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OVERVIEW OF INNOVATIVE DEVELOPMENTS ON THE SCIENTIFIC SUPPORT OF PLANT SELECTION FOR RESISTANCE TO DISEASES AND PESTS

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The Institute of Plant Protection of NAAS developed methods of plant selection for resistance to major pathogens and assessment methodology the resistance of winter wheat, potatoes, clover and alfalfa to pests to create complex resistant varieties. Donors of potato resistance to cancer, Alternaria spot, Phomosis and cyst-forming nematodes were identified. Methods for determining the resistance of cereals to high and low temperatures were developed. A collection of the Aegilops biuncialis L. wild wheat samples as sources of new resistance genes to plant diseases and pests was compiled. The soft winter wheat resistance genes to diseases by DNA markers were identified at the Institute of Plant Production named after V. Ya. Yuriev. The V. M. Remeslo Myronivka Institute of Wheat formed a set of winter wheat cultivars with group and complex resistance to diseases and pests. The Institute of Oilseed Crops of NAAS established physiological and biochemical mechanisms of resistance of sunflower, soybean, crown flax to pathogens. Collections of sunflower lines based on complex resistance to sunflower broomrape, dry rot, downy mildew and soybean lines based on complex resistance to white rot and Anthracnose were also created. In the National Scientific Center "Institute of Agriculture of NAAS", the fodder lupine resistance to the most important pathogens was investigated. The Institute of Agriculture in the Carpathian Region of NAAS revealed the spring barley, oat, rape, fiber flax varieties and selection numbers resistant to basic diseases; and the Institute of Rice of NAAS – rice cultivars resistant to diseases and pest pathogens. The resistance to main phytophagous insects of the modern genotypes of hemp, fiber flax and crown flax was assessed by the Institute of Agriculture of the North-East of NAAS. The assessment method of breeding value for the initial material of the main vegetables on the basis of disease resistance was developed by the Institute of Vegetables and Melons Growing of NAAS. Scientists of the Institute of Agroecology and Environmental Management of NAAS and V. M. Remeslo Myronivka Institute of Wheat of NAAS revealed the cucumber and barley resistance to viral diseases.

Key words: *crops, pests, pathogens, resistance, resistance gene, resistance source.*

Introduction. Crop yields are 2–3 times lower in Ukraine than in developed countries. The urgency of this problem is due to non-compliance by producers of cultivation technologies, as a consequence – the genetic potential of the main varieties and hybrids is used on average only 30 %. In view of this, one of the important elements of the crop cultivation technology is the timely implementation of protective measures against pests, diseases and weeds [1].

Over the last 25–30 years, the forms of agriculture and crop cultivation technology have changed considerably. The 8 and 10-field crop rotations were replaced by 3–4-field crop rotations. It halved the crop rotation period. Growing vegetable and potato has moved to the private sector, where compliance with the necessary crop rotation and distance separation has become impossible [2].

The integrated plant protection system takes on particular importance in such circumstances. The use of damage-resistant varieties and hybrids, considering the pests and diseases as well as the level of plant resistance is the most cost-effective and environmentally friendly in this protection system. Thus, for highly resistant varieties, the reproduction of pests and the spread of pathogens can be restrained even under conducive conditions to their development. Medium-resistant varieties can resist only with a low and medium degree of pests reproduction. At mass emergence of pests or epiphytic development of diseases it is necessary to apply in addition means of protection, but pesticide dozes and treatment quantity can be reduced [3]. Due to the use of resistant varieties of winter wheat, it is possible to simplify the technology of growing crops, reduce the use of pesticides by 30-35 %, increase yields by 0.4-0.5 t/ha and gross grain harvest by 2 .5–3.0 million tons annually even from 50 % acreage.

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Cost savings on pesticides from the Colorado potato beetle on potatoes under such conditions can reach 50 million UAH per year [4].

The number of crop varieties resistant to pests is still quite small, despite the significant achievements of modern selection. In addition, the strategy of breeding such varieties has many weaknesses. One of the reasons for this is the unavailability of comprehensive databases of innovative developments on scientific support of the selection process.

The purpose of the research is to create innovation databases for scientific support of selection on crops resistance to pathogens and pests, and to increase the efficiency of work for creating resistant varieties due to using these databases.

Materials and Methods. The 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 Center Plant Protection for 2006-2020 were the material for the study. Among them, those that directly relate to the problem of resistance of crops to pests and pathogens deserved attention. Innovative developments were analysed to determine their role in the selection process.

Results. The Institute of Plant Protection and other institutions of NAAS focused on innovative developments in plant protection according to the research program "Plant Protection". In the course of the work performed during 2006–2020, a database of innovative developments in plant protection in Ukraine was formed. The database includes more than 400 developments; the number of directly related to the scientific support of crop selection for resistance to diseases and pests exceeds 50.

The Institute of Plant Protection of NAAS developed methods of plant selection for resistance to major pathogens, considering the existing database of species and racial composition of major pathogens of wheat, barley, rape, mustard, tomatoes in different soil and climatic zones of Ukraine, virulence gene database of the main pathogens and known genes of crop resistance, and method of creation and application of complex artificial infectious backgrounds for selection of wheat on group resistance. Databases of effective resistance genes of wheat to the local population of brown rust pathogen, sources of resistance for winter and spring wheat to brown rust, septoria, and powdery mildew, head smut, for spring barley – to powdery mildew, head and loose smut were created and transferred to the National Center of Plant Genetic Resources of Ukraine. The use of available databases will create a gene pool of resistant plant forms, reduce the cost of finding sources of resistance by 40 % and quickly involve in the selection process the most effective resistance genes, as well as identify ineffective resistance genes and get rid of them.

The juvenile resistance of perspective lines of winter wheat selection to pathogens of brown rust, powdery mildew, septoria, and eyespot was investigated. We have numerous databases of: 1) sources of wheat resistance to local populations of brown rust, powdery mildew and septoria pathogens in the Northern Forest Steppe zone of Ukraine; 2) soft winter wheat varieties of Ukrainian selection by allelic state of resistance genes to fungal pathogens; 3) effective resistance genes of wheat to brown rust pathogen; 4) the racial composition of brown rust population of wheat; virulence genes of brown rust pathogen of wheat. Recommendations for identifying resistance sources of wheat to local populations of brown rust, powdery mildew and septoria in the Northern Forest Steppe of Ukraine and characteristics of the epidemiological status of the brown rust pathogen population (genetic structure and variability) were developed [5, 6].

Much attention is paid to the potatoes resistance to nematode diseases – nematodosis. For this purpose, about 1668 cultivars of 6 breeding institutions of Ukraine were tested in 2011–2016. The 1348 were resistant to golden potato cyst nematodes (*Globodera rostochiensis* Woll.) [7]. Of the 22 cultivars, 17 cultivars showed resistance to this disease in the field (state) trials. It was found 1 resistant (Povin) and 17 relatively resistant varieties to potato rot nematode (pathogen – *Ditylenchus destructor* Thorne).

A methodology to create the complex resistant varieties by using crop resistance to pests was developed. Its components are field assessment of the resistance of breeding material and varieties of winter wheat, potato, clover and alfalfa to main pests; availability of winter wheat cultivars with group resistance to pests, and resistant potato cultivars and hybrids to

Colorado potato beetle and wireworms, the availability of clover cultivars with different level of resistance to clover seed weevils and tarnished plant bugs, and domestic and foreign selection varieties of lucerne resistant to the main pests of generative organs. A valuable advance is the database of field assessment of the resistance of winter wheat cultivars to the main pests – sunn pest, wheat thrips, aphid, frit fly, cereal leaf beetle, cereal chafer, and sawfly. Purposeful selection of wheat is of great importance: 1) resistance to shattering – resistance to cereal leaf beetle and cereal chafer; 2) resistance to lodging – resistance to wheat stem sawflies. The multi-authored monographs "Methodology for assessing the resistance of wheat varieties to pests and pathogens" (2010) and "Methodology for assessing potato cultivars for resistance to major pests and pathogens" (2013) were prepared and published according to the results of joint research with the V. M. Remeslo Myronivka Institute of Wheat and the Institute of Potato Growing of NAAS.

Thus, a collection of samples of wild relative of wheat (*Aegilops biuncilais* L) was created, which are sources of new genes for plant resistance to diseases and pests. The directions of breeding programs for optimized use of the soft wheat gene pool resistant to pathogens and pests are developed: 1) molecular genetic marking the characteristic collection of the gene pool represented by donor varieties and resistance sources to pathogens; 2) the availability of genetic diversity at the reserve proteins loci of wheat varieties from world collection, identified resistance genes to pathogens of various diseases; 3) replenishment of the information database of the gene pool of domestic wheat varieties with genetic formulas of 90 newly created varieties by reserve proteins loci. There is also information on genotypes for molecular markers of potato resistance genes to the golden potato cyst nematode. All this makes it possible to increase the efficiency of plant breeding for resistance to pests and diseases by 60 %.

Scientists of the Ukrainian Research Station of Plant Quarantine of the Institute of Plant Protection of NAAS developed effective laboratory and field methods for assessing the resistance of potato breeding material to Alternaria spot and Phomosis. Resistant varieties of potatoes of domestic selection to Alternariosis (Skarbnytsia, Fantaziia, Luhivska, Slovianka, Yavir) and relatively resistant to Phomosis (Bernina, Madison, Myroslava, Solita) were found.

A system of rehabilitation of potato plants was also developed, and bank of varieties-differentiators of potato cancer pathotypes and species and races of cyst-forming nematodes was created. Resistance donors to the potato cancer (Bozhedar, Santarka, Shchedryk, Slovianka, Zabava, Serpanok, Bazis, Fantazia, Chervona Ruta varieties), and to nematodes (Slovianka, Vodogray, Partner, Chervona Ruta varieties) were identified.

Inheritance of potato resistance to cancer can be detected by PCR DNA analysis. Thus, PCR diagnostics of cancer DNA in real time allows: 1) to detect and quantify the potato cancer DNA in susceptible potato samples; 2) to determine the relative fluorescence from 25 to 350; 3) to identify the disease agent of cancer in the early stages of the disease. It is possible to obtain real results about the presence or absence of cancer DNA in the test samples for a short period of time, and determine the inheritance features of potato resistance to cancer for 2 days. Methodical recommendations for determining the resistance of cereals to high and low temperatures (information on optimal temperatures and incubation period, frost resistance of winter barley and wheat, heat resistance of barley, determination methods for the leakage of electrolytes) were published. It is indicated that the use of the Reglalg biologic for pre-sowing seed treatment and subsequent treatment of plants during the growing season increases the level of plant resistance to the negative abiotic factors and fungal pathogens, and the yields.

During 2016–2020, scientists of the V. M. Remeslo Myronivka Institute of Wheat of NAAS isolated stable samples among 203 collection numbers of winter wheat on separate artificial infectious backgrounds of pathogens, group resistance to diseases was revealed among 86 numbers of Myronivka Institute selection, 164 samples were identified for resistance to major pathogens among varieties of different breeding centers of Ukraine, pathogens of 2239 lines of initial selection units on artificial infectious backgrounds were investigated, and stable lines was specified. The winter wheat varieties with group and complex resistance to diseases

and pests were selected. In particular, 220 constant disease-resistant lines of the breeding nursery of the Plant Protection Department were transferred to the Laboratory of Winter Wheat Selection for further research, and 20 lines - to the National Center for Plant Genetic Resources of Ukraine.

The Institute of Oilseeds of NAAS established the physiological and biochemical mechanisms of sunflower, soybean, oil flax resistance to pathogens of major diseases. Scientifically substantiated bases on development of sunflower varieties and hybrids with complex resistance to broomrape and false mildew are a fundamentally new assessment method of sunflower resistance to broomrape in laboratory conditions, analysis of immunological variability of collection, and selection of cultivars with traits of complex resistance to false mildew and broomrape, detection of aggressive races of broomrape, application of modernized infectious artificial background to the main pathogens. It was created the collections of sunflower lines on the basis of complex resistance to broomrape, dry rot, false mildew, and of soybean lines on the basis of complex resistance to white rot and anthracnose. Methodical recommendations for the creation of effective methods for the selection of sunflower and soybean lines with a high resistance to a complex of major diseases were developed.

The Institute of Plant Production named after V. Ya. Yuriev identified resistance genes of soft winter wheat to diseases by DNA markers. Thus, 10 culture samples were identified by the IB-267 marker for the brown rust resistance gene Lr26, wheat-rye translocations (1RS of rye chromosome) were detected for 9 wheat samples, and a catalog of genetic value of soft winter wheat varieties with identified DNA – markers was formed. All this is necessary for use in breeding work.

The National Research Center Institute of Agriculture of NAAS studied the fodder lupine and soybean resistance to the main pathogens. The gene pool of resistant forms was created by assessing the damage of collection samples and breeding material on infectious backgrounds. The breeding numbers of lupine resistant to Fusarium wilt and bean yellow mosaic virus and sources of soybean resistance to diseases complex (bacteriosis, virosis, mycoses) were revealed, racial composition of major pathogens was detected.

The Institute of Agriculture in the Carpathian region of NAAS identified sources of crop resistance to major diseases, namely: 1) the most resistant varieties of potatoes to pathogens of late blight and dry rot; 2) the most resistant varieties of fiber flax to anthracnose, fusarium wilt and fusarium browning; 3) breeding numbers of oats with increased resistance to crown rust and helminthosporiosis; 4) oat varieties with high resistance to powdery mildew, leaf spots, dwarf and loose smut; 5) winter wheat varieties with relative resistance to septoria and fusarium head blight; 6) spring barley cultivars with high resistance to powdery mildew, stripe spot, dark brown, dwarf and crown rust, net blotch, loose smut, and helminthosporiosis; 7) spring rape varieties resistant to downy mildew and phomosis.

At the Prykarpattia State Agricultural Research Station of the Institute of Agriculture in the Carpathian Region of NAAS, the resistance of cruciferous oil crops to major diseases was assessed. It was isolated pathogens into pure culture and identified strains of fungi, namely: 1) Alternaria spot on the leaves, stems and pods of winter oilseed rape and mustard; 2) Phomosis on the leaves and stems of winter oilseed rape; 3) Sclerotinia stem rot of winter oilseed rape. This should be taken into account when conducting breeding work on the cruciferous oil crops resistance to local pathogen populations.

The Institute of Rice of NAAS studied the immunological properties of cultivars and varieties of rice. At the same time, varieties and cultivars resistant to pathogens and major pests were identified [8].

The Institute of Agriculture of the Northeast NAAS conducted extensive research on the resistance of modern genotypes of hemp, fiber and oil flaxes to the main phytophagous insects. Thus, Hloba hemp variety is significantly less damaged by hop flea beetle, and also has the highest resistance to major pests. The oil flax varieties with a larger leaf area and leafiness, and high succulence were damaged 1.3 times more than fiber flax varieties.

The Institute of Vegetable and Melon Growing of NAAS developed a method for assessing selection value of the initial material of the main vegetable plants on the disease re

sistance. At the same time, attention was focused on such opportunities as: 1) introduction of various mathematical and statistical methods for more effective assessment and selection of stable initial material on different infectious backgrounds; 2) creation of a computer programs package for expert evaluation of the phyto-immunological research results in vegetable growing, which includes the following modules: "Analysis of numerically insignificant variation series", "Analysis of the one-factor experiment results by the variance analysis", "Analysis of the experiment results by the correlation analysis", "Analysis of the experiment results by the regression analysis".

The Institute of Agroecology and Environmental Management of NAAS and V. M. Remeslo Myronivka Institute of Wheat of NAAS conducted a considerable amount of research work on crop resistance to viral diseases, and the creation of resistant and tolerant varieties. The availability of Cucumber green mottle mosaic virus (CGMMV) in greenhouses of different regions of Ukraine, as well as viral antigens of tomatoes and peppers is indicated. Tolerance of winter wheat cultivars was analysed on the basis of plant productivity under the influence of Barley yellow dwarf virus. As a result of diallel analysis on inheritance of tolerance to Barley yellow dwarf virus, wheat genotypes with high general and specific combination ability on this trait were identified. However, it was found out that the tolerance depending on characteristics of the cultivar genotypes has a different nature of inheritance.

Conclusions.

A significant part of the innovative developments of the Scientific and Methodological Center Plant Protection headed by the Institute of Plant Protection of NAAS concerns the issues of scientific support of selection for crop resistance to pests and pathogens. Breeding and other scientific institutions of agricultural profile can widely use these developments for the creation of sustainable varieties of cereals, oilseeds, vegetables, fodder crops, potatoes, and fiber flax. The duration of the breeding process can be reduced by 40–60 %.

Introduction into the production of resistant varieties will successfully solve the problems of plant protection from pests and increase the crops yield. This will support a further growing economic of Ukraine's agricultural sector and improve the welfare of the population.

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