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FORECASTING THE PHYTOSANITARY STATE OF AGROCENOSSES: INNOVATION DEVELOPMENTS

Goal. Development and implementation of new theories, methods, technologies and models that would allow more reliable forecasting of the development of pests and pathogens of agricultural crops. **Methods.** Analysis of innovative development of the Institute of Plant Protection of the National Academy of Agrarian Sciences of Ukraine and other institutions of the Scientific and Methodological Center «Protection of Plants» for 2001—2020. Isolation of those relating to the problem forecasting the development of pests and pathogens of plant diseases in agrocenoses of Ukraine. **Results.** The concept of formation of the phytopsanitary state of crops and plantations under the conditions of climate change has been developed. The theory of the dynamics of the number of locusts and the prediction of emergency situations in the agricultural sphere of Ukraine has been developed. The widespread use of pheromone traps for diagnosing the phytopsanitary state of agrocenoses of Ukraine is recommended. The cyclicity of outbreaks of mass reproduction of the *Anisoplia austriaca* beetle and the European corn borer was established, depending on the amount of solar activity. The possibility of applying GIS-technologies for the analysis of long-term data was studied. Predictive computer programs (models) of harvest shortages of rapeseed, sunflower, corn, sugar beet, and winter wheat from a complex of pests have been developed. An algorithm for the application of information technology programs for the analysis of multi-year dynamics of the phytopsanitary state of agrocenoses has been developed. The role of the developed computer model of the development of leaf spots of grain crops in determining the moment for the most effective application of fungicides has been established. Methods of forecasting the development of pathogens of grape diseases in the South of Ukraine have been developed. A system of forecasting the phytopsanitary state of agrocenoses of Ukraine in the conditions of the year and planning the implementation of protective measures has been developed. **Conclusions.** Innovative developments of the Scientific and Methodological Center «Plant Protection» make it possible to solve the following issues at a modern level:

forecasting changes in the agrosphere based on the analysis of a long-term database of hydrothermal conditions and indicators of the phytosanitary state of agrocenoses; prevention of emergency situations in the agricultural sector on the basis of a modern monitoring system using GPS-navigation and the development of regulations for carrying out protective measures; forecasting the development of dangerous pests and diseases of agricultural crops; forecasting crop failures and determining the economic feasibility of chemical plant protection; forecasting the appearance and spread of quarantine pests.

crops; agricultural sphere; agrocenoses; pests; pathogens; system of monitoring; forecasting; GPS-navigation; computer programs; plant protection

Climate change, which in recent decades has been manifested in Ukraine due to the equalization of the temperature field, the increase in the average annual temperature and the increase in the sum of the effective temperatures, leads to a change in the length of the seasons, optimizes the characteristics of the ecological factors of the environment for insects, promotes their reproduction and spread. At the same time, the ecological optimum of various types of harmful plant organisms is changing, the optimum zones for them are spreading to the north, due to which the pest population density is increasing [1–4]. As a result of the aggravation of the phytosanitary condition of agrocenoses, almost a third, and sometimes even a half, of agricultural crops are not harvested [5, 6].

One of the important reserves for obtaining additional crops is the protection of plants from harmful organisms. Forecasting is the basis for planning and carrying out protective measures, determining the need for chemical agents, as well as material and labour costs. But traditional methods and ways of forecasting the phytosanitary state of agrocenoses are still imperfect.

Goal of the work was to develop and implement new theories, methods, technologies and models that would allow more reliable forecasting of the development of pests and pathogens of agricultural crops.

Research methodology. The materials for the research were innovative developments of the Institute of Plant Protection of the National Academy of Agrarian Sciences of Ukraine and other institutions of the Scientific and Methodological Centre «Plant Protection» for 2001–2020. From them, those directly related to the issues of forecasting the development of pests and pathogens of plants in agrocenoses of Ukraine were highlighted.

Research results. Scientists of the Institute of Plant Protection, V.M. Remeslo Myronivka Institute of Wheat, Poltava State Agricultural Research Station named M.I. Vavilov, Magarach National Institute for Vine and Wine, Transcarpathian State Agricultural Research Station and Subcarpathian State Agricultural Research Station of the Institute of Ag-

riculture in the Carpathian Region NAAS have created 25 innovations in the field of forecasting the phytosanitary state of agrocenoses of field crops, orchards and grapes.

The concept of formation of the phytosanitary state of crops and plantations under the conditions of climate change has been developed. It is based on the analysis of a long-term database of hydrothermal conditions, indicators of the entomological and phytopathological state of agricultural crops and forecasting possible changes in the agrosphere. According to the results of numerous analyses, a significant increase in the average annual temperature, an increase in the sum of effective temperatures, and an equalization of the temperature field have been observed in recent decades in the conditions of Ukraine. At the same time, the annual amount of precipitation changed little, but began to increase.

The theory of the dynamics of the number of locusts and the prediction of emergency situations in the agricultural sphere of Ukraine has been developed. Thus, a modern locust monitoring system using GPS-navigation and the regulation of anti-locust measures have been conceptually substantiated. GPS allows to determine with great accuracy the geographical coordinates of foci of increased number of locusts and to create a database on the ecological characteristics of the stations (composition of phytocenosis, physical and chemical properties of the soil, nature of the terrain), which further contributes to reducing labour costs for monitoring by 5 times, increasing the reliability of control population dynamics of this group of pests and, at the same time, avoiding outbreaks of their mass reproduction [7, 8].

Much has been done in terms of improving the methods of diagnosing the phytosanitary state of agrocenoses of Ukraine using the latest technologies. Thus, in modern systems of integrated plant protection, the wide use of pheromone traps is recommended [9, 10]. For this, in the first half of May, attractive traps with the pheromone of lepidopteran pests are placed on the crops of sugar beet, winter wheat, corn, soybean, and on the plantings of vegetable crops and potatoes. With their help, it is possible to establish the start and duration of the flight of the turnip moth *Agrotis segetum* Schiff., the European corn borer *Pyrausta nubilalis* Hb., and in the south of Ukraine, the potato tuber moth *Phthorimaea operculella* Zell. Compared to the use of troughs with noisy molasses, the labor productivity of the accountants increases 10 times due to the increase in the daily rate of accounting to 250 hectares, as well as selective catching of certain types of butterflies. The obtained reliable information regarding the dynamics of the development of the turnip moth and the European corn borer allows timely planning of effective measures to protect cultivated crops. The data on the detection of the potato tuber moth is the basis for signaling the implementation of quarantine measures.

The use of pheromone traps has improved the methods of monitoring

and forecasting the development of pests of corn and soybeans in various subzones of the Left Bank Forest-Steppe of Ukraine, as well as in Transcarpathia, and apple glaze in the orchards of the Autonomous Republic of Crimea. The established long-term database on pests of corn and soybean can be the basis for work on operational signaling and forecasting of the entomological state of agrocenoses. The developed program for determining the expediency of using plant protection means can be used in practice. At the same time, a high level of reliability was noted in the determination of corn and soybean crop shortages, deviation from real indicators — within 7.5–11%.

The system of pheromone monitoring of the main lepidopteran pests of apple plantations of the Forest-Steppe of Ukraine under the conditions of climate change, which is presented in the developed and issued recommendations, is substantiated [11, 12]. The mathematical model (program) «Economic expediency of the use of protective means on apple trees» has been developed. Its use in practice allows you to save 10–15% of the harvest and reduce environmental pollution.

The cyclicity of outbreaks of mass reproduction of the *Anisoplia austriaca* beetle and the European corn borer was established, depending on the amount of solar activity. Algorithms for assessing the state of populations and the degree of threat to agricultural crops from larvae and adults of bread beetles have been developed, based on systematic records and calculations, and the methods of multi-year and long-term forecasting of these pests have been improved.

The possibility of applying GIS-technologies for the analysis of long-term data was studied. For this purpose, an electronic database of ten-year monitoring of harmful insects (eurygaster bug, May beetle *Melolontha melolontha* L., turnip moth) in agrocenoses was created, a database of indicators on the influence of abiotic factors (air temperature, rainfall) on the development of these pests was analyzed, electronic maps were created that reflect territorial zonal features of Ukraine, ecological specificity of regions (combination of long-term information of phytosanitary diagnostics with hydrothermal regime).

Predictive computer programs (models) of crop failures of rape due to a complex of dominant pests and sunflower due to a complex of pests have been developed, which are based on mathematical equations that take into account the number of pests, their economic threshold of harm and the complex economic threshold of harm for each entomological complex.

The interactive program «Plant Protection» includes a package of computer programs for determining crop shortages of rapeseed, sunflower, corn, sugar beet, and winter wheat from a complex of pests. It is a table in which information is entered on the number of certain pests according to seasonal complexes, crop losses due to them are automatically calculated and the

economic feasibility of using protective means is determined. The computer program allows in real time to transform operational environmental information about the current phytosanitary status into economic categories — possible crop shortages (in physical or monetary terms) and to determine the economic feasibility of chemical plant protection.

An algorithm for the application of information technology programs has been developed for the analysis of multi-year dynamics of the phytosanitary state of agrocenoses, the components of which are: 1) transformation of the information base of multi-year indicators of the number and distribution of pests into a multi-year electronic database; 2) transformation of the information base of long-term indicators into its cartographic display using computer programs; 3) consistent analysis of the dynamics of the number and distribution of pests in order to create a forecast of the phytosanitary state of agrocenoses and avoid epiphytotic situations.

The computer model of the development of leaf spotting of grain crops is based on the use of the temperature sensitivity function of pathogens (*Septoria tritici*, *Puccinia recondita*, *Erysiphe graminis*, *Puccinia triticina*) for the minimum and optimal value of the duration of leaf surface moistening, the calculation of the transition point of the development of a particular disease in the zone exponential growth. Thus, the moment for the most effective application of fungicides is determined.

Methods of forecasting the development of pathogens of grape diseases in the South of Ukraine have been developed. Thus, it is necessary to take into account the mycoflora of the bunches affected by the desiccation of grape ridges, the vulnerability of varieties to this disease and the effectiveness of treatments of grape plantations in the phases of berry growth, the beginning of ripening and ripening against other diseases with approved fungicides. Forecasts of the development of mildew and oidium turned out to be adapted for different regions of viticulture in the named zone. It is advisable to use a computer database on long-term meteorological conditions of the Black Sea Lowland and a database on the development and degree of spread of these diseases in grape plantations, on the basis of which to develop seasonal and short-term forecasts.

The system of monitoring and forecasting the development of harmful organisms on oilseed cruciferous crops (winter and spring rape, white, gray and black mustard, red mustard) is based on the analysis of data on the presence of a complex of pests and pathogens by crops, the application of improved methods of diagnosis and forecasting of the phytosanitary state of agrocenoses and forecasting possible harvest shortages. Thus, the use of this development in practice allowed the scientists of the Subcarpathian State Agricultural Research Station of the Institute of Agriculture in the Carpathian Region NAAS to form a reliable forecast of the phytosanitary state of oilseed cruciferous crops.

The Institute of Plant Protection of the NAAS has developed a system for forecasting the phytosanitary state of agrocenoses of Ukraine in terms of the year and planning protective measures, which includes: 1) analysis of agroclimatic indicators: temperature, humidity, precipitation, hydrothermal coefficient, sum of effective temperatures; 2) analysis of indicators of the state of harmful organisms: number, distribution, degree of damage to plants; 3) weekly operational information on the phytosanitary state of agrocenoses of Ukraine; 4) recommendations on the expediency of using protective equipment; 5) forecast of the development of harmful organisms for the next year. At the same time, it is possible to adjust the system of protection of agricultural crops, optimize the terms of application of chemical agents, save 10—50% of the harvest, improve its quality, and to a large extent keep the environment clean [13—15].

Issues related to forecasting the phytosanitary state of agrocenoses are extremely important for the activities of the Quarantine Service of Ukraine. Thus, prognostic models of the spread of harmful and regulated organisms in the western region of the country have been developed. Their component is the establishment of the boundaries of the free zone, which is based on the real absence of a harmful organism in this zone. In the case of organisms of limited distribution, to which the studied ones belong, the free zone can be an uninfected part of the country in which there is a limited infected zone. At the same time, the most typical symptoms of damage to host plants by the studied organisms are taken into account. Timely and qualitative forecasts of the appearance and spread of quarantine pests allow to significantly reduce the costs of combating them and increase the yield of agricultural crops.

CONCLUSIONS

Innovative developments of the Scientific and Methodological Center «Plant Protection» make it possible to solve the following issues at a modern level:

- forecasting changes in the agrosphere based on the analysis of a long-term database of hydrothermal conditions and indicators of the phytosanitary state of agrocenoses;
- prevention of emergency situations in the agricultural sector on the basis of a modern monitoring system using GPS-navigation and the development of regulations for carrying out protective measures;
- forecasting the development of dangerous pests and diseases of agricultural crops; forecasting crop failures and determining the economic feasibility of chemical plant protection;
- forecasting the appearance and spread of quarantine pests.

Innovations in the field of forecasting the phytosanitary state of agrocenoses can be widely used by the protection and quarantine departments

of the Department of Phytosanitary Safety, control in the field of seed production and seedlings of the State Service of Ukraine on Food Safety and Consumer Protection, as well as by institutions of an agrarian profile to effectively solve scientific, practical, economic and environmental problems.

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Прогнозування фітосанітарного стану агроценозів: інноваційні розробки

Мета. Розробка та впровадження оновлених теорій, методик, тех-
нологічних засобів та моделей, які б сприяли більш достовірному прог-
нозуванню розвитку шкідників та збудників хвороб сільськогосподар-
ських культур. **Методика.** Аналіз інновацій, створених Інститутом за-
хисту рослин Національної академії аграрних наук України та іншими

установами Науково-методичного центру «Захист рослин» за 2001—2020 рр. Відбір тих, що висвітлюють питання стосовно прогнозування ентомологічного й фітопатологічного стану агроценозів. **Результати.** Розроблено концепцію формування фітосанітарного стану посівів і насаджень за умов зміни клімату. Розроблено теоретичні основи щодо визначення динаміки розвитку саранових та попередження критичних ситуацій в агросфері. Рекомендовано широке застосування феромонних пасток для діагностики фітосанітарного стану агроценозів України. Встановлено циклічність масових розмножень хлібного жука-кузьки, кукурудзяного метелика, пов'язану з величиною сонячної активності. Вивчено можливість застосування ГІС-технологій для аналізу багаторічних даних. Розроблено прогностичні комп'ютерні програми (моделі), які дозволяють визначити недобори врожаїв ріпаку, соняшнику, кукурудзи, буряків цукрових, пшениці озимої від комплексу шкідників. Виявлено можливості аналізувати багаторічну динаміку фітосанітарного стану агроценозів за допомогою розробленого алгоритму застосування програм інформаційних технологій. Встановлено роль розробленої комп'ютерної моделі розвитку плямистостей листя зернових культур у визначенні оптимального моменту для ефективного застосування хімічних засобів захисту. Розроблено методики щодо прогнозування фітопатологічного стану виноградників на Півдні України. Розроблено методичні підходи щодо складання прогнозу фітосанітарного стану агроценозів в умовах року та планування заходів щодо захисту рослин. **Висновки.** Інноваційні розробки Науково-методичного центру «Захист рослин» дають підстави достовірного вирішення таких питань: прогнозування змін в агросфері на основі аналітичних матеріалів із багаторічної бази даних гідротермічних умов та інформації щодо фітосанітарного стану агроценозів; упередження критичних ситуацій в агросфері за використання сучасної системи моніторингу та розроблення регламенту проведення захисних заходів; прогнозування ентомологічного та фітопатологічного стану агроценозів; прогнозування величини недобору врожаю та економічне обґрунтування хімічного захисту рослин; прогнозування розвитку карантинних шкідників.

сільськогосподарські культури; агросфера; агроценоз; шкідники; збудники хвороб; система моніторингу; прогнозування; GPS-навігація; комп'ютерні програми; захист рослин

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