Chapter 20

PHYTOSANITARY STATUS OF LAVANDIN *(LAVANDULA HYBRIDA* REV.*)* PLANTATIONS IN THE CONDITIONS OF THE SOUTHERN STEPPE OF UKRAINE

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INTRODUCTION

The current challenges faced by humanity in the agricultural sector – namely, the consequences of global climate change, the high degree of land tillage, the rapid decline of natural biodiversity, increased pesticide loads, pollution of agro-landscapes with mineral fertilizers, and the rise of greenhouse gas emissions – compel scientists to develop effective programs, policies, and strategies aimed at maintaining the planet's ecological balance (e.g., the Sustainable Development Strategy[1], European Green Deal[2], European Biodiversity Strategy 2030 [3]).

A key element of the European Biodiversity Strategy 2030 is the gradual expansion of areas under organic farming and biodiverse ecosystems on agricultural lands [4]. Under the norms of the European Green Deal («EUGreenDeal»), it is planned to establish landscape elements with high biodiversity on 10% of agricultural lands by 2030. Ukraine has also joined the implementation of these programs [5, 6, 7] and has an active Concept of the National Program for Biodiversity Conservation for 2005–2025 [8], according to which biodiversity is defined as a national treasure. Its conservation and sustainable use are one of the priorities of state policy in the field of natural

[1] Transforming our world: the 2030 Agenda for Sustainable Development. URL: https://numl.org/1gfA.

[2] EU Green Deal. URL : https://numl.org/1gfB.

[3] Biodiversity strategy for 2030. URL : https://numl.org/1gfC.

[4] Стратегія біорізноманіття ЄС до 2030 року. Чернівці : Друк Арт, 2020. 36 с. URL : https://numl.org/1fUj.

[5] Про Цілі сталого розвитку України на період до 2030 року. URL : https://numl.org/Ugj.

[6] Україна та Європейський зелений курс 21.12.2023. Річний моніторинговий звіт 2023. URL : https://numl.org/1fUd.

[7] Європейський зелений курс: можливості та загрози для України. URL : https://numl.org/1fUb.

[8] Про схвалення Концепції Загальнодержавної програми збереження біорізноманіття на 2005-2025 роки. URL : https://numl.org/1gfD.

resource management, ecological safety, and environmental protection, and a essential condition for balanced socio-economic development.

However, a sharp transition to achieving these goals will create contradictions between economic and ecological components, since the soil and climatic conditions of Ukraine are favorable for growing grain, technical, oilseed, and vegetable crops, leading, according to FAO estimates, to the highest degree of agricultural land plowing in the world (79%), with the greatest extent observed in the Steppe and Forest-Steppe zones (81%) [9, 10]. Excessive tillage has disrupted the balance between different land categories, reduced biodiversity, and accelerated soil degradation processes, causing annual losses of about 40-50 billion UAH [11]. Avoiding these negative consequences is possible by replacing grain production on part of the low-productive, eroded, sloped, and other poor soils with niche high-margin crops, such as essential oil plants. This approach would allow ecological program objectives to be met while preserving economic production efficiency.

Scientists have proven that lavandin *(Lavandula hybrida* Rev.*)* – a perennial essential oil crop obtained by natural or artificial hybridization of narrow-leaved lavender *(Lavandula angustifolia* Mill.*)* and broad-leaved lavender *(Lavandula latifolia* Medic.*)* – is a promising plant for southern Ukraine. Compared to its parent species, lavandin has higher yields and a greater essential oil output due to heterosis expression and reproduces exclusively vegetatively. The floral raw material of *L. hybrida* Rev. is in high demand across production and processing industries (cosmetic, perfumery, pharmaceutical, veterinary, chemical, technical), and the plants and their plantations are popular in ornamental horticulture and the tourism sector[12,13,14].

In our view – consistent with that of foreign researchers – greater attention should be given to lavandin cultivation, as it yields twice as much and

[9] Земельний довідник України 2020 – база даних про земельний фонд країни. URL : https://numl.org/1gfE.

[10] Распопіна С.П. Шляхи оптимізації структури земельного фонду України. International Scientific and Practical Conference planning and use of territories within the context of inclusive development. 2023. С. 131–133.

[11] Про схвалення Концепції загальнодержавної цільової програми використання та охорони земель: Розпорядження Кабінету Міністрів України від 19.01.2022 р. № 70-р. URL: https://numl.org/1gfF.

[12] Свиденко Л.В., Єжов В.М. Перспективи вирощування деяких ефіроолійних культур у Степу Південному. *Вісник аграрної науки*. Київ, 2015. № 6. С. 20–24.

[13] Марковська О.Є., Стеценко І.І. Продуктивність лавандину сорту Іній залежно від способів зрошення та систем удобрення. *Таврійський науковий вісник*. 2023. № 131. С. 138–147. DOI: https://doi.org/10.32782/2226-0099.2023.131.17.

[14] Дементьєва О.І., Бойко Т.О. Особливості застосування багаторічних лікарських рослин в оформлені квітників міста. *Таврійський науковий вісник*. 2021. № 118. С. 333–340. DOI: https://doi.org/10.32851/2226-0099.2021.118.42.

produces 4-5 times more essential oil [15, 16]. Moreover, much of the lavender essential oil available on the market is actually lavandin oil, used to adulterate true lavender oil.

Like all other plants, species of the genus Lavandula L. are affected by a specific complex of harmful organisms. Therefore, protecting plantations of this genus from harmful organisms is one of the most important components of their cultivation technology. Lavandin is relatively resistant to pathogenic microflora and pests compared to other Lavandula L. crops [17]. At the same time, a significant factor that can substantially limit the productivity of *L. hybrida* Rev. is weed infestation, especially during the first to third years of life. The determination of the species composition of segetal vegetation, phytopathogenic microbiota, harmful and beneficial entomofauna in lavandin plantations was conducted during 2021-2023 on the landmass of the private enterprise «Krynytsia» located in the Southern Steppe subzone of Ukraine, southwest part of Kherson district, Kherson region, village Inhulets on the left bank of the Inhulets River (46°48'12.2"N 32°50'37.5"E).

1. Species Composition of Segetal Vegetation and Weed Infestation in *Lavandula hybrida* Rev. Plantations

As mentioned earlier, the most economically significant group among the harmful organisms in lavender and lavandin plantations are weeds, the control of which is quite complicated due to the high quality requirements for the raw materials of these plants, especially for medical purposes, the small number of herbicides permitted for use in such plantations, the relatively strong phytotoxicity of these substances towards lavender and lavandin plants

[15] Марковська О.Є., Свиденко Л.В., Стеценко І І. Порівняльна оцінка морфометричних показників і господарсько цінних ознак *Lavandula angustifolia* Mill. та *Lavandula hybrida* Rev. *Наукові горизонти*. 2020. № 87. № 2. С. 24–31. DOI: https://doi.org/10.33249/2663-2144-2020-87-02-24-31.

[16] Дудченко В.В., Стеценко І.І. Продуктивність лавандину та економічна ефективність його вирощування за різних елементів технології. *Наукові доповіді НУБіП України*. 2023. Т. 104. № 4. DOI: https://doi.org/10.31548/dopovidi4(104).2023.004.

[17] Свиденко Л.В., Глущенко Л.А. Лавандин (*Lavandula hybrida* Rev.). Біологія, біохімія, агротехніка та особливості вирощування в умовах Херсонської області : методичні рекомендації. Скадовськ : Інститут рису НААН, 2018. 32 с.

(particularly after the second year of use), and the negative impact of herbicides on overall plant productivity and the quality of essential oil [18, 19, 20].

The species composition of weeds in lavandin plantations is extremely diverse and, in most cases, depends on the region of cultivation, preceding crops, and the overall farming culture at the enterprise engaged in cultivating this crop.

Weeds compete with crops for moisture, light, and nutrients; they act as reservoirs for phytopathogenic microorganisms, serve as habitats for populations of harmful entomofauna, and create preconditions for reduced floral raw material yields, shortened plantation exploitation periods, deterioration in essential oil quality, and, consequently, reduced profitability of lavandin cultivation. Global climate change towards greater continentality leads to an increase in the proportion of perennial weeds with a powerful, deeply penetrating root system. The primary stage in decision-making regarding weed control is the systematic monitoring of changes in their species composition [21]. Therefore, one of the urgent tasks of scientific research is to analyze the weed infestation of lavandin agrocenoses depending on cultivation technology elements, namely irrigation methods and fertilization systems.

Recently, in Ukraine, there has been a trend towards a sharp increase in arable land weed infestation due to violations of scientifically grounded crop rotations, soil tillage systems, failure to comply with crop production technologies, improper use of herbicides, the application of fresh, non-decomposed manure, adaptation of segetal plants to climate change, and the emergence of herbicide-resistant weeds. According to researchers, the most harmful are perennial weeds, effective control of which should be carried out through a set of organizational-economic, agrotechnical, and chemical measures within an integrated plant protection system [22]. Annual weeds also pose a significant threat, with the number of seeds in the 0-30 cm soil layer

[18] Current trends for lavender (*Lavandula angustifolia* Mill.) Crops and products with emphasis on essential oil quality / I. Cris,an et al. *Plants*. 2023. Vol. 12. P. 357. DOI: https://doi.org/10.3390/plants12020357.

[19] Angelova D., Dobreva A., Baeva G. The impact of soil herbicides on the yield and quality of lavender (*Lavandula angustifolia* Mill.) essential oil. *Agricultural sciences*. 2021. Vol. 13, no. 31. P. 37–43.

[20] Zhelyazkov I., Delibaltova V., Krastev T. Study on the efficacy of some herbicides for weed controlling in lavender field. *Research journal of agricultural science*. 2018. Vol. 50 (1). P. 178–185.

[21] Сторчоус І. Стратегія і тактика контролю забур'яненості. *Агрономія сьогодні*. 2011. URL: https://numl.org/1gfI.

[22] Features of protection of row crops under irrigation conditions / F. Melnychuk et al. *Scientific Horizons*. 2020. Vol. 23 (12). P. 36–45. DOI: https://doi.org/10.48077/scihor.23(12).2020.36-45.

ranging from 100 million to 4 billion units per hectare [23]. Since the ultimate goal of essential oil crop cultivation is to obtain ecologically clean essential oil, the use of herbicides in such plantations is inappropriate; therefore, preference should be given to agrotechnical measures, the choice of which depends on the species composition of the weed component [24, 25, 26].

During the spring regrowth period of first-year lavandin plants, the species composition of segetal vegetation included both annual and perennial weeds, among which late spring annuals (33%), wintering annuals (22%), and root-shoot perennials (22%) predominated. The share of rhizomatous weeds was 11%, early spring annuals and winter annuals accounted for 6% each [27].

The biological group of late spring annuals included the following species: green foxtail (*Setaria viridis* L.), barnyard grass (*Echinochloa crus-galli* (L.) Pal. Beauv.), common lamb's quarters (*Chenopodium album* L.), common cocklebur (*Xanthium strumarium* L.), redroot pigweed (*Amaranthus retroflexus* L.), common purslane (*Portulaca oleracea* L.). Among wintering annuals, the following were widespread shepherd's purse (*Capsella bursa-pastoris* (L.) Medic.), field pennycress (*Thlaspi arvense* L.), field larkspur (*Consolida arvensis* Opiz.), cleavers (*Galium aparine* L.). The biological group of root-shoot perennials included perennial sow thistle (*Sonchus arvensis* L), creeping thistle (*Cirsium arvense* (L.) Scop.), leafy spurge (*Euphorbia virgata* Waldst. et Kit.), field bindweed (*Convolvulus arvensis* L.). The group of rhizomatous weeds, although less numerous, included bermuda grass (*Cynodon dactylon* (L). Pers.), quackgrass (*Agropyron repens* (L.) Pal. Beauv. Early spring annuals were represented by wild oat (*Avena fatua* L.), rough smartweed (*Polygonum scabrum* Moench), among winter annuals, the following were observed rye brome (*Bromus secalinus* L.), loose silky-bent (*Apera spica-venti* L.). Thus, the type of weed infestation of first-year lavandin plantations was defined as dicotyledon-monocotyledon, annual-perennial (Fig. 1).

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[23] Стратегія і тактика захисту рослин. Т. 1 Стратегія : монографія / за ред. В. П. Федоренка. Київ : Альфа-стевія, 2012. С. 215–228.

[24] Рудник-Іващенко О.І., Ярута О.Я., Кременчук Р І. Екологічно безпечні технології захисту лікарських та ефіроолійних культур від шкідливих організмів (науково-практичні рекомендації). *Садівництво*. 2018. Вип. 73. С. 177–181.

[25] Ecological and agrotechnical aspects of cultivation of Salvia sclareal under conditions of drip irrigation in the south of Ukraine / V. Chaban et al. Journal of Ecological Engineering. 2021. Vol. 22 (11). P. 114–119. DOI: https://doi.org/10.12911/22998993/143266.

[26] Lengyel A. Weed studies on Hungarian lavender plantations. *Journal of Plant Diseases and Protection*. 2006. Vol. 20 (4). P. 339–346.

[27] Стеценко І.І. Забур'яненість насаджень лавандину за різних способів зрошення та систем удобрення. *Аграрні інновації*. 2023. Вип. 19. С. 206–211. DOI: https://doi.org/10.32848/agrar.innov.2023.19.31.

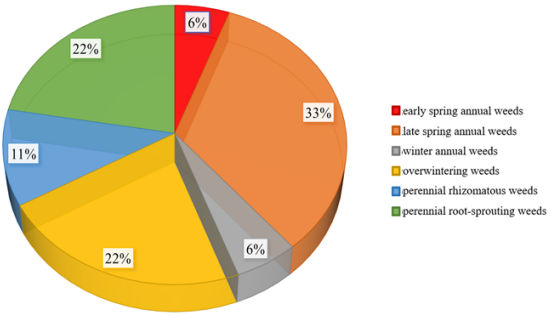

Fig. 1. Structure of the segetal vegetation complex in first-year lavandin plantations

Lavandin plants at the early ontogenetic stages during their first year of life exhibit slow growth and, thus, high sensitivity to weed competition. A large number of weeds suppress growth processes, inhibit flower shoot formation, and reduce the crop's winter hardiness. The highest weed infestation levels were observed during the first year of lavandin plantation use (Fig. 2).

Fig. 2. Weed infestation in first-year lavandin plantations (photo of the authors)

Weed control involved inter-row cultivations supplemented by manual weeding in the rows.

The type of weed infestation in second– and third-year lavandin plantations remained the same: dicot-monocot, annual-perennial.

Analysis of weed infestation dynamics across the years of lavandin cultivation revealed a gradual decrease in weed density from the first to the third year. Maintaining plantations weed-free through inter-row soil cultivation and manual weeding up to the fruiting phase of segetal plants

contributed to a reduction of the weed seed bank in the upper soil layer and proved effective against annual weed species (Fig. 3).

Fig. 3. Weed infestation in third-year lavandin plantations (photo of the authors)

Additionally, the expanding habitus of third-year lavandin plants effectively competed with weeds within the rows. During the mass flowering stage, the crop's canopy closure suppressed weed growth and development between the rows.

2. Phytopathogenic Microbiota in Lavandin Plantations

Due to the biological characteristics of lavandin plants – specifically their production of secondary metabolites with certain repellent, insecticidal, and fungicidal properties – the range of phytophagous insects and phytopathogenic microorganisms harmful to lavandin plantations is significantly smaller compared to lavender and other agricultural crops. However, there are already sufficient reports regarding lavandin infections caused by fungal, bacterial, and mycoplasma pathogens.

The most widespread lavandin diseases include septoria leaf spot (caused by *Septoria lavandulae* Desm.), which leads to leaf spotting, root rots, with common pathogens including *Rosellinia necatrix* Berl. ex Prill., *Armillaria mellea* (Vahl) P. Kumm., Fusarium spp., *Phytophthora* spp., Pythium spp. and Rhizoctonia spp. Phoma diseases and cankers, caused by *Phoma lavandulae* Gabotto and *Phomopsis lavandulae*, which manifest as stunted growth, leaf yellowing, defoliation, and eventual wilting of the entire plant. The polyphagous fungus *Botrytis cinerea* Pers. causes the development of gray mold. Under unfavorable environmental conditions, various symptoms – ranging from plant wilting to root rots – can also be caused by other soilborne

opportunistic pathogens such as *Verticillium* sp., *Sclerotium bataticola* Taubenh, and *Sclerotinia sclerotiorum* (Lib.) de Bary [28, 29].

Among bacterial pathogens found in lavandin plantations are *Xanthomonas campestris* (Pammel) Dowson, *X. hortorum* Vauterin et al., which cause bacterial leaf spots [30], *Xylella fastidiosa*, which hampers growth and causes leaf scorch [31], *Pseudomonas syringae* van Hall, which leads to wilting of young lavender and lavandin shoots.

The phytoplasma *Candidatus Phytoplasma solani*, which causes «lavender decline», has been a major factor behind the significant reduction of lavender and lavandin plantations in France. The disease develops chronically, with early symptoms being yellowing of the plants, followed by their death. The vector of transmission is the planthopper *Hyalesthes obsoletes* Signoret [32]. Lavandin can also be affected by viral pathogens, such as the Alfalfa Mosaic Virus (AMV), a non-persistent virus spread by aphids, gardening tools, and mechanical means, manifesting as leaf yellowing and plant dwarfism [33]. Root-knot nematodes – *Meloidogyne arenaria (Neal, 1889), M. incognita* Kofoid & White, *M. luci* – cause root-knot disease, leading to tissue dehydration, leaf yellowing, and flower abortion. This highly damaging pest can result in 30–50%, and in severe cases up to 100%, plant losses [34].

Research publications report infections of lavender by bacterial, viral (bacteriosis, phytoplasma, alfalfa mosaic virus, cucumber mosaic virus), and fungal (*Phoma lavandulae*), phomopsis (*Phomopsis lavandulae* Gabotto), septoriosis (*Septoria lavandulae* Dezm.), grey mold (*Botrytis cinerea* Pers.) pathogens. Plants of the Lavandula genus can also be affected by phytopathogens from the Fusarium, Verticillium, Sclerotium, Sclerotinia, and

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[28] Dlugos D.M., Jeffers S.N. *Phytophthora nicotianae* and *P. palmivora*: emerging pathogens of hybrid lavender (*Lavandula x intermedia*). *Graduate research and discovery symposium*. 2019. P. 252.

[29] Boudon-Padieu E., Cousin M. T. Yellow decline of *Lavandula hybrida* Rev and *L. vera* DC. *International journal of tropical plant diseases*. 1999. Vol. 17, no. 1/2. P. 1–34.

[30] Roberts S. J., Parkinson N. M. A bacterial leaf spot and shoot blight of lavender caused by *Xanthomonas hortorumin* the UK. *New disease reports*. 2014. Vol. 30. P. 1. DOI: https://doi.org/10.5197/j.2044-0588.2014.030.001.

[31] Update of the *Xylella fastidiosa* outbreak in France: two new variants detected and a new region affected / A. Cunty et al. *European journal of plant pathology*. 2022. Vol. 163, no. 2. P. 505–510. DOI: https://doi.org/10.1007/s10658-022-02492-z.

[32] Lavender decline in France is associated with chronic infection by lavender-specific strains of "*Candidatus* Phytoplasma solani" / O. Sémétey et al. *Applied and environmental microbiology*. 2018. Vol. 84, no. 24. P. 1–16. DOI: https://doi.org/10.1128/AEM.01507-18.

[33] Radev Z. Study of the representatives of pests in lavender (Lavandula L.). *New knowledge Journal of science*. 2020. Vol. 9, no. 3. P. 167–170.

[34] First report of root-knot nematode, *Meloidogyne arenaria*, on lavender in Turkey / T. Özalp et al. *Journal of nematology*. 2020. Vol. 52. P. 1–3. DOI: https://doi.org/10.21307/jofnem-2020-008.

Phytophthora genera [35]. For example, in the second half of the 20th century, French lavender plantations aged 3-4 years were destroyed due to infections by *Phomopsis lavandulae* Gabotto, whose pathogenicity increases when combined with infections by *Septoria* and *Phoma species* [36]. Fusarium pathogens have been detected in China, Croatia, and Saudi Arabia. In some years, soilborne diseases caused epiphytotics in Mediterranean countries, destroying more than 60% of lavender plantations and reducing their exploitation lifespan from 15-20 to just 3 years [37]. Comparing lavender and lavandin, scientists highlight the advantages of lavandin not only in terms of yield and essential oil output but also in greater resistance to diseases and pests.

In Ukraine, dangerous diseases of lavender and lavandin include septoria leaf spot (*Septoria lavandulae* Desm.) [38], manifesting as dark spots on leaf blades, phomosis (*Phoma lavandulae* Gabot), causing yellowing and drying of shoots[39]. Less frequently observed are root rots, provoked by mechanical damage to roots during cultivation or by gall-forming nematodes (*Melidogyne hapla* Chitwood). In Crimea, high harmfulness of viral diseases of lavender has been recorded [40], with some years characterized by epidemic development.

Analysis of weather conditions during the research period indicates that two out of the three years of observation were characterized by excessive rainfall (above long-term averages) from March to September. One of the determining factors ensuring disease development in plants is the creation of favorable environmental conditions. Different pathogens, depending on their biological characteristics, require specific temperature and humidity conditions for conidial or mycelial germination and for the spread of infectious structures within agrophytocenosis.

For forecasting disease development and spread, as well as assessing the favorability of weather conditions for epidemic development,

[35] Vasileva K. Monitoring of fungal diseases of lavender. *Agricultural science and technology*. 2015. Vol. 7, no. 4. P. 469–475.

[36] Buczacki S., Harris K. Pests, diseases and disorders of garden plants. London : Collins, 2014. 512 p.

[37] Crişan I., Vidican R., Stoian V. Induced modifications on secondary metabolism of aromatic and medicinal plants – an endomycorrhizal approach. *Hop and medicinal plants*. 2018. Vol. 26, no. 1-2. P. 15–29. **DOI:** https://doi.org/10.15835/hpm.v26i1-2.13228.

[38] Марковська О. Є., Дудченко В. В., Стеценко І. І. Моніторинг хвороб рослин роду Lavandula L. *Таврійський науковий вісник*. 2021. №. 122. С. 72–78. DOI: https://doi.org/10.32851/2226-0099.2021.122.10.

[39] Стеценко І. І., Марковська О. Є. Хвороби рослин роду Lavandula L. *Сучасна наука: стан та перспективи розвитку* : матеріали IV Всеукраїнської науково-практичної конференції молодих вчених з нагоди Дня працівника сільського господарства, м. Херсон, 17 листопада 2021 р. С. 101–103.

[40] Манушкіна Т. М., Манушкін М. Розповсюдження інфекційних хвороб *Lavandula angusifolia* Mill. в агроценозах Криму та біотехнологічні способи одержання оздоровленого посадкового матеріалу. *Наукові праці. Екологія*. 2010. Т. 132, № 119. С. 45–49.

phytopathologists use various indicators or coefficients, one of the main ones being Selyaninov's hydrothermal coefficient (HTC). These indicators are collectively called forecast predictors. Long-term observations of the dynamics of aerogenic disease development in relation to air temperature and moisture conditions have shown that when the hydrothermal coefficient (HTC) during the relevant period does not exceed 0.5, disease development remains at a low level. When the HTC is around 1.0, disease development can be expected at moderate to high levels. If the HTC exceeds 1.5, an epiphytotic outbreak of diseases should be anticipated.

The conditions of natural moisture supply varied over the years of the study. In 2021, the amount of precipitation from March to August totaled 526 mm, which was 3.2 times higher than the long-term average. The hydrothermal coefficient (HTC) for the spring–summer period was 1.54 (Fig. 4).

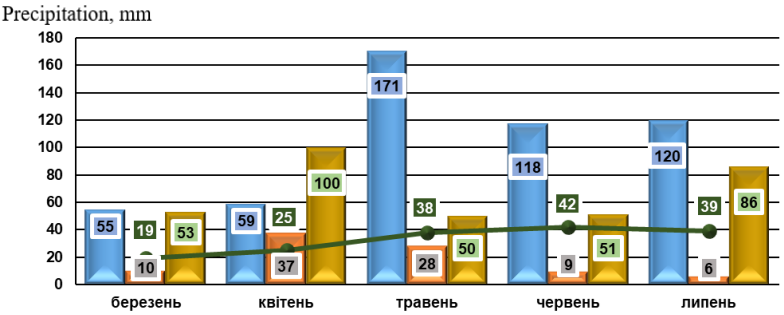

Fig. 4. Natural moisture supply conditions during the research years

The following year, 2022, was characterized by arid conditions, starting from the spring regrowth phase of the crop and continuing until the end of flowering. The amount of precipitation during this period was 90 mm, which is 1.8 times lower than the long-term average. Consequently, the hydrothermal coefficient (HTC) during this time was 0.39.

The growing season of 2023 was also characterized by excessive precipitation, amounting to 340 mm, which exceeded the long-term average for this period by 2.1 times. The hydrothermal coefficient (HTC) from the beginning of March to the end of July in the current year was 1.15.

Throughout 2021–2023, lavandin plants exhibited leaf lesions in the form of numerous small to medium-sized oval or irregularly shaped grayish-brown spots, often surrounded by a dark brown border (Fig. 5).

Fig. 5. Symptoms of lavender (Lavandula) infection caused by *Septoria lavandulae* Desm. and microscopic characteristics of pycnidiospores (a, b, c, d – disease symptoms; e – pycnidiospores) (photo of the authors)

Further observations of disease development showed that the pathological process initially led to yellowing of the leaves, followed by necrotic spot formation and premature defoliation of the infected plants.

Similar necrotic spots of rounded shape were observed on stems. Over time, in the infection sites on the leaves, numerous small black dots (pycnidia of the pathogen) were formed, immersed in the necrotic tissue. The first disease symptoms typically appeared on old leaves in the lower plant tiers (Fig. 5a, 5b, 5c, 5d). Microscopic analysis identified the pathogen causing the leaf spot as the ascomycete fungus *Septoria lavandulae* Desm., from the family Mycosphaerellaceae, whose pycnidia contained elongated, needle-shaped, colorless pycnospores with pointed ends and slightly curved shapes, with 1-3 septa (Fig. 5d).

3. Monitoring of entomofauna in Lavandin plantations

Among the pests that feed on lavandin plants are representatives of several insect orders: Diptera (the lavender gall midge *Resseliella lavandulae*, which feeds under the plant's bark and mainly damages the tips of the shoots, causing them to die off), Hemiptera (the cicadas *Hyalesthes obsoletus* Signoret, *Cechenotettix martini* Lethierry, the meadow spittlebug *Philaenus spumarius* L., and the mint aphid *Eucarazza elegans* Ferrari, which feed on plant sap and serve as vectors for viral and phytoplasma diseases), Coleoptera (leaf beetles

Arima marginata Fabricius, *Meligethes subfumatus* Ganglbauer, *Chrysolina americana* L.), and Lepidoptera (the combed leafroller *Argyrotaenia pulchellana* Haworth, the plume moth *Pterophorus spicidactyla* Chretien[41,42], and the lavender moth *Sophronia humerella* Denis & Schiffermüller).

In Ukraine, more than 250 pest species damage essential oil plants. Among insects, the dominant groups are Orthoptera, Hemiptera, Coleoptera, and Lepidoptera, while among arachnids, the dominant group is Acariform mites. Most of these pests are polyphagous, including bush crickets, locusts, the common mole cricket, cicadas, aphids, leaf beetles, weevils, jewel beetles, moths, cutworms, and others.[43]. Lavender and lavandin plantations can be damaged by the larvae of the beet webworm (*Loxostege sticticalis* L.), bush crickets (*Tettigoniidae*), flea beetles (*Alticinae),* harvester ants (*Messor*), he silver Y moth (Autographa gamma), and gall nematodes. In Crimea, lavender and other essential oil plants are additionally affected by the spittlebug (*Lepyronia coleoptrata* L.), the pale leafhopper (*Selenocephalus pallidus* Kbm), and the bilobed planthopper (*Agalmatium bilobum* Fieb.).

Observations of lavandin plantations during the research identified the following entomofauna species:

- Decorated Sphaerophoria (*Sphaerophoria scripta* L.) Belonging to the hoverfly family (Syrphidae) of the Diptera order, this species is an entomophagous predator of aphids (Fig. 6a). A single larva can consume 60-200 aphids per day, and 1000–2000 aphids over its entire development period. The larva grabs an aphid from the plant, sucks out its contents, and discards the empty skin.
- Seven-spotted lady beetle (*Coccinella septempunctata* L.) Belonging to the lady beetle family (Coccinellidae) of the Coleoptera order, it is a natural enemy of numerous agricultural pests, destroying over 60 species of aphids (Fig. 6b).
- Honey bee (*Apis mellifera* L.) A species of bee from the class Insecta, order Hymenoptera, family Apidae, it produces honey and is a strategic pollinator of flowering plants (Fig. 7).
- Giant resin bee (*Megachile sculpturalis* Smith) A species of wild bee from the family Megachilidae, order Hymenoptera. This invasive species was identified in lavandin plantations in early July 2022. According to researchers, its spread illustrates the effects of global climate change. Originally native to the subtropical regions of Southeast Asia[44], it was first recorded in Europe in

[41] Handbook of herbs and spices / ed. by K. Peter. Cambridge : Woodhead Publishing, 2004. Vol. 2. 376 p.

[42] Mason J. Growing and knowing lavender. Nerang : ACS Distance Education, 2014. 117 p.

[43] Сільськогосподарська ентомологія : підручник / ред.: Б. Литвинова, М. Євтушенка. Київ : Вища освіта, 2005. 511 с.

[44] Звіт про діяльність Національної академії наук України у 2022 році / НАН України. Київ : Академперіодика, 2023. 593 с.

2008 and in Ukraine in 2018. By 2022 [45], it had been found in Zaporizhzhia, Odesa, and Mykolaiv regions. This bee is polylectic but prefers plants from its native environment, such as *Styphnolobium japonicum* (Japanese pagoda tree), *Ligustrum* spp., as well as *Lavandula* spp. and members of the Fabaceae and Oleaceae families [46]. Due to its high ecological plasticity and the favorable climatic and weather conditions, the giant resin bee is capable of rapid adaptation, reproduction, and spread across Ukraine. This necessitates systematic monitoring, as scientists have not yet reached a consensus regarding the degree of threat this species poses to the biodiversity of natural landscapes through competition with native species of beneficial pollinating insects (Fig. 8).

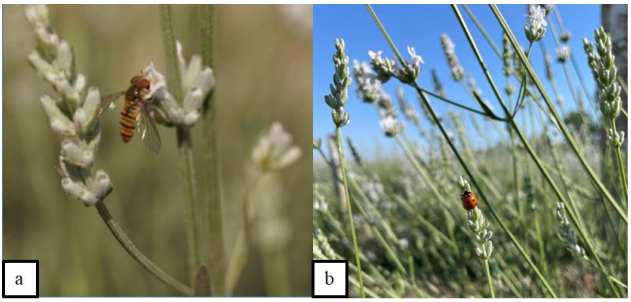

Fig. 6. *Sphaerophoria scripta* (a); *Coccinella septempunctata* (b) (photo of the authors)

Fig 7. Honey bee (*Apis mellifera* L.) (photo of the authors)

[45] New records of the invasive species *Megachile sculpturalis*, Smith, 1853 in Ukraine / M. Mulenko et al. *Studia Biologica*. 2022. Vol. 16, no. 3. P. 61–70. DOI: https://doi.org/10.30970/sbi.1603.690.

[46] *Megachile sculpturalis* (Smith, 1853) (Hymenoptera : Megachilidae), the giant resin bee new to South Tyrol with a newly described plant species interaction / E. Guariento et al. *Gredleriana*. 2019. Vol. 19. P. 209–215.

Fig. 8. *Megachile sculpturalis* Smith (photo of the authors)

- The lesser bee-fly (*Bombylius minor* L.) from the family *Bombyliidae*, order *Diptera*, is a parasite of solitary wild bees of the genus *Colletes*, which establish their underground nests in colonies within dry sandy habitats (Fig. 9a). This species feeds on nectar and pollen using its long, needle-like proboscis while slowly hovering over flowers, producing a high-frequency buzzing sound. It plays an important role in natural ecosystems by serving both as a pollinator and as a food source for certain bird species, thereby contributing to plant reproduction and the preservation of biodiversity[47].
- The giant scoliid wasp (*Megascolia maculata* Drury) from the family *Scoliidae*, order *Hymenoptera*, is listed in the Red Data Book of Ukraine and is encountered very rarely (Fig. 9b). In its larval stage, it is a parasite of rhinoceros beetle larvae and occasionally of other large scarab beetles, consuming them entirely before spinning a light cocoon in which it overwinters. In the adult (imago) stage, it is a phytophagous insect that feeds on the floral nectar of various plant species [48, 49].
- The common blue (Polyommatus icarus) is the most abundant representative of the family Lycaenidae, order Lepidoptera. It prefers habitats with grassy and flowering vegetation and is found throughout the entire territory of Ukraine (Fig. 10).

[47] Heath bee-fly *Bombylius minor*. *Back from the Brink*. URL : https://numl.org/1gfJ.

[48] Сколія-гігант *Megascolia maculata* (Drury, 1773). Червона книга України. URL: https://numl.org/1gfK.

[49] Червона книга Донецької області: тваринний світ : науково-інформ. довід. / ред.: В. Д. Залевського, О. І. Бронскова. Вінниця : ПрАТ «Вінн. обласна друк.», 2017. 452 с.

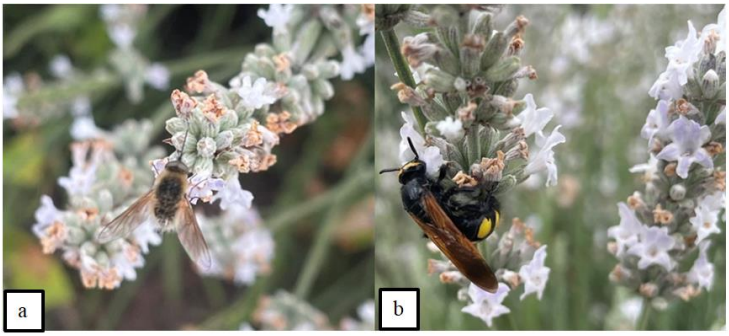

Fig. 9. The lesser bee-fly (a), The giant scoliid wasp (b) (photo of the authors)

Fig. 10. Male of the common blue (photo of the authors)

The imago feeds exclusively on floral nectar due to the specific structure of its proboscis. The male has blue upper wings with a narrow black margin, while the female's upper wings are dark brown with a bluish tint near the wing bases and rust-colored marginal spots. The underside of the wings in both sexes is gray, adorned with numerous small, black, eye-shaped spots. After fertilization, the female lays single eggs on the upper surface of young leaves of host plants, mainly from the family Fabaceae (legumes). Under favorable conditions, larvae hatch from the eggs within a week, move to the underside of the leaf, and begin feeding along its edges, eventually consuming the entire leaf.

- The spotted sulphur (*Emmelia trabealis*) is a harmless, narrowly specialized insect from the family *Noctuidae* (*Acontia*), order *Lepidoptera*. It

derives its name from its larval host plant, the field bindweed (*Convolvulus arvensis* L.) (Fig. 11).

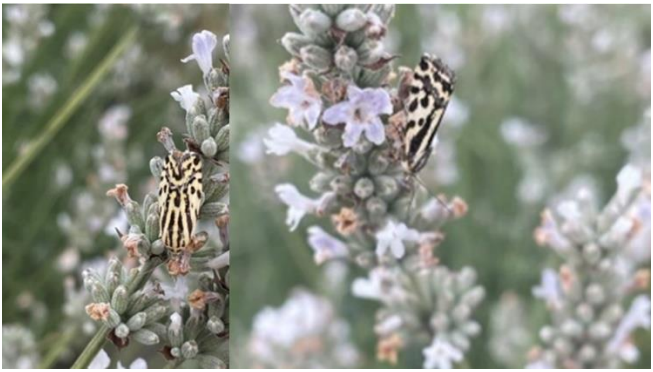

Fig. 11. Imago of the spotted sulphur (photo of the authors)

This perennial root-sprouting weed has infested lavandin plantations throughout the years of research, thus the presence of the spotted sulphur (Emmelia trabealis) is entirely understandable. The imago feeds on floral nectar and hides within flower buds. The primary coloration of the forewings is light yellow, marked with two longitudinal streaks, black dots, and spots. The hindwings are brownish-gray with a whitish fringe.

- The paper monk snail (*Monacha cartusiana*) is a mollusk from the family *Hygromiidae*, class *Gastropoda*. In recent years, the range of *M. cartusiana* in Ukraine has expanded significantly, although until the end of the last century this species was characteristic only of southern Ukraine and the Autonomous Republic of Crimea[50,51]. The paper monk snail can cause some damage to plants by feeding on their leaves and stems, creating competition for food with other species of mollusks and animals, which, in turn, may negatively affect biodiversity and ecosystem dynamics. However, their impact on the environment and agriculture can vary depending on weather conditions and regional factors. The potential risk of damage caused by paper monk snails depends on the size and overall health of the plants, the availability of other food sources, and the presence of natural predators (Fig. 12).

[50] Гураль-Сверлова Н., Гураль Р. Визначник наземних молюсків України. Львів : Держ. природознав. музей НАН України, 2012. 216 с.

[51] Gural-Sverlova N., Gural R. Three introduced Monacha (Gastropoda : Hygromiidae) species in and near Lviv with remarks on M. Cartusiana spreading in Ukraine and its Western part. *Folia malacologica*. 2023. Vol. 31 (2). DOI: https://doi.org/10.12657/folmal.031.012.

Fig. 12. The paper monk snail (photo of the authors)

– The large white (*Pieris brassicae*), a member of the family *Pieridae*, order *Lepidoptera*, is widespread and damages plants from the family *Brassicaceae*. The flight of imagos, which feed on floral nectar, was observed in lavandin plantations from the beginning of the crop's flowering period until its end (Fig. 13).

Fig. 13. Imago of the large white (photo of the authors)

Systematic monitoring of the entomofauna in lavandin plantations over the years of research has led to the conclusion that no pests of economic significance were identified. Lavandin plants attracted the existing entomocomplex exclusively during the flowering phase, serving as a source of additional nutrition for imagos in the form of floral nectar. An exception was the paper monk snail (*Monacha cartusiana*), whose individuals were present in isolated and insignificant numbers. A sharp decline in the activity of the observed entomofauna was recorded both before the onset and after the end of flowering, which corroborates the data of the Institute for Roses and

Aromatic Plants [52]. The absence of pests can be explained by several factors: the lack of a well-formed species-specific harmful entomocomplex characteristic of lavandin plantations; the plants' unattractiveness as a food source for native species due to the presence of certain secondary metabolites with repellent properties in their cell sap; the significant distance (over 100 km) from the nearest industrial plantations of plants from the genus Lavandula L. to the research site; the high level of agricultural practices employed during the study; and the overall high standard of land cultivation at the enterprise, which ensured effective control of polyphagous pest species. Additionally, the implementation of a modern crop protection system at the enterprise, compliant with the requirements of Integrated Pest Management (IPM), provided a reliable barrier against the reproduction and spread of harmful organisms.

CONCLUSIONS

Based on the conducted research, the type of weed infestation in lavandin plantations during the first to third years of use was determined to be dicotyledonous-monocotyledonous and annual-perennial. The highest number of segetal plants was observed during the spring regrowth phase of lavandin. Maintaining plantations weed-free through inter-row soil cultivation, manual weeding, and the increasing plant habitus contributed to a 2.4-3.8-fold reduction in weed infestation by the third year of lavandin use compared to the first year. Infection of lavandin leaves by the pathogen Septoria lavandulae Desm. (septoria leaf spot) was detected. The course of the pathological process, timing of the disease's initial manifestation, and percentage of infected plants depended on natural moisture conditions, from the beginning of spring regrowth to the end of the crop's flowering period. Throughout the study years, no pests of economic significance were detected in lavandin plantations. This can be explained by the absence of a species-specific harmful entomocomplex characteristic of lavandin, the plants' unattractiveness as a food base for native species due to the repellent properties of their cell sap, the considerable distance of more than 100 km from the nearest industrial plantations of Lavandula L. species, the high level of agricultural practices used in the study, and the overall high standard of farming at the enterprise, which ensured effective control of polyphagous pests. The existing entomofauna was mainly represented by beneficial species (*Apis mellifera* L., *Sphaerophoria scripta* L., *Coccinella septempunctata* L., *Megascolia maculata* Drury), contributing to the conservation and enhancement of

[52] Radev Z. Study on the use of honey bees (*Apis mellifera* L.) for biological control against pests in lavender (*Lavandula officinalis* L.). *New knowledge Journal of science*. 2020. Vol. 9, no. 1. P. 165–168.

agroecosystem biodiversity and the maintenance of ecological balance in general.

SUMMARY

In Ukraine, excessive land tillage has disrupted the balance among land use categories, decreased biodiversity, and accelerated soil degradation processes.

These negative consequences can be mitigated by replacing grain production on low-productivity, eroded, sloping, and otherwise infertile lands with high-margin niche crops, such as *Lavandula hybrida* Rev.

Lavandin is a perennial essential oil crop obtained through natural or artificial hybridization of narrow-leaved lavender (*Lavandula angustifolia* Mill.) and broad-leaved lavender (*Lavandula latifolia* Medic.). Compared to its parent species, lavandin demonstrates higher yields and greater essential oil output due to heterosis and propagates exclusively by vegetative means. The floral raw material of *Lavandula hybrida* Rev. is highly demanded in various production and processing industries (cosmetics, perfumery, pharmaceuticals, veterinary medicine, chemical, and technical sectors). Lavandin plants and plantations are also popular in ornamental horticulture and the tourism industry.

The species composition of segetal vegetation, phytopathogenic microbiota, and harmful and beneficial entomofauna in lavandin plantations was studied during 2021-2023 in the landmass of the private enterprise «Krynytsia», located in the southern subzone of the Steppe zone of Ukraine, in the southwestern part of Kherson district, Kherson region, village Inhulets (46°48'12.2"N 32°50'37.5"E). The obtained results confirmed that lavandin is relatively resistant to pathogenic microflora and pests compared to other *Lavandula L*. species. However, weed infestation, especially during the first to third years of plantation life, remains a significant factor that can substantially limit crop productivity. The high level of agronomic practices and overall farming culture at the enterprise, along with the use of a modern Integrated Pest Management (IPM) system, created an effective protective barrier against the reproduction and spread of harmful organisms in *Lavandula hybrida* Rev. plantations.

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