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ZONAL PATHOGEN COMPLEX OF SUNFLOWER IN THE LEFT BANK FOREST-STEPPE OF UKRAINE

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Aim. To determine a set of sunflower pathogens and their variability influenced by hydrothermal conditions of the crop growing season. **Methods**. Over the period of 2007–2016, due to phytosanitary monitoring of breeding crops of the scientific crop rotation of the Plant Production Institute named after V.Ya. Yuriev of NAAS, the prevalence degree, development intensity and variability of sunflower diseases in the Eastern Forest-Steppe of Ukraine were estimated. The hydrothermal coefficient (HTC) is presented for the sunflower growing season and by developmental phases of the crop. **Results.** Phomopsis blight (*Phomopsis/Diaporthe helianthi* Munt.-Cvet. et al.), gray mold (*Botrytis cinerea* Pers.), dry rot (*Rhizopus* sp.), charcoal rot (*Sclerotium bataticola*Taub), and downy mildew (*Plasmopara helianthi* Novot. f. helianthi) were the most common diseases on sunflower in the Eastern Forest-Steppe of Ukraine in 2007–2016. The weather conditions of 2007–2016 considerably varied and were characterized by fluctuations in the hydrothermal coefficient (HTC) from 0.57 in 2009 to 1.1 in 2014. Assessing the incidence of the five most common and harmful sunflower diseases (dry rot, charcoal rot, gray mold, Phomopsis blight, downy mildew) by cluster analysis for the ten-year study period in relation to the weather conditions of a year, we found that both dry and charcoal rots were co-associated with aridity, while downy mildew and gray mold were frequently promoted by waterlogging during a certain period of sunflower development. Unlike the other diseases, Phomopsis blight, being an annual disease, appears to have no clear dependence on any specific conditions. **Conclusions.** Based on the phytosanitary monitoring results of crops in the Eastern Forest-Steppe of Ukraine, the sunflower phytopathogen complex composition was determined. The prevalence degrees for Phomopsis blight, gray mold, dry rot, charcoal rot, and downy mildew as well as the development intensities of Phomopsis and gray mold were established. The co-incidence of the five most harmful sunflower diseases in the Eastern Forest-Steppe of Ukraine (dry rot, charcoal rot, gray mold, Phomopsis blight, downy mildew) was evaluated during the ten-year study period, depending on the weather conditions of a year.

Keywords: sunflower, diseases, pathogen complex, prevalence, intensity of development, epiphytoty.

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INTRODUCTION

Sunflower is the main raw material in the world for oil for food (OFF) in terms of production volume, and at present and in the near future it is one of the strategic crops of the country. The upward trend in the global seed production persists, and Ukraine remains the main country-producer of seeds as per FAO data. A dynamic increase in the acreage under sunflower is attributed to the high profitability of its production. Sunflower cultivation is one of the major sources of income for agricultural enterprises of different forms of ownership [1]. The analysis of sunflower cultivation in Ukraine indicates that its acreage grew threefold from 1990 to 2014 – from 1,636 to 5,257,000 hectares. Over this period, the production of sunflower seeds has grown sevenfold since 1994 – from 1,569,000 tons of seeds to the record value of 11,051,000 tons in 2013. During these 25 years, the yield was 0.89–2.17 tons per hectare [2]. Agrocenoses are transformed as a result of the concurrent impact of anthropogenic activity and weather conditions [3].

Due to the wide introduction of short crop rotations in production, which are more repaid than scientifically rationalized 9-field ones, and the narrowing assortment of cultivated crops, the general trends of changes in the phytopathogen complex composition of field crops have been revealed recently [4]. In Ukraine, crop rotations are focused on three major issues: cereals, oil crops and fodder crops. The simplification of crop rotations ignoring the traditionally established principles and regulations for crop rotating leads to the threatening spread of specialized weeds, pests and diseases, despite the increasing use of protective chemicals [5]. An enhancement in low pathogenic causative agents (polyphages), common to most cultivated crops [6], was recorded. There is an upward trend for charcoal rot – a disease that is adapted to affect any cultivated crop due to the drastic accumulation of long-lasting agents in soil [7].

The collection of information on the number and status of populations of harmful organisms to assess the phytosanitary condition of a field/a region is a primary measure in the integrated plant protection concept. This information serves as a basis to justify the application of chemicals, to determine the phytopathogen composition, as well as to assess the populations and their variability in multi-year observations [8, 9].

PURPOSE AND METHODS OF RESEARCH

The purpose of our research was to determine the phytopathogen complex of sunflower and its variability under the influence of hydrothermal conditions during the vegetative period as a factor that adapts to hybrids and, under favorable conditions, may limit the potential yield capacity to a large extent.

The phytosanitary monitoring of breeding crops of the scientific crop rotation of the Plant Production Institute named after V.Ya. Yuriev of NAAS in 2007–2016 determined the variability degrees for the most common sunflower diseases in the Left Bank Forest-Steppe of Ukraine, namely its eastern part. The prevalence of downy mildew was evaluated from a multi-year study of starting material in a disease nursery of the Laboratory of Plant Immunity against Diseases and pests of the Plant Production Institute n. a. V.Ya. Yuriev NAAS.

The diseases were assessed visually via direct examination of plants and via visual determination of the effect intensity by specific symptoms of each disease. To evaluate the development intensity of diseases, we examined calathidiums for gray mold, the middle part of stems for stem canker, and the bottom part of stems for charcoal rot. The plants with sporulation of the downy mildew pathogen were accounted in relation to the total number of affected plants.

Disease assessments included the prevalence or affection degree, percentages of affected plants [10], the disease development intensity, which was calculated from the affected surface area on plant organs [11]. To assess the disease intensity, a disease-specific eye scale was used [12]. Judging by the corresponding surface area of the affected tissue (organ), plants received a certain score. By the number of plants in each score, the weighted average area of the affected surface of an accession was calculated as a percentage [13].

To characterize the weather conditions during the vegetation period, the data of Kharkiv Regional Center of Hydrometeorology on air temperature and precipitation amount in 2007–2016 were used. The hydrothermal coefficient (HTC) is presented for the sunflower vegetation period and by the developmental phases [8].

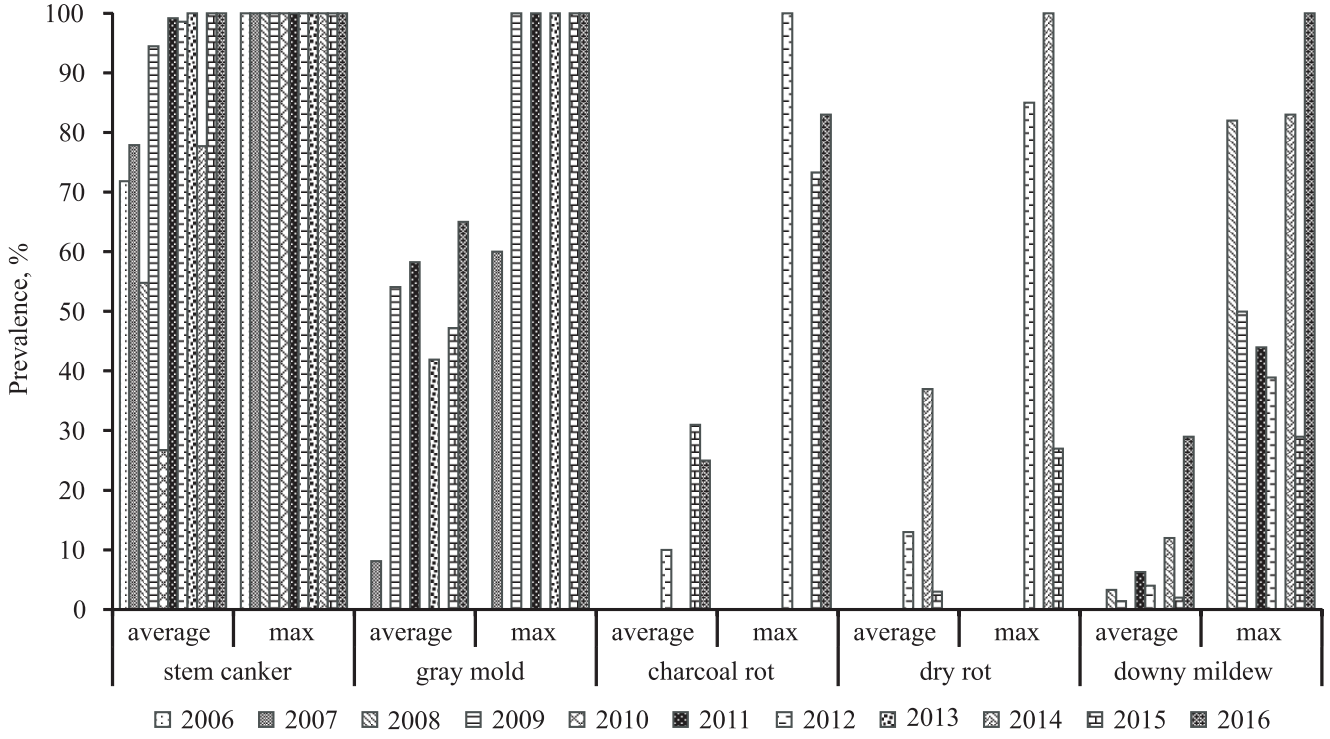
The data were statistically processed using Microsoft Excel; cluster analysis was performed with Statistics 6.1 software.

RESULTS

The pathogen complex composition, ratios of different pathogens, and intensities of their development were heterogeneous during the study years.

Phomopsis blight (also called stem canker) (*Phomopsis/Diaporthe helianthi* Munt.-Cvet. Et al.), gray mold (*Botrytis cinerea* Pers.), dry rot (*Rhizopus sp*.), charcoal rot (*Sclerotium bataticola* Taub), and downy mildew (*Plasmopara helianthi* Novot. f. *helianthi*) were the most common diseases on sunflower in the Left Bank Forest-Steppe of Ukraine in 2007–2016.

Investigating the dependence of the disease development on hydrothermal conditions, we observed the ambiguity in their manifestation. It is well-known that increased humidity contributes to the ingress of infection in plants and to pathogen development, while unfavorable conditions generally limit the development of fungal diseases. However, the cases of the intensive disease development during arid periods can be due to condensed moisture, for example, morning dew, which emerges from the difference in night and daytime temperatures. If this occurs, the disease development depends on the moisture time on the leaf surface, the high humidity period length after precipitation, features of plant architectonics, and the plant density, where a microclimate, which is favorable for fungal spore germination, is formed. The rise in



Dynamics of Variability in the Prevalence of the Major Sunflower Diseases in the Eastern Forest-Steppe of Ukraine, %

air humidity associated with moderate temperatures results in rapid distribution and development of gray mold on sunflower. If prolonged moistening of soil and air coincides with a phase of the plant development that is crucial for pathogen affection, the downy mildew pathogen spreads rapidly at the initial stages of the diffuse affection development. Regular, though short precipitation, the duration of which is sufficient for the pathogenic affection and preservation of aerogenic inoculum from drying out, is enough for secondary infection. Stem canker development reaches high levels even in a dry month, if the previous ones were optimal and waterlogged.

Downy mildew in the experimental plots of the disease nursery sown with non-dressed seeds ranged from 18.0 % to 83.0 % of affected plants in the years, when the first half of the sunflower vegetation period was cool and waterlogged: in 2008–2009, 2011–2012, and 2014–2015 (see Figure). The weather conditions in 2007–2016 were noticeable for significant variability and fluctuations in the hydrothermal coefficient (HTC) from 0.57 in 2009 to 1.1 in 2014. However, despite the overwhelming majority of years, which were characterized as arid by the HTC values, the peak prevalence of rots and stem canker amounted to 100.0 %. Therefore, to illustrate the year-by-year variability of diseases, we used the averages.

Only in 2008 and 2010, the disease prevalence was lower than that in the other years – 55.0 % and 27.0 %, respectively. These very years had higher average monthly air temperature during the sunflower vegetation period than the multi-year average values by 0.4 °C – 4.6 °C. In 2007 and 2014, the prevalence was 72.0–100.0 % of the affected plants. Such values are rated as an epiphytoty.

The wholescale outbreaks of gray mold on sunflower calathidiums were noted every second year during the period of 2007–2016, namely in 2007, 2009, 2011, 2013, and 2015–2016, with fluctuations from 8.0 % of the affected plants in 2007 to 58.0 % in 2011.

Due to oversaturation of crop rotations with sunflower, under hot conditions during the seed ripening, the epiphytotinous (maximum) level of charcoal rot was reported: 83.0 % of the affected plants in 2015 and 100.0 % in 2012. Concerning the averages, an upward tendency in the disease prevalence was observed: from mild degree (average = 10.0 % of the affected plants) in 2012 to severe degree (average = 65.0 %) in 2016.

The spread of charcoal rot was similar to that of dry rot. In 2012, the prevalence amounted to 85.0 %, reaching the maximum of 100.0 % in 2014. The weather conditions in 2015 were anomalous, as there was no rainfall for 3 months (August-October), when sun-

flower seeds ripened, which limited the average disease prevalence to 27.0 %. The prevalence of dry rot on sunflower calathidiums ranged within 3.0–37.0 % that year.

Since the development of stem canker is tightly linked to the hydrothermal conditions of a year, we think that it is most fully characterized by a qualitative index of damage – the disease development intensity, which is determined from the weighted average area of affected stem surface. In its turn, to describe this index, the analysis of the HTC is required not only for the entire vegetation period of sunflower, but also for each month of vegetation, which almost coincides with the developmental phase lengths of the crop. Thus, the optimal water availability (HTC = 1.0–1.5) for sunflower and favorable conditions for the plant infection or stem canker development were in June of 2007 and 2015. (HTC = 1.1–1.2), May and September of 2010 (HTC = 1.33 and 1.45, respectively), July of 2013 and 2016 (HTC = 1.2–1.34), August of 2012 (HTC = 1.3), and September of 2007 (see Table).

The moisture level in May of 2016 (HTC = 3.14), June of 2011 and 2014, July of 2011 and 2015 (HTC = = 1.6–1.8) was excessive (HTC > 1.5).

Over the ten-year period, the low average weighted values of the disease development intensity (2.0–5.0 %) and peak ones (21.0–31.0 %) were recorded in arid August of 2008 and 2010. In the other years, as the HTC in May increased, the average and peak values of the disease intensity grew from 13.0 % and 50.0 % to 33.0 % and 80.0 %, respectively. The peak values in most years (7 of 10) indicate significant levels of disease development intensity.

Gray mold was not widespread, as the arid weather conditions of the beginning of autumn in 2008, 2010, 2012, and 2014 restricted the disease development and its symptoms were only found on a few plants. The comparison of the average and maximum values of the disease development intensity in 5 years showed significant fluctuations from 6.0 % to 32.0 % of the affected calathidium area, respectively, and from 43.0 % to 100.0 %, respectively.

Thus, high degrees of gray mold manifestation on sunflower calathidiums of 43.0–100.0 % were noted every second year in 6 of 10 years.

Conjugate frequencies of occurrence of the five most damaging sunflower diseases (dry rot, charcoal rot, gray mold, stem canker, downy mildew) were established during the ten-year research (2007–2016). Cluster analysis grouped the diseases in two core clusters.

According to the paired incidence of diseases, depending on the weather, dry and charcoal rots, which occurred in arid conditions, were incorporated in clus-

Monthly Fluctuations in the HTC during the Sunflower Vegetation Period

Year	Month / phase of the vegetation period					Average HTC over the vegetation period of sunflower
	May “sowing – leaf formation”	June “calathidium formation”	July “anthesis – seed setting”	August “seed filling”	September “physiological – technical ripeness of seeds”	
2007	0.7	1.2	0.5	0.5	1.3	0.9
2008	0.9	0.7	0.7	0.4	0.9	0.7
2009	0.8	0.7	0.8	0.2	0.5	0.6
2010	0.8	0.3	0.8	0.2	2.5	0.9
2011	0.5	1.9	1.8	0.2	0.3	0.9
2012	0.8	0.5	0.2	1.3	0.2	0.6
2013	0.6	0.6	1.2	0.8	3.3	1.3
2014	0.9	2.5	0.6	0.8	0.9	1.1
2015	0.7	1.1	1.6	0.0	0.0	0.8
2016	3.14	0.89	1.34	0.93	0.33	1.33
Average multi-year HTC	0.99	1.02	0.96	0.88	0.97	1.00

Note. HTC ranking: < 0.5 – low (drought); 0.5–0.9 – insufficient (unstable); 1.0–1.5 – optimal; > 1.5 – excessive.

ter I; downy mildew and gray mold, which were associated with high wetness during a certain period of sunflower development formed cluster II. The Euclidean distance separates stem canker from the other diseases, as it occurs annually and, therefore, does not appear to clearly depend on any particular conditions.

CONCLUSIONS

Thus, the results of the phytosanitary monitoring of crops in the Left Bank Forest-Steppe of Ukraine determined the composition of the phytopathogen complex of sunflower. The prevalence of stem canker, gray mold, dry and charcoal rots, and downy mildew was evaluated. The development intensities of stem canker and gray mold were established. Establishing the conjugate frequencies of the five most damaging diseases of sunflower in the Eastern Forest-Steppe of Ukraine (dry rot, charcoal rot, gray mold, stem canker, downy mildew) during the 10-year-long research, depending on the weather conditions, we incorporated dry and charcoal rots, which occurred in arid conditions, in cluster I, while downy mildew and gray mold, which are associated with high wetness during a certain period of sunflower development, were included in cluster II. The Euclidean distance separates stem canker from the other diseases, as it occurs annually and, therefore, does not appear to clearly depend on any particular conditions.

Зональний патокомплекс соняшнику Лівобережного Лісостепу України

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Мета. Визначення фітопатогенного комплексу соняшнику і його внутрішньовидової мінливості під впливом погодних умов вегетаційного періоду культури. **Методи.** В ході фітосанітарного моніторингу селекційних посівів наукової сівозміни Інституту рослинництва ім. В. Я. Юр'єва НААН в 2007–2016 рр. оцінено ступінь поширеності, інтенсивність розвитку, мінливості хвороб соняшнику в умовах Лівобережного Лісостепу України. Гідротермічний коефіцієнт (ГТК) представлений за вегетаційний період соняшнику і за фазами розвитку культури. **Результати.** При визначенні частоти прояву п'яти найбільш поширених і шкідливих хвороб соняшнику в умовах східної частини Лісостепу України в 2007–2016 рр. в залежності від погодних умов року, виявлено, що в посушливих умовах сполученим проявом характеризувалися суха (*Rhizopus* sp.) і вугільна (*Sclerotium bataticola* Taub) гнилі, за високого рівня вологозабезпеченості в певний період розвитку соняшнику – несправжня борошниста роса і сіра гниль (*Botrytis cinerea* Pers.). Фомопсис (*Phomopsis/Diaporthe helianthi* Munt. – Cvet. et al.), який проявляється щорічно, на відміну від інших хвороб не має чіткої залежності від будь-яких певних погодних умов. **Висновки.** За результатами фітосанітарного моніторингу посівів в умовах Лівобережного Лісостепу України визначено склад фітопатогенного комплексу соняшнику. Встановлено ступінь поширеності фомопсису, сірої, сухої, вугільної гнилей, несправжньої борошнистої роси і інтенсивності розвитку фомопсису та сірої гнилі. Визначено сполучену частоту їх прояву за період десятирічних досліджень в залежності від погодних умов року.

Ключові слова: соняшник, хвороби, патогенний комплекс, поширеність, інтенсивність розвитку, епіфітотія

Зональный патокомплекс подсолнечника Левобережной Лесостепи Украины

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Цель. Определение фитопатогенного комплекса подсолнечника и его внутривидовой изменчивости под влиянием погодных условий вегетационного периода культуры. **Методы.** В ходе фитосанитарного мониторинга селекционных посевов научного севооборота Института растениеводства им. В. Я. Юрьева НААН в 2007–2016 гг. определены степень распространенности, интенсивность развития, изменчивости болезней подсолнечника в условиях Левобережной Лесостепи Украины. Гидротермический коэффициент (ГТК) представлен за вегетационный период подсолнечника и по фазам развития культуры. **Результаты.** При определении частоты проявления пяти наиболее распространенных и вредоносных болезней подсолнечника в условиях восточной части Лесостепи Украины в 2007–2016 гг. в зависимости от погодных условий года, выявлено, что в засушливых условиях сопряженной проявляемостью характеризовались сухая (*Rhizopus* sp.) и угольная (*Sclerotium bataticola* Taub) гнили, при высоком уровне влагообеспеченности в определенный период развития подсолнечника – ложная мучнистая роса (*Plasmopara helianthi* Novot. *f. helianthi*) и серая гниль (*Botrytis cinerea* Pers.). Фомопсис (*Phomopsis/Diaporthe helianthi* Munt. – Cvet. et al.), как ежегодно проявляющийся, в отличие от остальных болезней, не имеет четкой зависимости от каких-либо определенных погодных условий. **Выводы.** По результатам фитосанитарного мониторинга посевов в условиях восточной части

Лесостепи Украины определен состав фитопатогенных комплекса подсолнечника. Установлена степень распространенности фомопсиса, серой, сухой, угольной гнилей, ложной мучнистой росы и интенсивности развития фомопсиса и серой гнили. Определена сопряженная частота их проявления за период десятилетних исследований в зависимости от погодных условий года.

Ключевые слова: подсолнечник, болезни, патогенный комплекс, распространенность, интенсивность развития, эпифитотия

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