The conidia *Bipolaris sorokiniana* Sacc. Shoem. distribution in the soil of Altai and Kazakhstan arid regions

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**Abstract.** The purpose of the study was to assess the number and state of populations of *B. sorokiniana* conidia in the soil of agrocenoses and virgin areas. Studies were carried out in 2017-2021 in dry steppe regions of the Altai Territory (Russia) and Pavlodar Region (Kazakhstan) by conventional methods. For the experimental data analysis variance and correlation analytical methods were used. A comparative analysis of *Bipolaris sorokiniana* conidia populations in agrogenoses and virgin soils of arid areas was carried out. A significant phytopathogen conidia population in agrogenoses soils has been established, reaching 10.8 regional economic harmfulness thresholds in Altai and 16.6 thresholds in Kazakhstan. A lower population number in virgin soils was revealed in comparison with agrogenoses’ ones, which is associated with more active resting structures degradation. A clear tendency towards a decrease in the number of conidia with increasing depth was revealed, which manifests itself to different degrees in the regions and tillage systems, but has the same orientation: the upper layer (0-5 cm) is populated several times stronger than the lower (10-15 cm) one. The phytosanitary precursors in both regions (fallow, sunflower, peas, oat with vetch, sweet clover) reduced the conidia number in the soil on average 59%; they significantly increased the conidia proportion with the degradation signs - average by 27.1%. Soil suppressive activity against *B. sorokiniana* increased significantly (on 19.8-38.3%) after cultivation of phytosanitary predecessors, especially rape.

1. **Introduction**
In all arid zones of spring cereals cultivation, a common root rot is a widespread and harmful disease [1-3]. There is a thinning of seedlings, inhibition of plant growth and development during the growing season, reduced crop yields and grain quality [1]. The common root rot causative agent is an imperfect fungus *Bipolaris sorokiniana* Sacc. Shoem. (*Helminthosporium sativum* Pam., King et Bakke) forms stationary epiphytotic foci, possesses signs of K - life cycle strategies and for a long time, 5 or more years, survives in the form of conidia and chlamydospores in the soil [1, 4]. The conidia abundance in soil reflects two opposite processes: micromycete reproduction on cereal plants (cultivated, weedy, wild-growing) and gradual conidia degradation under the influence of soil microflora and mesofauna [1, 5, 6]. That is, by the density of conidia, one can judge the culture of agriculture (crop rotation structure, weed abundance) and the organic residues amount, required for antagonists activity in the soil [1, 8, 9]. Dry conditions and low soil moisture in drought regions increased soil borne plant pathogens aggressiveness, their parasitic activity, susceptibility of plants underground organs to...
infection. The strongest stimulus to the spring wheat common root rot development are drought conditions during the tillering-spine formation period, providing enhanced disease development by 33.5% compared with the optimum moisture on the background with high soil borne pathogens population [6]. In drought conditions, the saprotrophic microorganisms’ number decreases many times, soil suppressive activity inhibits, which caused the root infections development [10]. Drought conditions increases plant susceptibility to soil borne inoculum, as the population numbers increase from 5-15 to 150-180 conidia in 1 soil gram, so caused winter wheat common root rot infestation to 7.8 times [4, 6]. Drought-resistant grass weeds Panicum miliaceum (ssp. Ruderales L. (Kitag.) Tzvei), Setaria glauca (L). Beauv., Avena fatua L., Setaria viridis (L). Beauv. due to intensified competition by 20% or more of root rot development in drought conditions. Seeds of grass weeds, the number of which increased after the dry years, stimulated many soil borne plant pathogens reproduction and survival [6]. To reduce the population size of B. sorokiniana, it is effective to introduce phytosanitary precursors into crop rotations that actively cleanse the soil by the "germination - lysis" mechanism. The composition of the predecessors may vary by zone and include those crops that are advisable to cultivate in the arid zones of the steppe Altai and Kazakhstan. To limit the duration of conidia survival, it is important to introduce various types of organic fertilizers into the soil, which increase its suppressive activity and improve the structure. It has been established that under the conditions of the northern forest-steppe of the Ob region, the survival of B. sorokiniana conidia in leached black soil is most effectively limited by humus, green manure (peas and oats), as well as wheat straw together with a suspension of Pseudomonas fluorescens strains or by wheat straw with humus [11].

2. Methods and materials
The purpose of the study was to assess the number and state of populations of B. sorokiniana conidia in the soil of agroecosystems and virgin areas in dry steppe regions of the Altai Territory (Russia) and Pavlodar Region (Kazakhstan). Studies were carried out in 2017-2021 in the dry steppe regions of the Altai Territory and Pavlodar Region. Soil samples were taken in agroecosystems intended for spring wheat sowing, and in virgin lands, directly adjacent to the fields. Soil samples were taken and analyzed from two layers: 0-10 and 11-20 cm. The soil analysis was carried out by flotation, determining the total conidia number and the state of populations by the degradation degree of resting phytopathogen structures [1]. In total, more than 80 soil samples were analyzed.

The suppressive activity of the soil was studied by a new method (patent RU 25689013 C1) to limit the growth of B. sorokiniana colonies by the soil. The technique makes it possible to quickly (within 3 days) assess the general suppressiveness of a soil sample to suppress the growth of phytopathogenic fungi by the soil. The method is universal and can be used to assess the suppressiveness against any phytopathogenic micromycetes. Suppressiveness varies from 100% - complete suppressiveness (all blocks without signs of growth of the test object) to 0% or negative value - conductive soil (all blocks of the test object develop at the control level or stronger). If the soil stimulates the development of a phytopathogen, then the value of the suppressiveness indicator becomes negative. The technique is as follows. A sample of native soil with a moisture content of 60-70% of the field moisture capacity weighing 10 g is placed in a Petri dish with a diameter of 90 mm and poured with a cooled agar nutrient medium for cultivating a test object. On the surface of the solidified medium, 10 agar blocks of the same diameter (3-4 mm each) are placed, cut with a sampler from a 7-10-day-old pure culture of the test object. An agar medium without soil is used as a control, on which the same agar blocks with a test object are placed. Soil biocidal substances (of biotic or abiotic origin) diffuse into the medium and inhibit the growth of the test object on the surface of the medium and on the agar block. Colony diameters were measured on day 3. Two indicators testify to the suppressiveness of the soil: 1. Complete suppression of the growth of the fungus (by the number of blocks without signs of growth of the test object from the total number of blocks under study); 2. Restriction of radial growth of colonies developing from blocks (in comparison with control). To assess the suppressiveness of the soil, the
following scale was used: 100-81% - absolute, 61-80% - strong, 60-41% - medium, 21-40% - weak, 0-20 - absent, < 0 - conductive.

3. Results and discussion

The maximum population of soil samples from the Altai dry steppe amounted to 10.8 regional economic thresholds of harmfulness (TH), from Kazakhstan - 16.6 TH [3, 6] (table 1, 2).

Table 1. Population of Bipolaris sorokiniana conidia in the soil samples of Altai steppe zone

| Phytocenosis     | Soil horizon, cm | Total number, number / g air-dry soil | The proportion of degraded conidia, % |
|------------------|------------------|----------------------------------------|-------------------------------------|
|                  | lim              | average                                |                                     |
| Field            | 0-10             | 50-325                                  | 178.2                               | 81.3                                 |
|                  | 11-20            | 50-90                                   | 70.5                                | 76.0                                 |
| Virgin land      | 0-10             | 10-45                                   | 17.3                                | 66.5                                 |
|                  | 11-20            | 5-15                                    | 9.7                                 | 45.0                                 |

Virgin areas of Altai, regardless of soil type, were populated by conidia at or below the threshold value. The natural cenoses of North Kazakhstan are predominantly cereal type of vegetation, which contributes to the reproduction of B.sorokiniana and the maintenance of its population number at a significant level, higher than the Altai mixed grass virgin phytocenoses.

Table 2. Population of Bipolaris sorokiniana conidia in the soil samples of Kazakhstan steppe zone

| Phytocenosis     | Soil horizon, cm | Total number, number / g air-dry soil | The proportion of degraded conidia, % |
|------------------|------------------|----------------------------------------|-------------------------------------|
|                  | lim              | average                                |                                     |
| Field            | 0-10             | 218-498                                 | 366.6                               | 31-61                                |
|                  | 11-20            | 92-248                                  | 118.5                               | 22-46                                |
| Virgin land      | 0-10             | 91-210                                  | 139.6                               | 47-71                                |
|                  | 11-20            | 45-111                                  | 87.2                                | 33-51                                |

The B. sorokiniana conidia number in Kazakhstan virgin cenoses was on average 2.6 times lower than in agrocenoses, but averaged 5.6 severity thresholds, reaching 8.4 thresholds in some points.

A clear tendency towards a decrease in the number of conidia with increasing depth was revealed, which manifests itself to different degrees in the regions and tillage systems, but has the same orientation: the upper layer (0-10 cm) is populated several times stronger than the lower (11-20 cm) one. So B. sorokiniana conidia population in the upper (0–10 cm) layers of cultivated soils in Altai dry steppe was 7.9–10.5 times higher, and in the lower (11–20 cm) layers. The high phytopathogen’ soil population was closely associated with a decrease in the total organic matter reserves in the cultivated soils upper layers during the cultivation period by 39-40% (r = -0.960 ± 0.199 (p<1)), and 48-54% decrease in the humus content (r = -0.953 ± 0.215 (p<1)) [9].

Analysis of variance showed that the greatest influence on the number of conidia was exerted by the vegetation cover (crops or wild plant species) and the development of virgin lands with the subsequent traditional soil cultivation system, including intensive cultivation.

The most intensive plant pathogen propagation occurs on the basal leaves of cultivated plants, which are more susceptible to common root rot. The most insignificant impact on the phytosanitary soil state was exerted by the system of its treatment in agrocenoses, since both traditional cultivation and No-till can lead to both improvement and deterioration of the soil phytosanitary condition under the influence of crops cultivated in agrocenoses (crop rotation structure).

The proportion of B. sorokiniana conidia with the degradation signs in the analyzed samples of Altai soils was determined by the soil types and their natural suppression. It was maximal in leached black soil, minimal in less suppressive southern black soil. A higher proportion of conidia degradation was in the upper biogenic layer of the soil, where more plant residues, moisture and heat enter. In
Kazakhstan agrocenoses, the proportion of degraded conidia was 13% lower than the same indicator in the soil of natural phytocenoses. In general, the revealed activity of *B. sorokiniana* conidia degradation in soil samples from Altai Territory and Pavlodar Region should be considered moderate, which reflects the natural climate continental features and aridity, the soil antagonists-suppressors overwhelming activity, and the insufficient intake of organic fertilizers and plant residues into the soil [4].

The biological effectiveness of phytosanitary precursors in both regions (fallow, sunflower, peas, oat with vetch, sweet clover etc.) in reducing the conidia number in the soil was on average 59% in comparing with spring wheat as a predecessor; they significantly increased the conidia proportion with the degradation signs - average by 27.1% (table 3).

**Table 3. Influence of predecessors on the soil *Bipolaris sorokiniana* conidia population (2017-2020)**

| Predecessor       | Total number, number / g | Biological effectiveness, % | The proportion of degraded conidia, % |
|-------------------|--------------------------|----------------------------|-------------------------------------|
|                   | air-dry soil             | avg                        | lim                                 |
| Spring wheat      | 53-410                   | 186.3                      | 49.6                                |
| Fallow            | 50-265                   | 95.0                       | 49.0                                |
| Peas              | 80-200                   | 100.7                      | 46.0                                |
| Sweet clover      | 40-130                   | 68.2                       | 63.4                                |
| Oat with vetch    | 25-65                    | 45.0                       | 75.9                                |
| Sunflower         | 43-105                   | 95.2                       | 48.9                                |
| Corn              | 80-125                   | 100.6                      | 46.0                                |
| Rape              | 38-92                    | 54.1                       | 71.0                                |
| Perennial herbs   | 20-40                    | 30.2                       | 83.8                                |
| Total, average    | 25-526                   | 59.0                       | 46.0                                |

The best phytosanitary effect was shown by perennial cereals-leguminous grasses (meadow bluegrass, cocksfoot, alfalfa), their biological effectiveness compared to spring wheat was 83.8%, and the proportion of degraded *B. sorokiniana* conidia increased by 46%. Fallow, peas, and corn showed relatively low phytosanitary activity due to the high infestation of fields with cereal weeds, which ensure the reproduction of the phytopathogen.

The phytosanitary action of the precursors was associated with an increase in the suppressive activity of the soil against *B. sorokiniana* [11, 12] (table 4).

**Table 4. The influence of predecessors on soil suppression against *Bipolaris sorokiniana* in the steppe zone of Altai Territory by years, %**

| Predecessor       | 2019  | 2020  | Average |
|-------------------|-------|-------|---------|
| Spring wheat      | 38.9  | 42.1  | 40.5    |
| Fallow            | 64.5  | 68.6  | 66.6    |
| Rape              | 74.9  | 83.5  | 79.2    |
| Sunflower         | 58.4  | 62.2  | 60.3    |

The data in the table show that the suppressive activity of the soil increased significantly as a result of the cultivation of phytosanitary crops. After spring wheat soil suppression was low (2019) or medium (2020), and after rape, it reached the level of strong (2019) or absolute (2020). An increase in the suppressive activity of the soil was also noted after fallow and sunflower.

**4. Conclusion**

The soil phytosanitary state in the agrocenoses in the dry regions of Altai and Kazakhstan, according to the conidia population of the common root rot pathogen *Bipolaris sorokiniana*, is extremely unfavorable, significantly worse compared to virgin areas. This is due to the high saturation of crop
rotations with grain crops, insufficient input of organic matter into the soil, and low suppressive activity of the soil. The conidia number decreased with increasing depth, however, in the upper biogenic layer, the proportion of degraded conidia was higher. According to the analysis of variance, the most significant influence on the conidia abundance was exerted by the vegetation cover, and the development of virgin lands, followed by the traditional soil cultivation system, including intensive cultivation. \textit{B. sorokiniana} conidia degradation in the soil of arid regions was moderate, which reflects the extreme climate and low microbiological activity of the soils. The phytosanitary precursors in both regions (fallow, sunflower, peas, oat with vetch, sweet clover) reduced the conidia number in the soil; they also significantly increased the conidia proportion with the degradation signs. Soil suppressive activity against \textit{B. sorokiniana} increased significantly after cultivation of phytosanitary predecessors, especially rape.

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