Distribution of golden potato nematode in the soils of the Omsk region

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Abstract. The distribution of the golden potato nematode in the soils of the Omsk region has been recorded since 2003. The potential danger of expanding the area of colonization by this phytohelminth is associated with a loss of potato yield from 30 to 90%. Of the 32 districts of the Omsk region, 21 districts were found to be populated with the golden potato nematode. Potato production in the Omsk region is mainly carried out by private individuals. In many districts of the Omsk region, the share of personal subsidiary plots in the produced potatoes reached 95%. The studies were carried out in 2017 - 2020 and it was found that cysts with viable larvae of the golden potato nematode were detected in the samples of the studied soil samples, the degree of infection was high and ranged from 50 to 90 cysts. Under these conditions, the priority direction of reducing the number of phytohelminths is the use of environmentally friendly methods of control, such as the fungal microbiological preparation Nematofagin Mikopro. In the areas with the use of a biological product, the degree of infection was average and ranged from 45 to 13 viable cysts.

1. Introduction

In recent decades, the occurrence of the golden potato nematode (Globodera rostochiensis) has been observed in the Omsk region; only one non-aggressive pathotype R01 is widespread. The first foci of the golden potato nematode in the Omsk region were discovered in 2003 on the personal plot of the Gorky district of the village of Zimino [1]. Despite the fact that the danger of the parasite for Siberian potato growing arose much later than in Western Europe, the problem of combating the golden potato nematode in the region is one of the most urgent problems in potato growing. Golden potato nematode is one of the economically significant potato parasites. The potential loss of potato yield from this particular phytohelminth varies from 30 to 90%. In this regard, the problem of awareness of the harmfulness and active spread of the parasite in the region led to increased control and supervision over seed material and planting under potatoes. Since 2013, soil survey activities have been included in the annual work plan of the Rosselkhoznadzor [2]. From the same year, quarantine measures began to prevent the spread of the parasite. At the same time, explanatory work is underway with the population about the harmfulness of the parasite and environmentally friendly control measures. Golden potato nematode is especially harmful in household plots and fields with shortened specialized crop rotations, where potatoes are grown permanently [3]. Golden potato nematode is a highly specific parasite of the roots of nightshade plants [4]. Potatoes are the most produced crops after corn, rice and...
wheat. In 2016, world potato production was about 390 million tonnes. The priority direction in potato cultivation is the use of biological preparations [5]. In 2016, world production of potatoes was about 390 million tons [6]. The Russian Federation is a leader in the cultivation of foreign potato varieties: out of 455 varieties included in the "State Register of Breeding Achievements Permitted for Use" in 2019, 182 (40.0%) are bred from far-abroad countries, 34 (7.5%) are from CIS countries, and 239 (52.5%) varieties were created by Russian breeders [7]. Phytohelminths are subject to internal (G. rostochiensis) quarantine. Therefore, there is damage caused by the prohibition or restriction of the transportation of products from the contaminated zones, and as a result of the imposition of phytosanitary quarantine zones [8]. The harm caused by nematodes is aggravated by the fact that they contribute to the spread of bacterial, fungal, and viral plant diseases. The nematode came to Europe from South America with potatoes imported from there. The spread of parasitic nematodes is directly related to the use of poor-quality seed material inhabited by phytohelminths. The fight against phytohelminths is difficult due to the long (10-15 years) viability of cysts [9].

In many districts of the Omsk region, the share of personal subsidiary plots in the potatoes produced reached 95%. In this regard, the use of environmentally friendly control methods is the main task of regional environmental departments and subordinate institutions [10]. The preparation Nematofagin Mikopro is one of the most effective and safest biological preparations for combating mobile nematode larvae based on predatory fungi (Arthrobotrys oligospora). Various trapping devices develop on the mycelium of these fungi, most often sticky traps. These are undifferentiated hyphae outgrowths covered with a sticky substance or spherical sticky heads. The most common type of sticky trap is sticky nets, consisting of a large number of rings. They are formed as a result of abundant branching of hyphae. Having touched the sticky net, the nematode sticks, and trying to free itself, it is more and more captured by the net. Soon after capture, hyphae develops from the network, dissolving the cuticle and penetrating into the nematode's body. The process of absorption of the contents of the nematode's body by the fungus lasts no more than a day [3].

The aim of the study was to determine the distribution of the golden potato nematode in the Omsk region and to identify possible ways to reduce the number of phytohelminths.

2. Materials and research methods
Laboratory work on identification and diagnostics was carried out on the basis of the Center for Collective Use "Genetics of Grain Crops", "Breeding and Seed Production of Field Crops" of the Federal State Budgetary Educational Institution of Higher Education of the Omsk State Agrarian University and the PCR laboratory of the Department of Quarantine Phytosanitary Examinations and Surveys of the Federal State Budgetary Institution "Omsk Reference Center of Rosselkhoznadzor" in 2017 - 2020. The material for the study was soil samples taken from the private plots of the Omsk region in accordance with GOST 17.4.4.02-84. The presence of golden potato nematode was determined by the funnel-flotation method (STO VNIIKR 6.001-2010). Determination of the species composition of nematodes was carried out in accordance with the generally accepted methods developed by Federal state budgetary institution "All-Russian Research Institute of Plant Quarantine", based on the polymerase chain reaction. This is an artificial process of multiple copying (amplification) of a specific DNA sequence. The advantage of this method is its high productivity and high specificity in determining the genetic material of cyst nematodes [11].

Due to the high toxicity of pesticides against nematodes, not a single chemical preparation has been registered in the Russian Federation. On the test sites, the microbiological preparation Nematofagin Mikopro was used in a liquid preparative form with a mycelium cell content of at least 3 * 106 per ml. According to the instructions for use of the preparation, a working suspension was made (1 l of the preparation was diluted in 50 l of water), the consumption of the working suspension was 100 l / ha or 10 ml per 1 m². Terms of application 1 decade of May. In 2017 - May 5-6, 2018 - May 6, 2019 - May 6-7, 2020 - May 5. Potatoes were planted manually; the planting material was examined in the testing laboratory for the presence of the parasite, and was used only after confirming its absence. In total, two sites were analyzed with and without the use of a biological product (control). The area of each
site was 0.15 hectares. In the phase of growth and tillering of potatoes, together with the inspector of the Rosselkhoznadzor administration, monitoring and selection of soil samples was carried out to confirm and identify the quarantine object - golden potato nematode. Soil samples were taken at the plots according to generally accepted methods and with fixation of sampling schemes. 30 soil samples from each plot were formed into two combined average samples. Each sample was labeled with the name of the village and the area from which the sample was taken. After delivery to the laboratory center, the soil samples were recorded in the sample collection log, where they were assigned an identification number, after which the samples were depersonalized to exclude the researcher's personal interest in bias during research. In the laboratory of helminthology, an analysis was carried out for the detection and isolation of cysts from the soil by the funnel-flotation method. The level of soil contamination was determined using a scale:
- high level: one hundred cubic centimeters of soil contains more than 5 thousand larvae, which is more than fifty cysts of nematodes;
- medium level: one hundred cubic centimeters of soil contains no more than 5 thousand larvae, which is from ten to fifty cysts of nematodes;
- low level: one hundred cubic centimeters of soil contains no more than one thousand larvae, which is from one to ten nematode cysts. After isolation of cysts from the soil, sample preparation, isolation of DNA from larvae, and amplification procedure were carried out using a test system with a positive control.

3. Results and discussion

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Diagram of the distribution of the area of identified foci of golden potato nematode from 2013 to 2019 in the Omsk region

Analyzing the data, we see an increase in the population of the potato planting area with the golden potato nematode (Fig. 1).

According to the research results, it was revealed that in the control soil sample (without the use of a biological product) the number of viable cysts was from 50 to 94 pieces. The rate of detection of viable cysts of the potato aureus nematode using the biological product Nematofagin Mikopro significantly decreased and ranged from 45 to 13 pieces (Table 1).

According to the results of monitoring and laboratory studies of the phytosanitary state of soils under potato planting from 2013 to 2019, a tendency to an increase in the number of infected areas with the *Globodera rostochiensis* parasite was revealed: from 777 to 1213. The number of districts of the Omsk region and the number of established quarantine phytosanitary zones have increased over the years of observation. At the same time, there was a decrease in the area occupied by phytohelminths, which is explained by a decrease in the area of planting under potatoes in farms and
private household plots. The maximum area of detections was 134.44 hectares in 2016; then it began to decline, and in 2019 it amounted to 109.62 hectares (Table 2).

Table 1. The results of laboratory studies on the detection and degree of infection

| Research year | Number of cysts, pcs (control sample) | Infestation rate | Number of cysts, pcs (with the use of a biological product) | Infestation rate |
|---------------|--------------------------------------|------------------|----------------------------------------------------------|-----------------|
| 2017          | 50                                   | High             | 45                                                        | middle          |
| 2018          | 74                                   | High             | 33                                                        | middle          |
| 2019          | 90                                   | High             | 20                                                        | middle          |
| 2020          | 94                                   | High             | 13                                                        | middle          |

Table 2. Phytosanitary state of the Omsk region, 2013-2019

| Research year | Number of infected areas, pcs | Number of districts | Number of established quarantine phytosanitary zones | Infected area, ha |
|---------------|------------------------------|--------------------|----------------------------------------------------|------------------|
| 2013          | 777                          | 18                 | 51                                                 | 107,19           |
| 2014          | 1041                         | 19                 | 58                                                 | 124,18           |
| 2015          | 1053                         | 20                 | 61                                                 | 124,76           |
| 2016          | 1110                         | 21                 | 70                                                 | 134,44           |
| 2017          | 1110                         | 21                 | 70                                                 | 109,21           |
| 2018          | 1118                         | 21                 | 71                                                 | 111,81           |
| 2019          | 1213                         | 21                 | 72                                                 | 109,62           |

The distribution of the soil population by phytohelminths in the districts of the Omsk region is presented in Table 3. The maximum number of infected areas was identified in the Okoneshnikovsky district, which amounted to 123 settlements with a total area of 14.13 hectares, while the minimum detection of the parasite was found in the Kormilovsky region - one settlement on an area of 0.1 hectares. In 2019, the number of areas where nematodes were detected became 21, and the number of settlements in it increased to 240 in the Tyukalinsky district. In four districts of the Omsk region (Isilkulsky, Novovarshavsky, Odessa, Poltava), the minimum number of settlements was registered - 2 with a settlement area from 0.1 to 0.4 hectares.

As a result of the implementation of measures for systematic survey with sampling and laboratory research in the period from 2013 to 2019, quarantine phytosanitary zones were established, the number of which, according to the Rosselkhoznadzor Office for the Omsk Region, increased from 51 zones to 72 zones. The number of quarantine phytosanitary zones coincides with the number of settlements (Fig. 2).

After all laboratory studies, it was confirmed that this parasite belongs to the species *Globodera rostochiensis* - golden cyst-forming potato nematode, non-aggressive pathotype R01. Based on the results of all studies, a laboratory test protocol for these soil samples was formed and issued.

Based on the results of research from 2013 to 2019, 6232 soil samples were analyzed, of which 1451 samples were found with the detection of cysts of the golden potato nematode, 441104 larvae were isolated.
Table 3. Population of *Globodera rostochiensis* in soils of settlements of the Omsk region in 2013-2019

| Research year | Infected area | Number of settlements | Infected area, ha |
|---------------|---------------|-----------------------|-------------------|
| 2013          |               |                       |                   |
|               | Bolsherechensky district | 55                    | 5,43              |
|               | Kalachinsky district     | 8                     | 2,5               |
|               | Kolosovsky district      | 53                    | 11,54             |
|               | Kormilovsky district     | 1                     | 0,1               |
|               | Krutinsky district       | 13                    | 2,61              |
|               | Moskalensky district     | 7                     | 1,35              |
|               | Muromtsevsky district    | 65                    | 15,29             |
|               | Nazyvaevsky district     | 37                    | 3,7               |
|               | Nizhneomsky district     | 96                    | 12,83             |
|               | Novovarshavsky district  | 2                     | 0,1               |
|               | Odessa region            | 2                     | 0,14              |
|               | Okoneshnikovsky district | 123                   | 14,13             |
|               | Omsk District            | 2                     | 0,42              |
|               | Poltava region           | 2                     | 0,25              |
|               | Tavrichesky district     | 32                    | 6,94              |
|               | Tevriz district          | 27                    | 4,93              |
|               | Tyukalinsky district     | 240                   | 24,4              |
|               | Cherlaksy district       | 12                    | 0,53              |
| 2019          |               |                       |                   |
|               | Bolsherechensky district | 95                    | 6,28              |
|               | Isilkul district         | 2                     | 0,2               |
|               | Kalachinsky district     | 8                     | 2,5               |
|               | Kolosovsky district      | 84                    | 14,31             |
|               | Kormilovsky district     | 14                    | 0,88              |
|               | Krutinsky district       | 76                    | 7,47              |
|               | Moskalensky district     | 30                    | 3,7               |
|               | Muromtsevsky district    | 65                    | 15,29             |
|               | Nazyvaevsky district     | 37                    | 3,7               |
|               | Nizhneomsky district     | 96                    | 12,83             |
|               | Novovarshavsky district  | 2                     | 0,1               |
|               | Odessa district          | 2                     | 0,4               |
|               | Okoneshnikovsky district | 123                   | 14,13             |
|               | Omsk district            | 22                    | 0,94              |
|               | Poltava district         | 2                     | 0,25              |
|               | Tavrichesky district     | 143                   | 14,85             |
|               | Tarsky district          | 24                    | 2,58              |
|               | Tevriz district          | 27                    | 4,93              |
|               | Tyukalinsky district     | 240                   | 24,4              |
|               | Cherlaksy district       | 14                    | 0,53              |
Figure 2. Change in quarantine phytosanitary zones for golden potato nematode in the Omsk region for the period from 2013 to 2019

4. Conclusion
To reduce the accumulation of the number of cyst-forming nematodes, the biological product Nematofagin Mikopro was used. The use of this preparation has shown the effectiveness of reducing the soil population with the golden potato nematode. Growing potatoes in monoculture leads to an increase in the level of soil population with golden potato nematode. Biological methods of fighting Globodera rostochiensis only reduce its number, but do not lead to its complete destruction. Farmers prefer traditional varieties grown for many years, susceptible to Globodera rostochiensis, which contributes to the accumulation of the parasite population.

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