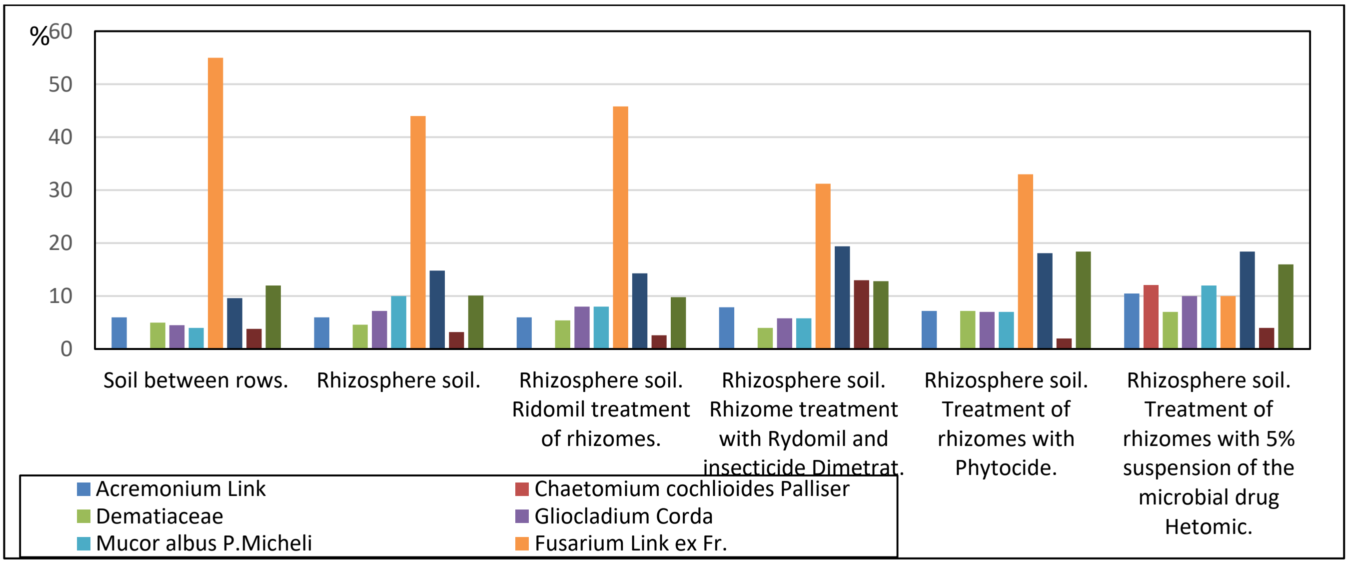

Fig. 1. The quantitative and qualitative composition of fungi in soddy podzolic soil between rows and from the rhizosphere of hops under the effect of chemicals and microbial preparations (2016–2020).

Before applying preparations, hops parents with root rot pathogens were on average 0.4–1.4 points with an extension of 30.0–45.0%. Before the experiment, the development and spread of root rot in all varieties did not differ; the experimental area had a balanced infectious background, contributing to the experiment's reliability.

After examination of the parents, the preparations were applied according to the experimental scheme. To establish the effectiveness of the tested preparations, the percentage of affection and the spread of root rot on hops, there was a further thorough examination of the parents in the autumn, after harvest.
After harvesting, a thorough examination of the parents was conducted to determine the tested preparations' effectiveness, the degree of affection of hops by pathogens of root rot, and their spread. As a result of autumn digging up, we found that biological preparations were quite effective against root rot on hops; the point of affection of hops parents decreased in each variety. However, the most effective measure was watering of hops parents with a suspension of microbial preparation Khetomic. In all varieties under investigation there was a reduction of affection by 28–50%, while under the use of Agat-25 K the reduction of affection was up to 25.0% for the variety Zagrava, 16.7% for the variety Slovyanka, 20% for Ksanta and 20.0% for Ruslan. The preparation Mikosan – N was the least effective; the affection decreased by 11.0–18.0% (Table 1).

Table 1. Effect of biological preparations on the affection of root system of hops with pathogens of root rot (2016–2020).

Variant	Variety	Affection				% of decrease	
		before application		after application			
		affection, point	extension,%	affection, point	extension,%	affection	extension
Control	Zagrava	0.8	40.0	1.2	60.0	0.0	0.0
	Slovyanka	0.5	36.0	1.4	49.0	0.0	0.0
	Ruslan	0.6	32.0	1.0	35.0	0.0	0.0
	Ksanta	0.4	37.0	0.8	30.0	0.0	0.0
Agat 25 K	Zagrava	0.4	45.0	0.3	40.0	25.0	11.1
	Slovyanka	0.6	42.0	0.5	38.0	16.7	9.5
	Ruslan	0.5	38.0	0.4	30.0	20.0	21.1
	Ksanta	0.5	36.0	0.4	27.0	20.0	25.0
Khetomic	Zagrava	1.4	35.0	0.8	25.0	42.9	28.6
	Slovyanka	0.8	40.0	0.4	30.0	50.0	25.0
	Ruslan	0.7	30.0	0.5	21.0	28.6	30.0
	Ksanta	0.4	39.0	0.2	28.0	50.0	28.2
Mikosan-N	Zagrava	0.6	35.0	0.5	30.0	16.7	14.3
	Slovyanka	0.9	33.0	0.8	31.0	11.1	6.1
	Ruslan	0.4	37.0	0.33	35.0	17.5	5.5
	Ksanta	0.6	40.0	0.5	39.0	167	2.5
HIP05					2.4	3.2	

The affection increased from 0.8 to 1.2% in the control variant and the extension from 40.0 to 60.0% for the variety Zagrava. As for the Slovyanka variety, the point tripled, and for the Ruslan and Ksanta varieties, it doubled.
The effectiveness of the microbial preparation Khetomik against root rot on hops is evidenced by the fact that watering the parents with a solution of this preparation provided a reduction in the extension of the disease by 16.7% on the variety Ruslan, by 30.0% on the variety Slovyanka, by 28.2% on Ksanta and 28.6% on Zagrava. After applying the biological preparation Agat-25 K, a reduction in the disease's extension was observed from 9.5% on the Slovyanka variety to 25.0% on Ksanta. The application of Mikosan N was the least effective; the extension of root rot was reduced by 2.5.0–14.3%.

Table 2. Effect of microbial preparations on growth and development of hops plants (2016–2020).

Variant	Variety	Number of shoots per bush				Spareness, %
		total		of them spike-shaped		
		Total, pcs.	+/- to control	total, pcs.	% of affected	
Control	Zagrava	18.4	-	4.4	24.0	4.0
	Slovyanka	18.2	-	4.2	23.0	4.1
	Ruslan	17.4	-	3.6	20.7	3.2
	Ksanta	16.6	-	2.4	14.5	3.4
Agat 25 K	Zagrava	19.8	+1.4	3.0	15.0	2.4
	Slovyanka	20.2	+2.0	2.4	11.9	2.7
	Ruslan	18.2	+0.8	2.0	11.2	2.2
	Ksanta	17.4	+0.8	1.8	10.3	2.4
Khetomic	Zagrava	20.4	+2.0	2.0	9.8	1.5
	Slovyanka	19.4	+1.2	1.6	8.2	1.6
	Ruslan	18.6	+3.2	1.2	6.5	1.1
	Ksanta	17.4	+2.2	2.0	11.5	1.3
Mikosan-N	Zagrava	19.4	+1.0	3.2	16.5	2.8
	Slovyanka	18.2	0	4.0	22.0	3.0
	Ruslan	16.8	-0.6	2.8	16.7	1.9
	Ksanta	16.2	-0.4	2.2	13.6	2.2
HIP05					0.75	

One of the main reasons for hops plantations' spareness is the death of hops plants, the so-called "loss" due to affection with pathogens of root rot. We found (Table 2) that the highest percentage of hops plants' spareness was observed in the control variant – 3.4–4.1%. In the variant where the biological preparation Khetomik was used, the spareness was the lowest and was on average 1.1–1.6%, which is three times less than the control variant and again proves its effectiveness against the pathogens of hops root

rot. After treatment with biological preparations Agat-25 K and Mikosan-N spareness was lower than in the control variant. Varieties Ruslan and Ksanta were the most stable; the loss percentage was the lowest in both control and experimental variants.
Phenological observations of the growth and development of hops plants in the experimental plots showed that the mass emergence of seedlings was observed in the third decade of April, regardless of the experiment's variant. We registered zero influence of microbial preparations on hops germination. On the plots where microbiological preparations were applied, more shoots were formed; they grew and developed more intensively compared to the control variant. The application of preparations did not significantly affect the total number of shoots but reduced the number of shoots affected with primary signs of false powdery mildew. At the beginning of June, 16.2 to 20.6 shoots per hop bush were formed on the experiment's variants (Table 2). More of them were on the varieties Zagrava and Slovyanka – 20.4–20.2 and less (18.6–17.4) on Ruslan and Ksanta. The lowest number of spike-shaped shoots was observed under the microbial preparation Khetomik – from 6.5 to 11.5%, depending on the variety. In the control variant, the number of spike-shaped shoots was the highest and ranged from 14.5 to 24.0%.
Thus, we found that watering the parents after pruning with a working solution of microbial preparations effectively protects hops seedlings from powdery mildew. It reduces the number of spike-shaped shoots (the primary source of mildew) and makes it possible to inhibit the disease at the early stages of plant development.
Calculations were carried out to determine the growth parameters of hops (Table 3). As a result, we found that hops plants, the parents treated with a suspension of microbial preparations, outran plants from the control variant in height and intensity of growth by 0.1–0.35 m.

Table 3. Effect of microbial preparations on the height of hops plants (2016–2020).

Variant	Variety	Plant height			
		before application		after application	
		m	+/- to control	m	+/- to control
Control	Zagrava	0.13	-	0.82	-
	Slovyanka	0.18	-	1.05	-
	Ruslan	0.17	-	1.00	-
	Ksanta	0.15	-	0.98	-
Agat 25 K	Zagrava	0.18	+0.05	1.15	+0.33
	Slovyanka	0.23	+0.05	1.23	+0.18
	Ruslan	0.22	+0.05	1.35	+0.35
	Ksanta	0.19	+0.04	1.18	+0.2
Khetomic	Zagrava	0.10	-0.03	1.27	+0.45
	Slovyanka	0.14	-0.04	1.52	+0.47
	Ruslan	0.12	-0.05	1.62	+0.62
	Ksanta	0.11	-0.04	1.35	+0.37
Mikosan-N	Zagrava	0.14	+0.01	1.00	+0.18
	Slovyanka	0.21	+0.03	1.14	+0.09
	Ruslan	0.24	+0.07	1.38	+0.38
	Ksanta	0.18	+0.03	1.12	+0.14

Plants, the parents treated with the microbial preparation Khetomik, were the highest in this period. Their height averaged 1.27–1.62 m depending on the variety, which is by 0.37–0.62 m higher than in the control variant. The intensity of growth and height increase in variants with microbial preparations is explained by the fact that the preparations used in the experiments have a direct fungicidal action. They also improve plants' mineral nutrition and have a growth-promoting effect and stimulate natural plant immunity improvement. In contrast to the control variant, microbial preparations inhibited the development of spike-shaped shoots that have shortened internodes, are permanently deformed and inhibit plant growth.
The study of the fungi's quantitative and qualitative composition in soddy podzolic soil of the hops rhizosphere showed that the total number of fungi in the rhizosphere soil was not affected by the varietal characteristics of hops.
Among the variants of the experiment, the suspension of the microbial preparation Khetomik was the most effective. The treatment of hops parents with this preparation contributed to a sharp decrease in the number of fungi of the genus Fusarium in the rhizosphere soil. Evidence to the fact that the decrease in the number of members of the genus Fusarium in the rhizosphere soil occurred under the influence of Khetomic is the presence of its bioagent-antagonist (*Chaetomium cochliodes*) in the hops rhizosphere.
High air temperature, light precipitation, and, as a consequence, lack of moisture in the arable soil layer, which lasted during the period of intensive growth, flowering, and cone formation, created such conditions that the yields of hops varieties ranged from 1.17 to 2.0 t/ha depending on the hops variety with a slight difference between the variants (Table 4).
In particular, in the variants where microbial preparations Agat-25 K and Mikosan-N were applied, there was a slight increase in yield up to 0.1 t/ha, which is within the experiment's error. The application of the suspension of the microbial preparation Khetomik on all varieties made it possible to obtain a significant increase in yield in the range of 0.25–0.42 t/ha. The harvest's recording showed the expediency of protective measures against root rot with the microbial preparation Khetomik.
We found that when the possibility of using superabsorbent with fungicide solutions was studied, the affection with root rot pathogens of the main rhizome before the introduction of preparations was 1.1–1.3 points with an extension of 83.3–88.2%. Subsequent inspections were performed in the autumn after harvest with the combined use of superabsorbent and fungicide. We found that in the control variant, hops plants' affection increased from 1.2 to 1.8 points, the percentage of disease spread also rose from 86.6 to 94.5%. In the reference variant, we established that under the use of Rydomil Gold MTs (water-dispersible granules), the main rhizome's affection with pathogens of root rot decreased by 0.4 points compared to the initial level and the extension rate by 14.8%. Under the use of dry crystals of Teravet T-400 with the application rate of 7.5 g on the main rhizome, the affection increased by 0.5 points compared to the initial level; and the spread of the disease by 7.7, so the preparation has no fungicidal properties.

Table 4. The economic effectiveness of microbial preparations on hops (2016-2020).

Variant	Variety	Yields, t/ha			
		average from 1 bush, kg of raw cones	t/ha of dry yield	regards control	alpha-acids, %
Control	Zagrava	1.9	1.58	-	5.7
	Slovyanka	1.4	1.17	-	
	Ruslan	1.7	1.42	-	
	Ksanta	1.8	1.50	-	
Agat-25 K	Zagrava	2.2	1.68	+0.10	6.0
	Slovyanka	1.5	1.25	+0.08	
	Ruslan	1.8	1.50	-0.08	
	Ksanta	1.9	1.58	+0.08	
Khetomic	Zagrava	2.4	2.00	+0.42	6.3
	Slovyanka	1.7	1.42	+0.25	
	Ruslan	2.0	1.67	+0.25	
	Ksanta	2.1	1.75	+0.25	
Mikosan-N	Zagrava	2.0	1.67	+0.09	5.9
	Slovyanka	1.5	1.25	-0.08	
	Ruslan	1.8	1.50	+0.08	
	Ksanta	1.8	1.50	0.0	
HIP05		0.6	1.2		

Under the combined use of Rydomil Gold MTs (water-dispersible granules) with dry crystals of Teravet T-400, the underground part of hops' affection decreased by an average of 0.5 points for all years of the investigation, and the extension by 18.6%. When spike-shaped shoots (the primary source of infection of powdery mildew) were calculated, we found that in the variants with the combined use of superabsorbent and fungicide, their number was lower by 3.9 pcs/bush; under Rydomil Gold MTs (water-dispersible granules) by 3.6 pcs/bush, and under Teravet T-400 higher by 0.5 pcs/bush, compared with the control variant. We suggested that the combined use of Rydomil Gold MTs (water-dispersible granules) with Teravet T-400 inhibits developing the primary source of pseudoperonosporosis infection (Table 5).

Table 5. Effect of combined superabsorbent Teravet T-400 with Rydomil Gold MTs (water-dispersible granules) on the affection of hops with root rot pathogens (2017–2020).

Variant	Application rate	The affection of main rhizomes with root rot			
		before application		after application	
		affection, point	extension,%	affection, point	extension,%
Control (watering of hops parents)		1.2	86.6	1.8	94.5
Rydomil Gold MTs (water-dispersible granules)	25 g/10 l of water	1.1	83.3	0.7	68.5
Teravet T-400	7.5 g / rhizome	1.2	85.7	1.7	93.4
Teravet T-400 + Rydomil Gold MTs (water dispersible granules)	7.5 g + 25 g / 10 l of water	1.3	88.2	0.8	69.6

The yield of hop cones depends on the productive lateral branches. In the variants with the application of preparations, productive lateral branches' formation began much earlier than in the control variant. When superabsorbent and fungicide were applied separately, the branches formed in late June, while under their combined application 3-4 days earlier. The most significant number of productive lateral branches was also formed in the variant with superabsorbent and fungicide – 39.6 pcs, under Rydomil Gold MTs (water-dispersible granules) 32.4 pcs, under Teravet T-400 31.7 pcs, while in the control variant, there were only 26.0 pcs.

Discussion

Hops growing is an essential branch of agricultural production. Its products have many applications, from brewing to cosmetology. More than 90% of hops' raw materials are used in the beer production process. Ukraine has a favorable geographical location and favorable soil and climatic conditions for hops cultivation and sale. Cones containing alpha-acids, polyphenolic compounds, and essential oil are the hops industry's raw materials (Venher et al., 2011).

In the context of global climate change, there is a need for a deeper scientific analysis of the agroecological system of perennial hops plantations, as well as for conducting fundamental research aimed at the creation of new forms and varieties of hops resistant to pests and diseases, adapted to the conditions of Ukrainian Polissia. The development of hops growing depends on the hops protection system, which should involve the spread of resistant varieties and adequate safe protection of hops plantations from pests, which guarantees high yields and has improved resistance to diseases, pests, and weeds.

M. V. Kandybin, N. V. Lapa, V. F. Drozda, V. M. Goral believe that biological preparations are the perfect form of using microorganisms and their metabolic byproducts (metaphalia) to protect plants. The advantage of biological preparations according to the regulations of their use is the lack of limitation terms (access of people to treated hops plantations) for manual and mechanized plant care, the term of the last treatment in the days before harvest, compliance with the sanitary zone) (Boucias & Pendland, 2008).

Yu. S. Aleynikova conducted a study on using bio fungicide Mikosan V in vineyards in the western foothills of Crimea. She has found that it is expedient to use this preparation in the general protection system when weak development of the disease (early vegetation) or at the end of vegetation when fungicides cannot be used to comply with regulations concerning waiting times. Thus, biological preparations can be used in the integrated system of protection of grapes against powdery mildew, making it possible to reduce the pesticide load and increase the ecotoxicological parameters of the applied protection systems (Aleynikova et al., 2013).

According to N. A. Lukashevych and V. M. Venher, the application of biofungicides Agat-25 K, solid powder – 0.15–0.2 kg/ha, and Mikosan-V 3% water-dispersible granules – to obtain a yield increase of 0.3-0.9 quintal/ha and a higher quality of yield. These biofungicides are recommended for extensive industrial use in hops yards, the recommended number of treatments – 2. The advantage of these preparations is the unlimited term of entry of people to the treated plantations. This makes it possible to protect hops plantations a few days before harvest. The duration of protective action is 10–12 days (Lukashevych & Venher, 2012).

V. D. Dzingilevskiy (Dzingilevskiy, 1985) showed that hops hybrids 8–4, 12–30, and 9–32 had a lower degree of affection with false powdery mildew under provocative conditions, or the affection was equal to the standard. Under production conditions, they showed great resistance to false powdery mildew. V. A. Melnychenko studied the effectiveness of the biological preparation Rizoplan against winter wheat diseases at Peremoha LLC in Zhytomyr raion. The study was performed by treating seeds and crops. Under the influence of the biological preparation, plants' affection with the powdery mildew pathogen decreased by 9.1–10.3; 14.7–17.4%, respectively, while grain yield increased by 0.014–0.019 t/ha, compared with the control where the preparation was not applied. Experiments aimed at testing Rizoplan against root rot on hops were conducted at this farm. They watered the root system when pruning the rhizomes with the application rate of 4.0 l/ha and before planting soaked cuttings and roots of seedlings for 2.5 hours in a solution of 50 ml of Rizoplan per 10 liters of water. The effectiveness was 60–65%. On vegetative plants, Rizoplan was applied against false powdery mildew of hops by double spraying in the amount of 3.0 l/ha, which reduced plant affection by 72% and increased dry yield cones 0.015 t/ha (Melnychenko, 2010).

In modern farming systems, environmental technologies for crop cultivation should be a priority. In this regard, microbial preparations based on agronomically beneficial microorganisms are becoming more common. Along with organic fertilizers, they play an essential role in increasing crop productivity and soil fertility. Microbial preparations are highly effective beneficial microorganisms that are aimed at the improvement of plant nutrition. Also, relatively low cost, high payoff, ease of use, and safety for the environment contribute to their significant spread (Volkohon et al., 2006).

This development has been tested in specialized hops farms of Ukraine: Private Enterprise Zarichne and Reia LLC in Berdychiv raion of Zhytomyr oblast. This method makes it possible to reduce the expenses on plant protection agents by 15%, increase plant productivity by 5-10%, and get environmentally friendly and high-quality hops raw materials, improve the ecological situation in the agrocoenosis of hops plantations and the environment by replacing chemicals with biological preparations. Based on the study results, a patent was obtained; it is called "Method of Effective and Environment-Oriented Protection of Hops Rhizomes from Fungal and Other Diseases" No. 135024 dated June 06, 2019, application number u 201900414.

Conclusion

The application of microbial preparations has a positive effect on the development of the root system, due to which a more significant number of growing shoots develop. The shoots are much more resistant to the initial infection of mildew. Root rot is one of the reasons that lead to the spareness of hops plantations and reduced yields. Fusarium rot accounts for 90% of the root rot of hops. Plants of hops varieties, the parents treated with a suspension of preparations, were better in terms of growth intensity than the control variant. The introduction of microbial preparations into the soil by watering the hops' parents makes it possible to promptly carry out necessary manual work in the spring since there is no treatment of hops plants with chemical fungicides. Bioagent of the microbial preparation Khetomic, *Chaetomium cochliodes* 3250 best worked in the rhizosphere of hops, actively colonized the root system, and effectively counteracted phytopathogenic fungi of the genus Fusarium. The use of superabsorbent Teravet treated with chemicals of systemic action and introduced into the soil to the rhizomes of hops makes it possible to reduce the point of affection by 30% and reduce the spread of root rot by 20%.

References

Aleynikova, N. V., Yakushina, N. A. & Galkina, E. S. (2013). Poteri urozhaya vinograda v zavisimosti ot effektivnosti zaschitnyih meropriyatiy. Vinogradarstvo i vinodelie. 43, 35–38. (in Russian).

Bilay, V. I. (1977). Fuzarii. Kyiv. Naukova dumka. (in Russian).

Boucias, D. G. & Pendland, J. C. (2008). Principles of insect pathology. Kluwer Academic Publ., Boston, USSA.

DSTU 4810-2:2007 Sadyvnyi material KhMELIu. Sortovi i sadyvni yakosti. Tekhnichni umovy.

Dzingilevskiy, V. D. (1985). Plotnost posadki i urozhay hmelya. Hmelevodstvo. 7, 15–17.

Fedorenko, V .P., Tkalenko, A. N. & Konverskaya, V. P. (2009). Dostizheniya i perspektivyi razvitiya biologicheskogo metoda zaschityi rasteniy v Ukraine. Karantin I zahist roslin. 6, 6–9. (in Russian).

Fursov, V. N. (2001). Biologicheskiy metod zaschityi rasteniy: mezhdunarodnyie issledovaniya i prioritetnoe znachenie taksonomii. Vestnik zoologii. 35 (3), 97–101. (in Russian).

Kramarets, V. O. & Matsiakh, I. P. (2017). Biolohichnyi zakhyst roslyn : navch. posib. Lviv : Panorama. (in Ukrainian).

Lukashevych, N. A. & Venher, V. V. (2012). Zastosuvannia biolohichnykh zasobiv zakhystu khmeliu vid nespravzhnoi boroshnystoi rosy. Ekolohicho bezpechni tekhnolohii zakhystu silskohospodarskykh roslyn vid shkidlyvykh orhanizmiv : materialy nauk.-prakt. konf. spetsialistiv zakhystu roslyn. Zhytomyr : V-vo «Volyn». (in Ukrainian).

Melnychenko, V. A. (2010). Vplyv biolohichnykh preparativ na urazhenist khmeliu ta ozymoi pshenytsi khvorobamy. Ekolohicho bezpechni tekhnolohii zakhystu silskohospodarskykh roslyn vid shkidlyvykh orhanizmiv : мaterialy nauk.-prakt. konf. spetsialistiv zakhystu roslyn. Zhytomyr: Volyn (in Ukrainian).

Pidoplichko, N. M. (1977). Gribyi – parazityi kulturnyih rasteniy. Opredelitel. K.: Naukova dumka. (in Russian).
Pryimachuk, T. Yu., Protsenko, A. V., Rudyk, R.I., Shtanko, I. P. (2016). Khmeliarstvo Ukrainy: shliakhy vykhodu z kryzy. Ahropromyslove vyrobnytstvo Polissia. 9, 54−60. (in Ukrainian).
Trybel, S.O., Siharova, D.D., Sekun, M.P. & Ivashchenko, O.O. (2001). Metodyka vyprobuvannia ta zastosuvannia pestytsydiv. Kyiv : Svit. (in Ukrainian).
Venher V. M., Lukashevych N. A. (2014). Tekhnolohiia vyroshchuvannia ta zakhystu khmeliu vid shkidlyvykh orhanizmiv. Kyiv : Kolobih. (in Ukrainian).
Venher, V. M. Lapa, O.M. (2004). Zakhyst khmeliu vid shkidnykiv, khvorob ta burianiv : nauk.-prakt. rekomendatsii. Kyiv : TOV "Kompaniia Yunivest Marketynh". (in Ukrainian).
Venher, V. M., Venher, O. V., Yakubenko, I. V., Fedorchuk, N. A. & Lapa O. M. (2007). Obgruntuvannia zakhodiv zakhystu khmeliu vid velykoho liutsernovoho dovhonosyka / Zakhyst i karantyn roslyn. 53, 28–39. (in Ukrainian).
Venher, V.M., Trybel, S.O., & Lapa, O.M. (2011). Tekhnolohiia vyroshchuvannia ta zakhystu khmeliu vid shkidlyvykh orhanizmiv. Kyiv : Kolobih : Feniks. (in Ukrainian).
Volkodav V. V. (2003). Okhorona prav na sorty roslyn : metodyka provedennia kvalifikatsiinoi ekspertyzy sortiv tekhnichnykh ta kormovykh kultur. Ofitsiinyi biuleten. Kyiv: Alefa (in Ukrainian).
Volkohon, V.V., Nadkernychna, O.V., Kovalevska, T.M., Tokmakova L.M. (2006). Mikrobni preparaty u zemlerobstvi. Teoriia i praktyka : monohrafiia Kyiv : Ahrarna nauka. (in Ukrainian).

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