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РОЛЬ СОРТА И ПРЕДШЕСТВЕННИКА В ДИНАМИКЕ ЧИСЛЕННОСТИ *RHIZOCTONIA SOLANI* В ПОЧВЕ

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Проведены многолетние (2014–2019) исследования динамики численности гриба *Rhizoctonia solani* Küch. в почве под сортами картофеля Purple Majesty, Vitelotte и Фиолетовый и предшественниками (картофель, овес и горчица сарептская). Исследования проходили в Новосибирской области в почвенно-климатических условиях, типичных для лесостепной зоны Западной Сибири. Для изучения особенностей динамики численности гриба *R. solani* в посадках картофеля осуществляли отбор почвенных проб под растениями в течение всего периода вегетации. Количество пропагул ризоктонии в почве определяли с помощью метода множественных почвенных таблеток. Установлены разница в численности и скорости накопления гриба *R. solani* под различными сортами, а также влияние на этот процесс предшествующих культур. Под сортом Purple Majesty наблюдали два пика численности гриба: первый (48,7 пропагулы/100 г почвы) – в период полных всходов, второй (57,2 пропагулы/100 г почвы) – в конце фазы созревания культуры. У сортообразцов Vitelotte и Фиолетовый наблюдали один пик в динамике численности гриба в конце периода созревания (59,0 и 49,1 пропагулы/100 г почвы соответственно). Наименьшая численность гриба *R. solani* в почве в среднем за период вегетации отмечена под сортом Фиолетовый – 33,3 пропагулы/100 г почвы. У сортов Purple Majesty и Vitelotte данный показатель составлял 41,5 и 40,4 пропагулы/100 г почвы соответственно. При возделывании в монокультуре сорта картофеля Agata идет быстрое и значительное накопление гриба *R. solani* в почве (от 34,6 до 126,8 пропагулы/100 г почвы). Если данный сортообразец культивируется после горчицы сарептской или овса, численность возбудителя варьирует в меньшей степени (25,1–52,2 и 19,8–41,0 пропагулы/100 г почвы соответственно). Резких подъемов численности пропагативных структур фитопатогена в почве не отмечено.

Ключевые слова: ризоктониоз картофеля, сорт, предшественник, динамика численности, почва

THE ROLE OF VARIETY AND FORECROP IN THE POPULATION DYNAMICS OF *RHIZOCTONIA SOLANI* IN SOIL

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Long-term studies (2014–2019) of the population dynamics of the fungus Rhizoctonia solani Küch. were carried out in the soil on the Purple Majesty, Vitelotte and Fioletovy potato varieties and preceding crops (potatoes, oats and tendergreen). The study was carried out in Novosibirsk region in the soil and climatic conditions typical of the forest-steppe zone of Western Siberia. To study the peculiarities of *R. solani* fungus population dynamics in potato plantations, soil samples were taken from under the plants during the entire growing season. The accumulation of rhizoctonia propagules in the soil was determined using the method of multiple soil pellets. The difference in the amount and rate of accumulation of the fungus *R. solani* on different varieties, as well as the influence of previous crops on this process, was established. Two peaks of the fungus accumulation were observed on the Purple Majesty variety: the first (48.7 propagules/100 g of soil) – during the full germination period, the second (57.2 propagules/100 g of soil) – at the end of the crop maturation phase. One peak was observed in the population dynamics of the fungus on Vitelotte and Fioletovy varieties, at the end of the ripening period (59.0 and 49.1 propagules/100 g soil, respectively). The smallest amount of *R. solani* fungus in the soil on average during the growing season was noted on the Fioletovy variety – 33.3 propagules/100 g of soil. In the Purple Majesty and Vitelotte varieties, this figure was 41.5 and

40.4 propagules/100 g of soil, respectively. When potato variety Agata was cultivated as monoculture, there was a rapid and significant accumulation of the fungus *R. solani* in the soil (from 34.6 to 126.8 propagules/100 g of soil). When this variety was cultivated following tendergreen or oats, the amount of the pathogen varied to a lesser extent (25.1–52.2 and 19.8–41.0 propagules/100 g of soil, respectively). No sharp increases in the number of propagative structures of the phytopathogen in the soil were noted.

Keywords: potato rhizoctonia, variety, forecrop, population dynamics, soil

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INTRODUCTION

The complexity of controlling a disease such as rhizoctoniasis is determined by the ecological plasticity and broad specialization of the pathogen, the complexity of its pathological process. Rhizoctonia solani Küch. mushroom can exist in a wide range of temperatures and soil moisture, so the disease is harmful both at low and high temperatures and at high and low soil moisture.

Currently, 16 anastomotic groups of the causative agent of potato rhizoctoniae have been described. Their number may increase as research expands. Some groups are widely specialized and affect a wide range of plants, others - only certain species, some groups, such as Ag 6, Ag 7, Ag 10, and Ag BI, are not plant pathogens[1] [1-3]. Isolates from the anstomotic groups Ag 1, Ag 2, Ag 4 and Ag 5 are widely specialized, the Ag 3 group is highly specialized, which affects only nightshades, AG 8 - cereals and potatoes, AG 9 - cruciferous plants and potatoes, AG 11 - wheat [2–9].

A number of strains of the fungus that infect potatoes can develop on the remains of corn, straw, especially in the post-harvest period, when there are no main sources of food.

The source of infection is diseased potato plants and tubers, as well as many cultivated and weed plants (sow thistle, horsetail, quinoa, etc.). The causative agent of the disease has several modes of transmission. The main factor in the transmission of the pathogen from year to year is the soil. The number of the pathogen in the cultivated soils of Siberia ranges from 0 to 20 propagules per 100 g of air-dry soil; the soils are more infected after planting potatoes. Diseased potato tubers are one of the main factors in the transmission of the pathogen: its frequency ranges from 29 to 70%. Transmission of the pathogen during the season also occurs through basidiospores at high air humidity (86–96% or more) by airborne droplets, but this transmission mechanism has additional importance. Thus, the circulation of the pathogen in nature occurs due to a combination of soil and tuberous transmission mechanisms from year to year with additional airborne droplets during the season. It is necessary to use techniques and methods that reduce the initial stock of infection of the pathogen in the soil and on tubers to protect potato plantings from rhizoctonia disease [10].

A simple disinfection of tubers is often not enough when fighting the causative agent of rhizoctonia. The accumulation of a significant amount of infection in the soil of crop rotations of specialized potato and vegetable farms can lead to a massive damage to potato plants by

[1]Carling D.E., Sumner D.R. Rhizoctonia. University of Alaska, Fairbanks, Palmer, AK 99645 and University of Georgia, Tifton, GA 31793 (representatively). 1990. 10 p.

rhizoctonia even in cases of exclusion of seed infection. The main role in the development of rhizoctonia is played by soil inoculum (pseudosclerotia of R. solani Kühn. stay in the soil for 2–6 years even in the absence of potatoes)[2] [11]. It is necessary to know the number of propagative structures of the pathogen in the soil and the role of varieties and precursors in the pathological process to successfully build a strategy and tactics for protecting potatoes from this disease.

The purpose of this work is to reveal the population of the fungus R. solani Kühn. in the soil under the potatoes of different kinds and under the crop cultivated after different predecessors.

MATERIAL AND METHODS

The studies were carried out in the Novosibirsk region in the soil and climatic conditions typical of the forest-steppe zone of Western Siberia.

The soil cover of the station is represented by a typical for the region leached medium loamy chernozem with the following agrochemical characteristics of the topsoil layer (0-30 cm): humus (according to Tyurin) about 5.0%, total nitrogen (according to Kjeldahl) - 0.34 mg / 100 g of soil , phosphorus and potassium (according to Chirikov) - 29.0 and 13.0 mg / 100 g of soil, respectively, pH = 6.7-6.8.

The growing seasons of 2014–2019 were characterized by different weather conditions. The HTI (hydrothermal index) for the potato growing season (May - August) according to Selyaninov in 2014 was 0.71, 2015 - 1.33, 2016 - 0.76, 2017 and 2018. - 1.30, 2019 - 1.00. Consequently, a slight drought was observed in 2014, 2016 and 2019 turned out to be insufficiently moistured, in 2015, 2017 and 2018 the level of heat and moisture supply was optimal for plants.

The main elements of potato cultivation technology corresponded to those generally accepted for the area [12]. Potato agricultural technology included non-moldboard fall tillage, early spring harrowing, cultivation (15–20 cm) and ridge tillage. Furrow planting was carried out followed by covering with soil. Planting care included the following techniques:

– herbicidal treatments (Metrifar 70, WSG (a.i. metribuzin 700 g / kg, consumption rate 0.7-1.4 l / ha) and Boxer, EC (a.v. prosulfocarb 800 g / l, consumption rate 3– 5 l / ha));

– inter-row cultivation, hilling;

– vegetation treatments against pests (Decis, EC (a.i. alpha-cypermethrin 100 g / l, consumption rate 0.1 l / ha));

– treatments against diseases (Revus Top, SC (a.v. difeconazole 250.0 g / l and mandipropamide 250.0 g / l, consumption rate 0.6 l / ha)).

Before harvesting, the foliage was desiccated with Reglon Super, WS (d.v. diquat 150 g / l, consumption rate 2 l / ha).

The experience was laid according to the methodology for conducting field studies[3]. The experiment was repeated twice, the number of plants in the replication was 20. Planting density 35.7 thousand plants / ha, feeding area 0.4 by 0.7 m.

The experiments were carried out by means of natural colonization of the soil by the causative agent of potato rhizoctonia disease (potatoes were planted on the same plot of land for 2 years in a row, which made it possible to form the above background). The peculiarities of the dynamics of the R. solani population under the colored potato varieties Purple Majesty, Vitelotte, and Violet were studied by planting them on a soil infectious background after potatoes on potatoes. Early potato varieties Agata were planted after various predecessors (potatoes, oats, and Sarepta mustard), also cultivated against the soil infectious background of R. solani.

Soil samples were taken under the plants before planting (May), during the full germination phase (June), during the budding period

[2]Shaldyaeva E.M., Pilipova Yu.V., Shatunova M.P. Optimization of the phytosanitary state of vegetable and specialized crop rotations in Western Siberia. Phytosanitary improvement of ecosystems: materials of the second All-Russian congress on plant protection (St. Petersburg, December 5-10, 2005). SPb., 2005. Vol. 1. pp. 585–586.

[3]Dospekhov B.A. Field experiment methodology (with the basics of statistical processing of research results). M.: "Book on demand", 2012. 351 p.

- the beginning of flowering (July) and during the maturation phase of the sample (August - September) before harvesting to study the features of the dynamics of the R. solani fungus population in potato plantings. The accumulation of rhizoctonia propagules in the soil was determined using the method of multiple soil pellets. 40–50 g of soil was taken from an average soil sample and sifted on a sieve with a 2 mm mesh, the moisture content was brought to 18%, and then ground to a homogeneous state. Sowing was performed with pellets using a sampler [13], 10 cups per sample (15 tablets in each cup) and one cup per dry weight (15 tablets) for further conversion to the selective medium of Co and Hora [14].

The population was determined in the spring before planting (initial); in the summer, in the phases of full germination and budding - the beginning of flowering; in the fall before harvesting.

Selective medium of Co and Hora per 1 liter of distilled water: agar - 20.0 g; K^2 HPO^4 1.0 g; $MgSO^4$. $7H_2O$ 0.5 g; KCl - 0.5 g; $FeSO_4$. $7H_2O$ - 0.01 g; $NaNO_2$ - 0.2 g. Sterilization for 35 min at 1 atm. After sterilization, gallic acid (0.4 g), streptomycin (0.05 g) and levomycin (0.05 g) were added.

The number of propagules per 100 g of dry soil was recalculated according to the formula

$$X = \frac{B \cdot 100}{A},$$

where B is the number of propagules in 150 tablets; A - the number of soil in 150 tablets, g; X is the number of propagules in 100 g of soil.

RESULTS AND DISCUSSION

Studies have shown that the amount of R. solani in the soil varied depending on the cultivar (see Fig. 1).

Under the potato variety Purple Majesty, two peaks of the fungus population in the soil were observed: the first (48.7 propagules / 10 g of soil) - during the full germination period, the second (57.2 propagules / 100 g of soil) - at the end of the crop maturation phase. The first peak in numbers was observed at the beginning of the growing season - the period of germination of tubers. This is probably due to the fact that the root exudates of the plants of this host cultivar stimulated the germination of spores of

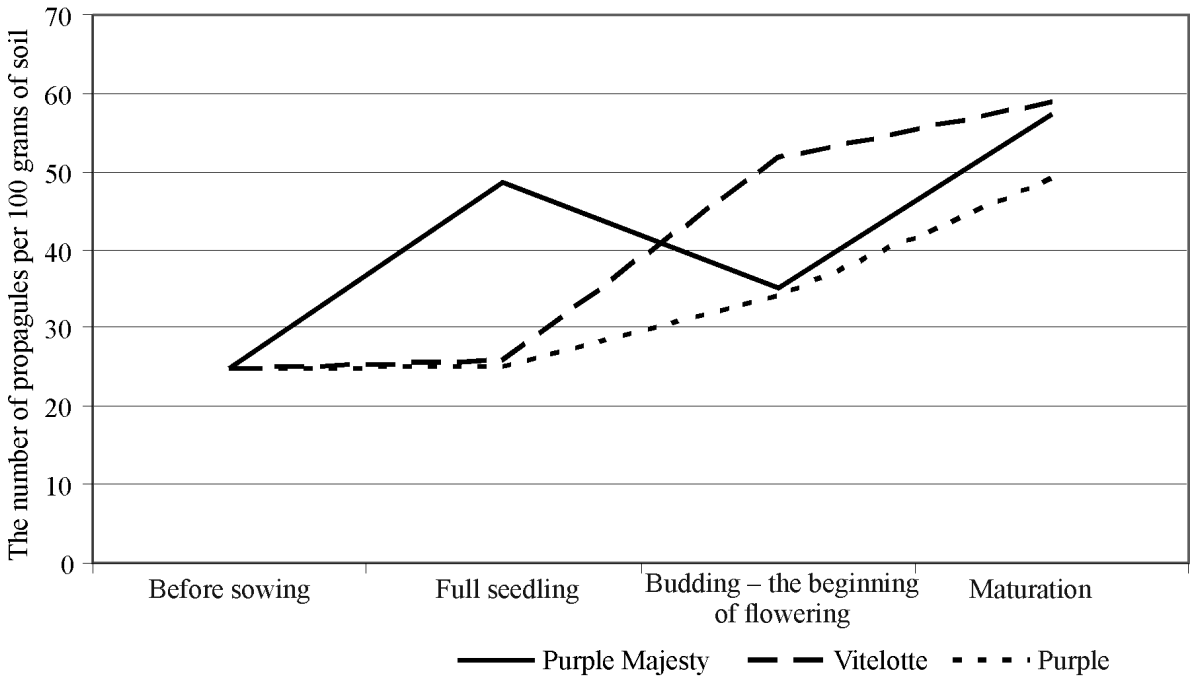

Рис. 1. Динамика численности пропагул *R. solani* в почве под разными сортами картофеля (среднее за 2017–2019 гг.)

Fig. 1. Population dynamics of *R. solani* propagules in soil on different potato varieties (average for 2017–2019)

the fungus R. solani, and the soil was actively colonized by this pathogen. A number of studies have noted that plant exudates affect the development of the causative agent of black scab and can provide both better opportunities for its penetration and infection [15] and suppress the development of the pathogen [16, 17].

The second peak in the abundance of R. solani for this cultivar was observed in the phase of maturation of the culture (August), which is obviously associated with the high saprophytic activity of the fungus. As a result, a large amount of infected plant residues entered the soil [1, 18].

In Vitelotte and Violet cultivars one peak was noted in the dynamics of population (59.0 and 49.1 propagules / 100 g of soil, respectively) at the end of the ripening period. The number of propagules in the soil under these two varieties during planting and during the germination period was almost the same, but by the budding phase - the beginning of flowering, the Vitelotte variety showed a sharp increase in the number of fungi - from 25.9 to 51.9 propagules / 100 g of soil with its further growth to 59.0 propagules / 100 g of soil. This phenomenon may be explained by the fact that by this period potato plants have rapidly accumulated a significant amount of carbohydrates and protein substances which are a good substrate for the development and active use of them by the fungus as a source of nutrition, which, in turn, contributes to a sharp increase in its parasitic properties growth[4].

The Violet variety showed a smooth increase in the number of propagules in the soil in comparison with two other varieties (25.1 propagules / 100 g of soil in the germination phase, 34.2 - budding - the beginning of flowering and 49.1 propagules / 100 g of soil during the ripening period). The indicators of the number of the fungus under this variety were the smallest.

The dynamics of development of the fungus R. solani in soil on the same cultivar grown according to different predecessors also varies. Thus, during the cultivation of potatoes of the Agata variety in monoculture at the beginning of the growing season a decrease in the number of propagules in the soil from 50.4 to 34.6 per 100 g of soil was noted. Subsequently, one peak in the number of the causative agent of rhizoctonia was observed, and the accumulation of the causative agent in the soil was very rapid. This indicator in the phase of full germination was 34.6 propagules / 100 g of soil, in the periods of budding - the beginning of flowering and ripening it was 1.6 and 3.7 times higher, respectively (see Fig. 2).

The dynamics of the fungus R. solani showed two peaks in population when cultivating potatoes of the Agata variety following tendergreen or oats. The first fell on the phase of full germination (June), the second - during the ripening of the culture (August). The first peak on these previous crops coincided with the lowest population of phytopathogen in continuous potato cultivation on potato.

The amount of the pathogen in the soil following oats and tendergreen was 2.5–3.1 times lower than in the monoculture in the ripening phase. The accumulation of the infectious principle in the soil after these predecessors also occurred, but the rate and dynamics of this accumulation in comparison with the monoculture turned out to be somewhat different. Thus, from planting to the germination phase, an increase in the number of the fungus was observed (1.6–1.7 times compared to the initial one), by the period of budding - the beginning of flowering, the amount of the pathogen in the soil gradually decreased, then its rise was observed again. When cultivating the Agata variety following tendergreen the second peak was 1.1 times lower than the first and 1.2 times after oats. It can be assumed that after the decomposition of tendergreen and oat stubble residues, the substances contained in them entered the soil and contributed to the suppression of the pathogen and the improvement of the soil [16, 17].

[4]Pochanina L.D. Features of the pathogenesis of potato rhizoctoniae and immunological assessment of varieties to the disease: author. dis. PhD in Agr. sciences. Samokhvalovichi, 1977.22 p.

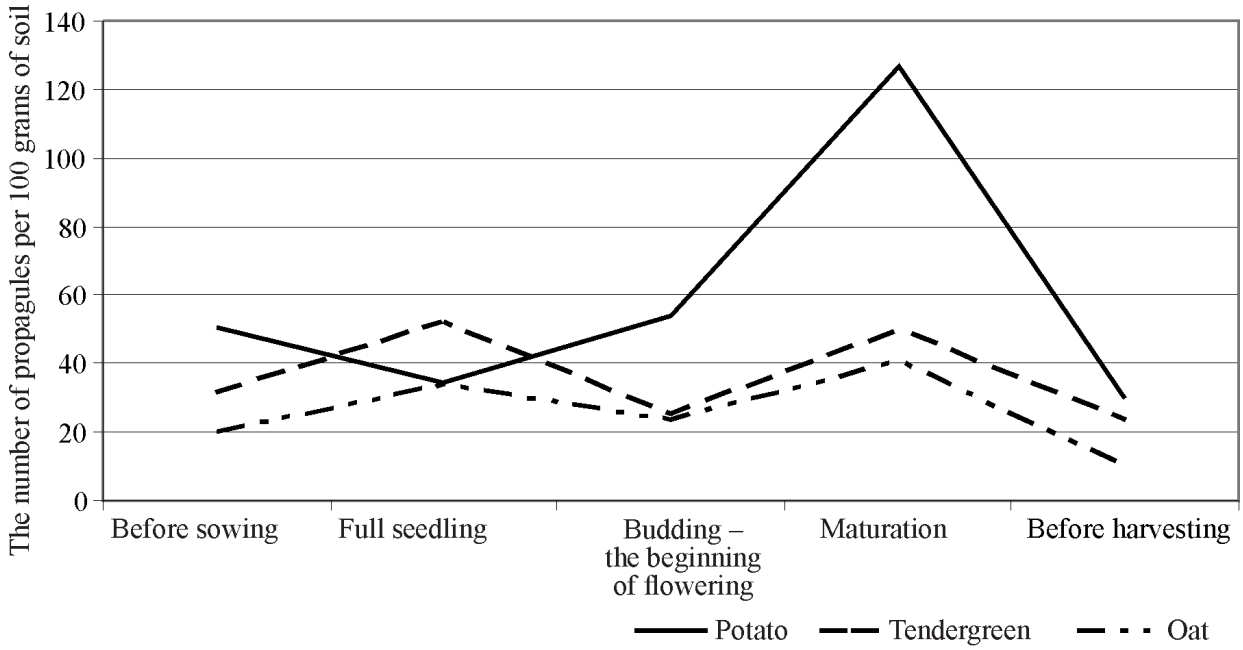

Рис. 2. Динамика численности пропагул *R. solani* при возделывании картофеля сорта Agata по разным предшественникам (среднее за 2014–2016 гг.)

Fig. 2. Population dynamics of *R. solani* propagules in the cultivation of Agata potatoes followed by different forecrops (average for 2014–2016)

CONCLUSION

1. The difference in the number and rate of accumulation of the fungus R. solani under different varieties of potatoes, as well as the influence of previous crops on this process, have been established.

2. The fungus R. solani population dynamics by cultivars differs in the soil. The smallest number of the causative agent of potato rhizoctonia blight in the soil on average during the growing season was noted under the Violet variety - 33.3 propagules / 100 g of soil, in Purple Majesty and Vitelotte - 41.5 and 40.4 propagules / 100 g of soil, respectively.

3. When the Agata potato is cultivated in monoculture, there is a rapid and significant accumulation of the fungus R. solani in the soil (from 34.6 to 126.8 propagules / 100 g of soil). If this specimen is cultivated after tendergreen or oats, then the number of the pathogen varies to a lesser extent (25.1–52.2 and 19.8–41.0 propagules / 100 g of soil, respectively); sharp increases in the number of propagative structures of the phytopathogen in the soil were not observed.

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