Affection of the studied potato varieties (*Solanum Tuberosum*) *Streptomyces scabies* and *Fusarium oxysporum* in irrigated conditions of the Orenburg region

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Abstract. A comprehensive phytopathological assessment of potato varieties of different ripeness groups was carried out in the Orenburg region in 2015-2018 in order to establish the prevalence of major pathogens using the Protect and Abiga Peak fungicides against a natural infectious background under irrigated conditions. The plot area is 140 m² (length is 50 m, width is 2.8 m). The accounting area is 70 m² (length is 50 m, width is 1.4 m). The arrangement of options in the repetition is systematic. In the research we studied 17 varieties, such as mid-early - Nevsky (standard), Spiridon (standard), Lyubava, Fresco, Red Scarlett, Sante, Impala, Sheri, Rosara, Agat, Itzil, Bracelet, mid - season - Kuzovok, Burren, Tarasov, Zakhar, Cavalier. In 2015 the most susceptible to *Streptomyces scabies* Waks. & Henr. were varieties: Lyubava – 13.8%, Agat – 5.6%, Red Scarlett – 5.2%, Tarasov – 5.1%, Fresco – 3.0% and Burren – 2.2%, including standard varieties: Nevsky – 12.8% and Spiridon – 5.1%. This year we also observed the greatest defeat of tubers with stolon rot (*Fusarium oxysporum* Schlecht.): Agat – 4.9%, Fresco – 5.3%, Burren – 8.7%, Nevsky – 4.9%, Spiridon – 3.0%. Eight of the 17 studied varieties, such as Tarasov, Sante, Impala, Sheri, Zakhar, Itzil, Cavalier, Bracelet were resistant to *Fusarium oxysporum* Schlecht and *Streptomyces scabies* Waks. & Henr. When using fungicides (Abiga Peak, Protect) plant damage was practically not observed. Cavalier and Zakhar potato varieties, which combine high productivity (40 t/ha) and resistance to the studied pathogens, have been identified and recommended for use under irrigated conditions of the Orenburg region.

1. Introduction

Potato growing is one of the priority areas for agricultural development. In recent decades the Russian Federation has been among the leaders in gross production of potatoes and their consumption [1]. Today our country accounts for 17% of the sown area of potatoes and 11% of the global gross harvest [2]. The main tasks of modern scientific research in potato growing include reducing the pesticidal load and the level of losses from pathogens and improving the quality of tubers. *Solanum tuberosum* L. is one of the most common agricultural plants in the world, but at the same time, it is strongly

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affected by various pathogens of viral, bacterial and fungal etiology. It should be noted that agriclimatic conditions have a complex effect on all components of agrocenoses [3]. The effects of climate warming have had an impact on the growth and development of potato pathogens [4]. Over the past 10 years, the number of abnormal temperatures and the number of periods of drought has increased, although interannual temperature fluctuations are 1.8 ... 2.2°C. It is known from literature sources that the effect of daily temperature fluctuations and relative humidity affect the growth and development rates pathogens of plant diseases [5].

*Streptomyces scabies* Waks. & Henr. (*scab vulgaris*) is a disease caused by pathogenic *Streptomyces* viruses which synthesize phytotoxin taxaomin [6]. Common scab develops on the surface of a tuber in the form of ulcers which have a different size and shape [7] and it appears in almost all regions of potato cultivation. Its harmfulness consists in reducing the commodity value of tubers: a deterioration in taste, a decrease in starch content, and a deterioration in the shelf life of tubers [8]. Damage to the peel, caused by the pathogen provides favourable conditions for penetration into the tubers of wound pathogens, pathogens of dry and wet rot [9].

*Fusarium oxysporum* Schlecht (*fusarium wilting of plants*) is caused by an imperfect fungus. The pathogen can affect all parts of the potato, including leaves, stems and tubers and can destroy entire fields within a few days. The fungus also develops in the underground part of the plant, which leads to wilting of the plant and increased formation of tubers with stolon rot. The disease is most dangerous in years with high air temperatures [10, 11] and causes a significant decrease in yield. Rot covers only the stolonous part of the tuber, where brown, diverging radiant lines of dead cells and blood vessels are visible at the site of a thin section of tissue [12].

Successful potato cultivation requires continuous monitoring of the availability of relevant pathogens in the individual field cultivation and seed material, to fully understand of the current situation and evaluation of prospects for the development and spread of diseases [13], as well as the study of varieties and evaluation in their stability to the presence of appropriate pathogens in the growing area. In the farms need to cultivate different varieties, thereby avoiding epiphytotics, as the leveled genetic background of one potato variety allows to manifest a specific physiological races of plant pathogens, which are very dangerous for such sorts. In the conditions of the arid climate of the Orenburg region with a strong spread of viral, fungal and bacterial diseases many highly productive varieties of domestic selection in the third and forth years of reproduction (foreign selection in the second and third years) sharply reduce productivity, their quality indicators deteriorate.

Thus, studies aimed at studying the pathogen susceptibility of potatoes are timely and have undoubted relevance.

To establish the degree of susceptibility of cultivated varieties of *Solanum tuberosum* L. to the main pathogens on a natural infectious background when using fungicides in the irrigated conditions of the Orenburg region.

2. Materials and methods

The experiment was carried out at the experimental site of LLC Agrofirm Krasnokholmskaya in 2015-2018. The soil cover of the experimental plot is southern chernozem, medium humus, and medium power. The humus content in the arable layer is 4.2% (GOST 26213-91). The average content of mobile phosphorus and potassium is 2.59 ... 3.89 mg/100 g and 33 ... 45 mg / 100 g of soil, respectively (GOST 26205-91), and total nitrogen is - 6.88 mg / 100 g of soil (GOST 26107-84).

**Object of study.** The objects of research were 17 varieties of potatoes of Russian and foreign selection of mid-early and mid-ripening groups of ripeness. The standard variety for the mid-early group was Nevsky, for mid-season - Spiridon (Table 1).
Table 1. Economic characteristics of the objects of study

| Grade           | Origin                | Appointment | Ripening period |
|-----------------|-----------------------|-------------|-----------------|
| Nevsky (standard) | St. Petersburg        | table variety | mid early       |
| Spiridon (standard) | Chelyabinsk          | table variety | mid-season      |
| Lyubava         | Moscow                | table variety | mid early       |
| Kuzovok         | Chelyabinsk          | table variety | mid-season      |
| Fresco          | Holland              | for processing | mid early       |
| Burren          | Ireland              | table variety | mid-season      |
| Red Scarlett    | Holland              | table variety | mid early       |
| Tarasov         | Chelyabinsk          | table variety | mid-season      |
| Sante           | Holland              | table variety | mid early       |
| Impala          | Holland              | table variety | mid early       |
| Sheri           | France               | table variety | mid early       |
| Rosara          | Germany              | table variety | mid early       |
| Zakhar          | Chelyabinsk, Orenburg| table variety | mid-season      |
| Agat            | Chelyabinsk          | table variety | mid early       |
| Itzil           | Chelyabinsk          | table variety | mid early       |
| Cavalier        | Chelyabinsk          | table variety | mid-season      |
| Bracelet        | Chelyabinsk          | table variety | mid early       |

Experiment design. Potato planting was carried out by a four-row potato planter GRUSE FL-20 KLZ with a row spacing of 0.75 m and a half-ridge planting of tubers in 2015 - May 20, 2016 - May 16, 2017 - May 15, 2018 - May 18. The plot area is 140 m². The accounting area is 70 m² (length 50 m, width 1.4 m). The arrangement of options in the repetition is systematic. The test planting was carried out according to the methodology of the field experience of B.A. Dospekhov [14].

Ridges with a height of 0.23 ... 0.25 m were formed by a rotary cultivator Schmotzer KNM-4-75. While planting the tubers were treated with a contact fungicide Protect (Fludioxonil 0.4 l/t). During the growing season of plants using sprayer BASF-32M two treatments with Abiga Peak (3.8 l/ha) were carried out in a tank mixture with Protect (2 l/ha): the first in the budding phase, the second in closing rows. In the control, tubers and plants were not treated.

In the period of vegetation from 5 to 8 irrigations were carried out with an irrigation rate of 2550 to 3400 m³/ha with DM-100 "Frigate" sprinkler. Harvesting was carried out manually in every plot.

Mineral fertilizers were applied annually for potatoes at the rate of 150 kg of active substance per 1 ha of nitrogen, phosphorus and potassium.

Recognition of the main pathogens was carried out by tuber analysis according to GOST 7194-81, 20290-74, 29267-91, P 55329-2012 and ELISA test.

The prevalence (P) and developmental index (DI) of Fusarium oxysporum Schlecht. were determined by the formulas:  \[ P = n \times 100 / N; \quad IR = \Sigma (aibi) \times 100 / 5 N, \]
where \( n \) is the number of diseased plants, \( \Sigma (aibi) \) is the sum of the products of the number of diseased plants (ai) and the corresponding lesion score (bi) according to the scale according to which the lowest score is 0 (no lesion), 1 is affected by 0.1 to10% of the plant, 2 – affected by 11 to 30% of the plant, 3 is affected by 31 to 60% of the plant, 4 is affected by 61 to 89% of the plant, 5 (highest) is affected 90 to 100% of the plant; \( N \) is the total number of sick and healthy plants (Prikhodko et al., 2019).

Climatic conditions. Weather conditions in the years of research were different. The wettest growing season was observed in 2015, when 143 mm of precipitation fell (of which 22.8 mm in May, 51.5 mm in June, 30.8 mm in July, and 37.9 mm in August), which is 106% of long-term average data. Under the conditions of 2016, precipitation fell unevenly, in May - 21.8 mm, in June - 10.7 mm, which is 72% less than the average long-term indicators, and during the tuber accumulation in medium early and mid-ripening varieties (July and August) - 29 mm and 2.3 mm, respectively. Arid weather conditions during the growing season occurred in 2017 - the amount of rainfall during the growing
season was 54.4 mm, and in 2018 - 79 mm, which is 40.3 and 58.5% of the average long-term data, respectively (Figure 1).

Figure 1. The amount of precipitation for the growing season (2015 - 2018) and annual average data.

By the amount of precipitation (143 mm) and the temperature regime of 2015, it was most favorable for the growth and development of potato pathogens during irrigation. The second half of May was abnormally hot (the average temperature was 22 ... 27°C). In the daytime, the air warmed up to 29 ... 35°C, i.e., above the long-term average norm by 1°C. In June and July, the average air temperature was at the level of long-term average - 24.7 and 21.8°C, respectively, in August - 0.2°C higher than normal (Table 2). In 2016, the average daily air temperature in both the third decade of May and in June was at the normal level, and in July and August exceeded the annual average by 2.6°C and 4°C, respectively.

Table 2. Average air temperature, °C (day/night) from 2015-2018

| Observation period | May | June | July | August |
|--------------------|-----|------|------|--------|
|                    | III | I    | II   | III    | I    | II   | III  | I    | II   | III  |
| 2015 year          | 24.7| 21.9 | 21.8 | 24.9   | 23.7 | 22.9 | 23.5 | 26.5 | 24.3 | 22.4 |
|                    | 14.1| 15.9 | 15.0 | 16.2   | 15.1 | 12.5 | 16.4 | 16.9 | 15.2 | 15.3 |
| 2016 year          | 20.8| 19.6 | 23.3 | 22.9   | 25.4 | 29.2 | 29.7 | 34.3 | 35.2 | 32.1 |
|                    | 16.1| 15.2 | 20.9 | 19.2   | 15.1 | 16.5 | 18.4 | 20.2 | 21.2 | 17.7 |
| 2017 year          | 20.0| 20.6 | 22.3 | 24.2   | 27.2 | 27.7 | 32.9 | 27.1 | 29.7 | 32.7 |
|                    | 12.9| 12.5 | 17.6 | 17.7   | 19.6 | 18.6 | 24.1 | 22.4 | 18.7 | 21.6 |
| 2018 year          | 20.0| 22.1 | 23.9 | 29.5   | 29.1 | 31.7 | 29.7 | 31.5 | 27.7 | 26.5 |
|                    | 14.6| 13.5 | 16.3 | 21.6   | 22.1 | 24.3 | 19.5 | 22.9 | 19.9 | 16.6 |

* in the numerator of the fraction indicates the average air temperature during the day, °C; the denominator is the average air temperature at night, °C.

The average air temperature in 2018 exceeded the norm in May by 1.2°C, in June - 1.8°C, in July - 3.4°C, in August - 1°C. The maximum (day) temperature from III decades of May to August 31 was at the level of 31 ... 35°C.

Statistical processing. Statistical analysis was performed using the office software package "Microsoft Office" using the program "Excel" ("Microsoft Office", USA).
3. Results and discussion

During the observation period from 2015 to 2018 climatic conditions were diverse, which allowed a multilateral assessment of the incidence of Solanum Tuberosum L varieties in the most common and dangerous pathogens. According to the results of studies on the experimental planting of potatoes, the diseases Fusarium oxysporum Schlecht and Streptomyces scabies Waks. & Henr. manifested themselves.

The first signs of *Fusarium oxysporum* Schlecht (yellowing of leaves on plants) in 2015 were observed in early July, they were provoked by heavy rains in the third decade of June (51 mm). In August brown stems and wilted plants were observed in the control variant. The prevalence of plant morbidity reached a maximum in all cases before digging in the control – 33.7%, and in plots using the Abiga Peak + Protect tank mixture – 15.5%. The index of the development of the disease in the budding phase during treatment with fungicides was lower than the control by 46.8% and before digging by 52.8% (Table 3).

**Table 3. Effect of fungicide treatment on the prevalence and development index of *Fusarium oxysporum* Schlecht. on potato varieties, 2015**

| Processing of tubers before planting | Processing during the growing season | Prevalence, % | Development index % |
|-------------------------------------|--------------------------------------|---------------|---------------------|
| Without processing (control)        | Without processing (control)         | 25            | 6.4                 |
| Protect + Abiga Peak NDS 05         | Abiga Peak                            | 10            | 3                   |
|                                     |                                      | 3.2           | -                   |

When using fungicides plant defeat was practically not observed (Figure 2 a).

![a) Example image](image1.png)

![b) Example image](image2.png)
In 2016 in the first decade of July, 21.8 mm of precipitation fell, after which dry and hot weather established, as a result of which the development of Fusarium oxysporum Schlecht was observed in the flowering phase on individual potato plants. A similar situation occurred in 2018 at the end of second decade of July as a result of which the plants defeat manifested itself in the phase of row closure.

As a result of our studies we found that in 2015 an increased defeat of fusarium leaves in the tops, contributed to the development of stolon rot of tubers in the varieties Agat (9.4%), Lyubava (4.8%), Fresco (5.3%), Burren (8.7%), Rosara (1.2%), Kuzovok (5.7%), Red Scarlett (9.1%) . On standard options, the defeat was Nevsky - 4.2% and Spiridon – 3.0% (Figure 2 c, 3).

For four years of research among susceptible varieties, the least tuber infection with stolon rot was observed in 2016 in varieties Lyubava (1.0%), Burren (1.0%), Kuzovok (1.0%), Nevsky (1.1%), except for the variety Agat (2.8%). In 2017, the drought period coincided with the period of tuber accumulation, which contributed to the development of stool rot, the level of damage to varieties Agat (2.1%), Lyubava (2.0%), Burren (5.7%), Nevsky (2.5%), Spiridon (1.4%),
Fresco (4.8%), Red Scarlett (3.6%). For the rest of the studied varieties, there was no lesion of stolon rot.

According to the data for 2017-2018, potato tubers were also affected by Streptomyces scabies Waks. & Henr. (common scab), the disease was noted both on the Nevsky standard varieties (0.5 ... 1.0%) and Spiridon (2 ... 3.1%), and on the plots of the Lyubava varieties (10.0 ... 12.1%), Agat (2.1 ... 3.2%), Fresco (0.7 ... 1.0%), Burren (1.8 ... 2.3%), Red Scarlett (0 ... 1.0%) (Figure 4).

![Figure 4. Potato infestation with Streptomyces scabies Waks. & Henr. 2015-2018.](image)

### Table 4. Productivity of the studied potato varieties, 2015-2018

| Grade             | Productivity, t/ha | The number of affected tubers by the studied pathogens in a bush, % |
|-------------------|--------------------|------------------------------------------------------------------|
|                   | 2015 year 2016 year 2017 year 2018 year | 2015 year 2016 year 2017 year 2018 year |
| Nevsky (standard) | 44.2 41.8 38.7 26.3 | 48.0 30.1 18.4 48.0 |
| Spiridon (standard) | 45.8 43.5 39.2 37.4 | 23.1 24.0 32.3 30.0 |
| Burren             | 46.4 39.9 36.5 31.7 | 51.1 22.3 20.4 42.6 |
| Fresco             | 50.1 47.1 43.8 42.6 | 41.0 24.9 22.7 30.1 |
| Agat               | 40.7 44.3 39.8 39.0 | 37.5 23.5 23.0 37.4 |
| Lyubava            | 50.9 46.9 44.6 42.8 | 44.0 34.0 29.1 40.0 |
| Tarasov            | 53.0 49.1 46.7 44.8 | 16.4 17.1 - - |
| Kuzovok            | 44.8 46.1 41.4 40.1 | - - - - |
| Red Scarlett       | 50.5 48.2 45.6 42.7 | - - - - |
| Sante              | 38.3 43.8 41.5 39.9 | - - - - |
| Impala             | 46.6 45.3 41.9 41.0 | - - - - |
| Sheri              | 45.8 43.6 39.7 40.8 | - - - - |
| Rosara             | 43.3 42.5 40.9 36.3 | - - - - |
| Zakhar             | 53.1 50.2 43.5 49.2 | - - - - |
| Itzil              | 31.2 35.9 33.2 33.4 | - - - - |
| Cavalier           | 49.7 51.2 49.0 50.9 | - - - - |
| Bracelet           | 45.8 43.8 40.9 38.7 | - - - - |
| NDS 05             | 0.6 1.3 1.2 2.3 | 4.07 3.7 2.28 2.1 |
In 2016 ulcers of various sizes were detected on tubers during the pre-harvest count, both varieties were struck-standard (Nevsky - 3.4%, Spiridon - 2.9%), as well as varieties Lyubava (5.0%), Agat (1.1%), Fresco (1.0%), Burren (1.0%), Tarasov (2.3%). The highest prevalence of this pathogen was observed in 2015 on the varieties Nevsky (12.8%), Spiridon (5.1%), Lyubava (13.8%), Agat (5.6%), Fresco (3.0%), Burren (2.2%), Tarasov (5.1%), Kuzovok (8.7%), Red Scarlett (5.2%). The remaining studied varieties were resistant to the causative agent of common scab.

The yield of varieties also varied by year. The highest value of this indicator was in 2015 - from 44.2 t/ha at grade Nevsky to 53.0 t/ha at grade Tarasov. In 2018 the decrease in yield compared to 2015 amounted to 12% ... 41% (Table 4).

The results of vegetation and field studies showed that the percentage of affected tubers in the bush did not significantly affect the yield.

4. Conclusion
As a result of studies in 8 of the 17 studied potato varieties, these are Tarasov, Sante, Impala, Sheri, Zakhar, Itzil, Cavalier, Bracelet; tuber was not affected by the most harmful pathogens Fusarium oxysporum Schlecht. and Streptomyces scabies Waks. & Henr. For the irrigated conditions of the Orenburg region the varieties Tarasov, Cavalier and Zakhar have been identified combining high productivity (over 40 t/ha) and resistance to the main potato pathogens. We recommend using the varieties selected by us as the starting material in the selection process.

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