Conference Paper

The Comparative Analysis of the Identification of Parasitic Fungi Races Affecting the Soil and Cultivated Vegetable and Cucurbits Crops in the Astrakhan Region

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Abstract

The habitat of plant pathogens does not remain constant and undergoes significant changes. Therefore, the reasons have to be revealed: the emergence of fungal infectious matter in the soil; the infection source and rate, which may have epiphytotic character under environmental factors of the disease development and consequently lead to the reduction in the yield of vegetable and cucurbits crops. As a result, it is necessary to conduct monitoring and objective diagnosis of the phytosanitary condition of the planting of vegetables and melons. In this case, the identification of parasitic fungi races of the Astrakhan region remains relevant and timely.

Keywords: races, phytosanitary monitoring, epiphytoty, vegetable and cucurbits crops, parasitic fungi, phytopathogens, phytosanitary diagnostics, object diagnostics, situational diagnostics.

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1. Introduction

The purpose of the study is to monitor the phytosanitary condition of planting of vegetable and cucurbits crops in the Astrakhan region using the example of the Chernoyarsky, Krasnoyarsky and Kharabalinsky districts along with the comparative analysis with the previously studied Akhtubinsky, Narimanovsky and Privolzhsky districts.

The research objectives are the following:

1. to carry out the phytosanitary monitoring of vegetable and cucurbits crops in the Astrakhan region by the example of planting onions in the Chernoyarsky district, watermelons in the Krasnoyarsk district, tomatoes in the Kharabalinsky district;

2. to predict a possible situation for the future development of crop diseases caused by parasitic fungi;

3. to reveal races of parasitic fungi in the Astrakhan region;
4. to carry out a comparative analysis of the parasitic contamination of the vegetable and cucurbits crops in the studied districts within 2014--2016.

The first stage (2016--2017) is preparatory and analytical. There was reviewed investigated problem background in the theory and practice of revealing the state of vegetable and cucurbits planting in the Astrakhan region. It included the sanitary diagnostics, the determination of the races of parasitic organisms, their harmfulness estimation and the identification of their cenoses (phytophagans, phytopathogens, weeds). It also involved the object diagnostics of various indication types (mycological, botanical, virological, bacteriological) as well as the testing of bioobjects and the analysis of their properties (biochemical, biological and molecular-genetic).

The research of V.A. Chulkina and E.Y. Toropova is of great interest. The scientists came to the conclusion that the situational diagnostics is to be taken into account, since it makes possible to diagnose the probabilities of occurrence, as well as the consequences of phytosanitary stress situations of biogenic nature [10].

The phytosanitary monitoring is the forecast and determination of the most probable level of the distribution, the development intensity and the harmfulness of organisms as well as their species-specific features, the specifics of biology and ontogenesis, their interrelation with host plants [7, 9].

The results of the research devoted to the revealing and recording of weeds, pests and diseases of agricultural crops in each studied area can be presented in the form of a phytosanitary cartogram. These cartograms are signaling and forecasting points of the entophytopathological state of agricultural crops, from which data are selected for each area. The cartographic basis for plotting the phytosanitary condition is the plan for intraeconomic land management [10].

Test areas for vegetable and cucurbits crops were selected taking into account the factors which influence the development of phytopathogens of these crops.

Test area No.1 was arranged in the Chernoyarsky district of the Astrakhan region. The research was carried out on the onion of the Manas cultivar, the field area is 2 ha with the drip irrigation. The soil cover is represented by agrozems, textural and carbonate, slightly saline, heavy loamy ground (arable light chestnut soils). There were applied fertilizers in the form of foliar dressings with complex water-soluble compounds.

The species composition of weeds in vegetable crops was monitored during the spring periods. At the beginning, the ephemerae such as China Jute (Abutilon Theophrastii), Muchweed (Chenopodium Album), Black Nightshade (Solanum Nigrum) were identified. At the end of the spring period, we found out late springs such as Cockspur (Echinochloa Crus-galli). The perennial weeds were presented with rhizomatous plants in a large number including Tansy (Tanacetum) and Couch Grass (Agropyron Repens). The soboliferous weeds included Field Milk Thistle (Sonchus Arvensis) and Field Bindweed (Convolvulus Arvensis). The Manas onion cultivar was planted in open ground in May 2016.

Test area No.2 was arranged in the Krasnoyarsk region to grow watermelons on the field of 3 ha. The soil cover is represented by alluvial, agro-humus, minor, light loamy soils (arable alluvial sod sour soils). The indicators of cucurbits crop infection were determined at planting watermelons of Crimson Sweet cultivar, which were sown in April 2016 with the seeding rate of 3 kg/ha. The germination rate was estimated as 79 %, the number of plants per ha was counted as 40.62 thousand plants, the seeding was dripping. The contamination of vegetables was represented by the ephemerae such as Weeded Sunflower (Helianthus Lenticularis Dong), Muchweed (Chenopodium Album) as well as late springs such as Cockspur (Echinochloa Crus-galli). The perennial weeds included soboliferous plants such as Russian Centaury (Acroptylon Repens) and Field Bindweed (Convolvulus Arvensis).

Test area No. 3 was located on the territory of the Kharabalinsky district, where tomatoes of Heinz cultivar were grown. The plot is arranged in the area of 2 ha. The soil cover is represented by alluvial agro-dark-humus hydrometamorphic medium loamy soils (arable alluvial meadow saturated soils). We planted 33 thousand plants through transplanting of seedlings. The preceding soil is virgin soil. When plowing, we introduced such fertilizers as Diammophoska 700 kg/ha and Ceramide -- 400 l/ha. Watering is through dripping. The planting is in the open ground in May 2016.

The research materials were collected on the territory of the Chernoyarsky, Krasnoyarsky and Kharabalinsky districts in the period of 2016--2017. There were taken 210 samples, 110 plant cuts were examined, 16 descriptions and determinations of tomato, watermelon and onion phytopathogens were carried out. The research materials were studied and determined in the plant protection department of the Federal State Budgetary Institution ``Rosselhoscentr'' (Russian Agricultural Centre) in the Astrakhan region via the laboratory equipment: BIOLAR polarization and interference microscope, DigiMicro LCD digital microscope.

For the determination of strain species we used the following methods: Yu.I. Avdeev; N.D. Yatsenko; Yu.B. Shurovenkov, A.F. Chenkin VIZR (Russian Research Institute of Plant Protection) as well as the scientific works of V.I. Zakutnova, N.V. Pilipenko, E.B. Zakutnova [1, 3, 4, 11, 12].

The determination of the number of pathogenic fungi infectious origins in agricultural plants was carried out through to the method of N.D. Yatsenko (1982). The analysis of soils in the Astrakhan region for sampling was made by means of the scientific works of V.N. Pilipenko, E.V. Yakovleva, A.V. Fedotova, as well as with the use of the Field Guide of Russian Soils [6, 8, 11].

Previously, the identification and recording of fungal infectious diseases in the soil were carried out by V.I. Zakutnova, A.E. Talyshkina [5].

The soil samples from different depths of the arable soil layer were taken with sterile tools and placed into sterile envelopes. Soil samples in envelopes were brought to the air-dry state:

1. each soil sample was packaged separately;
2. it was poured into the sieve with the hole size of 0.1--0.25 mm, and placed into water for a good soil slaking;
3. it was rinsed with water at gentle stirring;
4. the remainder was removed, dried and examined with the use of binocular to identify and account for large infectious formations.
5. we received small infectious origins of sclerotia pernosporosis.
6. suspension was cleaned on the sieve with a nylon mesh;
7. the number of infectious formations was examined under the microscope.

The analysis followed the experimental research.

The droppings and plantings of vegetable and cucurbits crops were examined for damage caused by rotting and wilting, which were carried out during the development of the second pair of leaves. From the test area we collected 10 samples of 0.25 m rows. In each sample, all the plants were exhumed, and the disease damage was recorded on-scale (in points): 0 -- healthy plants; 1-- weak damage (brown streaks are visible on the root and cotyledons); 2 -- moderate damage (the beginning constriction of rootlet); 3 -- severe damage (constriction covers more than half of the rootlet); 4 -- death of the rootlet.

The open ground research was carried out according to the recommendation on the registration and detection of agricultural plant diseases, developed by VIZR [12]. The diseases of sprouting seedlings (onions, cucumbers, tomatoes, etc.) were studied in hot frames and greenhouses, where the damage can be focal or scattered. At the focal damage of plants, we determined both the area of each lesion focus and the total affected area for each type of cover ground cultivation constructions. In the absence of the visible damage, 10 plants were examined in 10 places. As a result, the area of dead seedlings (m^2) was considered, the percentage of dead and diseased plants was determined. After planting the seedlings in the fields, from 100 to 250 plants in 10--20 samples were taken into account, depending on the cultivated plant, the disease type and the nature of disease manifestation.

The research was carried in three stages.

The research was carried out according to the studied methods in order to make a prediction of the diseases development depending on seasons, on the growing season weather conditions in 2016. The winter temperatures of 2016 and the spring ones of 2017 were taken into account.

The modern theories of plant disease predictions are based on the study of the pathogenesis mechanism and the influence of environmental factors on it. In this case, the disease development is considered as the function that depends on many environmental factors as well as on internal plant features and pathogens. The interrelation of a plant, a pathogen and the environment was called the disease triangle by Ya.E. Van der Plank [2]. Later, the time factor and the anthropogenic impact were added to these main components.

The analysis of the interrelation of the factors should be started with the infection source that is the first chain in the internal biological factors.

One of the main characteristics of the pathological process is the infection rate.

The infection rate is the growth of the damaged tissue area (or part) per unit time.

The rate of infection mainly depends on weather conditions. The mathematical modelling is widely used to determine the rate of epiphytotic development. It allows identifying the influence of definite factors on the disease dynamics as well as the impact of the pathological process conditions on them.

The soil phytopathogens are very widespread in almost all agricultural ecosystems of the world. They turn to be very dangerous in agrophytocenoses of agricultural crops, including Canada, the USA, Australia, South America, Asia and Europe [13--18].

For the evaluation of crops, the symptoms of damage are to be taken into account: wilting, discoloration, the presence or absence of rot, as well as specific plant extracts (resin, mucus, glutinous juice). Moreover, it is necessary to identify an infecting agent (sporulation, mycelium) or the pest (oviposition, larvae, pupae). Sometimes special indicators can be noticed: insects excreta or frass droplets, traces of mucus, honey dew, cobwebs.

The prevalence or frequency of disease detection determines the main elements of consideration.

To evaluate the overall plant state, the disease registration technique should be applied directly both in the field and in the laboratory where the plants or their individual organs are inspected. In case of focal disease manifestation and at uniform scattered spread of the disease on the field, sampling can be presented in the form of a quadrat. Samples are selected taking into account the field configuration: on diagonal, on two diagonals, or in a chessboard pattern. The main elements of recording are determined out of the disease prevalence or frequency.

The disease prevalence is the number of diseased plants or their organs, expressed as the percentage of the total number of inspected plants.

2. Results

The research and the review of the scientific works of the Department of Botany, Biology of Ecosystems and Land Resources have resulted in the identification of parasitic fungi races and their preliminary systematic list:

1. Peronospora Onion (Peronospora destructor)
2. Alternaria Onion (Alternaria porri)
3. Peronospora Cucumber (Pseudoperonospora cubensis)
4. Anthracnose Watermelon (Colletotrichum lagenarium)
5. Powdery Mildew of watermelon (Erysiphe cichoracearum)
6. Alternaria Tomato (Alternaria solani)
7. Phytophthora Tomato (Phytophthora parasitica) [3, 4]

After the study of test areas in different districts of the Astrakhan region, there was carried out a comparative analysis. The indispensable condition was the cultivation of one type of agricultural crop, taking into account the factors favorably affecting the phytopathogenic development in vegetable and cucurbits crops.

When studying onion of Manas cultivar in the Akhtubinsky district in the period of 2014 and the same cultivar in the Chernoyarsky district in 2016.

The first manifestation of Peronospora onions (Peronospora destructor) in the Akhtubinsky district in 2014 was noticed in the first ten days of June, in the phase of 2--3 true leaves. The total damaged area was 0.11 ha (1100 m^2), with the disease spread of 5 % and the disease development rate of 3 %. The infection source was in affected seed material.

During the sowing season of 2014--2015 in the Akhtubinsky district, the harmfulness of Powdery Mildew decreased slightly after the use of quality seeds free of infections by the agricultural producers. The level of disease development will also depend on the prevailing climatic characteristics of the environment.

In 2016 in the Chernoyarsky district, the first manifestation of Powdery Mildew in onions was noted at the end of June. The plants were infected in the phase of 4--5 true leaves. The spread of the disease was 10 % and the level of disease development was 4.6 %. In the summer, the disease progressed moderately. Hot dry weather and the absence of additional ways of infection transmission (using drip irrigation) restrained the disease spread.

In the Akhtubinsky district the year 2014 has become the year of the heaviest harm for onions caused by Alternaria porri. The first alternariosis signs were noticed in the onion cultivation in the phase of 3 true leaves starting May 14, with the disease spread of 1 % and rather weak disease development.

During the vegetation period the disease spread was 1--10 % and the disease development -- 1--20 % along with the harmfulness coming up to 30 %. At the end of the season, 0.85 ha were affected by Alternaria porri with the disease spread of 15--100 % and the disease development of 3--40 %. The harmfulness was up to 30 %.

The sandstorms accompanied with heavy rain which happened at the end of June and the first half of July, the period of the early phases of onion development in late onion crops, contributed to the rapid defeat by Alternaria porri.

Since the main source of infection is plant remains, the last autumn weather conditions were taken into account for making a long-term forecast. Despite the fact that the infectious supply was significant, the conditions of the autumn 2014 were not favorable for the pathogen development. In this case we predicted a weak infection of onion plantings with Alternaria porri in 2015, with the increase in the disease prevalence and disease development if the weather conditions turned favorable.

In the conditions of 2016 in the Chernoyarsky district, the Alternaria Onion (Alternaria porri) was not of economic importance, as it was expected. The disease manifestation was recorded in mid-June, but the subsequent dry summer period prevented the fungi from further development. During the growing season, the infection spread was up to 10 % and development of 5 %.

The study of test areas in the Narimanovsky district where watermelons of Crimson Sweet cultivar were grown in 2014, the first foci of Anthracnose watermelon (Colletotrichum lagenarium) appeared on July 2--3. The disease did not cause any significant harm due to the late manifestation. In general, the disease affected about 10 % of watermelon plantings with the disease spread from 6 to 48 % and the development rate of 20 %. The average number of affected fruit was 2--3 %. The disease had a high value throughout the whole autumn.

On the basis of the foregoing, in 2015 the infectious supply of the causative agent was significant, the air contagion in the summer of 2014 was sufficient for the primary infection of watermelons.

In the Krasnoyarsky region in 2016, the watermelon crops were infected with Anthracnose to various extents. The first foci of the disease appeared on July 2--3. (For comparison, in areas where the spatial isolation between last year crops was more than 5 kilometers, the disease manifested itself only on August 11--15). According to the calculations, the infection spread was 16 %, the disease development was 8 %. Since the second half of July, due to both high daily temperatures and insufficient moisture, Anthracnose was in depression.

In addition, in the Narimanovsky district in 2014, the first manifestations of Powdery Mildew (Erysiphe cichoracearum) in watermelon crops were noted at the end of the third decade of July on the area of 10 ha with the disease spread reaching 5 %.

Later, the appearance of the disease and the moderate pathogen development made no impact on the crop formation.

The warm autumn period allowed the resting wintering phase of the fungi, cleistothecia, to reach its full ripeness till winter set in. The crop contamination is probable in more vulnerable phases of the crop development which are flowering and fruiting at the average daily humidity of 60 % or more and the ambient temperature of 25--27 °C. After the infection threat, the manifestation of the disease is expected in 4--7 days.

In 2016, in the Krasnoyarsky district Powdery mildew of watermelons (Erysiphe cichoracearum) manifested itself in the usual long-term average annual period. The moderate pathogen development did not absolutely affect the crop formation. The compared data on the distribution and development of Powdery mildew in watermelon plantings in 2014--2016 are given in Table 1.

Table 1: The comparative data on the affection of watermelons with powdery mildew.

Districts	Year	Studied area, ha	Affected area, thousand ha	Affected area of crop area, %	Disease spread, average weighted %	Disease develop-ment, average weighted %
Krasnoyarsky	2016	3	0.015	0.3	6	5
Narimanovsky	2014	3	0.01	0.33	5	5
Long-term average annual period					21.1	10.8

In 2014, in the Privozhsky district the first manifestations of Alternaria tomato (Alternaria solani) on the leaves were noted starting with June 19. Alternaria was noted as single spots on the lower tier leaves, but it was not revealed on stems and fruits. During the season, Alternaria developed gradually and moderately on the leaves of the lower and middle tiers.

At the end of the season, Alternaria had infected tomatoes on the area of 0.33 ha, with the disease spread of 15--80 % and the disease development of 3--35 % along came up to 7 %. We identified the single fruits affected under fruit-stalks starting with August 8. Since the infectious reserve of Alternaria is rather significant, one can be sure that unrotten plant remains will undoubtedly become the primary source of infection in the air, and then determine the primary foci of disease manifestation.

In the Kharabalinsky district in 2016, the first Alternaria manifestations on the leaves were noted starting with June 1stas most vegetables were covered (agrospan) in April-May. During that period, the weather conditions were favorable for the growth and development of tomatoes under cover. After the removal of the cover, Alternaria was noted as single spots on the lower tier leaves; it was not revealed on stems and fruits.

When early tomatoes were harvested, the most crop area was plowed. During the season, Alternaria developed gradually and moderately on the leaves of the lower and middle tiers, particularly in medium and late tomatoes. At the end of the season, Alternaria affected tomatoes on the area of 0.36 ha, with the disease spread of 15 % and the disease development of 5 %. The comparative data on the defeat of tomatoes by Alternaria in the test areas of the Privolzhsky and Kharabalinsky districts of the Astrakhan region, on the example of tomatoes of Heinz cultivar, within the research period are presented in Table 2:.

In the season 2014, in the Privozhsky region, Phytophthora Tomato (Phytophthora parasitica) had no economic significance. The harmfulness of the disease was noted on the area of 0.12 ha, with fruit damage up to 1 %.

Table 2: The comparative data on the defeat of tomatoes by Alternaria.

Districts	Year	Studied area, ha	Affected area, thousand, ha	Affected area of crop area, %	Disease spread, average weighted, %	Disease development, average weighted, %
Krasnoyarsky	2016	3	0.015	0.3	6	5
Privolzhsky	2014	3	0.01	0.33	5	5
Long-term average annual period					21.1	10.8

Phytophthora is believed to infect plants if within 48 hours the minimum air temperature (in plant stand) does not drop below 10 °C, the maximum does not exceed 25 C, along with the relative humidity not dropping below 75 %. In 2016, the necessary conditions occur on August 15--16.

In 2016, in the Kharabalinsky district, the disease had no economic importance due to late infection of plants. The harmfulness of the disease was noted focally on the area of 0.2 ha, with the disease spread of 5 % and the fruit damage of up to 1 %. The comparative data on the defeat of tomatoes with Phytophthora are presented in Table 3.

Table 3: The comparative figures the defeat of tomato southern bligh.

Districts	Year	Studied area, ha	Affected rea, thousand ha	Affected area of crop area, %	Disease read, average weighted %
Kharabalinsky	2016	2	0.2	10	5
Privolzhsky	2014	2	0.12	6	1
Long-term average annual period					4.5

3. Conclusion

Thus, the prognosis and phytosanitary monitoring of the state of vegetable crops planting in the test areas of the Astrakhan region allows the following: to determine the development time and contamination with fungal and bacterial diseases as well as to show the general direction of pathological process development; to improve technologies of crop cultivation; to plan the purchase of fungicides; to inform land users and agricultural producers about the degree of damage and possible losses of crops caused by diseases in due time; to provide breeding institutions with data on new aggressive races in due time.

We developed and tested the system of measures for the crop protection against diseases on the basis of the official "List of pesticides and agrochemicals allowed for use on the territory of the Russian Federation in 2015--2016" and according to the generally accepted technologies for cultivating crops. It allows reducing the risks of epiphytoty development in the region, thereby improving the phytosanitary condition of crop seedings and plantings. Moreover, it leads, in some cases, to reducing the pesticide use and improving the ecological state, by reducing the amount of introduced pesticides due to their pointed application.

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