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EXPERIMENTAL ARTICLES
Pesticides

Fludioxonil-Based Preparations for Protecting Potatoes from Diseases and Their Effectiveness

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Abstract—Experimental compositions of preparations based on mechanochemically modified fludioxonil with plant metabolites (arabinogalactan and glycyrrhizic acid) and suspension preparations with tebuconazole, thiram, and carbendazim without the use of traditional shaping components in their composition have been developed in order to create environmentally friendly dressing agents for the comprehensive protection of potatoes from pathogenic dry phomosis-fusarium rot during storage and rhizoctonia. The testing of these drugs showed their high efficiency against storage rots, and they reduced the development of rhizoctonia on potato stems and influenced plant productivity in the field, increased crop yield, and its quality. It was shown that the proposed preparations had high biological efficiency at reduced consumption rates of active substances, which contributed to the production of environmentally friendly products.

Keywords: fludioxanil, tebuconazole, carbendazim, thiram, plant metabolites, mechanochemistry, solubility, fungicidal suspensions, dressing agent, potato, biological effectiveness, productivity

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INTRODUCTION

The destruction of large collective farms and the “farmerization” of agriculture resulted in a sharply deteriorated phytosanitary state of potato agrocenoses. Many Russian agricultural producers grow potatoes using seed material of dubious quality, without performing its phytosanitary examination. All this further leads to the accumulation of infection both in the soil and in the tubers of the new yield. The main methods that can effectively control the phytosanitary state of potato plantings include the preplanting treatment of tubers with disinfectants. To a large extent, obtaining high crop yields is hindered by the wide spread of diseases. Product losses in potato production from a complex of diseases can reach 45–80% in western Siberia [1].

Tuber dressing helps in the fight against various potato diseases, for example, various types of scurf (black and silver scurf) as well as dry phomosis-fusarium and watery wound rot, anthracnose, and alternariosis. The range of disinfectants recommended for use on potatoes includes one-component and two-component fungicidal preparations as well as combined insect-fungicidal plant protection products. Fungicides, acting on important biochemical processes in the cells of pathogens, reduce the stock of the infection on tubers, protecting potato plants from the moment of germination, as well as during the growing season, which also prevents the damage of new crop tubers by diseases [2].

The environmental friendliness of this technique is ensured by the fact that the hectare norm of the active ingredient (a.i.) of the disinfectants is small, it quickly decomposes in the soil, and is absent in the elements of the crop; this gives the maximum effect with a minimal negative impact on the agrocenosis [3]. The method of dressing potato tubers has also found wide application because of its high efficiency. For example, the results of a multifactorial experiment using such dressing agents as Maxim, Prestizh, and TMTD are presented, and the effect of dressing planting material on the size and quality of the potato crop is shown.

The purposes of the work are the development of environmentally friendly preparations both in the form of solid dispersions (**SD**) that form the corresponding supramolecular complexes and suspension preparations based on fludioxanil, tebuconazole, carbendazim, and thiram without the use of traditional form-building components and the study of their biological effectiveness against dry phomosis-fusarium rot during storage of tubers, potato rhizoctonia during

Table 1. Scheme of experiment with treating tubers with fungicides

Variant	Active ingredient (a.i.) and its content in the preparation	Consumption rate for the drug per 1 t of potato tubers
Control without treatment	–	–
Standard Maxim, SC (25 g/L)	Fludioxonil 2.5% a.i.	200 mL for autumn dressing, 400 mL for spring dressing
TMTD standard, WSC (400 g/L)	Thiram 40% a.i.	4000 mL
Analogue of Maxim, SC (25 g/L) (preparation 1)	Fludioxonil 2.5% a.i.	200 mL
Composition FDS : AG = 1 : 9 (preparation 2)	Fludioxonil 10% a.i.	1 g
Composition FDS : Na_2GA = 1 : 9 (preparation 3)	Fludioxonil 10% a.i.	1 g
Analogue of SK-210 (preparation 4)	Fludioxonil 2.5% a.i., Tebuconazole 1.25% a.i., Thiram 20% a.i.	200 mL
Analogue of SK-211 (preparation 5)	Fludioxonil 2.5% a.i., Tebuconazole 1.25% a.i., Thiram 20% a.i., Carbendazim 5% a.i.	200 mL
SK-210 (preparation 6)	Tebuconazole 1.25% a.i., Thiram 20% a.i.	560 mL
SK-211 (preparation 7)	Tebuconazole 1.25% a.i., Thiram 20% a.i., Carbendazim 5% a.i.	580 mL

Note: The designation of drugs is the same in Tables 3 and 4.

the vegetation of plants, and their effect on productivity and crop yields. The environmental safety of the proposed drugs was provided by the fact that plant metabolites, such as arabinogalactan (**AG**) and glycyrrhizic acid (**GA**), which have hepatoprotective, membranotropic, and immunostimulating properties and a wide range of therapeutic effects, were used when the preparations were created [5, 6].

METHODS

The following fungicides were chosen: fludioxanil (**FDS**), a.i. of which is 4-(2,2-difluoro-1,3-benzodioxol-4-yl)-pyrrole-3-carboxylic acid. Colorless crystals. Solubility (25°C) in water is 1.8 mg/L [7]; tebuconazole (**TBC**), a.i. of which is (RS)-1p-chlorophenyl-4,4-dimethyl-3-(1H-1,2,4-triazol-1-yl-methyl)pentan-3-yl. Colorless crystals. Solubility (25°C) in water is 32.0 mg/L [8]; thiram (**TMTD**), a.i. of which is bis (dimethylthiocarbamyl)disulfide. Crystalline substance of white or cream (yellowish-gray) color. Solubility (25°C) in water is 16.5 mg/L [8]; carbendazim (**BMC**), a.i. of which is N-(benzimidazolyl-2)-O-methylcarbamate. Crystalline substance from gray or blue to dark brown. Solubility (25°C) in water is 8.0 mg/L [9].

The following plant metabolites were chosen as polymers for the mechanochemical modification of FDS: arabinogalactan (**AG**) from Siberian larch *Larix sibirica* (TU 9363-021-39094141-08, series 02042013); glycyrrhizic acid disodium salt (Na_2GA) from Shaanxi Pioneer Biotech Co., Ltd, China; sodium salt of carboxymethyl cellulose (Na-CMC) brand CEKOL 700 from CP Kelco, Finland.

To obtain fludioxanil SD with AG and Na_2GA (preparations two and three), the technology of joint mechanical processing of components was applied at a mass ratio of 1 : 9 in a metal drum of an LE-101 grinder with adjustable power voltage under the conditions described earlier [10].

The preparation of SD with the composition FDS : AG = 1 : 9 was carried out in a metal drum of 800 cm^3 installed on the rolls of an LE-101 mill (Hungary). After preliminary mixing, 10 g of FDS, 90 g of AG, and 32 metal balls (diameter 25 mm, weight 54 g) were loaded into the drum and mechanical treatment was carried out for 3 h at a process modulus of 1 : 17, a roll rotation speed of 60 rpm, and drum loading of 55%. The product of mechanical processing in the form of TD with the composition FDS : AG = 1 : 9 was unloaded in the form of a loose beige powder (96 g) and represented preparation two (Table 1).

We obtained 97 g of a beige TD powder with the composition FDS : Na_2GA = 1 : 9 in a similar way from 10 g of FDS and 90 g of Na_2GA. The resulting product was preparation three.

Preparation one, an analogue of the preparation Maxim, SC (25 g/L) was prepared in the form of a suspension concentrate according to [11] with some changes, namely, 34.75 g 1% aqueous polymer solution (Na-CMC), 4.0 g of a nonionic surfactant (Tween 60), and 350 g of metal balls (25 balls with a diameter of 12–15 mm) for effective grinding of the components, their uniform mixing, and the formation of a stable suspension. Then, 10.0 g of propylene glycol (PG) was added to the mixture, and 1.25 g of FDS was added to the resulting mass with stirring and subjected to processing for 2 h at a roll rotation speed of 60 rpm. We unloaded 42 g (yield 85%) of suspension concentrate, analogue of Maxim, SC (25 g/L).

The solubility of SD based on FDS was determined by HPLC under the following conditions: liquid chromatograph Agilent 1100 with analytical column Hypersil HyPURITY Elite C18 (150 × 4.6 mm, 5 μm), column temperature 30°C, diode array detector, eluent acetonitrile acetate buffer pH 3.4 (1 : 1), flow rate 1 mL/min, detection at a wavelength of 270 nm.

Suspension forms of preparations based on FDS with the addition of TBA, TMTD, and BMC (preparations four to seven) were prepared similarly according to [11]. The compositions of the obtained TD and SC are presented in Table 1.

The effectiveness of the newly obtained preparations was compared with the effectiveness of the previously obtained suspension preparations six and seven as well as the TMTD standards and the Maxim preparation. Compositions of preparations one and four to seven are presented in Table 1.

Biological tests were carried out in 2018–2019 according to [10]. Field experiments were carried out in accordance with [12].

The fungicides Maxim, SC (25 g/L) and TMTD, WSC (400 g/L) were chosen as chemical control in accordance with the List of Pesticides and Agrochemicals Permitted for Use on the Territory of the Russian Federation [13]. The scheme of the experiment on the use of drugs during storage and in the spring before planting is presented in Table 1.

The prevalence of dry rot in winter when tubers were treated with dressing agents before storage [14] and features of the formation of a phytosanitary situation in potato plantings in relation to rhizoctonia during the treatment of tubers with dressing agents before planting [15] were studied in the experiments, and the productivity of potato plants under the action of developed dressing agents was also assessed [14].

In connection with the goal and objectives of the research, the objects of study were potatoes (*Solanum tuberosum* L.), potato rhizoctonia (*Rhizoctonia solani* Küch.), and dry rot during storage (*Fusarium* spp. and *Phoma exiqua* sp.).

RESULTS AND DISCUSSION

Chromatograms of HPLC analysis of the initial FDS and its SD are shown in Fig. 1. Calculated solubility data for obtained SD confirmed a significant increase in solubility, and they are presented in Table 2.

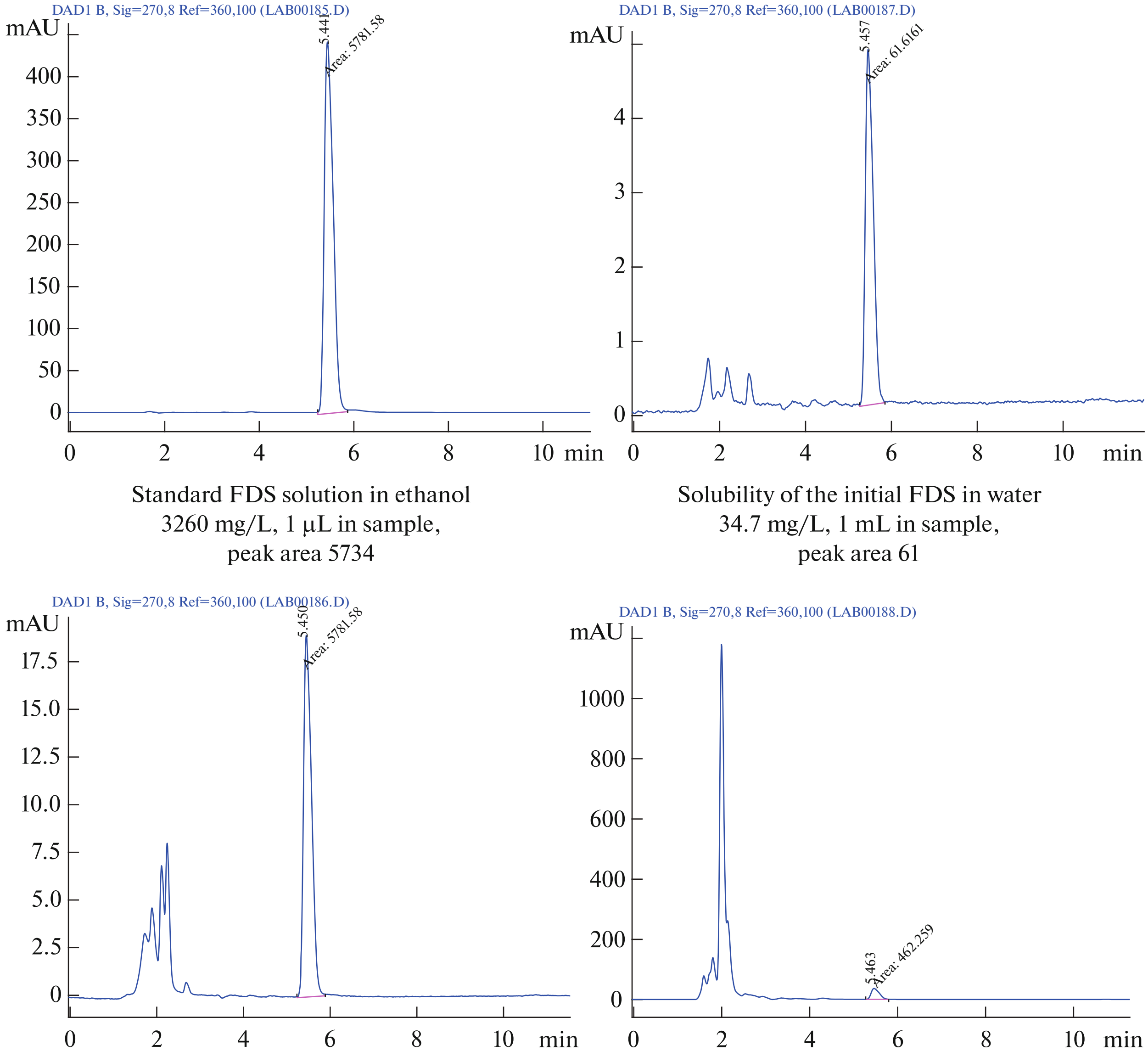
Table 2. Solubility of samples of preparations based on fludioxanil (FDS)

Sample name, NC content	Solubility	
	Absolute, mg/L	increase
FDS (initial substance, 99.0%)	35.0	–
SD for the composition FDS : AG = 1 : 9 (9.9%) (after 3 h of mechanical processing) (9.9%)	138	4.0
SD for the composition FDS : Na_2GA = 1 : 9 (9.9%) (after 3 h of mechanical processing) (9.9%)	267	7.7

It was shown that the solubility of FDS increased by four to eight times compared to the original FDS. Such an increase in solubility is explained by the formation of the corresponding supramolecular complexes upon dissolution of SD in water [16], and this factor, as expected, should also affect the increase in the biological efficiency of these SDs, since plant metabolites (AG and Na_2GA) included in preparations facilitated the penetration of FDS into plant objects due to the proximity of their structures to the structure of plant membranes [17]. Similarly, suspension preparations, being nanodispersed systems and having increased bioavailability, should exhibit high biological activity [18]. Subsequent biological tests of these preparations confirmed the above assumptions.

The study of the biological effectiveness of innovative preparations showed that preparation one, where there were practically no fusarium and phomosis rots, was the most healthy for stored potatoes (283 times lower than in control). Preparations three and five reduced the number of storage rots by 42.4 times in comparison with the control variant. Preparations two, four, six, and seven reduced the weight fraction of tubers with rot by 17.0–22.9 times. This indicator was 10.7–16.0 times for commercial preparations (Table 3). The biological efficiency of innovative preparations varied from 94.1 to 99.6; it was 90.7–93.7% for the standards.

Studies have shown that the developed preparations were also effective against the causative agent of potato rhizoctonia (Fig. 2). In comparison with the control, all experimental preparations significantly reduced the development of the disease during the germination period from 1.5 to 11.0 times. By the budding–beginning of flowering phase, the positive effect was preserved only in the variants with preparations one and two. In these cases, a significant decrease in the incidence was 1.3 times. Chemical standards during the period of germination and budding–beginning of flowering of potatoes reduced the development



Standard FDS solution in ethanol 3260 mg/L, 1 μL in sample, peak area 5734

Solubility of the initial FDS in water 34.7 mg/L, 1 mL in sample, peak area 61

Solubility SD of composition FDS: AG = 1 : 9, 138 mg/L, peak area 242

Solubility SD of composition FDS: Na_2GA = 1 : 9, 267 mg/L, peak area 469

Fig. 1. FDS chromatograms and its TD with plant metabolites (AG and Na_2GA).

of rhizoctonia compared to the control by 11.0 and 1.1 times (TMTD) and 15.6 and 1.2 times (Maxim preparation), respectively. The drug Maxim significantly reduced the development of the disease in both phases of culture development, while TMTD reduced it only during the germination period.

Experimental preparations one to three based on fludioxonil were less effective in the germination phase than the commercial preparation Maxim, SC by 4.8–10.4 times; a significant increase in the incidence of plants with rhizoctonia in this phase of ontogenesis was observed: 1.5 times in comparison with the drug Maxim, SC.

Preparations six and seven based on TBC, TMTD, and BMC suppressed the development of the black scurf at the level of the TMTD chemical standard. This trend was also preserved in preparation seven during the period of budding–beginning of flowering, while composition six significantly increased the development of the disease on stems during this period by 1.3 times in comparison with TMTD.

The preparations containing FDS and the above-mentioned active substances (four and five) were at the level of commercial preparations at the early phase of ontogenesis, while their effectiveness during the budding–beginning of flowering period was either at the level of chemical control or lower. For example, plants in the variant with preparation four were affected by rhizoctonia at the level of the variant with TMTD in the budding–beginning of flowering phase, and the affection was significantly higher than in the variant with the Maxim preparation. Preparation five showed significantly lower efficacy than that of commercial preparations by 1.1–1.3 times.

The study of the effect of preparations on the biometric parameters of the culture showed that there was no significant difference between the control variant and variants with innovative protectants during the germination period, as in the case between commercial and experimental preparations (Fig. 3).

The same regularity was noted in the period of budding–beginning of flowering when comparing the height of plants in the control and in the experimental variants. The exception was preparation two, where this indicator was significantly higher by 1.1 times.

Innovative preparations containing fludioxanil in their composition (preparations one to five) also did not have any stimulating effect on the growth of the culture in comparison with the Maxim dressing agent. The height of the plants in the variants where experimental protectants were used, which included thiram (preparations four to seven), was significantly higher in comparison with the TMTD standard: by 1.1–1.2 times.

Modified fungicides affected not only plant height but also their biomass (Fig. 4). During the period of potato sprouting, almost all experimental preparations (with the exception of preparation one) significantly reduced the weight of one stem from 21.3 to 47.5 g (from 24.7 to 55.0%) in comparison with the control. The most significant effect on the decrease in phytomass, by 40.0–47.5 g/stem (by 46.3–55.0%), was exerted by fungicidal compositions six and seven. Commercial preparations Maxim and TMTD significantly reduced this indicator by 7.5 and 26.3 g/stem (by 8.7 and 30.5%) respectively. Experimental preparations two to five, containing fludioxanil, significantly reduced the weight of one stem in comparison with Maxim by 13.8–22.5 g (by 17.5–28.5%). Dressing agent one did not affect this indicator in this case. Of compositions four to seven containing tiram, only preparations six and seven affected the phytomass, when a significant decrease in the index was observed in comparison with the variant with TMTD by 13.7–21.2 g/stem (by 22.8–35.3%).

Table 3. Influence of mechanically modified protectants on dry phomosis-fusarium rot during storage

Variant	Weight % of infected tubers	Biological efficiency, %
Control without treatment	84.8	–
Maxim (standard–Fludioxonil)	5.3	93.7
TMTD (standard–thiram)	7.9	90.7
Preparation 1	0.3	99.6
Preparation 2	3.7	95.6
Preparation 3	2.0	97.6
Preparation 4	4.3	94.9
Preparation 5	2.0	97.6
Preparation 6	4.0	95.3
Preparation 7	5.0	94.1

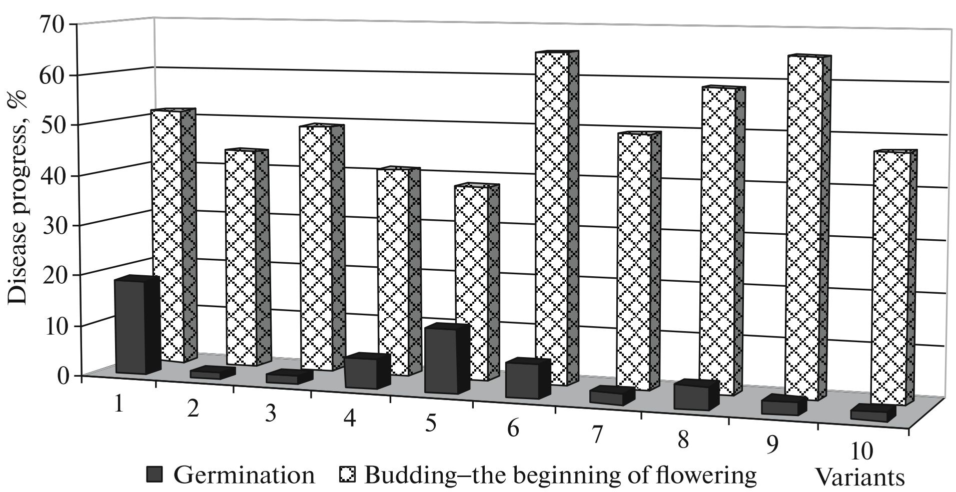


Fig. 2. Effect of mechanical chemically modified drugs on the development of risoctoniosis (LSD_{05}: developmental phase factor 1.4, protection factor 3.2, partial averages 4.6; variants: 1—control; 2—Maxim, standard; 3—TMTD, standard; 4—preparation 1; 5—preparation 2; 6—preparation 3; 7—preparation 4; 8—preparation 5; 9—preparation 6; 10—preparation 7. The same in Figs. 3–8.

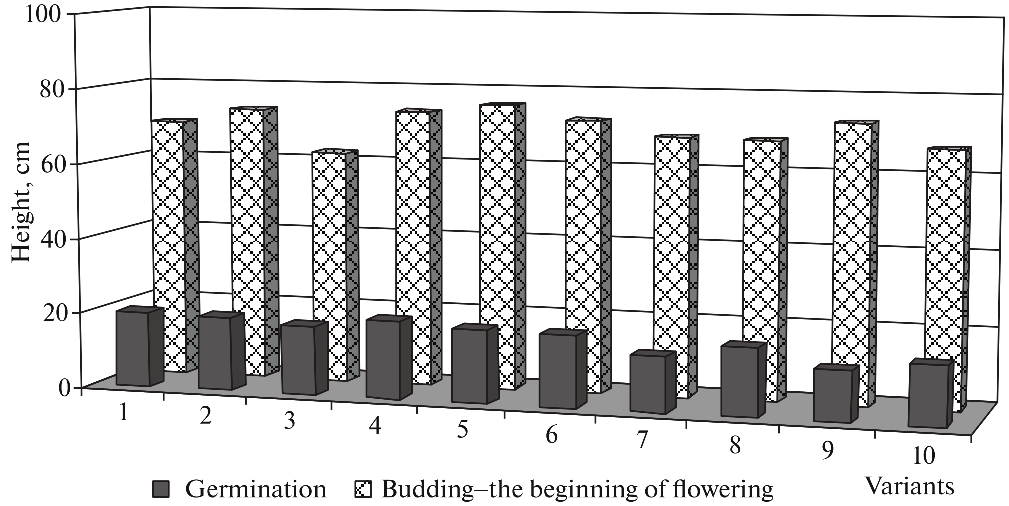


Fig. 3. Effect of mechanochemically modified preparations on the height of potato plants (LSD_{05} of partial averages: sprouting phase 3.5, budding–beginning of flowering phase 5.0).

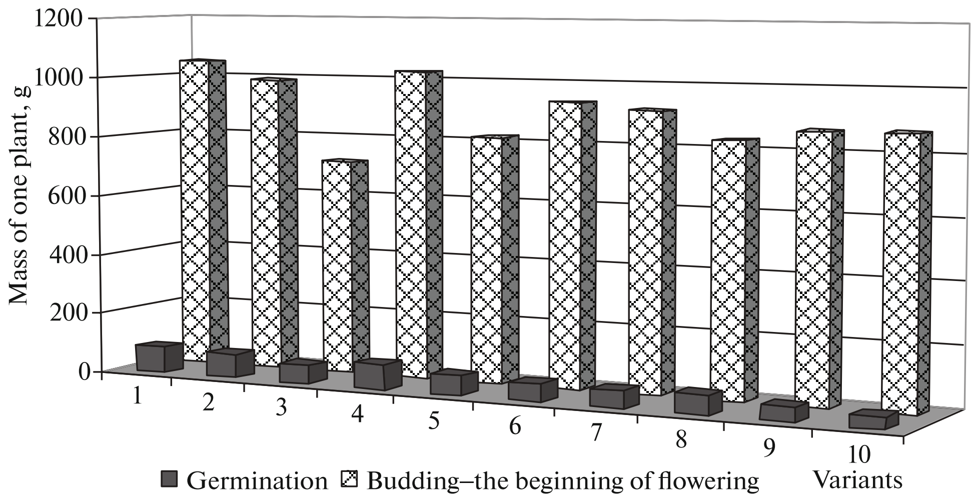


Fig. 4. Effect of innovative drugs on the phytomass of potatoes, g/plant (LSD_{05} of partial averages: sprouting phase 5.8, budding–beginning of flowering phase 86).

By the budding–beginning of flowering phase, this indicator remained significantly lower in variants with preparations two to seven than in the control: the weight of one stem was lower by 113–234 g (10.7–22.3%), reaching a minimum value when using protectant two. Preparation one and the commercial protectant Maxim had no significant effect on plant mass, while TMTD reduced potato phytomass by 333 g/stem (by 31.7%). This was possibly caused by a more significant outflow of plastic substances into the tubers in the variants with protectants, as a result of which the phytomass of the stems decreased. A significant decrease in the mass of one stem was noted in variants with preparations two and five containing fludioxanil in comparison with the Maxim preparation: by 158–173 g (by 15.9–17.5%). Dressing agents one, three, and four did not affect this indicator in this case. When using compositions four to seven containing thiram, the potato phytomass was significantly higher in comparison with the variant with TMTD: the weight of one stem in these cases was greater by 114–201 g/stem (by 15.9–28.1%).

The developed preparations two to seven and commercial fungicides did not have any significant effect on the stem culture, and only preparation one significantly increased the number of stems per plant: by 1.5 times (by 62.5%) (Fig. 5). This pattern was also preserved for compositions one to five based on fludioxanil in comparison with the Maxim preparation. Compositions four and five based on thiram had no

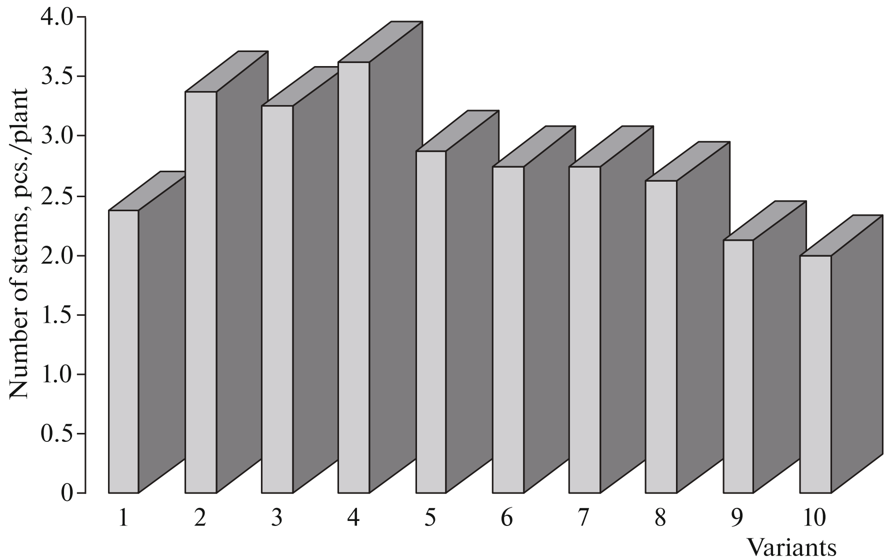


Fig. 5. Effect of innovative drugs on the number of potato stems (average for vegetation) (LSD_{05} of partial averages = 1.1).

effect on this parameter compared to TMTD, while preparations six and seven significantly reduced it by 1.5–1.6 times (by 46.2–50.0%).

The developed innovative preparations also influenced not only such indicators of crop productivity as phytomass and stem but also the total number and damage of stolons (Table 4). Only preparations one and two contributed to a significant increase in this indicator in comparison with the control variant by the budding–beginning of flowering phase. In these cases, there were 4.0 and 11.0 more stolons per plant, respectively, (by 36.7 and 98.3%). The use of other innovative preparations for spring dressing either did not affect stolon formation (preparations three and six) or led to a significant decrease in their number (preparations four, five, and seven): by 2.5–5.0 pcs. (by 21.4–42.7%) per plant. The commercial drug Maxim also contributed to a significant increase in this indicator by 2.0 pcs/plant (by 19.7%), while it was at the control level in the variant with TMTD. Of all the drugs studied, only drug one and TMTD significantly reduced the damage of stolons by rhizoctonia by 16.9 and 7.2%, respectively. In other variants, this indicator was either at the control level or significantly higher than it.

The developed innovative preparations also influenced the number and mass of tubers per plant (Fig. 6). It was found that only preparation one contributed to the formation of a significantly larger number of tubers per plant, by 3.8 pcs. (by 40.0%). The remaining innovative fungicides either did not affect this indicator (preparations two and three) or significantly reduced their number on a potato bush (preparations four to seven) by 1.7–4.7 units, which amounted to 17.9–49.5% of the control.

The treaters used as standards also affected the number of tubers. Compared to the control, Maxim significantly increased the number of tubers per plant by 0.8 pcs. (by 8.4%), the TMTD drug significantly reduced this indicator by 3.5 pcs. (by 36.8%).

Preparations containing fludioxanil in their composition (with the exception of preparation one) did not contribute to tuberization compared with the commercial preparation Maxim. There were significantly fewer tubers per plant, from 0.5 to 3.8 pcs/plant

Table 4. Influence of innovative preparations on the quantity and quality of stolons on plants in the budding–beginning of flowering phase of potatoes

Variant	Number of stolons, pcs./plant	Damaged stolons, %
Control without treatment	11.7	27.4
Maxim (standard–Fludioxonil)	14.0	27.0
TMTD (standard–thiram)	12.5	20.2
Preparation 1	23.2	10.5
Preparation 2	16.0	23.5
Preparation 3	11.7	48.9
Preparation 4	9.2	39.4
Preparation 5	9.2	32.9
Preparation 6	13.0	55.8
Preparation 7	6.7	24.3
LSD_{05}	2.1	

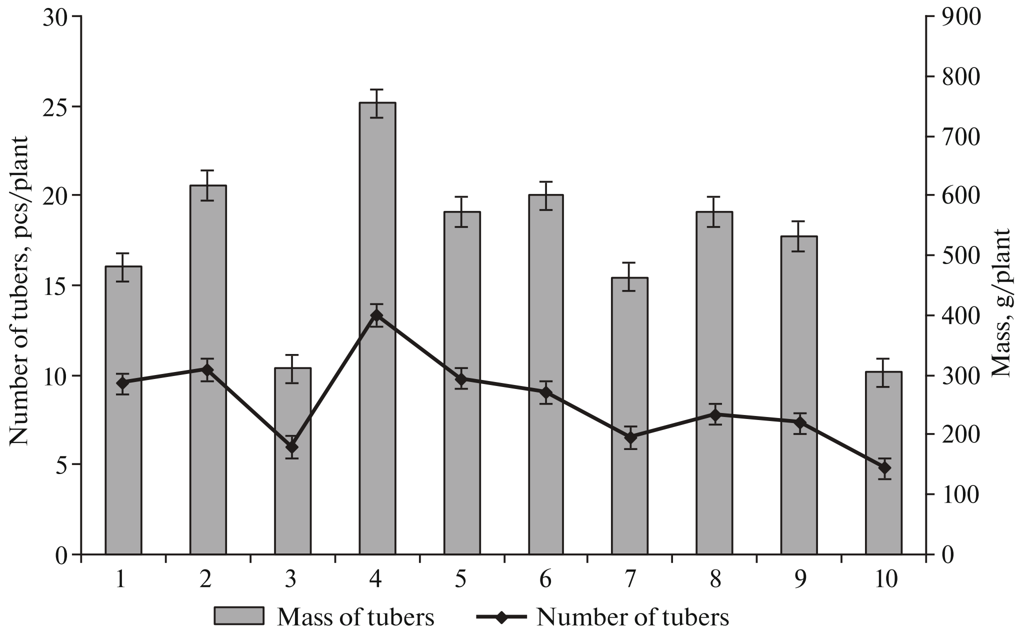


Fig. 6. Effect of innovative preparations on the number and weight of potato tubers in the budding–beginning of flowering phase (LSD_{05} of partial averages: the number of tubers 0.6, the mass of tubers 25).

(from 4.8 to 36.9%). Preparation one significantly increased this indicator by 3.0 pcs/plant (by 29.1%) in comparison with the chemical standard. Compositions containing thiram were either at the level of a chemical standard (preparation four) or significantly stimulated tuberization (preparations five and six) by 1.3–1.8 pcs/plant (by 21.7–30.0%) or significantly reduced the number of tubers (preparation seven) by 1.2 pcs/plant (by 20.0%) in comparison with TMTD.

The mass of tubers from one plant when using all innovative preparations (with the exception of preparations four and seven) was significantly higher than in the control: from 52.5 to 274 g (from 10.9 to 57.0%). When using standard disinfectants, the drug Maxim significantly increased the productivity of the culture by 138 g/plant (by 28.6%), and TMTD decreased it by 170 g (by 35.4%).

Preparations one to five based on fludioxonil had a different effect on the mass of tubers compared to the Maxim standard: preparation one significantly increased it by 136 g (by 22.1%), preparations two, four, and five significantly reduced this indicator from 45.0 to 153.7 g (from 7.3 to 24.9%), while protectant three had no effect on this parameter. All developed preparations (with the exception of preparation seven) containing thiram significantly increased the mass of tubers compared with TMTD: by 154–263 g (by 49.6–84.7%).

The complex effect of the proposed preparations on the development of the disease and the development and growth of potato plants affected the crop yield (Fig. 7).

Innovative preparations one and three significantly increased the gross yield of tubers compared with the control: by 2.7 and 11.9 t/ha (by 11.2 and 49.2%), respectively. The rest of the treaters either ensured potato yield at the control level (preparations four and five) or significantly reduced it (preparations two, six, and seven) by 1.6–4.1 t/ha (by 6.6–16.9%). Standard disinfectants made it possible to obtain more products in comparison with the control by 3.4–4.1 t/ha (by 14.0–16.9%).

In comparison with the Maxim standard (a.i. fludioxonil), only treater one significantly increased the gross yield of potatoes by 7.8 t/ha (by 27.6%), while other innovative preparations significantly reduced this indicator from 1.4 to 8.2 t/ha (from 4.9 to 29.0%). The gross yield of potatoes in variants with compositions four to seven containing tiram was significantly lower than when using TMTD for dressing (from 3.8 to 7.5 t/ha or from 13.8 to 27.2%).

The preparations we offer influenced not only the gross yield of the crop but also its quality (Fig. 7, 8). All proposed innovative treaters reduced the yield of unsuitable tubers from 4.2 to 40.9% compared with the control and significantly increased (with the exception of preparations three and seven) the yield of healthy tubers from 3.1 to 15.8 t/ha (from 47.0 to 239%). For preparation three, there was a tendency towards an increase in the second indicator by 1.8 t/ha (by 27.3%), and the effect of preparation seven did not statistically differ from the control variant. The greatest effect was observed with fungicide-protectant one, which ensured the maximum yield of healthy tubers, 22.4 t/ha (239%). The standard drug Maxim reduced

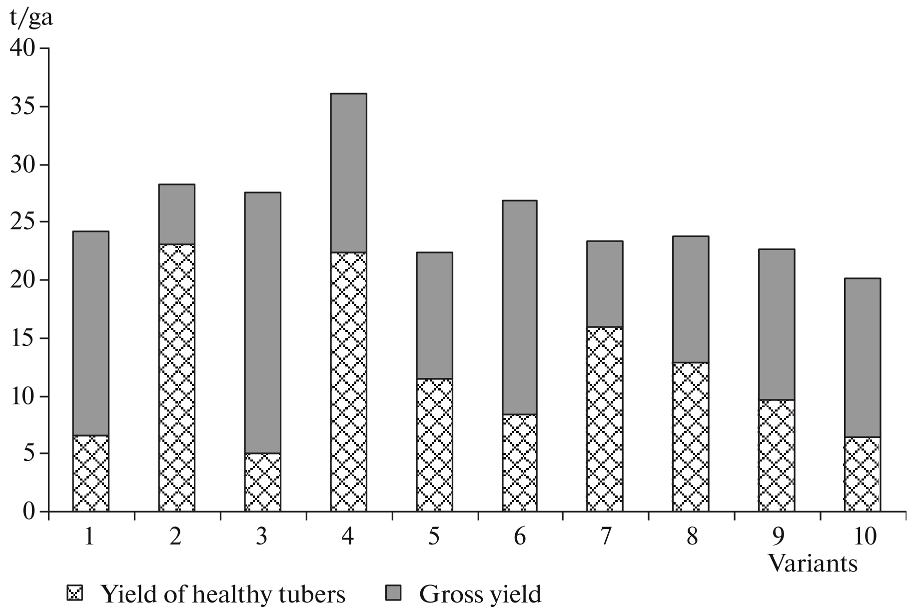


Fig. 7. Effect of innovative preparations on crop productivity and phytosanitary state of new crop tubers (LSD_{05} of partial averages: healthy tubers yield 3.0, gross yield 0.9).

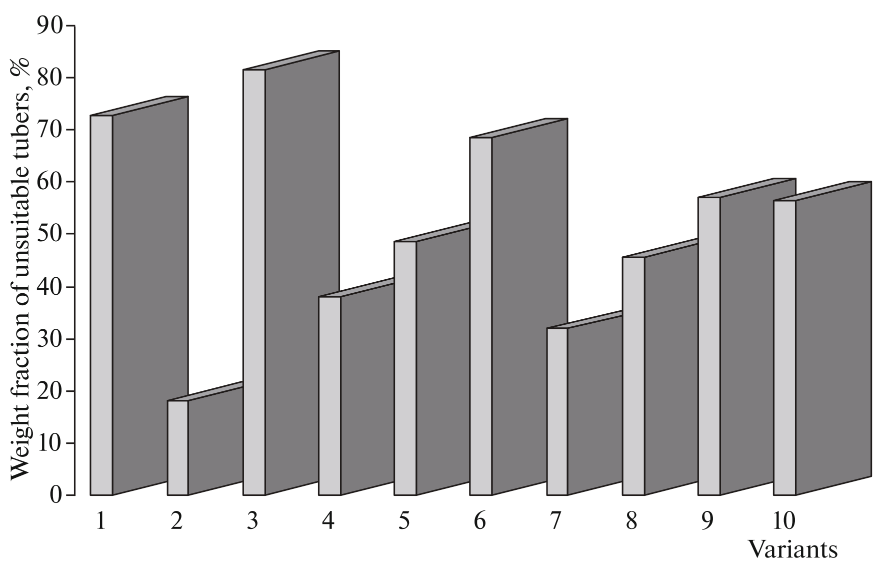


Fig. 8. Effect of innovative preparations on the quality of new crop tubers.

the number of unsuitable tubers by 54.5% and contributed to an increase in the yield of healthy potatoes by 16.5 t/ha, which amounted to 250%, while TMTD did not differ from the control.

It was found that all innovative preparations containing FDS were inferior to the commercial disinfectant Maxim by the weight fraction of unsuitable tubers (by 19.8–50.4%) and the yield of healthy tubers (with the exception of preparation one, where it was at the level of the standard) by 7.1–14.7 t/ha (by 30.7–63.6%).

When using compositions containing thiram, a decrease in the weight fraction of unsuitable tubers by 24.2–49.5% in comparison with TMTD was noted. The yield of healthy tubers obtained with the use of compositions four, five, and six increased significantly by 4.6–10.9 t/ha (by 90.2–214%) compared with the variant of using the chemical standard. Preparation seven had no effect on the yield of healthy products.

Thus, preparation one turned out to be the most effective, which most of all contributed to obtaining a high quality crop along with the standard disinfectant Maxim.

CONCLUSIONS

1. Innovative preparations (two alternative forms, solid dispersions, and suspensions) have been developed based on FDS, TBA, TMTD, and BMC, which had increased solubility and stability. Their biological effectiveness against dry rot during storage and potato rhizoctonia during the growing season was studied. The biological efficiency of innovative preparations varied from 94.1 to 99.6%, which was higher than that of commercial standard disinfectants. This result may be caused by the inclusion of plant metabolites, such as arabinogalactan and sodium salt of glycyrrhizic acid, in the preparations, which can interact with lipids of plant membranes and facilitate the penetration of drugs into plant objects.

2. Preparations one and two, which contained arabinogalatactan, most significantly reduced the development of rhizoctonia during the growing season.

3. The influence of experimental preparations on the biometric parameters of plants, crop yield, and quality of the new crop yield was shown. Preparations one and three, which contained the sodium salt of glycyrrhizic acid, significantly increased the gross crop yield by 2.7 and 11.9 t/ha (by 11.2 and 49.2%), respectively, in comparison with the control.

4. All innovative treaters reduced the yield of unsuitable tubers from 4.2 to 40.9% compared with the control and significantly increased (with the exception of preparations three and seven) the yield of healthy tubers from 3.1 to 15.8 t/ha (from 47.0 to 239%).

5. Preparation one in the form of a suspension concentrate was the most effective drug against potato rhizoctonia during the growing season, and it also contributed to an increase in crop productivity and the quality of the products obtained.

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