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Proceeding Paper

Pest and Disease Impact on Tomato Genotypes in a Hedgerow System †

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Abstract: Hedgerow systems are capable of modulating the environmental impacts of cultivated species, thus supporting them by providing beneficial ecosystems services. The study focuses to assess the impact of insect damage caused by potato beetle (*Leptinotarsa decemlineata*), cotton bollworm (*Helicoverpa armigera*), fungal infections by (*Phytophthora infestans*), and wildlife damage from rabbits (*Oryctolagus cuniculus*), and roe deer (*Capreolus capreolus*) on three tomato genotypes, 'Szentlőrinckáta', 'ACE55', and 'Roma' produced in a hedgerow sytem. Plants were grown in random block design on both sides of a hedgerow at the Soroksár experimental field of the Hungarian University of Agriculture and Life Sciences in 2022. The plots were situated at five distances (3m, 6m, 9m, 12m, and 15m) from the hedgerow on both windy and protected sides. The results indicate, that variety selection has a significant effect on fruit production; 'ACE55' yielded less amounts of healthy unripe and ripened fruits compared to 'Roma' and 'Szentlőrinckáta'. Tomato variety, side, and distance significantly influenced insect damage and overall yield in tomato plants. Fungal damage was not significantly affected by variety, side, and distance. Potato beetle damage was more prevalent on the protected side, '' had significantly fewer damaged fruits compared to other genotypes. Wild animal damage was significantly affected by distance from the hedgerow. Insect damage was higher on the protected side and lower on the windy side of the hedgerow, depending on insects and survey date. Despite higher insect damage, protected side generally promoted healthy red and green fruit production, particularly for 'Roma' and 'Szentlőrinckáta'.

Keywords: Insect damage; Fungal infection; Tomato; Hedgerows

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1. Introduction

Pests and diseases in tomato production can impact yield and profitability by reducing the economic value of the fruits [1], affecting plant development and yield [2]. Pest and disease control is a critical element of agricultural operations. Disease-resistant traits are advantageous for producers [3]. Infections in the field or along the post-harvest processing significantly impact tomato quantity and quality [4]. Four major fungi damage tomatoes, these are Fusarium wilt (*Fusarium oxysporum f. sp. lycopersici*), Fusarium crown (*Fusarium oxysporum f. sp. radicis-lycopersici*), late blight (*Phtophthora infestans*), and Sclerotinia rot (*Sclerotinia sclerotiorum*). Late blight, a dangerous disease caused by *Phytophthora infestans*, cause the most significant losses among them. *Helicoverpa armigera*, a polyphagous bollworm, is a major economic threat to various crops, including cotton, soybeans, tobacco, chickpea, and pigeon pea [5].

The hedgerow system and other agroforestry methods can benefit sustainable agriculture systems in a variety of ways [8]. These systems support ecosystem services providing habitat for beneficial organisms participating in biological and natural pest control in crop protection. These diverse production systems support environmetal cycles and may boost the beneficial microorganisms in the soil, which can act as predators, parasites, and pathogens to the crop phytopathogens and pests. [6,7].

Farmers, producers are encouraged to switch to agroecological agriculture, in which activity of phytopathogens and insect pests are controlled by the system. This obviously, requires a thorough study of all parts of the agricultural system, as well as a working knowledge of local conditions and basic ecological principles [8,9]. This research aims to evaluate pest and disease infections in three tomato genotypes in an organically managed hedgerow system, comparing performance on windy and protected sides. The results can contribute to sustainable farming practices by providing effective pest and disease management methodology in organic vegetable production.

2. Materials and Methods

2.1. Study area, experiment design and plant material

The experiment took place in the summer season (May- October) of 2022 at the certified organic field of Soroksár Experimental and Research farm of the Hungarian University of Agriculture and Life Sciences. Experimental blocks were positioned in different distances from the hedge (R1, R2, R3, R4, and R5); each distance was three meters farther, with R1 being the closest and R5 the farthest from the hedgerows.

The purpose of the genotype selection is to have international varieties ('ACE55' and 'Roma') for comparability, along with a Hungarian landrace ('Szentlőrinckáta'). All of them has determinate growth and are suitable for field cultivation. Other important viewpoint was the resistance or tolerance to most common infections of tomato. 'Szentlőrinckáta' is a Hungarian landrace with favorable yield having resistance against blight [10]. 'Roma' and 'Ace 55' are commercial varieties with resistance to disease and pests [12, 13].

The experimental design employed a random block design (RBD), consisting of five replicates of tree genotypes on both sides resulting 2x15 plots. Each plot had 8 plants in two rows, 120 plants on each side, and 240 plants on the overall experiment on both sides of the hedgerow strip, accounting for both windy and protected sides. The spacing between plants and rows was set at 60 x 60 cm, resulting in a plant density of 3.5 plants per m^2.

Organic plant protection, was applied in the experiment. Against insect pests, Dipel (*Bacillus thuringiensis, var Kurstaki*, BT) was used to control *Helicoverpa armigera*, applied two times in August, while Laser (*Saccharopolyspora spinosa*) was sprayed against *Leptinotarsa decemlineata* in June. We observed the active contribution of beneficial organisms (*Coccinella septempunctata* and *Syrphidae* species) to the natural control of aphids. [11].

2.2. Measured and observed parameters.

2.2.1. Insect damage by Colorado potato beetle (*Leptinotarsa decemlineata*) and Cotton bollworm (*Helicoverpa armigera*)

The potato beetle caused damage in the adult and larval stages during June. The damage was visually assessed on the foliage of the tomato plants on June 18. 2022.

On 10th of August, cotton bollworm on the tomato fruits was observed. Data on this damage was collected on August 23rd and August 30$^{th.}$

2.2.2. Fungal infection by *Phytophthora infestans*

On August 10, 2022, data was collected regarding the fungal attack caused by *Phytophthora infestans*. This involved observing and calculating the number of infected fruits that had fallen from the plants. Specifically, fruits affected by fungal diseases such as *early blight, late blight, and buckeye* rot were carefully enumerated and documented.

2.2.3. Physical damage by wild animals (rabbit (*Oryctolagus cuniculus)* and roe deer (*Capreolus capreolus*))

The data on animal damage on the protected and windy sides was collected by quantifying the number of intact fruits on the plants as well as the fallen fruits that were consumed by visiting animals. This assessment was conducted on August 10, 2022.

2.2.4. Harvested fruit number and weight.

Fruits were harvested on October 5 and sorted into healthy green and healthy red fruits. Data on four (4) randomly selected middle plants was recorded. The harvested fruits were then also classified into (1) infected, (2) fungal-infected, (3) insect-damaged, and (4) physically damaged fruits, as well as into (5) damaged by wild animals. Within categories, the number of harvested fruits was counted, and their weight was measured directly after harvest using a digital spring balance scale.

Insect damage (1) **Fungal infection (2)** **Wild animals damage (3)**

Helicoverpa armigera *Phytophthora infestans* *Capreolus capreolus*

Figure 1. Symptoms of damages caused by pests (1) , fungi (2), and wild animals (3) on tomato fruit These figures are cited by the author (Z Szalai 1, 2 and Mohammed 3, 2022).

2.3. Statistical Analysis

Three-way multivariate analysis of variance (3-way MANOVA) was used, considering factors like variety, side, distance, and interactions. Pillai trace was used as a test statistic. Normality was checked using boxplots, and covariance matrices were checked using Box's M-test and two-variable scatterplots. Mahalanobis distance was calculated and compared against a chi-square distribution.

3. Results

3.1. Potato beetle (Leptinotarsa decemlineata) damage

The study evaluated the impact of variety, side, and distance on potato beetle damage in plants during the vegetation season. The results showed that variety had the most significant effect on insect damage, independent of side and distance. The relationship between varieties and insect damage was consistent across sides and distances. The study also found that 'ACE55' had significantly fewer damaged compound leaves compared to 'Roma' and 'Szentlőrinckáta' as seen in Figure 1.

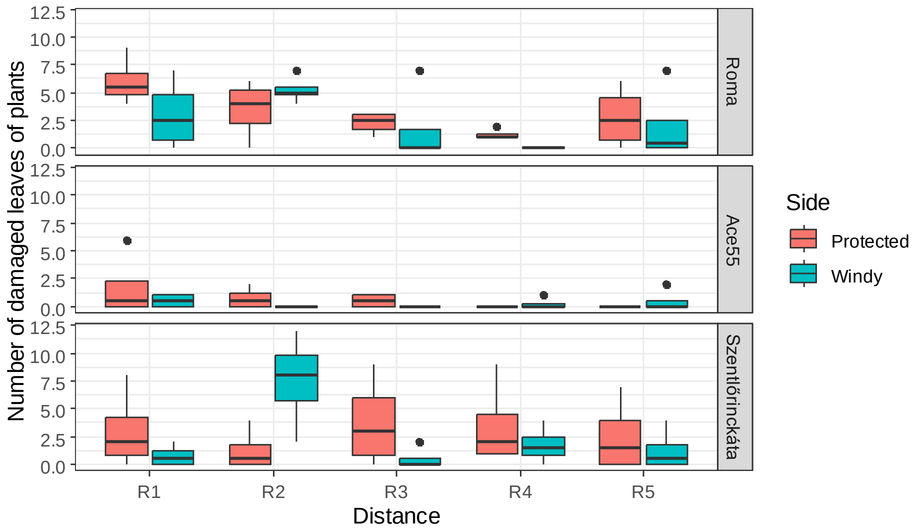

Figure 2. Number of leaves damaged by potato beetle, categorized by variety, side, and distance, with whiskers representing maximum and minimum damage.

3.2. *Cotton bollworm (Helicoverpa armigera) damage*

Cotton bollworm damage was measured on two different days, with significant main effects and interactions observed for both dates. 'Szentlőrinckáta' genotype was more susceptible to damage, while 'ACE55' and 'Roma' showed similar levels of resistance. Side and distance had significant effects on 'Szentlőrinckáta', with side and distance having a highly significant effect. The interaction between these factors was also less than 0.001, as shown in Figure 2.

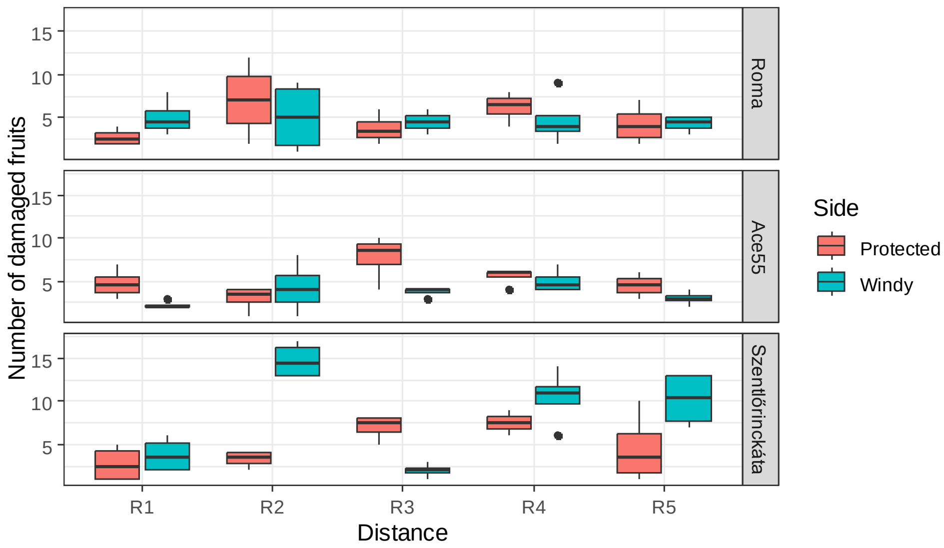

Figure 3. Number of fruits damaged by cotton bollworm (*Helicoverpa armigera*) by variety, side, and distance, with whiskers representing maximum and minimum damage.

3.3. *Fungal damage*

Results found no significant main effects or interactions between tomato genotypes and fungal damage, suggesting that they were equally susceptible to damage. The interaction of side and distance did not affect fungal damage levels, and the impact of variety on fungal damage remained consistent regardless of side and distance.

3.4. *Wild animal damage*

The result found a strong relationship between distance and animal damage in fruit damage. Larger distances led to more damaged fruits, while windy and protected sides showed different patterns of damage. Distances at R1 showed more damage on the protected side, while R3 and R4 showed more damage on the windy side.

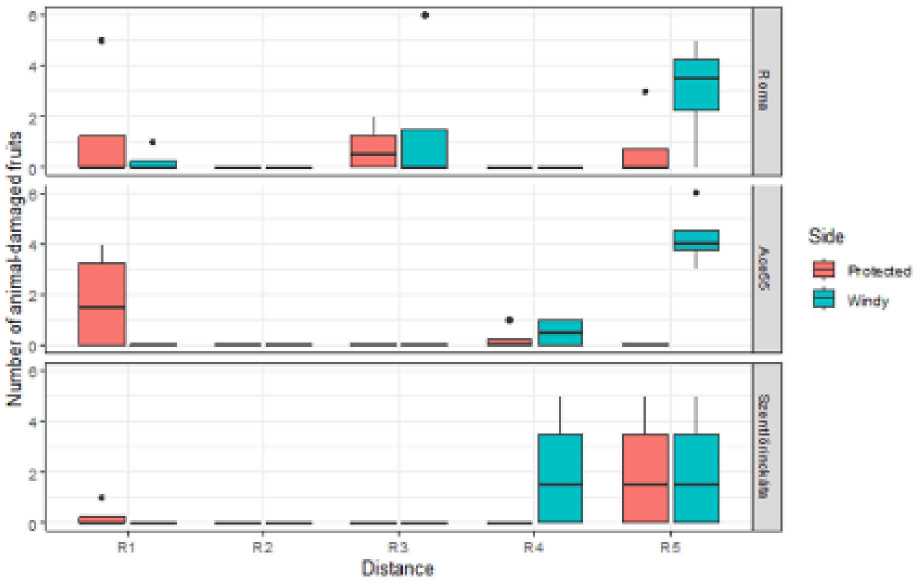

Figure 4. Number of tomato fruits damaged by wild animals (*Capreolus capreolus)* visualized with box-plot diagram. Whiskers representing maximum and minimum damage.

3.5. Tomato fruit yield harvested in physiological ripening (green and red stages)

3.5.1. Number of healthy green fruits

The study found a significant impact of variety on the number of healthy green fruits harvested, with both side and distance interactions playing a role. However, the weight of healthy green fruits was only significantly influenced by the plant's location and distance. 'Roma' and 'Szentlőrinckáta' were found to be more productive for healthy green fruits, with more fruits harvested on the protected side at R1 and the windy side at R2.

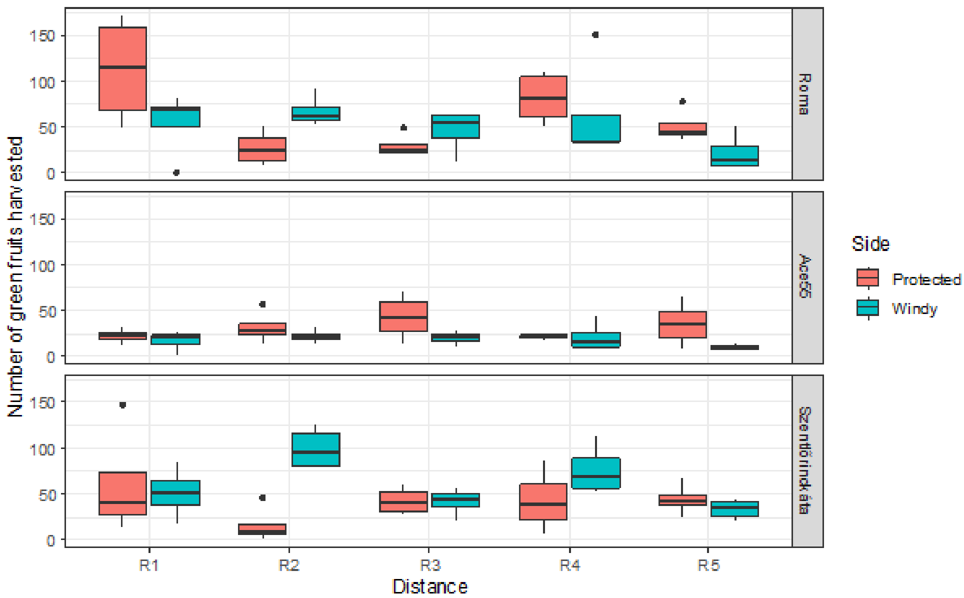

Figure 5. Number of healthy green harvested fruits by variety, side, and distance, with the median representing the number of fruits, whiskers representing damage, and dots representing outliers.

3.5.2. Number of healthy red fruits

Variety and side significantly impacted the number and weight of healthy red fruits harvested. 'ACE55' produced fewer fruits than 'Roma' and 'Szentlőrinckáta'. However, no significant difference was found between the two varieties. The protected side produced more fruits than the windy side, while the distance and all interactions were not significant. The results suggest that variety and side influence fruit production.

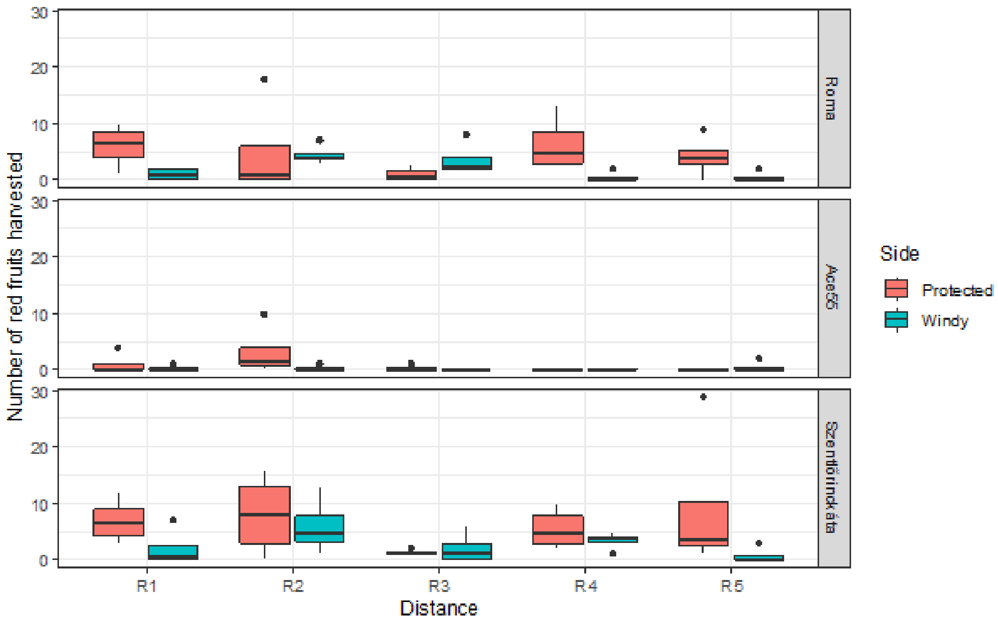

Figure 6. Number of healthy red harvested fruits by variety, side, and distance, with the median representing the number of fruits, whiskers representing damage, and dots representing outliers.

4. Discussion

The study investigates the impact of windy and protected sides of the hedgerow, and distances from hedgerows on insect, fungal, and wild animal damage of tomato genotypes. Three tomato genotypes, 'ACE55', 'Roma', and 'Szentlőrinckáta', were involved and plant protection measures were applied according to the organic farming regulations of the European Union. Results show variety is the most significant factor affecting potato beetle damage, while susceptibility to cotton bollworm damage varies among varieties. Side and distance also had a significant impact on potato beetle damage, with more damage observed on the protected side on 'Szentlőrinckáta' genotype. No significant difference was found among genotypes in terms of susceptibility to fungal damage; distance from hedges and sides did not significantly impact fungal damage. Distance and side significantly affected wild animal damage, with larger distances leading to more damage. Farmers should consider distance and take measures to protect crops. Our results revealed, that tomato variety and location significantly influence the quantity of healthy green and red fruits. 'ACE55' produced fewer fruits than 'Roma' and 'Szentlőrinckáta', with side and distance interactions affecting fruit weight. The protected side yielded the highest amount of healthy red fruit, while the windy side produced less damaged red fruits, which is in agreement with the results of Nordey et al [14] on the protected cultivation of vegetable crops in sub-Saharan Africa. Despite insect damage, the protected side was more favourable for establishing healthy, marketable crops, suggesting further research for exploring strategies to reduce insect damage on organically managed tomato fields.

5. Conclusions

This investigation evaluates the impact of insect damage, fungal infection, and wild animal damage on tomato yield on both windy and protected sides of a hedgerow. The results showed that variety had the most significant effect on potato beetle damage, with 'ACE55' being more resistant. Side and distance also had a significant impact on potato beetle damage, with more damage observed on the protected side than on the windy side. The choice of tomato variety and location significantly impacted fruit production, with 'ACE55' producing fewer healthy green and red fruits compared to 'Roma' and 'Szentlőrinckáta'. The protected side was found to be more favorable for producing healthy red and green fruits. On the other hand, growers should consider that provided habitat on wind protected side can also be favorable for pests. The use of the wind-protected side in agroforestry-type hedgerow systems for tomato production can be recommended - according to our present result - for producing higher amounts of healthier, pest- and disease-free, and infection-free tomato fruits.

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Conflicts of Interest: The authors declare that this article being submitted is original; they have no known competing financial interests in this manuscript. While carrying out this investigation, we followed ethical standards and processes.

References

1. Kandel, D. R.; Marconi, T. G.; Badillo-Vargas, I. E.; Enciso, J.; Zapata, S. D.; Lazcano, C. A.; et al. Yield and fruit quality of high-tunnel tomato cultivars produced during the off-season in South Texas. *Scientia Horticulturae* 2020, *272*(June), 109582. doi:10.1016/j.scienta.2020.109582.
2. Mrosso, S. E.; Ndakidemi, P. A.; Mbega, E. R. Farmers' Knowledge on Whitefly Populousness among Tomato Insect Pests and Their Management Options in Tomato in Tanzania. *Horticulturae* 2023, *9*(2). doi:10.3390/horticulturae9020253.
3. Akino, S.; Takemoto, D.; Hosaka, K. Phytophthora infestans: A review of past and current studies on potato late blight. *Journal of General Plant Pathology* 2014, *80*(1), 24–37. doi:10.1007/s10327-013-0495-x.
4. Olaniyi, J. O.; Akanbi, W. B.; Adejumo, T. a; Akande, O. G. Growth , fruit yield and nutritional quality of tomato varieties. *African Journal of Food Science* 2010, *4*(6), 398–402.
5. Clark, M. S.; Ferris, H.; Klonsky, K.; Lanini, W. T.; Van Bruggen, A. H. C.; Zalom, F. G. Agronomic, economic, and environmental comparison of pest management in conventional and alternative tomato and corn systems in Northern California. *Agriculture, Ecosystems and Environment* 1998, *68*(1–2), 51–71. doi:10.1016/S0167-8809(97)00130-8.
6. Wang, Q.; Xu, Z.; Hu, T.; Ur Rehman, H.; Chen, H.; Li, Z.; et al. Allelopathic activity and chemical constituents of walnut (Juglans regia) leaf litter in walnut–winter vegetable agroforestry system. *http://dx.doi.org/10.1080/14786419.2014.913245* 2014, *28*(22), 2017–2020. doi:10.1080/14786419.2014.913245.
7. Harterreiten-Souza, É. S.; Togni, P. H. B.; Pires, C. S. S.; Sujii, E. R. The role of integrating agroforestry and vegetable planting in structuring communities of herbivorous insects and their natural enemies in the Neotropical region. *Agroforestry Systems* 2014, *88*(2), 205–219. doi:10.1007/s10457-013-9666-1.
8. Earnshaw, S. Hedgerows for California Agriculture. *Informe Técnico* 2004, *95616*(530), 1–18.
9. Brandle, J. R.; Hodges, L.; Zhou, X. H. Windbreaks in North American agricultural systems. 2004, 65–78. doi:10.1007/978-94-017-2424-1_5.

10. Boziné-Pullai, K.; Csambalik, L.; Drexler, D.; Reiter, D.; Tóth, F.; Bogdányi, F. T.; et al. Tomato landraces are competitive with commercial varieties in terms of tolerance to plant pathogens-a case study of hungarian gene bank accessions on organic farms. *Diversity* 2021, *13*(5). doi:10.3390/d13050195.
11. M.P. Garratt, D. Senapathi, D.J. Coston, S.R. Mortimer, S.G. Potts: The benefits of hedgerows for pollinators and natural enemies depends on hedge quality and landscape context Agr. Ecosyst. Environ., 247 (2017), pp. 363-370
12. Kathimba, F. K.; Kimani, P. M.; Narla, R. D.; Kiirika, L. M. Characterization of tomato germplasm accessions for breeding research. *Journal of Agricultural Biotechnology and Sustainable Development* 2021, *13*(2), 20–27. doi:10.5897/JABSD2021.0386.
13. Asma BelhachemiM MaatougM AmiratAbdelkader DehbiAbdelkader Dehbi. A Study of the growth and yield of Solanum lycopersicum under greenhouses differentiated by the LDPE cover-film. *Ukrainian Journal of Ecology* 2020, *10*(2), 69–75. doi:10.15421/2020_66.
14. Nordey, T.; Basset-Mens, C.; De Bon, H.; Martin, T.; Déletré, E.; Simon, S.; et al. Protected cultivation of vegetable crops in sub-Saharan Africa: limits and prospects for smallholders. A review. *Agronomy for Sustainable Development* 2017, *37*(6). doi:10.1007/s13593-017-0460-8.