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Phytopathogenic Mycobioma in Organic Production of Raspberry (*Rubus idaeus* L.) Cultivars J Jay and Himbo-Top

Abstract. This study presents the findings on the influence of raspberry varieties on the species composition of micromycetes in rhizosphere soil and on the vegetative organs of plants in organic production. The mycobiota of raspberry varieties Joan J and Himbo-Top was analysed during plant ontogeny and the species composition of phytopathogenic microspecies in the rhizosphere and on plant leaves was determined. It was found that the population is dominated by fungi: Septoria rubi, West, Botrytis cinerea, Pers, Aspergillus niger, V. Tiegh, Alternaria alternata, (Fr.) Keissl., Fusarium graminearum, Schwabe, regardless of the phase of plant ontogeny, which are producers of mycotoxins. The results of the study suggest that during the phase of inflorescence in the rhizosphere soil mycobiota and on the vegetative organs of raspberry plants of the Joan J and Himbo-Top varieties, the isolates of Septoria rubi and Alternaria alternata fungi are characterised by the highest competitive ability. A study of raspberry cultivars has shown a significant differentiation in the effect on the mycobiota of rhizosphere soil and vegetative organs during intensive fruiting. It was found that isolates of Aspergillus flavus, Aspergillus niger,

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Aspergillus oryzae and Alternaria alternate, which parasitise plants of the Himbo-Top variety, are characterised by a higher rate of radial mycelial growth and competitive ability compared to those parasitising the raspberry variety Joan J

Keywords: raspberries, rhizosphere, mycobiota, radial growth rate, vegetative organs of plants, isolates, phytopathogens, organic production

RELEVANCE

Raspberries are a valuable berry crop but obtaining high and sustainable yields depends on reducing losses caused by a range of pests and pathogens, including widespread fungal infections. The chronic nature of these diseases, the propagation of raspberries by vegetative means, and the lack of insufficient disease control during the growing season contribute to the accumulation and spread of phytopathogenic microbes. In the Forest-Steppe of Ukraine, raspberries are affected by diseases, among which the most common are anthracnose, septoria, fusarium, and alternaria (Hvozdiak, R.I., 2011). Their extensive spread can lead to the loss of fruiting stems and shoots, which significantly reduces yields. Plants lose resistance to low temperatures and react poorly to soil drought. The quality of planting material deteriorates. Yields can drop as much as 40% (Ostapenko, V.M., *et al.*, 2013). In addition, the pathogens of these diseases significantly reduce the nutritional and commercial quality of berries. Among them are toxin-forming fungi, which are considered to be factors of biological pollution of biocenoses. Nowadays, the organic nature of fruits is highly regarded, and the presence of toxin-forming micro-microbes in raspberry agrophytocenoses poses a potential danger of accumulation of harmful metabolites in plant products. Therefore, it is necessary to explore new technologies and varieties of raspberries that can inhibit the development of phytopathogenic microbes long-term. Therefore, the present study investigated the biological properties of isolates of phytopathogenic microbial agents present in the rhizosphere and ground vegetation organs of raspberry plants of foreign-bred raspberry varieties Joan J and Himbo-Top during plant ontogeny.

The purpose of the study was to determine the influence of remontant raspberry varieties on the number and competitive ability of isolates of phytopathogenic fungi parasitising the rhizosphere and vegetative organs of plants under organic production conditions.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The cultivation of berry crops, in particular remontant raspberries, using organic technologies on industrial plantations involves the introduction of resistant varieties (Archer, L., *et al.*, 2016, Prakash, B., *et al.*, 2011, Sekizuka, M., 2014, Ternovyi, Yu.M., *et al.*, 2010, Wang, Shiow, Y. & Lin, Hsin-Shan, 2000). Ukrainian scientists confirm the expediency of evaluating cultivars of cultivated plants as an ecological factor in the formation of a phytopathogenic background, which makes it possible to address the problem of controlling the number of populations of phytopathogenic microbes in agrocenoses (Parfeniuk *et al.*, 2015, Parfeniuk *et al.*, 2020). Varieties and hybrids are known to stimulate or restrain the intensity of spore formation of phytopathogenic fungi at different stages of ontogeny (Parfeniuk, A.I. & Beznosko, I.V., 2012). It is known that the species

of *Fusarium spp.* cause pathological changes in experimental plants (stunted growth and wilting), although their aggressiveness is only moderate and they were classified as the second pathogenicity group (Furtat, I., 2020). However, there is no data on the effect of raspberry remontant varieties on the pathogenic mycobiota of the rhizosphere and vegetative organs of plants at different stages of their development. But it is the pathogenic mycobiota that significantly reduces the quality and biological safety of raspberry products.

MATERIALS AND METHODS

The research was conducted at the Department of Agrobiological Resources and Environmentally Safe Technologies of the Institute of Agroecology and Nature Management of the National Academy of Agrarian Sciences of Ukraine and at the experimental field of Friendsbury LLC, located on typical chernozem in the Myronivskyi district of Kyiv Oblast and characterised by moderate agroclimatic conditions. The study was performed using raspberries of the Joan Jay (British selection) and Himbo-Top® (Swiss selection) remontant varieties cultivated according to the standard organic production technology (Polianchikov, S. & Kapitanska, O., 2017). Microbiological, phytopathological, mycological methods and methods of sampling raspberry plants during the growing season were used during the research (Bilay, V.I., *et al.*,1982, Parfeniuk, A.I., *et al.*, 2014, Zvyagintsev, D.G., 1991). Statistical analysis of the obtained results was performed using Microsoft Office Excel.

RESULTS AND DISCUSSION

The results of the study showed that the mycobiota of the rhizosphere and vegetative organs of raspberry plants of the varieties Joan J and Himbo-Top are dominated by fungi: *Septoria rubi,* West, *Botrytis cinerea,* Pers, *Aspergillus niger,* V. Tiegh, *Alternaria alternata,* (Fr.) Keissl., *Fusarium graminearum,* Schwabe, regardless of the phase of plant ontogeny, which are producers of mycotoxins. These micromycetes are producers of mycotoxins characterised by different mechanisms of action on living organisms and lead to biological contamination of agroecosystems and a decrease in crop quality (Table 1). Their mycotoxins can cause dangerous diseases in humans and animals.

Table 1. Species composition of phytopathogenic micromycetes of mycobiota of raspberry plants of Joan J and Himbo-Top varieties

Disease	Pathogen	Mycotoxins
Septoria	*Septoria rubi*	Properties only
Grey rot	*Botrytis cinerea*	Botrydial
Black mold	*Aspergillus niger*	Aflatoxin
Cladosporiosis	*Cladosporium herbarum*	Properties only
Alternariasis	*Alternaria alternata*	Tentotoxin

It is known that one of the important indicators characterising the physiological activity of phytopathogenic microsporidia is the average radial growth rate of fungal cultures on nutrient media (Parfeniuk, A.I., *et al.*, 2014). The results of the studies revealed that the identified phytopathogenic micromycetes have different rates of radial mycelial growth (Figs. 1, 2, 3).

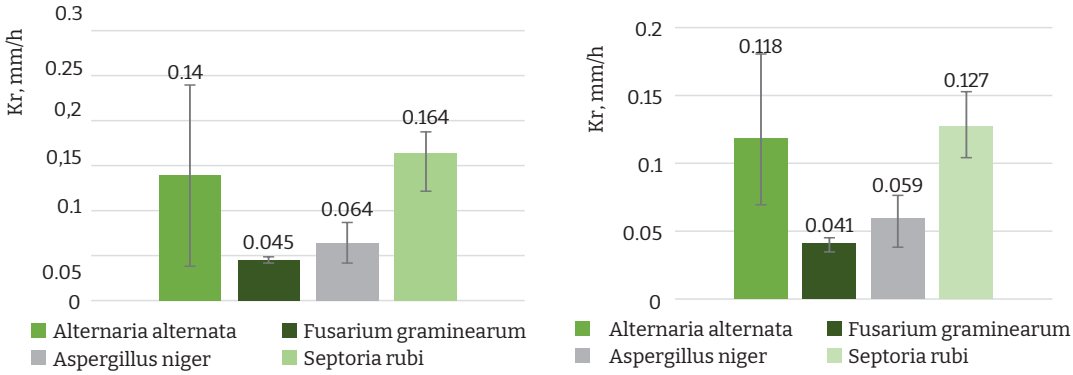

Figure 1. Radial growth rate *Kr* (mm/h) of fungal isolates isolated from rhizosphere soil and vegetative organs of raspberry plants in the phase of inflorescence extension (*left – raspberry variety Joan J, right – raspberry variety Himbo-Top*)

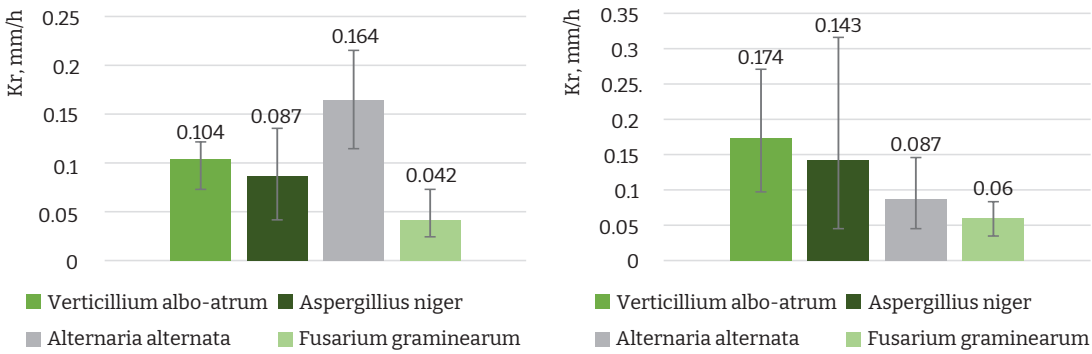

Figure 2. Radial growth rate Kr (mm/h) of fungal isolates isolated from rhizosphere soil and vegetative organs of raspberry plants of the studied varieties in the phase of bud separation in inflorescences (*left – raspberry variety Joan J, right – raspberry variety Himbo-Top*)

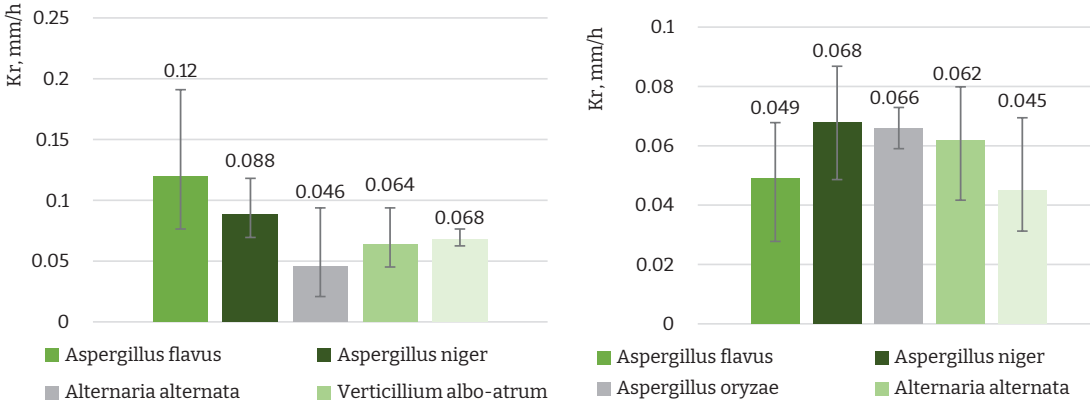

Figure 3. Radial growth rate *Kr* (mm/h) of fungal isolates isolated from rhizosphere soil and vegetative organs of raspberry plants of the studied varieties in the phase of intensive fruiting *(left – raspberry variety Joan J, right – raspberry variety Himbo-Top)*

According to the data presented in Fig. 1, the highest radial growth rate of mycelium (0.164 mm/h and 0.127 mm/h) was observed on isolates of *S. rubi* isolated from raspberry leaves of Joan J and Himbo-Top varieties in the phase of inflorescence extension. At the same time, the radial growth rate of *F. graminearum mycelium* isolated from both studied varieties was almost three times lower and averaged 0.045 mm/h and 0.041 mm/h, respectively. The results of the study suggest that during the phase of inflorescence in the rhizosphere soil mycobiota and on the vegetative organs of raspberry plants of the Joan J and Himbo-Top varieties, the isolates of *S. rubi* i *A. alternata* fungi are characterised by the highest competitive ability.

During the bud separation phase, a significant increase in phytopathogenic mycobiota was observed in the mycobioma of the rhizosphere and on the vegetative organs of raspberry plants of the studied varieties. According to the data shown in Figure 2, the highest rate of radial mycelium growth was observed in the culture of isolates of the species *A. alternata* (0.164 mm / h), isolated from rhizospheric soil and vegetative organs of raspberry plants of the Joan Jay variety. At the same time, on the variety Himbo-Top, the maximum radial growth rate of mycelium was observed in the culture of isolates of *A. flavus* (0.174 mm/h). During this period, the growth of the mycelium of *A. niger* fungi was almost unaffected by varietal differences in raspberry plants. The highest activity and diversity of phytopathogenic micromycetes was found in the inflorescences during the period of bud separation compared to other periods of raspberry plant ontogeny of the studied varieties. This may be due to weather conditions and characteristics of the physiological and biochemical properties of plants during this period. At the same time, the lowest rate of radial growth of fungal mycelium was observed in isolates of the species *F. dhamipeagim,* selected from both raspberry varieties (0.042 mm/h and 0.06 mm/h).

The results of the analysis of the rate of radial growth of fungal colonies of isolates isolated from the rhizosphere and leaves of raspberry plants in the phase of intensive fruiting (Fig. 3) showed that the highest rate of radial growth of mycelium was characterised by isolates of the species *A. flavus* (0.12 mm/h), isolated from the rhizosphere and leaves of raspberry plants of the raspberry variety Joan J. At the same time, the highest rate of radial mycelial growth was demonstrated by isolates of *A. niger* (0.068 mm/h), *A. oryzae* (0.066 mm/h) and *A. alternata* (0.062 mm/h) isolated from rhizosphere soil and leaves of plants of the Himbo-Top variety. They showed the highest competitiveness among the isolates of phytopathogenic microbial species. The lowest rate of radial growth of fungal mycelium during this period was observed in isolates of *A. alternata* isolated from plants of the raspberry variety Joan J (0.046 mm/h) and *F. graminearum* from plants of the variety Himbo-Top (0.045 mm/h).

CONCLUSIONS

In the phase of inflorescence extension in the mycobiota of rhizosphere soil and vegetative organs of raspberry plants, isolates of *S. rubi fungus showed the highest competitiveness on raspberry varieties Joan J and Himbo-Top.* During the period of bud separation in the inflorescences, the activity and diversity of phytopathogenic micromycetes significantly increase compared to other periods of raspberry plant ontogeny of the studied varieties. The raspberry varieties Joan J and Himbo-Top differ significantly in their effect on the competitiveness of phytopathogenic micro-microbes. In the mycobiota of rhizosphere soil and vegetative organs of raspberry plants of the variety Joan J during intensive fruiting of

plants, the most competitive fungal isolates were *A. flavus*, and on the variety Himbo-Top, isolates of *A. niger*, *A. oryzae* та A. *alternata* showed high competitiveness.

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Фітопатогенна мікобіома в органічному виробництві малини (Rubus idaeus L.) сортів Джей Джей та Хімбо-Топ

Анотація. У статті представлено результати дослідження впливу сортів малини на видовий склад мікроміцетів у ризосферному ґрунті та на вегетативних органах рослин в умовах органічного виробництва. Проаналізовано мікобіоту сортів малини Джоан Джей та Хімбо-Топ протягом онтогенезу рослин та визначено видовий склад фітопатогенних мікроміцетів у ризосфері та на листках рослин. Встановлено, що в популяції домінують гриби: Septoria rubi, West, Botrytis cinerea, Pers, Aspergillus niger, V. Tiegh, Alternaria alternata, (Fr.) Keissl., Fusarium graminearum, Schwabe, незалежно від фази онтогенезу рослин, які є продуцентами мікотоксинів. Результати дослідження свідчать, що у фазу цвітіння в мікобіоті ризосфери ґрунту та на вегетативних органах рослин малини сортів Джоан Дж і Хімбо-Топ найвищою конкурентною здатністю характеризуються ізоляти грибів Septoria rubi та Alternaria alternata. Дослідження сортів малини показало значну диференціацію впливу на мікобіоту ризосферного ґрунту та вегетативних органів під час інтенсивного плодоношення. Встановлено, що ізоляти Aspergillus flavus, Aspergillus niger, Aspergillus oryzae та Alternaria alternate, які паразитують на рослинах сорту Хімбо-Топ, характеризуються вищою швидкістю радіального росту міцелію та конкурентною здатністю порівняно з тими, що паразитують на рослинах малини сорту Джоан Дж

Ключові слова: малина, ризосфера, мікобіота, радіальний ріст, вегетативні органи рослин, ізоляти, фітопатогени, органічне виробництво