chemistry proceedings

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Proceeding Paper

Complex of Barley Leaf Spots in Ukraine †

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† Presented at the 1st International Online Conference on Agriculture—Advances in Agricultural Science and Technology, 10–25 February 2022; Available online: https://iocag2022.sciforum.net/.

Abstract: Barley is one of the most important cereal crops globally. In Ukraine, it is grown on an area of 2.4–2.8 million hectares annually and is the second largest grain crop in Ukraine after wheat. Barley grain export is about 4.3 million tons p.a. At the same time, one of the limiting factors for obtaining a high-quality yield is diseases, in particular leaf spots. In recent decades, there have been significant changes in the technology of cultivation, the composition of varieties and the pathogenic complex. Net blotch (*Pyrenophora teres* Drechsler) in net and spot forms and spot blotch (*Bipolaris sorokiniana* Shoem.) remain the most common among the diseases of barley leaves. They occur in all regions where barley is grown. Barley scald (*Rhynchosporium secalis* (Oudem.) Davis) is distributed mainly in the forest zone and western part of the forest-steppe zone and has become more widespread in recent years with rainy summers. Outbreaks of stripe spot (*Pyrenophora graminea* S. Ito & Kurib.) occur sporadically. Ascochyta leaf spot (*Ascochyta* spp.) was found in the Lviv and Dnipropetrovsk regions in 2020, and in the Lviv, Donetsk and Zaporizhia regions in 2021. In the field, spots can be misdiagnosed as barley scald, so their prevalence may be much higher. In 2021, during the seed ripening period, ramularia leaf spot was found in the Kherson and Vinnytsia regions. The disease was diagnosed in the laboratory by obtaining a typical conidial sporulation of the fungus *Ramularia collo-cygni* B. Sutton & J.M. Waller on affected tissues (wet chamber). Therefore, in recent years, the composition of the barley leaf spot pathogens has become wider and requires further investigation.

Keywords: barley; leaf disease complex; emerging pathogens

Citation: Retman, S.; Melnichuk, F.; Kyslykh, T.; Shevchuk, O. Complex of Barley Leaf Spots in Ukraine. *Chem. Proc.* **2022**, *10*, 1. https://doi.org/10.3390/IOCAG2022-12290

Academic Editor: Raimundo Jimenez-Ballesta

Published: 16 February 2022

1. Introduction

Barley is one of the most important cereal crops globally. In Ukraine, it is grown on area of 2.4–2.8 million hectares annually and is the second largest grain crop in Ukraine after wheat. Both winter and spring barley are grown in Ukraine. The area of spring barley is 1.3–1.6 million hectares, and that of winter barley is 1.0–1.2 million hectares. Barley grain export is about 4.3 million tons p.a.

Diseases are one of the limiting factors for obtaining a high-quality yield of barley. The most noticeable effect is observed in the case of leaf spots. In almost all regions of barley cultivation in the world, the most common and harmful is net blotch caused by *Pyrenophora teres* Drechsler [1–4]. Direct crop losses can reach 10–40% [3–5]; further, it also causes grain quality loss [5]. Manifestation of the disease can be in the typical (net) form, in the case of *P. teres* f. *teres*, and in the spot form, in the case of *P. teres* f. *maculata* [3].

Stripe blotch (*Pyrenophora graminea* S. Ito & Kurib) and spot blotch (*Bipolaris sorokiniana* Shoemaker) also belong to the complex of diseases that have historically been called helminthosporium spots [3]. Scald, along with net blotch, is one of the most common

and harmful diseases of barley in the world [6,7]. Ramularia leaf spot has become an important disease of barley in Europe, Canada, South America and New Zealand [8–10]. It can cause yield losses of up to 20% [10]. Other leaf spots that occur sporadically include septoria leaf blotch (*Phaeosphaeria nodorum* (E. Müll.) Hedjar, *Stagonospora avenae* f.sp. *tritici* Bissett, *Septoria passerinii* Sacc.) [11] and ascochyta leaf spot (*Ascochyta hordei* Hara, *Ascochyta graminea* (Sacc.) R. Sprague & Aar.G. Johnson) [3,12].

In recent decades, there have been significant changes in the technology of cultivation, the composition of varieties, climate conditions and the pathogenic complex. The aim of our investigations was to determine the composition and ratio of barley leaf spots in Ukraine.

2. Materials and Methods

Surveys of barley crops and selection of plant material were conducted in 24 regions of Ukraine in 2020–2021 during the flowering period–milk ripeness. At four points in the field, 100 leaves with symptoms of lesions were collected. They were labeled, stored in paper bags and transported to the laboratory. The material was examined in the laboratory by microscopy. The proportion of each disease was determined based on its incidence.

In order to identify the pathogen of ramularia leaf spot, segments of leaves with symptoms were placed in a humid chamber [13] and maintained in a thermostat at a temperature of 24 °C.

3. Results and Discussion

The maximum manifestation of the complex of spots was observed in the period of flowering–wax ripeness. Symptoms of ramularia leaf spot were observed from the period of grain filling.

Net blotch prevailed among the barley leaf spots (Figure 1). Its share ranged from 31 to 78%. The incidence of the disease under favorable weather conditions reached 100%. The maximum manifestation was observed in the central regions. Both the typical manifestation of the disease (net form) and lenticular spots (spot form) were noted. The symptoms characteristic for *P. teres* f. *teres* prevailed.

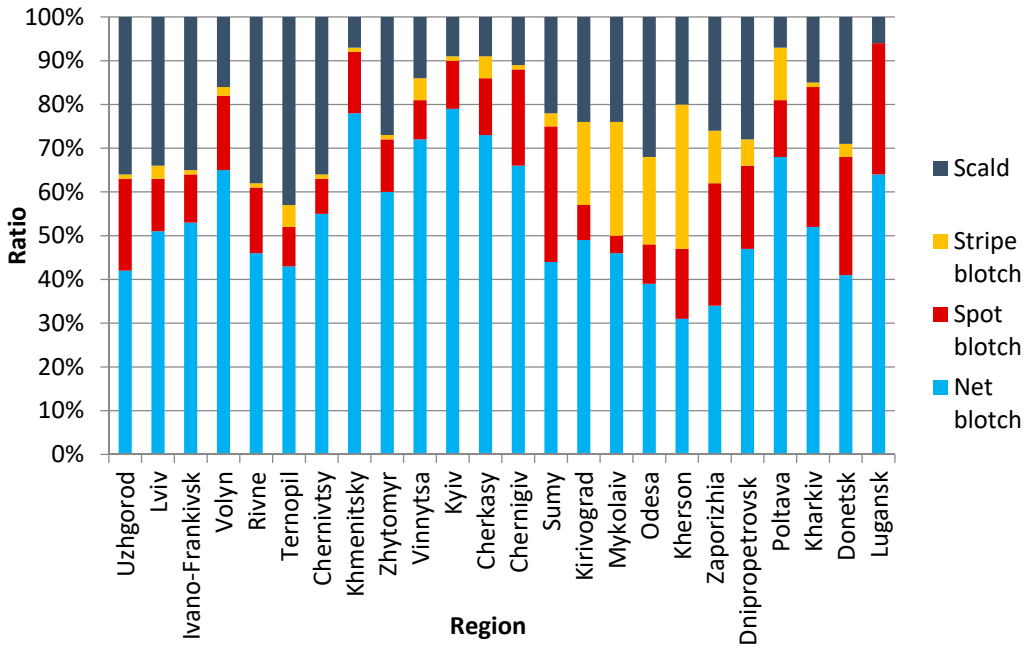

Figure 1. The ratio of the main barley leaf spots in Ukraine (2020–2021).

The share of spot blotch ranged from 4 to 32%. The highest rates were found in the northern and eastern regions of Ukraine.

Outbreaks of stripe blotch were observed in the southern regions, where the proportion of the disease was 12–33%. In the rest of the regions, it was either not found or did not exceed 3%.

In recent years, there has been an increase in the incidence and severity of scald. The disease was found everywhere, but it was most common in Polissya and the western regions of the forest-steppe of Ukraine, especially in the rainy summer. The proportion of the disease ranged from 6 to 43%.

During 2020–2021, the spread of ascochyta leaf spot was detected. In 2020, the disease was detected in the Lviv and Dnipropetrovsk regions, and in 2021, in the Lviv, Donetsk and Zaporizhia regions. In the field, its symptoms can be misdiagnosed as scald. Spots had a light center and were rounded or irregularly shaped, with a dark brown border and more or less noticeable pycnidia. The size of the pycnidia was 110.1–171.4 × 91.3–134.2 µm, and that of pycnospores was 14.6–19.4 × 5.2–6.3 µm.

During the ripening period in 2021, barley was affected by ramularia leaf spot in the Kherson and Vinnytsia regions. Small brown spots were found on both sides of the leaf blades; in addition, symptoms were observed on stems, ears and spikes. Microscopy revealed the mycelium of fungi that penetrated the tissues. After being kept in a humid chamber for 12–16 h, it was possible to observe the formation of conidiophores, which came out of the stomata in bundles and had a characteristic curve resembling a swan's neck. The fungus was identified as *R. collo-cygni* on a set of morphological and metric indicators (Figure 2).

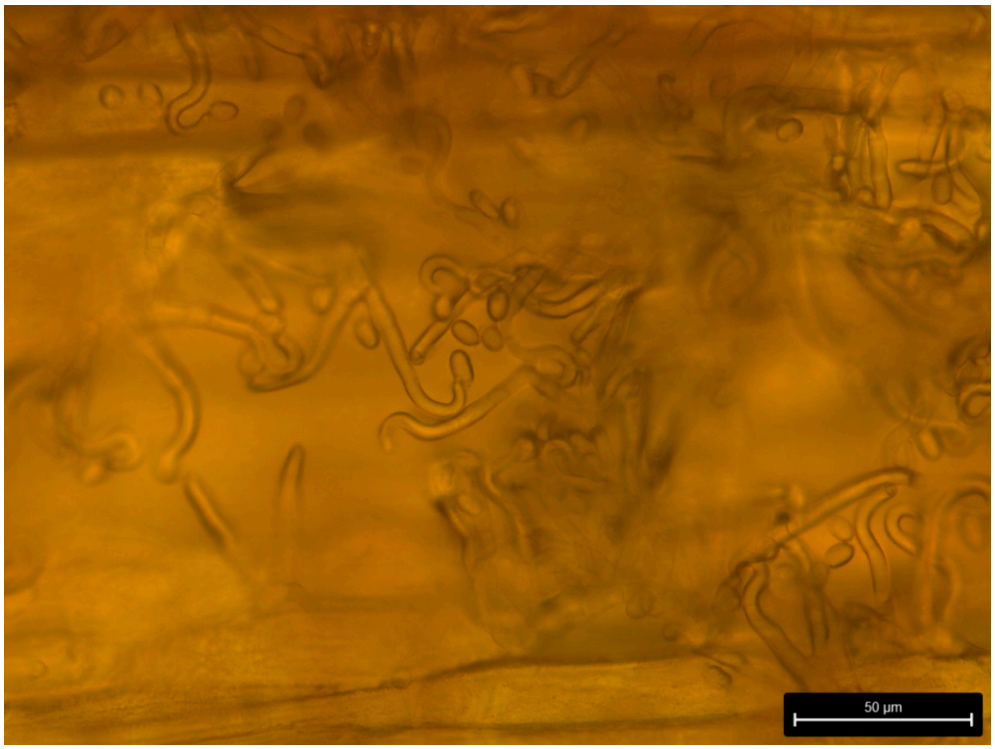

Figure 2. Conidiophores and conidia of *R. collo-cygni*.

Therefore, barley plants in Ukraine are affected by net blotch, stripe blotch, spot blotch, scald, ascochyta leaf spot and ramularia leaf spot. Net blotch is the most common among the barley leaf spots. It was found in all regions and its incidence was higher.

Ascochyta leaf spot is considered a minor disease of barley [3]. There are few reports of its spread, but the disease importance may be underestimated. As evidenced by the results of our observations, the main problem for identification is that in the field, its symptoms can be misdiagnosed as scald. Other researchers noted the similarity of ascochyta

leaf spot to other necrotrophic foliar pathogens or frost injury [12,14], which can lead to underestimation of the disease incidence.

Ramularia leaf spot occurs sporadically. Previously, this disease was recorded in the northern and northeastern regions (Chernihiv, Sumy, Kharkiv, Luhansk) of Ukraine [15]. This is a late-season disease. It may be asymptomatic during the season and then cause fast premature leaf senescence [8,10]. In our investigations, symptoms appeared during the seed ripening period when the window for fungicide application is closed. Additionally, in the field, it can be confused with symptoms caused by other pathogens or abiotic factors [8–10]; therefore, it is difficult to determine the actual spread of the disease.

4. Conclusions

In Ukraine, net blotch is the most widespread leaf spot disease of barley. However, attention needs to be paid to the new diseases such as ramularia leaf spot and ascochyta leaf spot, which can be threatening. The species composition of the causative agents of ascochyta leaf spot requires further investigations.

Author Contributions: Conceptualization, S.R. and F.M.; methodology, T.K. and O.S.; investigation, S.R., F.M. and T.K.; data curation, T.K. and O.S.; writing—original draft preparation, T.K. and S.R.; writing—review and editing, T.K. and O.S.; visualization, T.K. and O.S.; project administration, F.M. and S.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available upon request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Liu, Z.; Ellwood, S.R.; Oliver, R.P.; Friesen, T.L. Pyrenophora teres: Profile of an increasingly damaging barley pathogen. *Mol. Plant Pathol.* **2011**, *12*, 1–19. [CrossRef] [PubMed]
2. Clare, S.J.; Wyatt, N.A.; Brueggeman, R.S.; Friesen, T.L. Research advances in the Pyrenophora teres-barley interaction. *Mol. Plant Pathol.* **2020**, *21*, 272–288. [CrossRef] [PubMed]
3. Mathre, D.E. *Compendium of Barley Diseases*, 2nd ed.; American Phytopathological Society: St. Paul, MN, USA, 1997.
4. Gangwar, O.P.; Bhardwaj, S.C.; Singh, G.P.; Prasad, P.; Kumar, S. Barley disease and their management: An Indian perspective. *Wheat Barley Res.* **2018**, *10*, 138–150. [CrossRef]
5. Murray, G.M.; Brennan, J.P. Estimating disease losses to the Australian barley industry. *Australas. Plant Pathol.* **2010**, *39*, 85–96. [CrossRef]
6. Zhan, J.; Fitt, B.D.L.; Pinnschmidt, H.O.; Oxley, S.J.P.; Newton, A.C. Resistance, epidemiology and sustainable management of Rhynchosporium secalis populations on barley. *Plant Pathol.* **2008**, *57*, 1–14. [CrossRef]
7. Vahamidis, P.; Stefopoulou, A.; Lagogianni, C.; Economou, G.; Dercas, N.; Kotoulas, V.; Kalivas, D.; Tsitsigiannis, D. Pyrenophora teres and Rhynchosporium secalis Establishment in a Mediterranean Malt Barley Field: Assessing Spatial, Temporal and Management Effects. *Agriculture* **2019**, *10*, 553. [CrossRef]
8. Walters, D.R.; Havis, N.D.; Oxley, S.J.P. Ramularia collo-cygni: The biology of an emerging pathogen of barley. *FEMS Microbiol. Lett.* **2008**, *279*, 1–7. [CrossRef] [PubMed]
9. Havis, N.D.; Brown, J.K.M.; Clemente, G.; Frei, P.; Jedryczka, M.; Kaczmarek, J.; Kaczmarek, M.; Matusinsky, P.; McGrann, G.R.D.; Pereyra, S.; et al. Ramularia collo-cygni—An emerging pathogen of barley crops. *Phytopathology* **2015**, *105*, 895–904. [CrossRef] [PubMed]
10. Kaczmarek, M.; Piotrowska, M.J.; Fountaine, J.M.; Gorniak, K.; McGrann, G.R.D.; Armstrong, A.; Wrightc, K.M.; Newton, A.C.; Havis, N.D. Infection strategy of Ramularia collo-cygniand development of ramularia leaf spot on barley and alternative graminaceous hosts. *Plant Pathol.* **2016**, *66*, 45–55. [CrossRef]
11. Krupinsky, J.M.; Steffenson, B.J. Septoria/Stagonospora Leaf Spot Diseases on Barley in North Dakota, USA. In *Septoria and Stagonospora Diseases of Cereals: A Compilation of Global Research, Proceedings of the Fifth International Septoria Workshop, Mexico, 20–24 September 1999*; CIMMYT: Méx, Mexico, 1999; pp. 37–38.
12. Huftalen, C.S.; Bergstrom, G.C. First Report of Ascochyta Leaf Spot Caused by Ascochyta hordei var. americana on Barley in New York. *Plant Dis.* **1986**, *70*, 1074. [CrossRef]

13. Afanasenko, O.S.; Mironenko, N.V.; Bespalova, L.A.; Ablova, I.B.; Lashina, N.M. Ramulariosis of barley in the Russian Federation: Diagnosis and spread. *Mycol. Phytopathol.* **2019**, *53*, 236–245. [CrossRef]
14. Perelló, A.E.; Moreno, M.V. Occurrence of Ascochyta hordei var. europaea on wheat (*Triticum aestivum*) leaves in Argentina. *Australas. Plant Pathol.* **2003**, *32*, 565. [CrossRef]
15. Retman, S.V.; Shevchuk, O.V.; Kyslykh, T.M. Ramularia leaf spot—Emerging disease of barley. *Quar. Plant Prot.* **2012**, *7*, 1–2.