ANNALS OF THE UNIVERSITY OF CRAIOVA

Series: ✓*Biology*
✓*Horticulture*
✓*Food products processing technology*
✓*Environmental engineering*

Vol. XXXI (LXVII) – 2026

SUGAR BEET CONTROL OF CERCOSPORA LEAF SPOT AND RAMULARIA LEAF SPOT USING SOME FUNGICIDES AND ALTERNATIVE PRODUCTS

Adam (Hristea) Lorena[1], Hermeziu Manuela[1]*
[1*]National Institute of Research and Development for Potato and Sugar Beet Brasov
* *Correspondence author. E-mail*: manuela.hermeziu@potato.ro

Keywords*: Cercospora leaf spot, Ramularia leaf spot, sugar beet, sugar content, yield*

ABSTRACT

Very common diseases infesting sugar beet crops are cercospora leaf spot and ramularia leaf spot. To the National Institute of Research and Development for Potato and Sugar Beet Brasov, in 2025, using Bukovina hybrid were assessed the intensity and the frequency of attack of the both foliar diseases in an experiment which included different variants sprayed with conventional and unconventional products. The intensity recorded for cercospora leaf spot varied from 7.8 to 0.4 %, after treatments and for ramularia leaf spot varied from 18.2 to 6.1 %. Also the frequency was assessed and the values varied between 8.8 % and 1.1 % for cercospora leaf spot and between between 6.4 % and 2.5 % for ramularia leaf spot.The yield was between a maximum of 69.95 t/ha and a minimum of 53.98 t/ha and the sugar beet content between16.65°S and 12.36 °S.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.), belonging to the family Chenopodiaceae, is a biennial root crop known for sugar production after sugarcane (Mall et al., 2021). The European Union (EU) is a major producer of sugar beet, producing approximately 50 % of the total world production. Sugar beet is being cultivated on about 55 million ha all around the world, in Romania on about 20 thousand ha, having an average production about 55t/ha (Toth and Cristea, 2018).

Sugar beet crop is susceptible to a number of diseases which causes severe damage to the plant and result in significant losses in yield (Misra et al., 2022a, Misra et al., 2022b.) Notably, *Cercospora beticola* Sacc, the pathogen responsible for cercospora leaf spot disease, can lead to yields dropping by as much as 50 %. The disease is particularly recognized as one of the most severe foliar diseases affecting sugar beet, damaging the shoot system and disrupting photosynthesis, which ultimately reduces root sugar production (El-Naga et al., 2024). This disease impacts approximately 44 % of global sugar beet cultivation areas, with severity levels varying across different regions (Tan et al., 2023). Furthermore, sugar production can decrease by up to 42 %, and increased impurity levels may result in significant economic losses (Khan and Smith, 2005; Knight et al., 2019).

Cercospora beticola spreads in a polycyclic manner (Weiland & Koch, 2004), and the infected sugar beet leaf material from previous growing seasons

serves as the primary inoculum source (Imbusch et al., 2021). The fungus is able to survive up to 22 months in the soil (Khan et al., 2009). Currently, both naturally derived and synthetic fungicides, both protectant and systemic, are available for cercospora leaf control control (Ioannidis and Karaoglanidis, 2000). Depending on environmental conditions, resistance of varieties, sugar beet crop protection against cercospora require 1-2 up to 6-7 treatments per season (Toth and Cristea, 2020).

Ramularia leaf spot develops in colder weather; optimal temperature is 17 °C, relative humidity higher than 95 % (Asher and Hanson, 2006). The disease can apper in late autumn and can cause excessive leaf loss, resulting in re-growth which decreases the sugar concentration in the roots. The distribution of the spores takes place through wind and rain splash. The fungus overwinters on crop residues, and crop rotation is therefore important in order to minimize the risk of attack (Thach et al., 2013).

Both diseases can occur on sugar beet in one season, consecutively or simultaneously, and outbreaks can result in a significant loss of the crop in years with high disease pressure (Heick et al., 2020).

Trichoderma spp. are known to be promising tool in biocontrol. To avoid the negative consequences associated with chemical control, is considered a viable alternative (Burks and Stevens, 2011). To this end, plant-beneficial *Trichoderma* species are primarily defined by their antagonism against plant pathogens, activation of the plant defense system and as opportunistic plant symbionts that increase the systemic resistance of plants (Shoresh et al., 2010; Kappel et al., 2022) .

The application of treatments in different control schemes and the behavior of varieties continues to be important measures in controlling cercospora leaf spot and ramularia leaf spot at sugar beet (Toth and Cristea, 2021).

The aim of the present study was to analyzed the dynamics of foliar fungal diseases in sugar beet crop in order to establish the efficacy of some products and their effect on the yield and quality of sugar beet roots.

MATERIAL AND METHODS

The experiment, which used the Bukovina hybrid, was designed on the principle of randomized blocks, with seven (7) treatment variants, in four (4) repetitions (Table 1).

Table 1

Experimental design and treatment variants included in the study

Variant	Product	Active substance	Dose	Date of treatment
1	Untreated (control)	-	-	-
2	Copfort	natural foliar fertilizer based on copper complexed with gluconic acid.	2 l/ha	6.08.2026
3	Amistar Gold Score 250 EC	125 g/l azoxystrobin+ 125 g/l difenoconazole 250 g/l difenoconazol	1 l/ha 0.3 l/ha	6.08.2026 27.08.2026

		250 g/l		
4	*Beauveria bassiana* (granules on a maize-based nutrient substrate)*	granules on a maize-based nutrient substrate	0.100 kg/25 mp	7.04.2026
5	*Trichoderma* spp.*	suspension of spore (1 x 106 spores ml^{-1})	2.5 l/ha	6.08.2026 27.08.2026
6	Score 250 EC Thiovit Jet 80 WG	difenoconazol 250 g/l 80% sulfur	0.3 l/ha 5 kg/ha	6.08.2026 27.08.2026
7	Sekvenca Amistar Gold	difenoconazol 250 g/l 125 g/l azoxystrobin+ 125 g/l difenoconazole 250 g/l	0.4 l/ha 1 l/ha	6.08.2026 27.08.2026

*the products were made available by RDIPP Bucharest

Each experimental variant was organized in four rows, with a length of 8 m and a width of 1.8 m.

To evaluated the diseases symptoms the following formulas were used:
I (intensity) = Σ (i x f)/n (%), where, I = percentage for, f = number of plants (organs) with the respective percentage, n = total number of attacked plants (organs),
F (frequency) = n x 100/N, where N = number of observed plants (%), n = n° of characteristic symptoms plants (%),
DA (degree of attack) = F x I/100 (%), where: F = attack frequency (%), I = attack intensity (%).

Assessments of foliar fungal diseases (August, 4th and August, 26th) were done in record plots in 4 places per plot on 5 plants in a row (20 plants per plot). The intensity (I%) and the frequency of attack (F%) were the parameters assessed for the evaluation of foliar diseases and was determined the degree of attack.

Sugar beet yield was determined at harvest (October, 14th 2025) by harvesting two rows per treatment/replication, with the results converted to yield per hectare.

To determine sugar content, 10 roots were manually harvested from each of the 7 experimental variants, specifically from rows 2 and 3 of each replication. The topped roots were placed in woven bags and transported for analysis. The samples were washed via centrifugation, and the cleaned roots were then shredded. The resulting pulp from each sample was collected in numbered containers and analyzed in the laboratory. A 13 g sample of pulp was weighed into a volumetric flask; lead acetate and distilled water were added up to the flask's neck, followed by 3 drops of ether to prevent foaming. The samples were boiled for 20 minutes at 77 °C. After cooling, the volume was made up with distilled water, 3 drops of acetic acid were added for clarification, and the mixture was filtered through filter paper. The filtered solutions were analyzed using a polarimeter to determine sugar content, with the instrument being rinsed with distilled water after each sample (ICUMSA method, 2022).

RESULTS AND DISCUSSIONS

Climatic conditions

The thermal values from October 2024 to March 2025 recorded larger positive deviations in December (+2.9 °C), January (+4.1 °C) and March (+4.6 °C). As for the level of recorded precipitation, it was lower by 28.8 mm/sqm. The month of April 2025, in terms of precipitation, was deficient (-25.7 mm/sqm), and temperatures were slightly higher (9.7 °C) compared to the multiannual average (8.5 °C). In May, temperatures were recorded lower by 1.7°C compared to the multiannual average (13.6 °C) and a very high amount of precipitation (149.4 l/sqm), making access to the field difficult. During the summer, in June and July, temperatures were higher by +3 °C and +2.3 °C, respectively, compared to the multiannual average, but lower by -1.8°C in August, while the precipitation regime was deficient in June (42.2 mm/sqm) and August (-61.0 mm/sqm), which negatively influenced most crops (Figure 1).

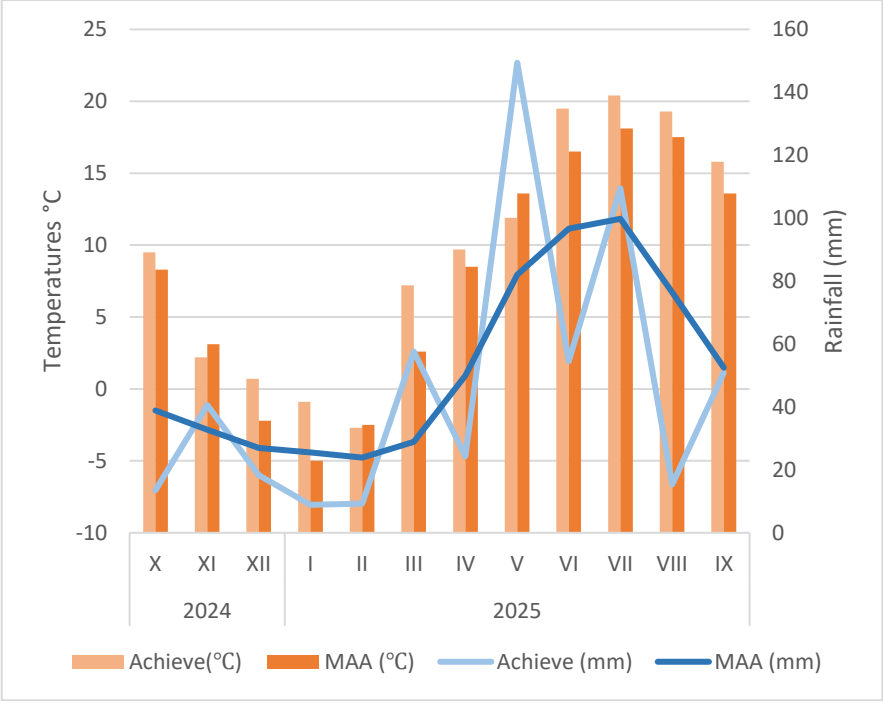


Figure 1. Climatic conditions during the experiment (Brasov, 2025)

Cercospora leaf spot. In 2025, on August 4 (the first assessment) after the fungicides application the attack intensity varied between 9.4 % to control (untreated V1) plot and 5.2 % to variant V7 (treated with Sekvenca). In August the amount of rainfall was very low but daily temperature was higher than normal not so favorable for the disease development. The frequency of attack also ranged between 11.4 % (control plot) to 7.5 % (both *Beauveria bassiana* and *Trichoderma* plots). During the second assessment (on 26 August) cercospora leaf spot intensity in the control plot was 7.8 % , but in the sprayed plots ranged between 3.7 % (Copfort variant) and 0.4% (*Trichoderma* variant). The frequency also ranged between 8.8 % to V1 (control

plot) and 1.1 % to V5 (*Trichoderma*). Degree of attack ranged between 1.07 % (V1 - control variant) and 0.39 % (V5 - *Trichoderma*), and to the second assessment rich a maximum of 0.686 % at the control variant (V1) and 0.004 % at the same variant V5 (*Trichoderma*) (Table 2).

Table 2.

Treatments influence on the Cercospora leaf spot attack (Brasov, 2025)

Variant	Attack intensity (%)		Attack frequency (%)		Degree of attack (%)	
	1st Assess. 4.08.25	2nd Assess. 26.08.25	1st Assess. 4.08.25	2nd Assess. 26.08.25	1st Assess. 4.08.25	2nd Assess. 26.08.25
V1	9.4	7.8	11.4	8.8	1.07	0.686
V2	5.5	3.7	8.2	4.5	0.45	0.166
V3	6.3	1.5	8.8	2.5	0.55	0.04
V4	5.5	1.4	7.5	2.1	0.41	0.037
V5	5.3	0.4	7.5	1.1	0.39	0.004
V6	5.5	1.5	8.0	2.5	0.44	0.037
V7	5.2	2.0	7.9	3.6	0.41	0.072

Ramularia leaf spot. The average intensity of the Ramularia leaf spot intensity of attack, determined at the first evaluation (August 4th), varied between 15.5 % at the control variant (V1) and 11.5 % at variant V3 (treated with Amistar Gold), and at the second evaluation (August 28th) between 18.2 % at the control variant untreated (V1) and 6.1 % at variant V7 (treated with Amistar Gold). Also, the frequency of the attack varied between 5.1 % at the untreated (V1) variant and 2.5 % at variant V4 *(Beauveria bassiana)* to the first assessment and between 6.4 % at the untreated (V1) variant and 2.5 % to variant 3 (after the treatment with Score 250 EC). The degree of attack ranged between 0.79 % (untreated variant – V1) and 0.28 % (variant 3), and a maximum of 1.16 % at the control variant and 0.18 % at variant V3 (after the treatment with Score 250 EC) (Table 3).

Table 3.

Treatments influence on the Ramularia leaf spot attack (Brasov, 2025)

Variant	Attack intensity (%)		Attack frequency (%)		Degree of attack	
	1st Assessm. 4.08.25	2nd Assessm. 26.08.25	1st Assessm. 4.08.25	2nd Assessm. 26.08.25	1st Assessm. 4.08.25	2nd Assessm 26.08.25
V1.	15.5	18.2	5.1	6.4	0.79	1.16
V2	13.5	10.2	4.8	3.8	0.64	0.38
V3	11.5	7.5	3.5	2.5	0.28	0.18
V4	14.9	7.2	2.5	4.1	0.40	0.29
V5	15.2	10.1	3.9	4.0	0.59	0.40
V6	11.6	8.6	2.7	3.0	0.31	0.25
V7	12.9	6.1	3.5	3.2	0.45	0.19

Yield obtained at harvest and determination of sugar beet content

Table 4.

The effect of the fungicides on yield and sugar content of Bukovina variety (Brasov, 2025)

Variant	Yield (t/ha)	Sugar content
V1	58.25	12.36
V2	69.95	14.96
V3	61.30	15.11
V4	63.40	15.82
V5	53.98	14.73
V6	62.80	15.03
V7	58.55	16.65

Dry conditions during August and September restricted diseases intensity, so, application of various fungicides had no significant effect on sugar beet yield. The yield was between 53.98 t/ha V5 (*Trichoderma*) and 69.95 t/ha V2 (Copfort).

The variant with Copfort, a fertilizer with copper, resulted in high yield. Authors like Mekdad and Shaaban (2020) consider that foliar application of nutrients can increase crop yield and quality and reduce the need for soil incorporation of fertilizers, so a significant increase may appear in sugar beet root yield as the result of the foliar application of nutrients.

Poor yield results obtained with *Trichoderma* make us think that ongoing research should focus on refining formulation and application methods to ensure the durability, efficacy, and compatibility of *Trichoderma*-based products.

The sugar content of beet sown at NIRDPSB Brașov in the experiment varied between a minimum of 12.36 °S in the control (untreated) variant and a maximum of 16.65 °S in the V7 variant (applied fungicides Sekvenca and Amistar Gold) (Table 4).

As other researchers (Jaskulska et al., 2023) have observed, the effect of fungicidal protection depends greatly on habitat conditions, especially weather. Precipitation and thermal conditions determine not only root yield but also the need for and effectiveness of chemical plant protection, including those that combat fungal pathogens (Piszczek et al., 2015; Farhaoui et al., 2023).

CONCLUSIONS

The presented research results prove that fungicides application has a beneficial effect on the root yield and sugar yield. The effect of the application of different fungicides depends on weather conditions from the studied year as well on the interaction between weather conditions and the applied treatments.

According to EU Directive 2009/128/ECI it's important to reduce the impact and use of pesticides and alternatives must be found, namely the application of less toxic (biological) products for the control of foliar diseases.

Regarding cercospora leaf spot the degree of attack ranged between 1.07 % untreated variant - V1) and 0.39 % (variant 5 - *Trichoderma*), and to the second assessment rich a maximum of 0.686 % at the untreated variant and 0.004 % at the

same variant 5, and about ramularia leaf spot the degree of attack was ranged between 0.79 % (untreated variant - V1) and 0.28 % (variant 3), and a maximum of 1.16 % at the untreated variant and 0.18 % at variant 3 (after the treatment with treated Score 250 EC).

ACKNOWLEDGMENT

This paper was prepared within the framework of the ADER 2023 Project no. 5.1.6/2023 "Research on the establishment of low input systems to combat major pests in beet and potato crops by using phytosanitary products with low environmental impact" funded by Ministry of Agriculture and Rural Development Romania.

REFERENCES

Asher M..J.C., Hanson L.E. 2006. Fungal and bacterial diseases. Draycot A. P. (ed.). Sugar beet. Oxford, UK, pp. 286–315.

Burks E., Stevens M. Fungicides for 2011: one spray or two. British Sugar Beet Review.79

El-Naga G., Maswada H., Ghazy N., El-Nagar A. El-Zahaby H. 2024. Evaluating the resistance of some sugar beet cultivars to cercospora leaf spot, pp. 21-25. 10.21608/jsaes.2024.325575.1103.

Farhaoui A., Tahiri A., Khadiri M., El Alami N., Lahlali R. 2023.Fungal root rots of sugar beets: A review of common causal agents and management strategies. Gesunde Pflanzen, 75, 1411–1440. https://doi.org/10.1007/s10343-023-00861-0

Heick T.M., Hansen A.L, Munk L., Labouriau R., Wu, K., Jørgensen Nistrup, L. 2020. The effect of fungicide sprays on powdery mildew and rust and yield of sugar beet in Denmark, Crop Protection, Volume 135, https://doi.org/10.1016/j.cropro.2020.105199.

ICUMSA method GS1-1. 2022. Polarimetric Sucrose Content of Raw Sugar by VIS-Polarimetry.

Imbusch F., Liebe S., Erven T., Varrelmann M. 2021. Dynamics of cercospora leaf spot disease determined by aerial spore dispersal in artificially inoculated sugar beet fields. Plant Pathol. 70: 853–861. https://doi.org/10.1111/ppa.13337

Ioannidis P.M., Karaoglanidis G.S. 2000. Resistance of *Cercospora beticola* Sacc. to fungicides. 123-145. In: M.J.C. Asher, B. Holtschulte, M.R. Molard, F. Rosso, G. Steinrücken, R Beckers (Eds), Advances in Sugar Beet Research. vol. 2.

Jaskulska I., Kamieniarz J., Jaskulski D., Radziemska M., Brtnický M. 2023. Fungicidal protection as part of the integrated cultivation of sugar beet: an assessment of the influence on root yield in a long-term study. Agriculture, 13, 1449. https://doi.org/10.3390/ agriculture13071449.

Kappel L., Kosa N., Grube S. 2022. The multilateral efficacy of chitosan and *Trichoderma* on sugar beet. Journal of Fungi, 8(2), 137. https://doi.org/10.3390/jof8-020137.

Khan J., Qi A., Khan M.F.R. 2009. Fluctuations in number of *Cercospora beticola* conidia in relationship to environment and disease severity in sugar beet. Phytopathology, 99:7, 796-801. https://doi.org/10.1094/PHYTO-99-7-0796

Khan, M.F., Smith, L.J. (2005). Evaluating fungicides for controlling Cercospora leaf spot on sugar beet. Crop Protection, 24(1), pp. 79-86.

Knight N.L., Vaghefi N., Kikkert J.R., Bolton M.D., Secor G.A., Rivera V.V., Pethybridge SJ. 2019. Genetic diversity and structure in regional *Cercospora beticola* populations from *Beta vulgaris* subsp. vulgaris suggest two clusters of separate origin. Phytopathology, 109(7), pp. 1280-1292.

Mall A.K., Misra V., Santeshwari, Pathak A,D, Srivastava S. 2021. Sugar beet cultivation in India: Prospects for bio-ethanol production and value-added co-products. Sugar Tech 23, 1218–1234 https://doi.org/10.1007/s12355-021-01007-0.

Mekdad A.A., Shaaban A. 2020. Integrative applications of nitrogen, zinc, and boron to nutrients-deficient soil improves sugar beet productivity and technological sugar contents under semi-arid conditions. J. Plant Nutr., 43(13): 1935–1950.

Misra V., Lal R.J., Mall A.K., Srivastava S., Baitha A. 2022b. Integrated disease management in sugar beet for sustainable productivity. In: V. Misra, S. Srivastava, A.K. Mall , (Eds.). Sugar Beet Cultivation, Management and Processing. Springer, Singapore. https://doi.org/10.1007/978-981-19-2730-0_29.

Misra V., Srivastava S., Mall A.K., Srivastava S. 2022a. Foliar sugar beet diseases and their management approaches in India. In: V. Misra, S. Srivastava, A.K. Mall (Eds), Sugar Beet Cultivation, Management and Processing. Springer, Singapore. https://doi.org/10.1007/978-981-19-2730-0_26.

Piszczek J., Górski D., Ulatowska A., Miziniak, W. 2015. Late infection of sugar beet crops with leaf spot (*Cercospora beticola* Sacc.) and profitability of crop protection against it in central Poland. Prog. Plant Prot. 55, 207–210.

Shoresh M., Harman G.E., Mastouri F. 2010. Induced systemic resistance and plant responses to fungal biocontrol agents. Annual review of phytopathology, 48(1), 21-43.

Tan W., Li K., Liu D, Xing W. 2023. Cercospora leaf spot disease of sugar beet. Plant Signaling and Behavior, 2023. 18(1), 2214765.

Thach T., Munk L., Hansen A,L., Jørgensen L.N. 2013. Disease variation and chemical control of Ramularia leaf spot in sugar beet. Crop Protection, volume 51, 68-76, https://doi.org/10.1016/j.cropro.2013.04.010.

Toth, K., Cristea, S. 2020. Efficacy of Treatments in Controlling Cercosporiosis *(Cercospora beticola* Sacc*.)* in Sugar Beet. Scientific Papers. Series A. Agronomy, 63(2), pp. 236–239.

Toth, K., Cristea, S. 2021. *Influence of the Treatment Scheme on the Cercosporiosis Attack (Cercospora beticola Sacc.)*. Scientific Papers. Series A. Agronomy, 64(2), pp.325-329.

Toth, K.G., Cristea, S. 2018. Evolution Areas Planted With Sugar Beet and Markets Beet in Romania. Proceedings of the 31st International Business Information Management Association (IBIMA), ISBN: 978-0-9998551-0-2, Milan, Italy, p. 1689-1695.

Weiland J., Koch, G. 2004. Sugarbeet leaf spot disease (*Cercospora beticola* Sacc.). Molecular Plant Pathology, 25: 157-166. https://doi.org/10.1111/j.1364-3703.2004.00218.x