



ФУНГИЦИДНЫЕ ПРОТРАВИТЕЛИ ДЭЛИТ ПРО И РЕДИГО ПРО ПРОТИВ ГРИБНЫХ ФИТОПАТОГЕНОВ СОИ

✉ Безмутко С.В., Черепанова Т.А.

Дальневосточный научно-исследовательский институт защиты растений

Приморский край, с. Камень-Рыболов, Россия

✉ e-mail: dalniiizr@mail.ru

Представлены результаты изучения эффективности фунгицидных протравителей в борьбе с корневыми гнилями и листостебельными болезнями сои. Исследования проведены в Приморском крае в 2019, 2020 гг. в условиях деляночного опыта. Препарат Дэлит Про (д.в. пираклостробин, 200 г/л) применяли в норме расхода 1,0 л/т, Редиго Про (д.в. протиоконазол, 150 г/л + тебуконазол, 20 г/л) – 0,9 л/т. Препараты использовали для протравливания семян полусухим способом перед посевом. Выявлено, что Дэлит Про и Редиго Про не оказывают негативного действия на культуру и положительно влияют на всхожесть семян сои. Отмечена высокая фунгицидная активность опытных протравителей в отношении корневых гнилей, поражающих культуру. Препараты способствовали снижению интенсивности развития инфекций в фазу цветения на 17,0% (Дэлит Про) и 24,9% (Редиго Про). Защитное действие предпосевной обработки семян протравителями проявлялось также в снижении пораженности листостебельными заболеваниями. Установлено, что препараты обладают высокой биологической эффективностью против септориоза (16,7–25,2%), церкоспороза (0–44,6) и пероноспороза (29,5–87,5%). Применение Дэлит Про и Редиго Про способствовало активному росту растений и повышению основных показателей продуктивности: массы семян на 0,1–0,6 г, их числа на 1,4–2,8 шт. с одного растения, а также массы 1000 семян на 8,5–9,3 г. Достоверные прибавки урожая зерна 0,19 т/га (2019 г.) и 0,20 т/га (2020 г.) получены в варианте с использованием протравителя Редиго Про. Применяемые препараты способствовали росту уровня рентабельности на 222 и 564% соответственно.

Ключевые слова: соя, патоген, грибные болезни, протравитель, эффективность, урожайность

FUNGICIDAL PROTECTANTS DELETE PRO AND REDIGO PRO AGAINST FUNGAL PHYTOPATHOGENS OF SOYBEANS

✉ Bezmutko S.V., Cherepanova T.A.

The Far Eastern Research Institute of Plant Protection

Kamen-Rybolov, Primorsky Territory, Russia

✉ e-mail: dalniiizr@mail.ru

The results of research into effectiveness of fungicidal protectants against root rot and leaf-stem diseases of soybeans are presented. The study was carried out in the Primorsky Territory in 2019, 2020 in the conditions of plot experiment. Delete Pro (active agent pyraclostrobin, 200 g/l) was used at a consumption rate of 1.0 l/t, Redigo Pro (active agent prothioconazole, 150 g/l + tebuconazole, 20 g/l) – 0.9 l/t. The preparations were used for seed treatment in a semi-dry way before sowing. It was revealed that Delete Pro and Redigo Pro do not have a negative effect on the crop and have a positive effect on the germination of soybean seeds. A high fungicidal activity of the protectants used in the experiment was noted in relation to root rot affecting the crop. The chemicals helped

to reduce the intensity of infections during the flowering phase by 17.0% (Delete Pro) and 24.9% (Redigo Pro). The protective effect of pre-sowing seed treatment with protectants was also revealed in reducing leaf-stem diseases. It was found that the chemicals have high biological effectiveness against septoria (16.7–25.2%), cercosporosis (0–44.6%) and peronosporosis (29.5–87.5%). The use of Delete Pro and Redigo Pro contributed to active growth of plants and an increase in the main productivity indicators: seed weight by 0.1–0.6 g, seed number by 1.4–2.8 pcs from one plant, as well as thousand-seed-weight by 8.5–9.3 g. Significant increase in grain yield of 0.19 t/ha (2019) and 0.20 t/ha (2020) was obtained in the variant with Redigo Pro. The protectants used contributed to the increase in the profitability level by 222 and 564%, respectively.

Keywords: soybean, pathogen, fungal diseases, protectant, efficiency, yield

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Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Conflict of interest

The authors declare no conflict of interest.

INTRODUCTION

Soybeans, one of the leading grain legume crops in the world, are of great economic, environmental and social importance in the agricultural sector [1, 2]. The area occupied by soybeans in world production is 123.5 million hectares (the third place after wheat and rice). Such widespread distribution of soybeans is associated with the versatility of its use as food, fodder and industrial crops [3]. In Russia, soybeans are sown in 45 regions. The Far Eastern Federal District accounts for 88% of the sown area and 86% of the gross harvest of soybeans [4, 5]. In 2020, 377.4 thousand tons of soybeans were harvested in the Primorsky Territory from an area of 252.6 thousand hectares with a yield of 1.5 t/ha¹.

One of the main problems hindering the increase in soybean yields is the harm caused by pathogens [6]. More than 50 soybean diseases have been identified in the world, about 30 of them have a fungal etiology. They can both negatively affect the state of soybean crops and not cause significant damage to the crop [7, 8]. Fungal diseases of soybeans are widespread in

Primorye. Among them, the causative agents of peronosporosis, septoria, cercosporosis, ascochytosis, and fusarial root rot are dominant [9]. Leaf-stem infections (septoria, cercosporosis, peronosporosis) are especially dangerous as the most harmful in the Primorsky Territory, since they sharply reduce the assimilation surface of plants, preventing them from realizing the potential yield of the variety [10, 11].

Most soybean diseases are transmitted through seed, since seeds are a complete nutrient medium for many microorganisms that produce mycotoxins [12]. High contamination of soybean seeds significantly reduces their sowing qualities (energy, germination), leads to damage to the root system by various types of rot, significant shortfalls in grain yield and a decrease in its quality [13].

An operative method of protecting seeds and seedlings from damage by phytopathogenic fungi is their treatment with fungicides [14]. Seed dressing is the most important strategic technique for the formation of the optimal phytosanitary state of crops, which contributes to an increase in yield by 0.2–0.7 t/ha [15].

¹Information on the progress of agricultural work in the regions of the Primorsky Territory as of December 16, 2020 // Data of the Department of Agriculture and Food of the Primorsky Territory [Electronic resource]. 2020. Access mode: http://agrodv.ru/f/svodka/16_dekabrya_2020_g_.xlsx.

There are many drugs based on one to three-component active substances of different classes on the modern market. Their use contributes to obtaining healthy seedlings, even with an initially high level of seed infection. However, the effectiveness of individual disinfectants varies greatly depending on the type of disease. With the widespread use of chemicals for plant protection, resistance of pests to pesticides arises. In this regard, there is a need to create new drugs or expand their range at the expense of those registered in other cultures [16].

At present, given the high cost of high-quality dressing machines, there are violations in the processing technology of the seed material. It is important that the technique is correctly calibrated. Often, in practice, the consumption rate of the drug can be very different from the planned one. It is possible for the disinfectant to settle on the walls of the processing machine: the consumption rate will be underestimated and the drug will not show effectiveness. An outdated or inaccurate technique applies liquid preparations unevenly: most of the working solution falls on the seeds that arrive first, the rest, which enter the applicator (auger) later, remain practically untreated. About 20-30% of the seeds receive an excess of the chemical. From this it can be concluded that it is necessary to test drugs in high dosages.

In connection with the need for phytosanitary optimization of soybean cultivation technologies, it is important to form an assortment of dressing agents that are effective against the main pathogens of crop diseases.

The purpose of the work is to obtain experimental data on testing the chemical preparations Delit Pro and Redigo Pro as fungicidal dressing agents for pre-sowing treatment of soybean seeds against the main fungal phytopathogens; to determine the effect of dressing agents on the structure of soybean yield and crop productivity.

MATERIALS AND METHODS

The studies were carried out in 2019, 2020 at the experimental field of the Far Eastern Research Institute of Plant Protection. The soil of the experimental site belongs to the subtype

of meadow-brown podzolized, medium loamy in granulometric composition. Humus in the soil is 3.8%, the reaction of the soil solution is weakly acidic (pH 5.3).

Soil preparation was carried out according to the agricultural technology adopted in the Primorsky Territory: autumn plowing to a depth of 18–20 cm, early spring harrowing, and two cultivations. Sowing was carried out in a single-line method with a row spacing of 45 cm. The area of the experimental plot was 10.8 m² (1.8 × 6 m), fourfold replication, the placement of variants was randomized. Soybean variety - Asuka, seeding rate - 110 kg / ha. Seeds were treated before sowing in a semi-dry way. Experiment scheme: control (without treatment); Delit Pro, KS (d.v. pyraclostrobin 200 g / l) at a consumption rate of 1.0 l / t; Redigo Pro, KS (a.v. prothioconazole 150 g / l + tebuconazole 20 g / l) - 0.9 l / t.

The work is experimental. Redigo Pro, not registered in the "List of pesticides and agrochemicals permitted for use in the Russian Federation" on soybeans, but having a strong suppressive effect on a wide range of various pathogens of other crops was selected for the study. The drugs were tested in overestimated doses in order to assess not only the biological effectiveness, but also the safety for the culture. In agricultural organizations, drug overdose often occurs due to the use of etching equipment with inaccurate dispensers.

During the growing season of soybeans, manual weeding of experimental plots was carried out. When conducting field experiments, records, observation of growth and development, statistical processing of data was carried out in accordance with generally accepted methodological recommendations ²⁻⁶.

The manifestation and intensity of development of soybean diseases are largely determined by weather conditions. Growing seasons 2019 and 2020 were humid and warm, which favorably influenced the spread of pathogens. The amount of precipitation in June 2019 amounted to 144.4 mm, which is 63.7 mm higher than the average annual indicator (80.7 mm). The air temperature varied from 16.7 to 18 °C. The amount of precipitation in June 2020 was

115.4 mm (29.2 mm more than the average annual), the temperature was from 17.2 to 18.4 °C. July of 2019 was very hot with temperatures reaching 24.5 °C with 121.4 mm of precipitation per month. In 2020, in the third decade of July, a drought was recorded: the total amount of precipitation for the month did not exceed 69.8 mm at an average air temperature of 21.5 °C. August in both years of research turned out to be wet: the total precipitation in 2019 was 225 mm, in 2020 - 209.4 mm, which is 59.5 and 54.5 mm, respectively, more than the average annual values. Such weather conditions led to the rapid development and spread of root rot and leaf-stem diseases in soybeans.

RESULTS AND DISCUSSION

Evaluation of the safety of higher doses of preparations for soybeans showed that the dressing agents do not have a negative effect on the crop. On the contrary, the use of drugs has a positive effect on seed germination. On average, over 2 years of testing, the field germination of seeds in the control variant was 79%,

when using the disinfectants Delit Pro and Redigo Pro - 80 and 83%, respectively (LSD 05 = 7%).

The use of fungicidal dressing agents Delit Pro and Redigo Pro made it possible to significantly reduce the intensity of root rot development on soybeans. Both drugs had a healing effect on soybean seedlings (see Fig. 1).

The biological efficiency of Redigo Pro in the full germination phase was 73.6%, in the flowering phase - 41.4%. The use of this disinfectant made it possible to significantly (relative to control) reduce the degree of pathogen development: by 3.8 times (full shoots) and 1.7 times (flowering). The effectiveness of Delit Pro against root rot turned out to be low (28.2%) and was recorded only in the soybean flowering phase.

The first signs of leaf-stem diseases in soybeans were noted in the second decade of June in the phase of the appearance of the third trifoliate leaf, the maximum development of the disease - by the end of August. During the study period, such leaf spots as septoria (*Septoria glycines* Hemmi), cercosporosis (*Cercospora*

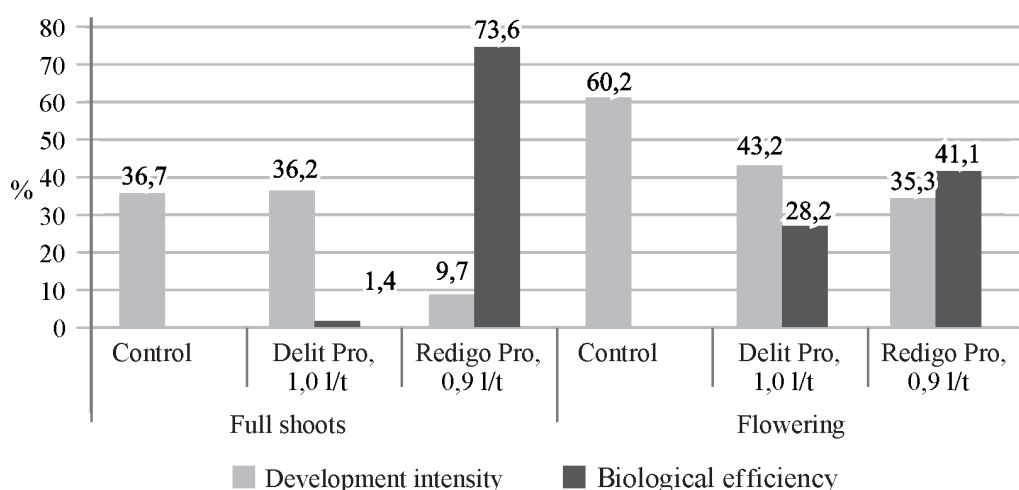


Рис. 1. Интенсивность развития корневых гнилей сои и биологическая эффективность протравителей (среднее за 2019, 2020 гг.)

Fig. 1. Intensity of development of soybean root rot and biological effectiveness of the protectants (average for 2019, 2020)

²Dospekhov B.A. Field experiment technique. M.: Agropromizdat, 1985.351 pp.

³Korsakov N.I., Ovchinnikova A.N., Mizeva V.I. Study of the resistance of soybeans to fungal diseases: method. directions. L.: VIZR, 1979.46 pp.

⁴Chumakov A.S., Minkevich I.I., Vlasov Yu.I. The main methods of phytopathological research: scientific works. Moscow: Kolos, 1974.190 pp.

⁵James B. Sinclair. Compendium of Soybean Diseases. St.Paul, Min, 1982, 104 p.

⁶Methodical instructions for registration tests of fungicides in agriculture. SPb.: VIZR, 2009.378 p.

sojina Hara), ascochytirosis (*Ascochyta sojicola* Abramov) and peronosporosis (*Peronospora manshurica* (Naum.) Syd.) were recorded. Septoriososis manifested itself in the phase of the third trifoliate leaf on primordial leaves. On average, the development of the disease in the control during the growing season was in the range of 6.1–41.0% (see Table 1). The overall assessment of the intensity of the growth of infection and its harmfulness is the relative indicator of AUDPC, which is a graphical display of the area under the curve of the development of the disease during the growing season. The greater its value, the more intensive the growth of the disease occurs in the culture. Judging by the AUDPC indicator (area under disease progress curve, c. u.), the development of the disease

in the variant with the use of Delit Pro was 1.3 times less than in the control. The biological effectiveness of the drug was 25.2% (see Fig. 2).

The years of research were favorable for the development of cercosporosis. For the first time, the disease was noted in the phase of three trifoliate leaves. It was found that Delith Pro had no protective effect against the disease. Redigo Pro, on the other hand, significantly reduced the development of cercospora, while the biological efficiency was 44.6% (see Fig. 2).

Ascochytirosis was registered in the phase of three trifoliate leaves in the form of single spots. In the control variant, the intensity of development on average for the growing seasons of 2019, 2020. varied from 0.1 to 2.8% (see Table 1). It is impractical to evaluate the bio-

Табл. 1. Влияние протравителей на интенсивность развития листостебельных болезней сои (среднее за 2019, 2020 гг.)

Table 1. Effect of the protectants on the intensity of development of soybean leaf-stem diseases (average for 2019, 2020)

Experiment option	Vegetation phase				AUDPC, c. u.
	Three trifoliate leaves	Flowering	Beans plumpness	Maturation start	
<i>Septoria blight</i>					
Control	6,1	14,4	24,3	41,0	1280,9
Delit Pro, 1,0 l / t	2,2	5,4	22,9	40,9	958,3
Redigo Pro, 0,9 l / t	3,0	12,5	17,1	18,8	1066,7
LSD ₀₅	3,4	4,9	1,1	3,0	137,2
<i>Cercospora blight</i>					
Control	0,0	0,2	5,6	12,3	215,7
Delit Pro, 1,0 l / t	1,0	0,8	14,2	33,9	241,2
Redigo Pro, 0,9 l / t	0,0	0,4	2,7	5,1	119,6
LSD ₀₅	0,0	0,7	2,1	3,9	64,9
<i>Ascochyta blight</i>					
Control	2,8	0,4	0,1	0,7	34,5
Delit Pro, 1,0 l / t	0,0	0,0	0,0	1,1	13,5
Redigo Pro, 0,9 l / t	0,0	0,2	0,0	0,6	9,5
LSD ₀₅	0,0	0,6	0,5	0,5	24,5
<i>False mildew</i>					
Control	0,0	6,3	10,8	33,0	823,2
Delit Pro, 1,0 l / t	0,0	0,0	5,2	10,3	580,5
Redigo Pro, 0,9 l / t	0,0	0,0	1,1	4,2	102,6
LSD ₀₅	0,0	2,0	5,4	4,4	68,2

logical effectiveness of drugs at such low rates of disease development, since the behavior of the disinfectants at a high infectious load is unknown.

Weather conditions in late July - early August were favorable for the development of downy mildew. For the spread of the pathogen's conidia, rains, prolonged fogs or abundant dew are necessary, when water droplets remain on the leaves for at least 5 hours.

The damage of adult plants was observed in a local form. For the first time, the disease was recorded in the flowering phase on the leaves of the upper tier in the control variant with a development rate of 6.3%. In the experimental variants, the pathogen manifested itself in the phase of filling the beans, the degree of its development was 5.6% (Delit Pro) and 9.7% (Redigo Pro) less than in the control. By the beginning of the ripening of the beans, peronosporosis in the control variant exceeded the established threshold of harmfulness (25%), but the disinfectants continued to effectively control the disease. The drug Redigo Pro (87.5%) had the highest biological effectiveness against peronosporosis (see Fig. 2) 7.

The analysis of the sheaf material showed the presence of quantitative differences in some structural elements of the crop. The height of

soybean plants on average for 2 years was the maximum with the pre-sowing treatment of seeds with Delit Pro, 3.6 cm more than in the control. In the variant with the use of Redigo Pro, no changes in this indicator were noted (see Table 2).

The size of the yield depends on many indicators, among which the characteristic of the structure of its commercial part occupies an important place. The Redigo Pro preparation stimulated an increase in the mass of seeds (by 0.6 g) and their number (by 2.8 pcs.) From one plant in comparison with the unprotected variant. Both preparations significantly increased the thousand-seed-weight (see Table 2).

Correlation analysis of research results showed that the relationship between the yield of soybeans and the intensity of development of the main fungal phytopathogens, such as septoria ($r = -0.57$), cercosporosis ($r = -0.82$), ascochytosis ($r = -0.89$), root rot ($r = -0.94$) and peronosporosis ($r = -1.00$), characterized as moderate and strong negative.

In the control variant, on average for 2 years, the lowest yield (1.64 t / ha) was obtained than with the use of dressing agents, which had an effective suppressive effect on crop diseases. In the variant with the use of Redigo Pro, a significant increase in yield was obtained (0.19–

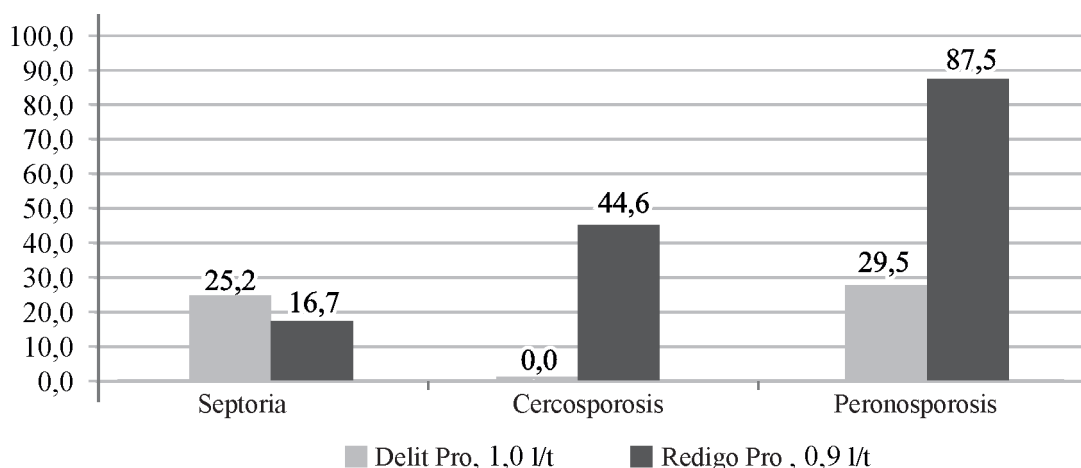


Рис. 2. Биологическая эффективность препаратов против листостебельных болезней сои (среднее за 2019, 2020 гг.)

Fig. 2. Biological efficacy of the chemicals against leaf-stem diseases of soybeans (average for 2019, 2020)

⁷Review of the phytosanitary state of agricultural crops in 2018 and the forecast of the development of harmful objects in 2019 / FSBI "Russian Agricultural Center", Branch of FSBI "Rosselkhoztsentr" in the Primorsky Territory. Vladivostok, 2019.72 p.

Табл. 2. Влияние препаратов на структурные элементы урожая (среднее за 2019, 2020 гг.)**Table 2.** Influence of the protectants on the structural elements of the crop yield (average for 2019, 2020)

Experiment option	Preparation consumption rate, l/t	Plant height, cm	Number of seeds per one plant, pcs.	Seed weight from one plant, g	Thousand-seed-weight, g
Control	—	56,4	19,5	3,1	154,4
Delit Pro	1,0	60,0	20,9	3,2	162,9
Redigo Pro	0,9	56,3	22,3	3,7	163,7
LSD ₀₅		2,5	2,0	0,4	3,2

0.20 t / ha). When using Delit Pro, there was a tendency to increase the yield relative to the control, but the increase turned out to be insignificant: 0.08 t / ha in 2019 and 0.11 t / ha in 2020 (see Table 3).

High values of net income indicate the cost-effectiveness of experience options. This indicator, taking into account prices for 2020, amounted to 2.3 thousand rubles / ha (Delit Pro) and 5.9 thousand rubles / ha (Redigo Pro). The level of profitability increased relative to control by 222% (Delit Pro) and 564% (Redigo Pro).

CONCLUSION

In the course of the two-year tests of fungicidal dressing agents, it was found that in the agro-climatic conditions of the Primorsky Territory, pre-sowing treatment of soybean seeds is a highly effective way of protecting against root rot and leaf-stem diseases. The use of Delit Pro (1.0 l / t) and Redigo Pro (0.9 l / t) preparations contributed to the active growth of plants and an increase in the main elements of the yield structure: plant height, seed mass and their

number per plant, as well as 1000 seeds. In the experimental variants, a tendency to an increase in yield relative to control was noted.

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Табл. 3. Влияние препаратов на урожайность сои, т/га**Table 3.** Effect of the protectants on the soybean yield, t/ha

Option	2019	2020	Mean
Control	1,52	1,76	1,64
Delit Pro, 1,0 l / t	1,60	1,87	1,74
Redigo Pro, 0,9 l / t	1,71	1,96	1,84
LSD ₀₅	0,12	0,15	

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ИНФОРМАЦИЯ ОБ АВТОРАХ

✉ **Безмутко С.В.**, научный сотрудник;
адрес для переписки: Россия, 692684, Приморский край, с. Камень-Рыболов, ул. Мира, 42а;
e-mail: dalniizr@mail.ru

Черепанова Т.А., младший научный сотрудник

AUTHOR INFORMATION

✉ **Svetlana V. Bezmutko**, Researcher;
address: 42a, Mira St., Kamen-Rybolov, Primorsky Territory, 692684, Russia, e-mail: dalniizr@mail.ru
Tatiana A. Cherepanova, Junior Researcher

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