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STUDY AND ASSESSMENT OF NEW FUNGICIDE ACTIVES AGAINST CERCOSPORA LEAF-SPOT (CLS) CAUSED BY *CERCOSPORA BETICOLA* SACC. IN HUNGARY

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1. INTRODUCTION AND OBJECTIVES

The pathogen *Cercospora beticola* Sacc., responsible for cercospora leaf spot in sugar beet, plays a pivotal role in modern sugar beet cultivation from a plant protection perspective. The success of sugar beet production heavily depends on the effectiveness of control measures against cercospora leaf spot and on the rapid development of new fungicidal active compounds, as resistance profiles change rapidly.

An epidemic outbreak of this disease alone can cause yield losses of up to 50%. Fungicide use has been—and remains—an indispensable component of control strategies against cercospora leaf spot (C. beticola), primarily due to the lack of effective non-chemical alternatives. Over past decades, the effectiveness of fungicides has continually declined due to the emergence of resistant C. beticola strains. Resistance to various fungicide classes has been documented in many countries, including Hungary.

In his PhD research, the author aimed to evaluate the efficacy of novel fungicides belonging to a completely new chemical class (picolinamides), namely fenpicoxamid and florylpicoxamid, thereby introducing an innovative solution for controlling Cercospora leaf spot in sugar beet.

2. MATERIALS AND METHODS

2.1. Field Sites and Experimental Design

Over two seasons (2020–2021), ten field trials were conducted in one of Hungary's major sugar beet regions, located northeast of Jászberény in the North-Great Plain, where climatic and soil conditions favour *C. beticola* infection. Trials were performed according to Good Experimental Practice (GEP) standards approved by the relevant authorities, ensuring data reliability, comparability, and reproducibility.

Sites were selected to reflect real-world cultivation conditions, considering soil type, pathogen incidence, and microclimate. Soils were predominantly clay and clay-loam, supplemented with irrigation during the growing season. These conditions were optimal for sugar beet growth and conducive to cercospora infection and its monitoring.

The experimental layout followed a randomized complete block design (RCBD) with four replicates. Plot size was 16 m², and assessments were conducted visually on the two central rows per plot. The sugar beet cultivars tested — 'KWS Smart Belamia', 'KWS Smart Djerba', and 'KWS Balaton' — exhibit varying degrees of susceptibility to cercospora leaf spot.

2.2. Fungicidal Treatments and Application Methods

The study evaluated new picolinamide fungicides—fenpicoxamid and florylpicoxamid—applied at four dose levels (50, 75, 100, 150 g a.s./ha) and compared with reference fungicides. Combination treatments included

fenpicoxamid + prothioconazole (60+130, 75+150, 100+200 g a.s./ha and florylpicoxamid + difenoconazole (60+60, 75+75, 75+100, 100+100 g a.s./ha).

Reference treatments included single applications of EU-approved triazoles in sugar beet: difenoconazole (100 g a.s./ha), epoxiconazole (125 g a.s./ha), and prothioconazole (150 g a.s./ha). A commercial mixture of difenoconazole + fenpropidin (100+375 g a.s./ha) was used as a benchmark for combined treatment efficacy. Untreated plots served as controls.

Fungicides were applied two to three times per season, timed to crop phenology and the first appearance of infection symptoms to maximize efficacy. Application dates in 2020 were June 20, June 28, and August 3; in 2021, treatments were on August 24 and September 7.

2.3. Measurements and Data Collection

Several parameters were recorded to assess fungicide performance and crop development:

- ***Disease incidence****: percentage of infected plants per plot, assessed regularly*.
- ***Disease severity****: visual estimation of leaf damage caused by cercospora leaf spot, comparing treated and untreated plots*.
- *Yield: for the 2020 season, root fresh weight was measured in each plot at harvest.*

Statistical analysis was performed using the ARM software. One-way ANOVA identified significant differences between treatments, followed by Tukey's post hoc test. The four-replicate RCBD ensured robustness of results.

3. RESULTS

3.1. Infection Dynamics and the Role of Weather

Disease pressure in untreated control plots differed significantly between years: in 2020, the epidemic reached a severe level, whereas 2021 saw considerably lower infection levels. Weather conditions were the primary cause: warm and wet conditions in 2020 accelerated disease spread, while cooler, drier conditions in 2021 suppressed infection intensity. Analysis of AUDPC values confirmed significantly higher disease pressure in 2020.

3.2. Cultivar Susceptibility

Among the tested cultivars — 'Smart Djerba KWS', 'Smart Belamia KWS', and 'Balaton' — 'Smart Djerba' proved most susceptible, 'Smart Belamia' showed moderate susceptibility, and 'Balaton' was the least susceptible. Note: 'Balaton' was only grown in 2020; conclusions for this cultivar are based on a single season.

3.3. Efficacy of New Fungicides

The biocontrol efficacy (control %) of fenpicoxamid (Inatreq™) and florylpicoxamid (Adavelt™) was evaluated. ANOVA showed both agents, particularly at higher doses, significantly reduced disease incidence and severity. The best results were observed in combinations of picolinamides

with triazoles, achieving up to 98% control compared to untreated controls.

When compared with standalone triazoles (difenoconazole, epoxiconazole, prothioconazole), picolinamides exhibited equal or superior efficacy. Mixtures of fenpicoxamid + prothioconazole and florylpicoxamid + difenoconazole provided exceptional protection at all dose levels, matching or outperforming the commercial difenoconazole + fenpropidin combination. Untreated plots experienced rapid disease progression, especially during the 2020 epidemic, underscoring the necessity of fungicide use.

Picolinamide treatments exhibited a residual activity of approximately three to four weeks, indicating that appropriately timed applications can effectively manage disease pressure. In 2021, two fungicide applications sufficed to control the disease, offering a cost-effective strategy for farmers.

Overall, the results highlight that cercospora leaf spot poses a significant threat to sugar beet production, especially under favourable weather conditions. Among tested fungicides, the fenpicoxamid + prothioconazole and florylpicoxamid + difenoconazole combinations were the most effective, while other treatments also provided strong control. Comparing 2020 and 2021 emphasizes that application timing and choice of active ingredients are key to reducing disease pressure, with fewer applications needed under unfavourable weather conditions.

4. NEW SCIENTIFIC FINDINGS

(1.) This is the first study in Hungary to evaluate fenpicoxamid (a picolinamide fungicide) against *Cercospora beticola* in sugar beet, assessing its biocontrol efficacy, yield-enhancing effect, and phytotoxicity. We confirmed that fenpicoxamid offers excellent control, significantly increases yield, and shows no phytotoxic effects, making it safe for use. Its combination with prothioconazole further improved efficacy. Efficacy and yield responses were cultivar dependent. Official approval would greatly enhance crop protection in Hungarian sugar beet production.

(2.) Similarly, this is the first Hungarian study on florylpicoxamid (another picolinamide fungicide) against *C. beticola* in sugar beet, evaluating its disease control, yield benefits, and phytotoxic safety. Florylpicoxamid also proved highly effective, significantly increased yield, and was non-phytotoxic. When combined with difenoconazole, it provided superior efficacy. Responses depended on cultivar susceptibility. Registration would significantly improve disease management in Hungarian sugar beet cultivation.

5. PUBLICATION LIST

5.1. Scientific Articles in National Journals

1. Biró, Á. F.; Kukorelli, G.; Molnár, Z. (2021): A cukorrépa (*Beta vulgaris* L.) legjelentősebb fertőző betegségei és az ellenük való védekezés lehetőségei. ACTA AGRONOMICA ÓVÁRIENSIS 62: 1 pp. 127-144., 18 p.

2. Biró, Á. F.; Kukorelli, G.; Molnár, Z. (2021): A cukorrépa (*Beta vulgaris* L.) cerkospórás levélragyája (*Cercospora beticola* Sacc.), az ellene való védekezés lehetőségei és a fungicidekkel szembeni rezisztenciája. ACTA AGRONOMICA ÓVÁRIENSIS 62: 1 pp. 149-173., 24 p.

5.2. Scientific Articles in International Journals

1. Biró, Á. F.; Leader, A.; Hufnagl, A.; Kukorelli, G.; Molnár, Z. (2024): A picolinamide fungicide for controlling Cercospora-leaf spot (CLS) of sugar beet. BIO Web of Conferences 125, 01007

   https://doi.org/10.1051/bioconf/202412501007

2. Biró, A.F.; Leader, A.J.; Hufnagl, A.; Kukorelli, G.; Molnár, Z. (2024): Evaluation of Novel Picolinamide Fungicides (QiI) for Controlling *Cercospora beticola* Sacc. In Sugar beet. Horticulturae. 10,1202.
   https://doi.org/10.3390/horticulturae10111202

5.3. Participation in International Patents Related to the Topic

1. Gallup, C., Huang, Y-H., **Biró, A.**, Yao, Ch., Meyer, K. G., Da Cunha, L. C. V., Fairfax, M., Husband, B., Richburg, J., Martin, M. (2020): Use of acyclic picolinamide compound as a fungicide for control of phytopathogenic fungi in row crops. Patent publication number: 20200077656; UA127713 (C2), https://worldwide.espacenet.com/publicationDetails/biblio?FT=D&date=20231213&DB=EPODOC&locale=en_EP&CC=UA&NR=127713C2&KC=C2&ND=4

2. Gustafson, G. J., Delgado, J., **Biró, A.**, Gallup, C. (2021): Use of a difluro-(2-Hydroxyprpyl) pyridine compound as a fungicide for control of leaf spot of sugar beets. Patent Publication number: US20210274787(A1), https://worldwide.espacenet.com/publicationDetails/biblio?DB=EPODOC&II=6&ND=3&adjacent=true&locale=en_EP&FT=D&date=20210909&CC=US&NR=2021274787A1&KC=A1

5.4. Presentations at Scientific Conferences

1. Biró, Á.; Kukorelli, G.; Molnár, Z. (2021): ÚJ FUNGICID HATÓANYAG, A FLORILPIKOXAMID EREDMÉNYES HAZAI ALKALMAZÁSA *CERCOSPORA BETICOLA* SACC. ELLEN. In: Haltrich, A.; Varga, Á. (szerk., 2021): 67. Növényvédelmi Tudományos Napok konferenciakiadványa: Növényvédelmi Tudományos Napok 2021. 76 p. pp. 27-27., 1 p.

2. Biró, Á. F.; Kukorelli, G.; Molnár, Z. (2021): A florilpikoxamid, hazai szabadföldi vizsgálatai Cercospora beticola Sacc. ellen - Field studies of florylpicoxamid against *Cercospora beticola* Sacc. In Hungary. In: Szalka, É. (szerk., 2021): „INNOVÁCIÓ ÉS DIGITALIZÁCIÓ" XXXVIII. ÓVÁRI TUDOMÁNYOS NAP Absztraktkötet. Mosonmagyaróvár, Magyarország: Széchenyi István Egyetem Mezőgazdaság- és Élelmiszertudományi Kar. pp. 99-99. Paper: N3, 1 p.

5.5. Posters at Scientific Conferences

1. Biró, Á. F.; Leader, A.; Hufnagl, A.; Kukorelli, G.; Molnár, Z. (2024): A picolinamide fungicide for controlling Cercospora-leaf spot (CLS) of sugar beet. The 10th International Conference on Agricultural and Biological Sciences (ABS 2024). Győr, Széchenyi István Egyetem

2. Biró, Á. F.; Kukorelli, G.; Molnár, Z. (2021): A florilpikoxamid, hazai szabadföldi vizsgálatai *Cercospora beticola* Sacc. ellen - Field studies of florylpicoxamid against *Cercospora beticola* Sacc. „INNOVÁCIÓ ÉS DIGITALIZÁCIÓ" XXXVIII. ÓVÁRI TUDOMÁNYOS NAP", Mosonmagyaróvár, Magyarország: Széchenyi István Egyetem Mezőgazdaság- és Élelmiszertudományi Kar.