MODERN TRENDS IN THE DEVELOPMENT OF AGRICULTURAL PRODUCTION

PROBLEMS AND PERSPECTIVES

EDITED BY
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The monograph presented for review is a collection of the results of actual achievements of domestic agricultural scientists, obtained directly in real conditions. The authors are recognized experts in their fields, as well as young scientists and postgraduate students of Ukraine. Research is conceptually grouped into 5 sections: modern technologies in crop production and fodder production; economy of the agro-industrial complex; breeding and breeding in the 21th century; protection and quarantine of plants; agrochemistry and soil science. The monograph will be interesting for experts in plant breeding, economics, plant protection, selection, agrochemistry, soil science, scientific workers, teachers, graduate students and students of agricultural specialties of higher education institutions, and for all those who are interested in increasing the quantity and quality of agricultural products.

Keywords: modern technologies, crop production, fodder production, plant protection, quarantine, agrochemistry, soil science, economy of agro-industrial complex.

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DIAGNOSTICS, PREVALENCE AND HARMFULNESS OF THE MAIN CUCUMBER DISEASES OF GHERKIN TYPE

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By examinations the phytosanitary condition of agrocenoses of cucumbers under open ground conditions, it was established that the main diseases symptoms on the plants in the field looked like spots, coating (sporulation or mycelium), rot, complete or partial wilting of plants. All these symptoms had the characteristic visual signs of damage (leaf apparatus, stems, fruits). During further incubation of the affected plant particles (selected herbarium material) in a wet chamber, the appearance of coating of mycelial hyphae on them indicated the fungal origin of the disease, exudate drops indicated the bacterial nature of the disease. The results of our research clearly showed that in the region of conducting research under open ground conditions on cucumber plants in recent years, the nature of the development and intensity of the main diseases spread is actively changing, in particular downy mildew – from moderate to strong, angular bacterial spot disease, anthracnose, powdery mildew – from moderate to depressive. However, we would like to note separately that today fusarium wilt should be added to the zonal list of potentially dangerous diseases of cucumber of Gherkin type in the open ground. All the above arguments allow us to draw a convincing conclusion that it is downy mildew that today annually occupies a dominant position in the zonal pathocomplex of open ground cucumber of the Left-Bank Forest-Steppe of

Ukraine, which served as the main argument for choosing it as the main scientific object of our research.

Key words: *diagnostics, prevalence, harmfulness, cucumber of gherkin type.*

Monitoring studies, collecting herbarium infectious material and analysis of seasonal changes in populations of the main pathogens were carried out by us on breeding crops of cucumber of Gherkin type during 2011–2013.

During every decadal examinations, the absence or presence of symptoms expression specific to each disease on various organs of cucumber plants was determined visually according to the recommended scales and methods.

By examinations the phytosanitary condition of agrocenoses of cucumbers under open ground conditions, it was established that the main diseases symptoms on the plants in the field looked like spots, coating (sporulation or mycelium), rot, complete or partial wilting of plants. All these symptoms had the characteristic visual signs of damage (leaf apparatus, stems, fruits).

During further incubation of the affected plant particles (selected herbarium material) in a wet chamber, the appearance of coating of mycelial hyphae on them indicated the fungal origin of the disease, exudate drops indicated the bacterial nature of the disease.

Symptoms or diagnostic signs of the disease expression on cucumber of Gherkin type and the species affiliation of disease pathogens were determined by macro-and microscopic analysis using the appropriate specialized literature.

Materials and methods. The monograph summarizes and analyzes the results of research obtained by the author directly during 2011–2013 in the fields of breeding rotation of the laboratory of pumpkin crop selection of the Institute *of* Vegetables and Melons growing of NAAS – the branch scientific center of Ukraine for breeding and genetic research on the main vegetable and melon crops.

Phytosanitary monitoring of seasonal changes in pathocomplex of a cucumber of Gherkin type and immunological studies of the level of resistance of this vegetable crop breeding material were carried out on the original author's material in the dynamics of its creation.

The author expresses his sincere gratitude to the breeders, namely the

head of the laboratory Oksana Sergienko and researcher Lina Dmytrivna Solodovnik for the presented original breeding material and joint fruitful scientific cooperation.

When conducting research, we used the following methods of research and analysis of experimental material: field – when monitoring the phytosanitary state of crops, when collecting herbarium material and determining the immunological characteristics of the breeding material of Gherkin type cucumber under conditions of a natural infectious background; laboratory – when determining the species composition of pathogens of the most common diseases; statistical – when determining the parameters of trustworthiness, stability and variability of the obtained experimental data and the research of interrelations between a complex of economic characteristics.

Field experiments were laid down and conducted in accordance with the "Methods of field experience in vegetable growing" (Grinko, Rodigin & Zherdeckaya, 1993).

Results of the research. Before proceeding to the direct presentation of the results of our research, it should be noted that when analyzing the specialized literature, it was found that the symptoms of cucumber plant damage by diseases are described differently by researchers from different regions of the world (Babadoost, Weinzieri & Masiunas, 2004).

In accordance with this, during the route surveys of Gherkin type cucumber crops we have studied their specific diagnostic symptoms in the dynamics of development and maximum spread on the crop. Apart from that we have established the degree (R, %) and intensity of spread (P, %) of a number of diseases.

Immunological characteristic of all cucumber breeding material about a diseases complex were provided to samples at the end of the critical phase of ontogenesis for this crop – mass fruiting of plants. In the region of breeding research, this process coincides with the first and second decades of July.

Based on the experimental data obtained by us, it was primarily determined that diseases such as downy mildew, angular bacterial spot disease and fusarium wilt took part in the zonal pathocomplex of cucumber of Gherkin type under open ground conditions, with different dynamics of seasonal development.

The original description of zonal (regional) specific diagnostic symptoms of these diseases on cucumber plants of Gherkin type in the open

ground (taking into account the biological peculiarities of its growing) during the research period is given below. Thus, based on the obtained results of phytosanitary monitoring, it was established that in the field, downy mildew on cucumber plants developed first on the upper surface of leaf plates in the form of angular, first light yellow, and then light brown spots.

Fig. 1. Specific diagnostic symptoms of downy mildew expression on cucumber plants are characteristic spots on the upper surface of the leaf blade (a), the outer look of leaves at severe lesion (b), the beginning of sporulation (c) and its active phase, (d) – the view from the underside of the leaf blade.

In the future, these spots quickly increased in size and later merged. This period lasted under open ground conditions from 1 to 8 days. The severely affected tissue of such leaves in the sun rapidly dried up, became brittle, the leaves twisted and fell off. With this course of the pathological process, only leaf petioles remained on the stems of severely affected plants (fig. 1 a, b).

0 score

0.1 scores

1 score

2 scores

3 scores

Fig. 2. Visual three-point scale for assessing the lesion degree of cucumber samples by downy mildew (photo by S. V. Bondarenko)

Our research found out that in the future, the rapid loss of leaf mass directly affected the process of forming the fruits setting that were on the plant earlier (before the lesion), their further physiological development. Thus, in plants severely affected by downy mildew (scores 3, 4) (fig. 2) the formed fruits had slight colouration, were necrotic, and did not have a characteristic cucumber taste or smell.

When the leaf surface of plants is strongly moistening both in the field and in laboratory conditions (wet chamber), on the lower surface of the affected leaves, namely in places of spots from the outer surface (see fig. 2.1 a) there was an active sporulation of this fungi-like organism – an abundant greyish-purple coating of sporulation was formed (fig. 1 c, d) (Cohen, 1977).

When conducting a microscopic analysis in the laboratory, we have found that this process is a consequence of asexual sporulation of the fungi-like organism *Pseudoperonospora cubensis*, which in this representative of oomycetes is represented by zoosporangia and zoospores (fig. 3) (see section 1) (Criswell et al., 2008).

As it noted above, the second place in the pathogenesis of this vegetable crop in the region of research in years was occupied by such disease as bacterial leaf rust (the causative agent is the bacterium *Pseudomonas syringae* pv. *lachrymans*). The characteristic diagnostic symptoms of this disease on cucumber plants of Gherkin type are shown in fig. 4.

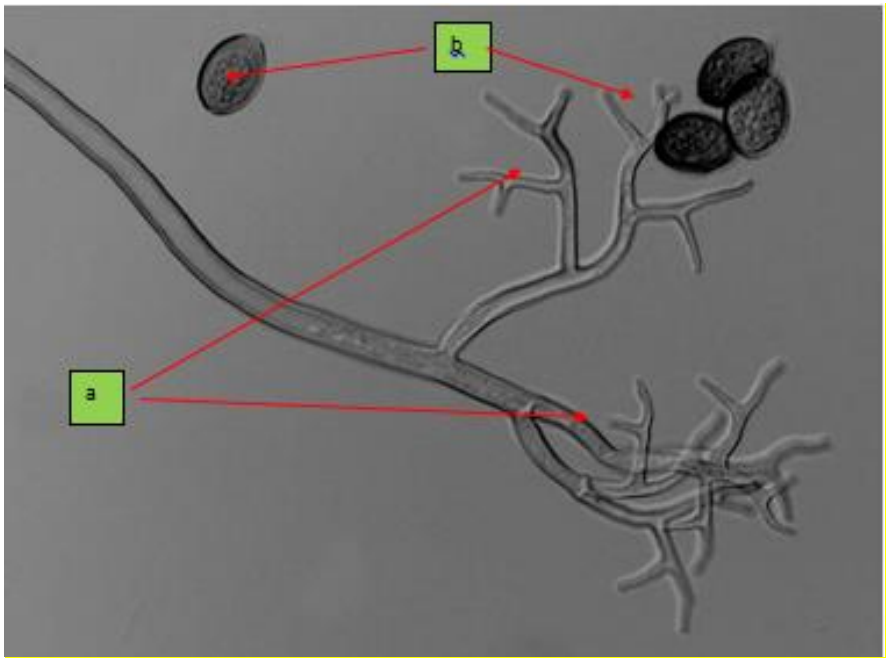

Fig. 3. Zoosporangia (a) with zoospores (dark balls – b) of the fungi-like organism *Pseudoperonospora cubensis* (wet chamber, washout, Lumam M1 microscope, UFO DS-8330 camera, 2012)

Initially, on physiologically young plants that were beginning to bloom, on the leaf apparatus, the disease had a characteristic expression in the form of small, irregular in shape, slightly greasy greyish-brown marginal spots (like sunburns). At the same time, the colour of tissues that were not damaged by the pathogen did not change and remained rich green (fig. 4 a).

Gradually, on severely affected leaves, the spots merged and became angular due to the restriction of their size by leaf veins. The affected tissue discoloured, and the leaves themselves looked like "burned". Limited by the veins, the affected tissue then quickly dried out, rotted and destroyed, which made the leaf surface parchment-like and holey (fig. 4 b).

a)

b)

Fig. 4. Characteristic diagnostic symptoms of angular bacterial spot disease expression on cucumber plants of Gherkin type: a – physiologically young plants; b – severe lesion by bacteriosis

Among other diseases of cucumber of Gherkin type in the open ground, we have recorded plants with characteristic symptoms of fusarium wilt (the main causative agent is the fungus *Fusarium oxysporum* f. sp. *cucumerinum*) (fig. 5).

a)  b) 

Fig. 5. Specific diagnostic symptoms of fusarium wilt expression on cucumber plants: a – most of the plant has wilted, b – the plant is underdeveloped, dwarf, the internodes are short, the leaves and fruits are small, drying out

It should be noted that when cucumber plants were affected by fusarium wilt in the field, we met two forms of visual specific symptoms of its expression – when the entire plant or a significant number of lateral shoots directly withered (fig. 4 a).

Often, if the second type of pathogenesis of this disease occurred, the cucumber plant had a visually noticeable suppressed physiological state (dwarfism), the shoots remained underdeveloped, the internodes were short, the leaves and fruits were small and without turgor (fig. 5 b).

When analyzing the specific seasonal combination of weather and climatic factors, it was found that the main indicators of harmfulness – the intensity of spread (P, %) and the degree of lesion (R, %) of cucumber samples of Gherkin type by a diseases complex, in particular downy mildew, under open ground conditions directly depended on two basic components:

– firstly, it depends on the peculiarities of the meteorological factors combination at the end of June and in July, which falls on the critical phase of ontogenesis of this vegetable crop – the period of plants mass fruiting (table. 1);

– secondly, it depends on the level of reaction expression of field (protracted) resistance to downy mildew of the studying cucumber breeding material (fig. 6).

As can be seen from the indicators given in the table 1, the variability of the intensity value of development or prevalence (P, %) of downy mildew in different by the resistance of the breeding material of Gherkin type cucumber in the years of research ranged from 24 to 100 %. At the same time, the calculated weighted average population indicator of downy mildew prevalence ($\bar{X}$weighted average population indicator = 63 %) on breeding crops of cucumber of Gherkin type in the critical phase of ontogenesis (the end of the first decade of plants mass fruiting) confirmed the annual high intensity of the natural infectious background of this disease and the objectivity of the obtained characteristics of the resistance level to it of breeding material. As a comparative analysis showed, calculated by us the weighted average population intensity indicator ($\bar{X}$weighted average population indicator**)** of development (prevalence) of downy mildew in the cucumber crops of Gherkin type annually amounted to more than 63 %, angular bacterial spot disease – 10 % (less by 6.4 times), fusarium wilt – 3 % (less by 20 times) (Table 1).

Table 1

The intensity of development or prevalence (P,%) of the main diseases, open ground cucumber – the end of the first decade of fruiting, %

Year	Downy mildew	Angular bacterial spot disease	Fusarium wilt
	LV $v_{min} \div v_{max}$*	**LV $v_{min} \div v_{max}$**	**LV $v_{min} \div v_{max}$**
2011	25,5 ÷ 100	0,0 ÷ 5,0	0,0 ÷ 5,0
2012	29,0 ÷ 100	0,0 ÷ 34,0	0,0 ÷ 1,0
2013	24,0 ÷ 100	0,0 ÷ 20,0	0,0 ÷ 10,0
In total by years	24,0 ÷ 100	0,0 ÷34,0	0,0 ÷ 10,0
$\bar{X}$ weighted average population indicator*	63,0	10,0	3,0
Frequency of occurrence	82,0	13,2	4,8

Note: * here and in the future, LV $v_{min} \div v_{max}$ is the limit of trait variation (the smallest ÷ the largest), $\bar{X}$weighted average population indicator is its weighted average population value.

Thus, according to our research, it was established that the individual share of the contribution to the overall process of zonal pathocomplex

formation of open ground cucumber of Gherkin type (the frequency of occurrence of a biological object [128]) of such a disease as downy mildew was 82% in the years of research, angular bacterial spot disease – 13.2%, fusarium wilt – only 4.8 % (fig. 7, table 1).

In the future, we determined that between such valuable economic characteristics of cucumber of Gherkin type as the total crop capacity, yield for the first fruiting decade, the period of mass fruiting and the basic indicators of downy mildew harmfulness (lesion degree, intensity of spread) on breeding samples with different expression of reactions, the correlation interrelation was medium and close, but opposite in the direction of action.

It should be emphasized separately that a certain number of breeding samples that did not have field (protracted) resistance to downy mildew under conditions of a natural infectious background had stable crop losses at the level of 60-80%, in some years (2011) were characterized by the complete death of all plants on the experimental plots even before the beginning of fruiting phase.

At the same time, we have found that from 80 to 100 % of plants of susceptible and highly susceptible groups (1–3 scores of the immunological scale) could not reach the critical for this vegetable crop in the research region phase of ontogenesis– the period of mass fruiting (fig. 6).

Fig. 6. The immunological reaction of a control breeding sample susceptible to downy mildew (Nizhynsky local variety, the last on the right, 2011)

Taking into account this fact, we consider it necessary to specifically focus on the peculiarities of seasonal dynamics of the development of the main zonal diseases of Gherkin type cucumber under open ground conditions for all years of research.

Thus, in 2011, the first specific diagnostic signs of cucumber plants lesion by downy mildew under open ground conditions in field crop rotation (fig. 2) were recorded by us during route surveys of breeding crops in the third decade of June (formation phase of runners). The mass spread of the disease in plants of breeding crop rotation occurred in the first half of July (Table 2).

In addition, in 2011, during a phytopathological examination of breeding crops, we recorded individual cucumber plants with characteristic symptoms of lesion by angular bacterial spot disease and fusarium wilt, but these diseases did not become widespread under open ground conditions (Table 1, Table 2).

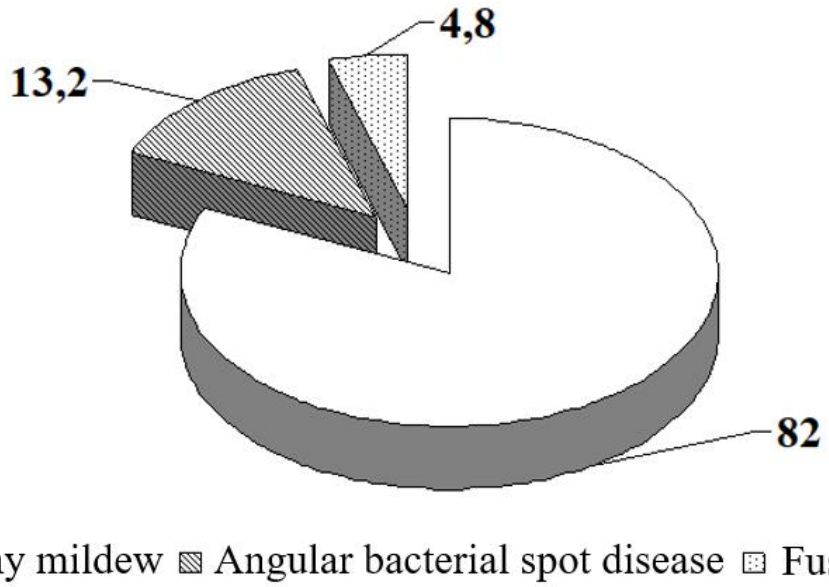

Fig. 7. Zonal pathocomplex of open ground cucumber of Gherkin type, individual share of the main diseases contribution, summarized for 2011-2013, %

As we noted abov, the hydrothermal conditions of June – July 2012 were specific (abnormal) and by the indicators of temperature regime and moistening regime did not meet the standard values of the long-term climate norm for the zone of conducting research.

The first visual lesion signs of cucumber samples of Gherkin type by downy mildew in the breeding crop rotation on the experimental plots in 2012 were recorded in the first decade of July. Mass disease development on the leaf apparatus of plants of control cucumber samples (as a priori – in the field crop rotation) was in the second decade of July (Table 2).

In addition, under the field conditions, on some breeding samples this year were visually recorded specific symptoms of damage to cucumber plants by diseases such as angular bacterial spot disease (for the first time – in early June, en masse – in the second decade of this month) and fusarium

wilt – focal. Occasions of individual plants damaged by fusarium wilt pathogens in experimental areas were noted in the third decade of June (Table 2, fig. 8).

The study of seasonal changes in the zonal pathocomplex of cucumber of Gherkin type on breeding crops in 2013 showed the following.

Table 2

Characteristics of the development of the main cucumber diseases of Gerkin type under open ground conditions of the Left-Bank Forest-Steppe of Ukraine

Year	Disease	Beginning (appearance of the first lesion signs)	Mass spread of the disease
2011	downy mildew	III decade of June	I–II decade of July
	fusarium wilt	II decade of June	--
	angular bacterial spot disease	III decade of June	--
2012	downy mildew	I decade of July	II–III decades of July
	fusarium wilt	III decade of June	--
	angular bacterial spot disease	I decade of June	II decade of June
2013	downy mildew	III decade of June	I decade of July
	fusarium wilt	III decade of June	--
	angular bacterial spot disease	III decade of June	--

Fig. 8. Characteristic specific falling out of cucumber plants on experimental plots when they are affected by fusarium wilt, 2013.

The beginning (third decade of June) and further spread of this fungi-like organism against the background of a rapid increase in the intensity indicators (P, %) and degree of lesion (R, %) of breeding crops of Gherkin type cucumber were usually recorded by us in the first decade of July.

It was this time period that coincided in most breeding samples with the critical ontogenesis period of this vegetable crop – namely, the phase of mass fruit formation in experimental plants of different breeding origin (Table 2).

These facts once again clearly confirmed the presence of an annual hard natural infectious background of downy mildew in the research region (basic breeding and genetic center of Ukraine), which indicates a high representativeness of the conducted assessments of cucumber breeding material by the protracted resistance trait.

In the future, to confirm the above conclusion about the constant dominance of such disease of Gherkin type cucumber as downy mildew in the open ground in the region, we have combined the experimental data obtained by us with 16-year research results of other authors.

Comparison of long-term changes in the list of cucumber diseases, the nature of their dynamics, variability of basic indicators of harmfulness in the open ground with the obtained experimental data is summarized in Table 3.

Thus, according to summary data, the nature of downy mildew development for the period from 1990 to 2005 is characterized as moderate, only in some years – as strong. At the same time, the indicator of development intensity (P, %) in agrocenoses of open ground cucumber fluctuated at the level of 8.9–54.6 % (weighted average population indicator or $\bar{X}$weighted average population indicator – 27.8 %), the value of lesion degree of plants (R,%) – at the level of 2.2–27.4 % ($\bar{X}$weighted average population indicator – 14.5 %) (Table 3).

During the period from 2011 to 2013, against the background of global climate changes, the weighted average population intensity indicator of downy mildew prevalence on the crops increased more than 2 times – from 27.8 to 63.1 %. Accordingly, the limits of the maximum values of this indicator also increased – from 24 to 100 %. The maximum indicator values of the lesion degree of samples also increased – from 27.4 to 75 %. The weighted average population value ($\bar{X}$weighted average population indicator) of this indicator increased 2.5 times – from 14.5 to 35.6 % (Table 1, Table 3).

All this gives us reason to say that during the period from 1995 to 2013 in the region of research, the nature of downy mildew development on cucumber crops in the open ground gradually changes its character from moderate to consistently strong (by the type of epiphytotia) (Table 3).

Table 3

Characteristics of zonal ecologically and adaptive changes in the development intensity (P) and lesion degree (R) of cucumber by a diseases complex (Left-Bank Forest-Steppe of Ukraine, Kharkiv region), %

Disease	1990–2005 pp. [104]			2011–2013 pp.		
	LV $v_{min} \div v_{max}$ $\bar{X}$ weighted average population indicator		The nature of the disease development *	LV $v_{min} \div v_{max}$ $\bar{X}$ weighted average population indicator		The nature of the disease development *
	P	R		P	R	
Downy mildew	8,9÷54,6 27,8	2,2÷27,4 14,5	M - S	24,0 ÷ 100 63,1	2,5÷75,0 35,6	S
Angular bacterial spot disease	4,0 ÷ 42,2 22,1	1,0÷20,0 11,1	M	0,0 – 34,0 9,8	2,1÷50,0 17,4	M
Powdery mildew	1,0÷38,0 13,2	0,1÷9,0 3,9	M	The disease has not been diagnosed		
Anthracnose	2,7÷7,0 5,1	6,0÷14,0 10,3	D	Affected fruits on single seed plants		
Fusarium wilt	No data available			0,0 ÷10,0 2,95	0,0÷9,8 4,9	D

Note: * D – depressive; M – moderate; S – strong (in some years – epiphytotic) [60].

Unlike downy mildew, our summary data of long-term changes in the dynamics of cucumber disease such as angular bacterial spot disease showed that against the background of a gradual decrease in the weighted average population value of development intensity (P) by more than 2 times (9.8 vs. 22.1 %), the average value of lesion degree of plants (R) in crops in recent years have been gradually increasing – from 11.1 to 17.4 % (more than 1.5 times) (Table 1, Table 3).

Taking into account the obtained data, we specifically emphasize that determined by us tendency of gradual increase in the aggressiveness of bacteriosis in pathocomplex of open-ground cucumber bases on proved by

various authors the evolutionary ability of this disease to dramatically change the nature of its development in certain weather conditions from depressive to moderate and strong.

Based on the obtained research results, we also note that due to the global changes of weather and climatic conditions over the past decades, the nature of the dynamics of the development intensity and the prevalence of this disease in the region in recent years is sufficient reason to include it in the list of potentially dangerous.

In the future, we'll note that long-term changes in the characteristic of expression of weather and climatic conditions negatively (depressingly) affected the development and parameters of harmfulness of such cucumber diseases as powdery mildew and anthracnose in zonal agrocenoses of cucumber of open-ground (Table 3).

Thus, for the entire period of research, only in August 2012, characteristic lesion symptoms by anthracnose were recorded on single fruits of cucumber seed plants of Gherkin type (Table 3). At the same time, when conducting monitoring studies of crops, no specific lesion symptoms of cucumber plants of Gherkin type of open ground by such a disease as powdery mildew were recorded during the study period (Table 3). In addition, we have found that in recent years, the symptoms of manifistation of fusarium wilt – the main pathogen is the fungus *Fusarium oxysporum* f. sp. *cucumerinum* are annually recorded on cucumber under open ground conditions.

Thus, according to our data, fusarium wilt in various types of its expression (fig. 5), for the period from 2011 to 2013, was annually found in cucumber crops of open-ground (Table 1). The variability of indicators of the intensity of its expression on breeding cucumber samples in the open ground varied by year at the level of 0 to 10 % ($\overline{X}$ weighted average population indicator – 2.95 %), the indicator variability of the degree of plant lesion was by years from 0 to 9.8 % ($\overline{X}$ weighted average population indicator – 4.9 %) (Table 3).

Thus, the results of our research clearly showed that in the region of conducting research under open ground conditions on cucumber plants in recent years, the nature of the development and intensity of the main diseases spread is actively changing, in particular downy mildew – from moderate to strong, angular bacterial spot disease, anthracnose, powdery mildew – from moderate to depressive.

However, we would like to note separately that today fusarium wilt should be added to the zonal list of potentially dangerous diseases of

cucumber of Gherkin type in the open ground.

All the above arguments allow us to draw a convincing conclusion that it is downy mildew that today annually occupies a dominant position in the zonal pathocomplex of open ground cucumber of the Left-Bank Forest-Steppe of Ukraine, which served as the main argument for choosing it as the main scientific object of our research.

Conclusions:

1. The results of our research clearly showed that in the region of conducting research under open ground conditions on cucumber plants in recent years, the nature of the development and intensity of the main diseases spread is actively changing, in particular downy mildew – from moderate to strong, angular bacterial spot disease, anthracnose, powdery mildew – from moderate to depressive.

2. However, we would like to note separately that today fusarium wilt should be added to the zonal list of potentially dangerous diseases of cucumber of Gherkin type in the open ground.

3. All the above arguments allow us to draw a convincing conclusion that it is downy mildew that today annually occupies a dominant position in the zonal pathocomplex of open ground cucumber of the Left-Bank Forest-Steppe of Ukraine, which served as the main argument for choosing it as the main scientific object of our research.

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