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DETECTION OF THE CAUSAL AGENT OF TAN SPOT (*PYRENOPHORA TRITICI-REPENTIS*) USING SPORE-CATCHING DEVICES

Kremneva Oksana Yu.*, Gasiyan Kseniya E., Ponomarev Artem V.

[*]*Federal State Budgetary Scientific Institution*
«Federal Research Center of Biological Plant Protection», Russia;

[*]Corresponding Author Kremneva Oksana Yu, e-mail: kremenoks@mail.ru;

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ABSTRACT

Drechslera tritici-repentis (*Died*.) *Shoem*. (teleomorph *Pyrenophora tritici-repentis* (Died.) Drechsler) is the causal agent of a tan spot, a major wheat disease worldwide. Wheat yield losses can reach up to 60%. Accurate and timely monitoring of harmful objects is crucial for effective crop protection against economically significant pathogens. Thus, in our study, we aim to evaluate the detection of tan spot operating spore trapping devices of various designs. As a result, the possibility of detecting tan spot pathogen spores using various spore-catching devices was shown. The number of pathogen spores caught by different devices varied from 1 pc. up to 18 pcs. depending on the design of the device, variety and sampling time. Our study demonstrates that spore traps of various designs help to detect tan spot prior to its visible manifestation at its minimum development (up to 1-5%). It's, crucial for the development of effective protective measures.

Keywords: winter wheat, tan spot, *Pyrenophora tritici-repentis*, spore-catching device, disease development, spores, monitoring.

INTRODUCTION

Drechslera tritici-repentis (*Died*.) *Shoem*. (teleomorph *Pyrenophora tritici-repentis* (Died.) Drechsler) is the causal agent of a tan spot, a major wheat disease worldwide. The disease was first described in 1902 in Germany (Diedicke, 1902). Tan spot is noted in such countries as Australia, USA, Russia, Germany, China, Czech Republic, Brazil, Chile, Algeria, Kazakhstan, Mongolia, Iran, India, Ukraine, etc. (Kariyawasam, et al., 2016; Kokhmetova, et al., 2017; Kremneva, et al., 2021). It negatively affects selective toxins on the plant and is accompanied by two characteristic symptoms - chlorosis and leaf necrosis, the size of which can vary from a few millimeters to several centimeters (Kremneva, et al., 2021). Tan spot mainly infects leaves, less often sheaths of leaf blades, grains and stalks of wheat (Shashko, Podorsky, 2019). Wheat yield losses can reach 60% (Kariyawasam, et al., 2016; Kremneva, et al., 2021). In Russia, tan spot occurs in Kaliningrad Oblast, Western Siberia, the Volga Region, and in the Altai Republic (Grigorovich, 2006; Markelova, et al., 2010). In the North Caucasus, the disease was first discovered in 1985. Since then, it has been detected annually in Krasnodar and Stavropol Krai, Rostov Oblast, and the Republic of Adygea (Kremneva, Volkova, 2011; Kremneva, et al., 2019; Kremneva, et al., 2021).

Accurate and timely monitoring of harmful objects is important for the development of effective crop protection against economically significant pathogens. Currently, portable and stationary spore collectors are widely used for early diagnosis and prevention of the development and spread of fungal diseases. These devices help to quickly and accurately perform a quantitative and qualitative assessment of fungal phytopathogens on wheat crops before visible manifestations of diseases or their minimal development. In world practice, stationary spore samplers Burkard, Lanzoni and Rotorod are the most popular ones (Kremneva, et al., 2023). Some researchers mention the combined use of portable spore-catching devices and unmanned aerial vehicles (Savage, et al., 2012) and point the benefits of this approach.

In our study, we aim to evaluate the detection of tan spot operating spore trapping devices of various designs.

MATERIALS AND METHODS

We conducted research in the experimental fields of the Federal Research Center of Biological Plant Protection, Krasnodar (FRCBPP) from 2019 to 2020. The objects of the study were three cultivars of winter wheat: “Aksinya” and “Krasnodarskaya 99” in 2019, and “Grom” in 2020. Plot area of each cultivar was 20 m^2. The classical phytopathological technique using the scale of plant damage was used to assess the development and distribution of *P. tritici-repentis* (Kremneva, et al., 2021). To assess the possibility of detecting pathogen spores at the early stages of development, spore-catchers of various designs developed at FRCBPP were used: a stationary spore trap, a device for determining plant infestation (Kremneva, et al., 2020), and an air sampler (Sadkovsky, et al., 2019) mounted on a UAV.

A stationary spore trap (Figure 1) is a weather vane with a holder in front, on which a special frame is fixed, previously lubricated with petroleum jelly, which serves as a trapping surface. The spore trap was installed in crops and every seven days the catching surface (frame) was replaced with a new one. After the replacement, microscopy of the obtained material was carried out to determine and count the spores of *P. tritici-repentis*.

Figure 1. A stationary spore trap

A device for determining plant infestation (Figure 2) is an impactor in which there is a standard glass slide coated with petroleum jelly. Through the slotted pipe, by means of aspirator, the air containing fungal spores enters the glass, on which the air impurities are deposited. Sampling by this device was carried out along the diagonal of each plot at five points. The sampling time for one sample was 1 minute.

Figure 2. A device for determining plant infestation.

An air sampler (Figure 3) is designed to analyze the content of biological microparticles in the air above the plants and is installed on a UAV. Sampling was carried out along the diagonal of each plot, repeating the operation of the device for determining plant infestation. The sampling time for one sample was 1 minute.

Figure 3. An air sampler mounted on a UAV

Spores were identified under a light microscope at a 10x objective magnification. The quantitative calculation of spores was carried out in accordance with the methodological recommendations for the use of infection control agents and environmental parameters in plant protection (Sokolov, et al., 2007; Sokolov, et al., 1994).

RESULTS AND DISCUSSION

In 2019, we conducted research on the detection of *P. tritici-repentis spores* using a device for determining plant infestation and an air sampler mounted on a UAV.
A visual assessment of the development of yellow leaf spot in the studied winter wheat crops made it possible to establish that in the Aksinya variety, the disease reached 1% in the wheat development phases Z 51-59 "heading", Z 61-69 "flowering", and Z 75 "milky ripeness" (Zadoks et al., 1974). At the same time, the device for determining plant infestation revealed a single number of spores of this pathogen - 1, 2, 3 pcs. on a glass slide, according to the dates of the visual counts. The portable device also detected a small number of spores - 1, 4 and 6 pieces, respectively.

The disease development in the Krasnodarskaya 99 variety in the Z 51-59 phase was not detected, in the Z 61-69 phase it was 1%, and in the Z 75 phase it reached 5%. At the same time, the number of spores detected by spore-catching devices increased. A device for determining the plant infestation at 0.5% development detected 1 spore of the pathogen, at 1% - 18 pieces, at 5% - 10 pieces. A portable spore-catching device mounted on a UAV at 0% development detected 1 spore of the pathogen, at 1% - 17 pieces, at 5% - 4 pieces (Figure 4).

a) b)

Figure 4. *a* – spores of *P. tritici-repentis*; *b* - symptoms of yellow leaf spot

The data obtained suggest that the degree of disease manifestation in wheat crops depends on the number of spores produced in the phase of plant development, since with an increase in the number of spores found, the disease manifestation in the subsequent phase of development of wheat plants increased (Figures 5–6).

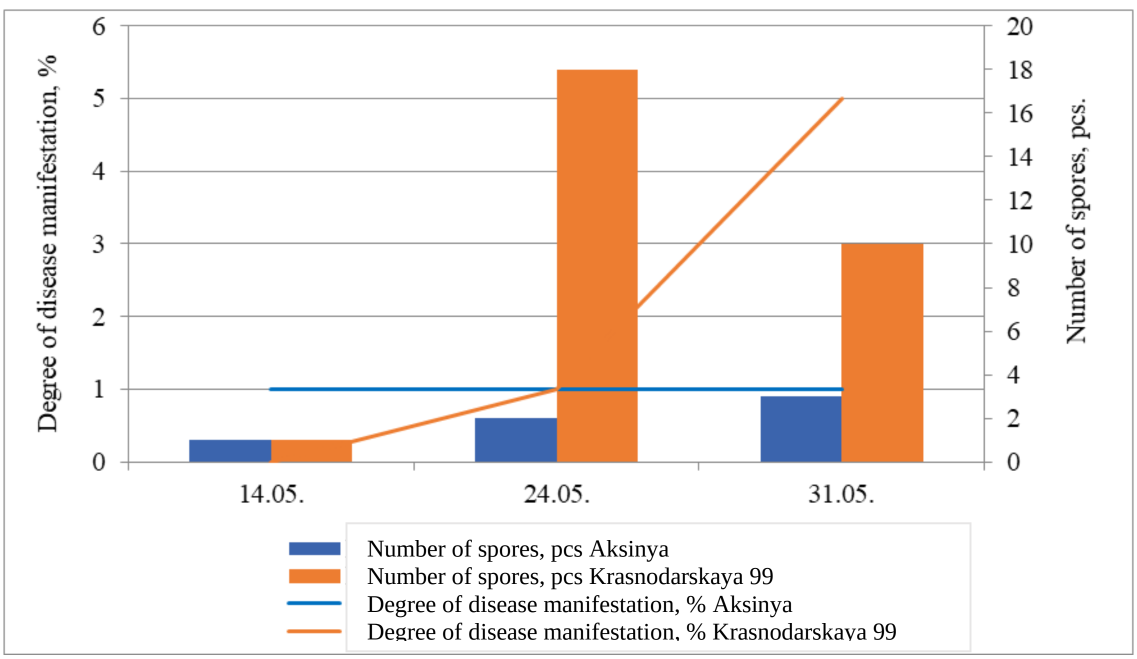

Figure 5. Dependence of the degree of disease manifestation on the number of *P. tritici-repentis* spores (data from the device for determining plant infestation)

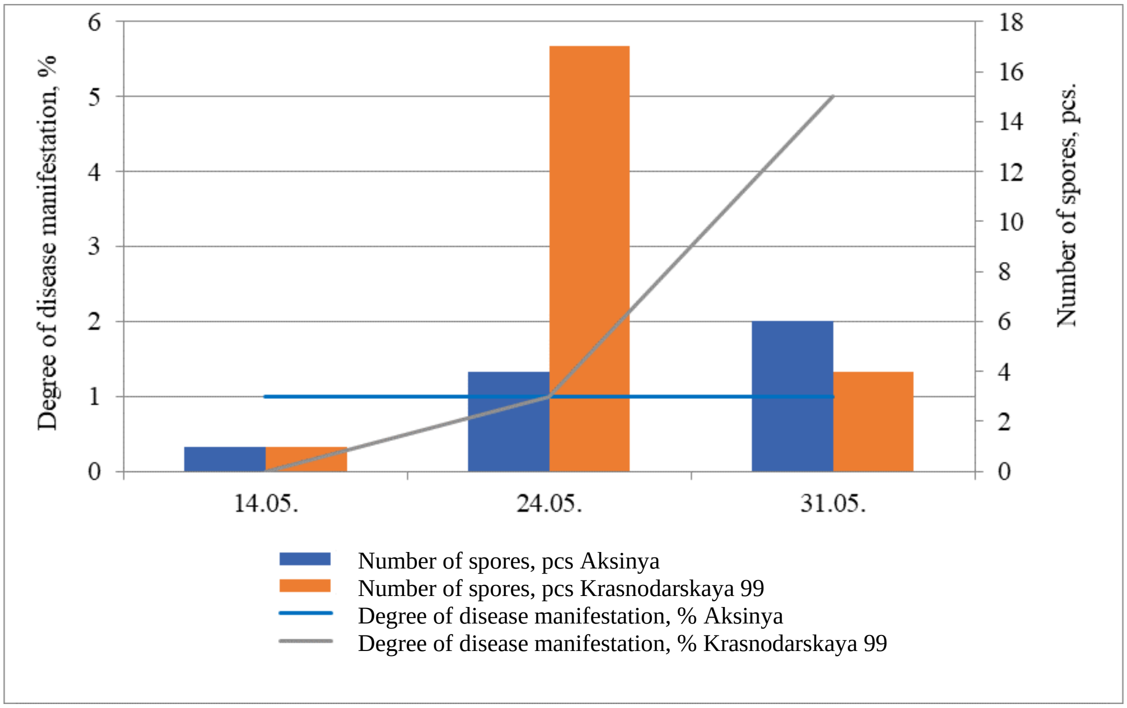

Figure 6. Dependence of the degree of disease manifestation on the number of *P. tritici-repentis* spores (data from an air sampler mounted on a UAV)

We detected 70 spores of the pathogen in a 2019 field trial conducted with a portable spore-trapping device mounted on a UAV. The manifestation degree of yellow leaf spot was 5% at one of the sampling points. This suggests that spore-trapping devices can identify the source of infection.

We conducted our research in the experimental fields of the FRCBPP in 2020 using both a stationary spore trap and a device for determining plant infestation. The weather of 2020 was unfavorable for the development of yellow leaf spot. Therefore, the disease was detected only at the end of the growing season, in the development phase of wheat Z 75 “milky ripeness” with a maximum development of 0.5% in the Grom variety. At the same time, a stationary spore trap recorded 3 pieces of pathogen spores. A device for determining plant infestation detected 12 pieces of spores.

We came to the conclusion that the device for determining the plant infestation catches a greater number of spores, since the very principle of operation of the device makes it possible to detect pathogen spores in the air space directly near the plants. The stationary spore trap is designed for the primary detection of spores and tracing the beginning of their flight.

CONCLUSIONS

Our study demonstrates the feasibility of detecting the tan spot pathogen using spore-catchers of various designs. Different devices capture different amounts of pathogen spores. The device for determining the infestation of plants turned out to be the most effective. We show that pathogen spores can be detected with a minimum (0.5 -1 %) degree of *P. tritici-repentis* manifestation. We believe it’s crucial for the disease management.

Thus, spore-catchers of various designs allow the detection of tan spot infection before the plants show visible symptoms or when they are minimally developed. This is important for the development of effective protective measures.

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