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# The Role of Soil Fungistasis in Winter Wheat Infestation with Root Rot

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**Abstract:** In recent decades, the concept of ecologized cereal crop protection is widespread. The basis of this concept is such a natural phenomenon as soil fungistasis. The results of the study showed that the extent of infectious potential of root rot pathogens, *B. sorokiniana and Fusarium spp.* in the rhizosphere of Winter wheat is greatly affected by soil fungistasis which in its turn depends on the preceding crop. Soil fungistasis is appeared to be slight after preceding cereal crop. Thus, the number of ungerminated *B. sorokiniana* conidia was 35.1%, *F. gibbosum* conidia 30.5% after Winter wheat and after spring wheat 15.4 and 25.2%, respectively. A direct relationship between antagonistic activity of the soil and its fungistasis, antagonistic activity and viability of *F. gibbosum* conidia is determined that means an increase in antagonistic activity leads to increased soil fungistasis and the reduction of viable conidia.

**Key words:** Winter wheat, root rot, fungistasis, pathogenicity, conidia, antagonistic activity

## INTRODUCTION

Among the measures that enhance crop yield, cereal production, improve crop quality, plant protection plays the essential role. Traditional protection of cereal crops with the use of the chemical method is often ecologically unsafe and ineffective (Bonanomi *et al*., 2014; De Boer *et al*., 2013). The real threat of pesticides to the environment lies in the fact that since the second half of the last century they have become a constant factor that has both positive and negative consequences (Dutta *et al*., 1982; Epstein and Lockwood, 1982). The data of the laboratory studies on the effect of the chemicals on reproduction and their toxic effects on soil microflora show that many microorganisms are insensitive to high concentrations of chemicals under artificial conditions where temperature, humidity, aeration are controlled, therefore these results should not be transferred to natural conditions. Under natural conditions interaction between applied chemicals and microorganisms in the soil is much more complicated as they are determined not only by the action of the chemical but also complicated relationship between microorganisms in microbiota and chemical properties of the soil. Under certain environmental and physicochemical conditions of the development of soil microflora composition, chemicals can cause negative side effects on the population of microorganisms in agrocoenoses which are revealed in the reduction of the total number of microorganisms, their group and species diversity, inhibition of total, enzymatic and metabolic activity, nutrient cycle disruption, dissimilation of ecological associations, etc., (Garbeva *et al*., 2011).

In this connection the concept of ecologized cereal crop protection is highly important. This concept involves the use of safe means and methods of plant protection, but preferably non-chemical organizational and economic, agronomic, biological. The basis of these methods is natural phenomena of superparasitism and antibiosis (fungistasis) which control the relationship between saprophytic and pathogenic microbiota. Relationships between pathogens and soil microorganisms are various. Most often, they are of antagonistic nature, that is they have two main types of impact: fungicidal-antagonist causes the death of other organisms and fungistatic-antagonist creates unfavorable conditions for the life of other objects mainly with antibiotics and other specific substances (Xu *et al*., 2004; Lisboa *et al*., 2015). In the early 1950s soil fungistasis was discovered which limits the growth of filamentous fungi and slows germination of dormant forms of pathogens. Fungistasis phenomenon allows us to look at the development of soil plant pathogenic fungi and the whole agro-ecosystem from a new angle. Fungistasis as one of the properties of the soil can contribute to long-term preservation of fungal spores in a dormant state, even if they have no special dormant structures and it makes the process of spore germination of pathogenic fungi slow, what reveals its negative role (Nikonorova and Voznyakovskaya, 1991). There is no doubt about biological nature of fungistasis,

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since the inhibiting properties of the soil disappear when it is sterilized and can be restored again by adding non-sterile soil, certain microorganisms and their communities to it. One of the main reasons of fungistasis is considered to be trophic competition between pathogenic and saprophytic microflora when there are not enough nutrients in the soil. Apparently, it is the reason why fungistasis is slight in the lower layers of soil where the number of microorganisms is quite small as well as in degraded soils. The application of organic matter stimulates the "provocative" spore germination of pathogens which prevents the soil from infection (Zou *et al*., 2007; Scala *et al*., 2011).

## MATERIALS AND METHODS

The study was carried out both in the laboratory. The method of A. Dotsenko in 1972 was used to determine soil fungistasis. The soil samples were placed in sterile petri dishes and wetted up to 80% of the maximum water holding capacity. After that filter paper was put on the soil surface. Petri dishes were kept in the laboratory for 48 h. Then cellophane disks, 10 mm in diameter with conidia suspension of the tested fungus (5 per petri dish) were put on the surface of the samples and left in a moist chamber for 24 h. Then the discs were removed and microscoped. The indicator of soil fungistasis is the percentage of ungerminated conidia of the fungus.

The antagonistic activity of the soil to root rot pathogens was determined as follows. Suspension of the fungus was placed in petri dishes with nutrient agar and then kept in an incubator for a day. Then soil lumps prepared by moistening 1 g of soil with sterile water were put on the surface of the grown tested fungus (25 lumps per petri dish). After that, the Petri dishes were placed into an incubator at the temperature of 28°C and after 4-5 days the formed lysed zones of the tested fungus around lumps were first counted. The next count was done on the 10th day.

The number of conidia of pathogens in the soil was counted by flotation. About 2 g of soil, 10 mL of distilled water and 1 mL of mineral oil were poured into the flask. Then the suspension was shaken and left for 5 min. After that a drop of the suspension was microscoped. Conidia with wrong structure were considered as nonviable.

## RESULTS AND DISCUSSION

The results of the study showed that the degree of infectious potential of root rot pathogens *B. sorokiniana* and *Fusarium* spp. in the rhizosphere of winter wheat is greatly affected by soil fungistasis which in its turn depends on the preceding crop. When Winter wheat followed grain crop in the crop rotation, soil fungistasis was slight. Thus, after Winter wheat the number of ungerminated conidia of *B. sorokiniana* was 35.1%, *F. gibbosum* 30.5% and after Spring wheat 15.4 and 25.2%, respectively. When winter wheat followed clean fallow the number of ungerminated conidia of *B. sorokiniana* was 45.3% and *F. gibbosum* 41.0%. High degree of fungistasis was observed after potatoes. The percentage of ungerminated conidia was 2.5 times lower than after Winter wheat (Table 1).

Table 1: The effect of the preceding crop on the rhizosphere soil fungistasis of Winter wheat

| | Fungistasis (%) | |
|---|---|---|
| Preceding crop | *Bipolaris sorokiniana* (Sacc.) | *Fusarium gibbosum* App. et Wr. emend. Bilai |
| Clean fallow | 45.3 | 41.0 |
| Winter wheat | 35.1 | 30.5 |
| Summer wheat | 15.4 | 25.2 |
| Potatoes | 86.3 | 72.0 |

Table 2: The effect of the preceding crop on fungistasis and infestation of Winter wheat by *B. sorokiniana*

| Preceding crop | Fungistasis (%) | Infestation (%) |
|---|---|---|
| Clean fallow | 45.3 | 31.7 |
| Winter wheat | 35.1 | 52.3 |
| Summer wheat | 15.4 | 57.6 |
| Potatoes | 86.3 | 28.2 |

Table 3: The effect of preceding crop on fungistasis and Winter wheat infestation by *F. gibbosum*

| Preceding crop | Fungistasis (%) | Infestation (%) |
|---|---|---|
| Clean fallow | 41.0 | 38.6 |
| Winter wheat | 30.5 | 72.1 |
| Summer wheat | 25.2 | 76.2 |
| Potatoes | 72.0 | 36.2 |

Thus, the degree of soil fungistasis can be controlled by the choice of preceding crop. When, Winter wheat followed grain crop, an increase in infestation of plants with root rot and slight soil fungistasis were observed. So, after Winter wheat plants infestation was 52.4% and after Spring wheat, 57.6%. When crop followed clean fallow, high degree of fungistasis reduced plant infestation with root rot to 31.7%. The best results were obtained when winter wheat sowing was after potatoes. High degree of soil fungistasis reduced the number of plants infested by *B. sorokiniana* to 28.2% (Table 2).

In experiments with *F. gibbosum*, fungistasis was slight when winter wheat followed clean fallow. The infestation of the plants was 38.6% and the number of ungerminated conidia was 41.0% (Table 3).

After preceding grain crop the degree of soil fungistasis was low that resulted in the growth of plant infestation. When crop sowing was after potatoes the degree of fungistasis to *F. gibbosum* was lower than to *B. sorokiniana*.

Preceding crops of winter wheat had different effects on the number of viable conidia of F. gibbosum in the soil.

Table 4: The effect of various crops on the viability of conidia of *F. gibbosum*

| Crop | Fungistasis (%) | Antagonistic activity of the soil (%) | Viable conidia (%) |
|---|---|---|---|
| Clean fallow | 41.0 | 26.3 | 49.0 |
| Winter wheat | 30.5 | 19.4 | 63.3 |
| Summer wheat | 25.2 | 12.3 | 69.4 |
| Potatoes | 72.0 | 38.3 | 35.3 |

The viability of conidia was greatly influenced by fungistasis and antagonistic activity of the soil (Table 4).

The greatest number of viable conidia was in the rhizosphere of plants: in the rhizosphere of Winter wheat 63.3%, in the rhizosphere of spring wheat 69.4%. High degree of fungistasis and antagonistic activity of the soil after potatoes reduced the number of viable conidia to 35.3%.

A direct relationship between antagonistic activity of the soil and its fungistasis, between antagonistic activity and viability of conidia of *F. gibbosum* was determined, that is an increase in antagonistic activity leads to significant soil fungistasis and the reduction of viable conidia. The correlation coefficient in the first case is $r = 0.973$, $t_r = 35.53$, $t_{theor} = 18.51$. The determination coefficient $d = 0.947$ shows that the proportion of the dependence of soil fungistasis on its antagonistic activity is 95%. The correlation coefficient in the second case is $r = 0.990$, $t_r = 104.67$, $t_{theor} = 18.51$. The determination coefficient $d = 0.981$ shows that the proportion of the dependence of viable conidia of the pathogen in the soil on antagonistic activity is 98%. It was also established that the viability of conidia depends on fungistasis. The correlation coefficient in this case is $r = 0.963$, $t_r = 25.63$, $t_{theor} = 18.51$. The determination coefficient $d = 0.928$ shows that the proportion of the dependence of viable conidia of *F. gibbosum* on soil fungistasis is 93%.

## CONCLUSION

- Cereals contribute to an increase in infectious potential of the soil, providing a stimulating effect on the germiation of pathogenic conidia. When Winter wheat followed Winter wheat in the crop rotation the infestation of plants by *B. sorokiniana* and *Fusarium* spp. was twice as much as after potatoes
- The degree of soil fungistasis can be controlled by the choice of preceding crop. The high degree of fungistasis was after potatoes that helped reduce the infestation of plants with root rot, as well as reduce the percentage of viable conidia of *F. gibbosum*
- There is a direct relationship between the antagonistic activity of the soil and its fungistasis, antagonistic activity and viability of conidia of *F. gibbosum* ($r = 0.973$ and $r = 0.990$)

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