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MODERN TRENDS IN AGRICULTURE SCIENCE: PROBLEMS AND SOLUTIONS

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The monograph 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 at 7 sections: Plants protection and quarantine; vegetable growing in open and closed ground; horticulture, fruit growing, viticulture; breeding and seed production; agrochemistry and soil science; agriculture and modern agricultural technologies; management and strategies for future development. 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: agriculture, modern technologies, plants protection, quarantine, vegetable growing, horticulture, fruit growing, viticulture, breeding and seed production, agrochemistry, soil, management, strategies, development.

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RESISTANCE OF BREEDING MATERIAL OF GHERKINS TO DOWNY MILDEW

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At present, a comprehensive assessment of breeding (in a broad aspect) material in order to search for and select the initial forms resistant to downy mildew and further creation (selection and multiple self-pollination) on their basis an initial resistant material of Gherkins is exceptionally relevant and priority for domestic agricultural science. It was obtained an immunological characteristic of 331 breeding samples (collection, hybrid, linear, initial material) of Gherkins of Ukrainian and World breeding according to the level of downy mildew resistance under natural infectious background. It was selected groups of 63 samples (or 19 %) of cucumber– promising sources of genetic resistance to downy mildew, the lesion degree of which under the field conditions at the end of the first decade of mass plants fruiting did not exceed the value of 10 % (score 7 of the immunological scale). It was identified a group of 139 samples (42 %), which revealed suitability for purposeful tandem selection of promising sources in order to harmoniously combine high downy mildew resistance in their genotypes in a complex with other valuable for selection and production traits.

***Key words**: cucumber, diseases, prevalence, phytopathological complex, immunity, selection, variety, hybrid*

Introduction. It is generally known that the success of breeding Gherkins for disease resistance is determined by the presence of initial resistant material of both collection and breeding origin in crossbreeding schemes (Kartashov & Kazakova, 1988; Vitchenko & Meleshkina, 1991; Gorohovskij & Berlin, 2009).

For this purpose, it is recommended to work with the most polymorphic plant populations for purposeful multiple selections of genotypes with better combinative combinations of genes and gene complexes of various economic traits, including resistance traits to the primary diseases (Strajstar, 1991; Dhillon, Pushpinder & Ishiki, 1999; Tockij, 2002; Kilchevskij & Hotyleva, 2008).

Thus, V.L.Nalobova in her monograph "Cucumber breeding for diseases resistance" (Nalobova, 2005), notes one of the main conclusions that taking into account the formation peculiarities of the structure of natural populations of certain phytopathogens types in cucumber agrocenoses, breeding for the resistance of this vegetable crop to downy mildew should be carried out on a protracted (polygenic, race-nonspecific, horizontal) type. At the same time, the author emphasizes that this type of sustainability will allow scientists to conduct a more effective selection of resistant forms of cucumber and create on its basis competitive varieties and hybrids that are most in-demand today in commercial production in Ukraine. So, at present, a comprehensive assessment of breeding (in a broad aspect) material in order to search for and select the initial forms resistant to downy mildew and further creation (selection and multiple self-pollination) on their basis an initial resistant material of Gherkins is exceptionally relevant and priority for domestic agricultural science (Skripnik & Lopotun, 1993; Skripnik & Lopotun, 2003).

Materials and methods. The main elements of field accounting were such parameters as the disease prevalence (P, %) and the degree of plant damage (R, % or score) (Nalobova, 2005; Yarovii, 2006).

The prevalence index of the disease was determined by the formula:

$$P = (a / N) \cdot 100, \quad (1)$$

where: *a is the number of sick plants, pieces;*

N – total number of examined plants, pieces.

The degree of plant damage that characterized the direct effect of the pest on the plant (sample) was determined by the formula:

$$R = (\Sigma(a \cdot b) / N \cdot K) \cdot 100, \quad (2)$$

where $\sum$ *(a • b) is the sum of the product of the score of plants damage degree (a) and the number of plants (b) that have the corresponding score;*

N – total number of plants, pieces;

K – is the highest score on the accounting scale.

Accounting for the lesion degree of cucumber plants by spot disease, in particular downy mildew and bacteriosis, was carried out as a percentage, visually assessing the area of the affected surface of the leaf apparatus of the sample, which most optimally reflects the ranges of areas of damage during field assessments (Fig. 1) (Gannibal, Gasich & Orina, 2011; Kirichenko & Petrenkova, 2012).

Fig. 1. Visual three-point scale for assessing the lesion degree of cucumber samples by downy mildew (photo by S.V. Bondarenko)

When assessing the immunological potential of the breeding material of cucumber of Gherkin type, the standard of susceptibility was Nizhynsky local variety (Ukraine), the standard of resistance to varietal populations – Dzherelo (Ukraine), Phoenix 640 (Russia), hybrid – Ajax F1 (Netherlands).

When assessing the lesion degree and simultaneously determining the level of resistance of cucumber breeding samples, the following summary three-point scale was used, where: 0 scores of lesion scale – plants are healthy, without signs of damage (9 scores of the immunological scale – highly

resistant sample); 0.1 scores – the disease affects from 0.1 to 10 % of the leaf apparatus of the plant's sample (score 7 – resistant sample); 1 score – from 10.1 to 35 % (score 5 – medium-resistant sample); 2 scores – from 35.1 to 50 % (score 3 – susceptible sample); 3 scores – from 50.1 to 100 %, plants completely dry up, die (score 1 – highly susceptible sample) (Fig. 1) (Nalobova, 2005; Koshnikovich et al., 2008; Chistyakova & Biryukova, 2012).

Experimentally obtained data were processed using statistical methods of analysis – variational, correlation, and dispersal (Dospehov, 1985; Bondarenko & Yakovenko, 2001; Chistyakova & Biryukova, 2012). The economic effect of growing Gherkins samples in the field with different resistance to downy mildew was determined according to a typical technological map for growing this vegetable crop (Bolotskih, 1988; Bondarenko & Yakovenko, 2001).

Results. When researching this area, we used recommendations on how to work more effectively with a complex of small or minor genes (polygenic blocks) of cucumber resistance to downy mildew in order to concentrate them as much as possible in the genotypes newly created by a breeder (Yevtushenko et al., 2004; Shkalikov et al., 2005).

In addition, it should be separately noted that today only a close tandem "immunologist-breeder" can most effectively study the breeding material for a complex of essential, valuable, and economic characteristics of a variety or hybrid for the future user, conduct multiple mass selections and obtain valuable initial material. It is under this scheme that breeders are guaranteed the fastest (in two-four years) effect of increasing the concentration of a complex of small resistance genes (polygenes) and other traits in the selected cucumber plant populations (Tockij, 2002; Yevtushenko et al., 2004).

By such a scheme of the breeding process of creating a new resistant initial material, we recommended involving local aboriginal varieties and hybrids that were created against the background of constant annual crops lesion in crossbreeding. It also allows to effectively optimize the effectiveness of the cucumber breeding process for protracted genetic resistance to downy mildew (Forsberg, 1986; Plotnikova, 2007; Mitchell et al., 2011). Along with this, experimental studies have earlier determined the presence of a very close ($r = 0.97$) correlation relation between the lesion degree (R,%) of cucumber plants by downy mildew in the cotyledon leaf phase during artificial infection (*classical, but resource-intensive method*) with this indicator, but under conditions of natural infectious background (Nalobova, 2005; Nalobova, 2008).

In addition, we emphasized that the differentiation of cucumber samples by resistance to downy mildew should be carried out only under conditions of gradually increasing tension of the natural infectious background because all artificially created cucumber samples known today have not genetically acquired the ability to withstand the high infectious

Table 1

Reaction of *Cucumis sativus* L. genotypes to the intensity of downy mildew lesion under open ground conditions, 2011

Scales of assessment		number	Original name of the sample
of resistance	of lesion degree		
score	%	pieces	
9	0	0	there is no
7	0,1–10	20	**F1 Ajax – standard, Dzherelo – standard, Phoenix 640 – standard,** F_3I_2 (F_1 Patriarh x F_3I_2 D96a№2-96), F_1 (F_3I_3 Fansipak x F_4I_1 Solovey), F_3I_2 (F_1 Ivolga x F_3I_3 D96a№2-95), F_4I_2 Semkross, F_4I_2 Semkross, F_4I_1 Semkross, F_4I_2 Krak, F_5 (F_2 Regina x F_1 Mazaj), F_5 (F_2 Regina x F_1 Mazaj), F_5I_1 (F_2 Regina x F_1 Mazaj), F_5I_2 (F_1 Maliia x Geim), F_5I_1 Hermes Skernevytsky, F_5I_3 (F_1 Romans x F_3I_3 D96a№2-95), F_6I_1 Zasoliuvalny, F_6I_1 Zasoliuvalny, F_1 (Nizhynsky local x Era), F_1 (Nizhynsky 12 x Nosivsky).
5	10,1–35	44	F_1 Samorodok, F_3I_1 Nastoyashchij polkovnik, F_7I_4 Kozyrnaia karta, F_4I_3 Danila, F_4I_3Muravej, F_5I_2Amur, F_5I_2 Yemelia, F_6I_3 Gepard, F_6I_4 Polina, F_6I_3 Podmoskovnye vechera, F_1I_1Gerkin, F_3I_2 (F_1 Buyan x F_3I_3 D96a№2-96), F_5I_2 (F_1 Aurach x F_3I_3 D96a№2-95), F_5I_3 (F_1 Fortuna x F_3I_3 D96a№2-95), F_1 (F_3I_2 Fansipak x F_3I_1 line P-1), F_1 (F_5I_1 Donia x line 23162 D96a№2-95), F_1 (Gerkin x bush cucumber), F_3I_1 (F_1 Ivolga x F_3 D96a№2-95), F_3I_1 (F_1 Ivolga x F_3 D96a№2-95), F_3I_1 Yulian, F_4I_2 (F_1 Mastak x F_3I_3 D96a№2-95), F_4I_1 Prestige, F_4I_2 Krak, F_4 Pervyj klass, F_4 Tsygan, F_4I_2 Tsygan, F_4 (F_1 Finist x Phoenix), F_4 (F_1 Phoenix x Finist), F_3I_3 Odocheck, F_5 (F_2 Regina xMazaj), F_5I_2 Potomak, F_5I_2 (F_1 Maliia x Geim), F_5I_2

Table 1 (continuation)

Scales of assessment		number	Original name of the sample
of resistance	of lesion degree		
score	%	pieces	
3	35,1–50	42	(F_1 Maliia x Geim), F_5I_3 Syn polka, F_5I_3 Syn polka, F_6I_2 Zasoliuvalny, F_1 Etap, F_2I_1 (Geim x Nizhynsky 12), F_2I_1 (Dzherelo x Nizhynsky 12), F_2 (Era x Geim), F_2 (Era x Geim), F_2I_1 (Era x Nizhynsky 12), F_1 (Geim x Nizhynsky local), F_1 (Nosivsky x Nizhynsky Local), F_4Izyd, F_6I_9Chistyie prudy, F_3I_2 Denek, F_4I_1 (F_1 Denek x F_3I_3 D96a№2-95), F_1 (F_4I_1 line P-1 x F_3I_3 D96a№2-95), F_1 (F_8I_3 Donia x F_1I_1 Dzherelo), F_1 (F_8I_3 Donia x F_5I_1 Solovey), F_1 (F_5I_3 Ametyst x F_4I_1 Solovey), F_1 (Gerkin x bush cucumber), F_1 (Gerkin x bush cucumber), F_1 (Gerkin x bush cucumber), F_1 (Gerkin x bush cucumber), F_1I_1 Melnitsa, F_1I_1 Melnitsa, F_2I_2 Bush cucumber, F_3 (F_1 Sultan x F_3I_3 D96a№2-95), F_4I_3 Krak, F_4 Pervyj klass, F_4I_2 Tsygan, F_4I_1 Tsygan F_4 (F_1 Romans x F_3I_3 D96a№2-95), F_4 (F_1 Romans x F_3I_3 D96a№2-95), F_4I_1 (F_1 Romans x F_3I_3 D96a№2-95), F_3I_3 Odochek, F_6I_3 (F_1 Masha x Geim), F_1 Etap, F_2I_1 (Nizhynsky 12 x 2316D96a№2-3), F_2I_1 (Geim x Nizhynsky 12), F_2I_1 (Dzherelo x Nizhynsky local), F_2 (Era x Geim), F_2 (Staya x Nizhynsky 12), F_1 (Geim x Nizhynsky local), F_1 (Geim x Era), F_1 (Era x Nizhynsky local), F_1 (Nizhynsky local x Era), F_1 (Nosivsky x Geim), F_1 (Nosivsky x F_3I_3 D96a№2-96), F_1 (Nosivsky x Nizhynsky 12), F_1 (Nizhynsky x line 2316D96a№2-3), F_1 (Nizhynsky local x Etap), F_1 (Nizhynsky 12 x line 2316D96a№2-3), Melkij, Unknown hybrid, Unknown hybrid.
1	50,1–100	46	**Nizhynsky local – standart,** F_4I_2 Odogs, F_4I_1 Zhelud, F_4I_1 Regina plus, F_5I_1 Kuznechik, F_5I_3 Syn polka, F_3 (Amur x Geim), F_4I_2 (F_1 Mar'ina roshcha x F_3I_3 D96a№2-95), F_1 (Gerkin x bush cucumber),

Table 1 (continuation)

Scales of assessment		number	Original name of the sample
of resistance	of lesion degree		
score	%	pieces	
1	50,1–100		F_2 Hrustyashchij, F_1 Gomes, F_2 Gomes, F_2I_1 Bush cucumber, F_2I_1 Bush cucumber, F_2I_2 Bush cucumber, F_2I_2 Bush cucumber, F_2I_2 Bush cucumber, F_1I_1 Bush cucumber from Russia, F_1 Bush cucumber from Russia F_3I_2 Finist, F_3I_1 Finist, F_3I_1 Finist, F_3 Tomast, F_1 Filippok, F_2 Filippok, F_2I_1 Filippok, F_3I_1 Filippok, F_3I_2 Filippok, F_3 Filippok, F_3 Yulian, F_3 Yulian, F_3 Yulian, F_3 (F_1 Sultan x F_3I_3 D96a№2-95), F_5I_1 Tsezar, F_6I_2 Tsezar, F_2 (Dzherelo x Nizhynsky local), F_2I_1 (Dzherelo x Nizhynsky 12), F_2 (Staya x Nizhynsky 12), F_1 (Era x Nizhynsky local), F_1 (Era x Nizhynsky local), F_1 (Era x Nizhynsky local), F_1 (Era x Dzherelo), F_1 (Nosivsky x F_1I_1 Dzherelo), F_1 (Nizhynsky 12 x F_1I_1 Dzherelo), Unknown hybrid, F_8I_5 Kozyrnaya karta, F_1 (Buyan F_1 x Bush cucumber).

load of this disease for a long time yet (Nalobova, 2003; Shihmatova, 2006; Nalobova, 2008). Cucumber breeding material received a basic assessment of the level of protracted genetic resistance to downy mildew by years at the end of the first decade of the mass fruiting plants phase. It was during this period of ontogenesis that the lesion degree of the collection sample Nizhynsky local (Ukraine) of susceptibility standard to downy mildew exceeded the values of 50-70% over the years of research (resistance score1 by the REV scale) (Tables 1–3). At the same time, the lesion degree by downy mildew of collection samples – resistance standards Dzherelo (Ukraine), Phoenix 640 (Russia), Ajax F_1 (Netherlands), during this period did not exceed the mark of 2034% over the years (resistance scores 7, 5).

For purposeful rejection from the breeding process of susceptible and highly susceptible forms to downy mildew, all the breeding material of Gherkins of the collection, hybrid (breeding) nursery gardens, and linear and initial material nursery gardens were involved in immunological screening (Tables 1–3). Thus, an immunological characteristic of the reaction level of protracted genetic resistance to downy mildew in the open ground at the end of the first decade of the mass fruiting phase was obtained

in 2011 by 152 cucumber breeding samples, in 2012 –110 samples, in 2013 – 69 breeding samples. So, for the entire period of research under conditions of natural infectious background, we determined the level of resistance to downy mildew of 331 breeding samples.

Table 2

Reaction of *Cucumis sativus* L. genotypes to the intensity of downy mildew lesion under open ground conditions, 2012

Scales of assessment		number	Original name of the sample
of resistance	of lesion degree		
score	%	pieces	
9	0	0	There is no
7	0,1–10	28	**F1 Ajax – standard, Dzherelo – standard, Phoenix 640 – standard,** F_7I_5 Chistyie prudy, F_8I_2 Begio 1802, F_9I_2 Fansipak, F_4I_2 Nastoyashchij polkovnik, F_5I_3 Odys, F_6I_3 Amur, F_5I_2 Mirabell, F_5I_3 (F_1 Mar'ina roshcha x F_3I_3 D96a№2-95), F_3I_3 (F_1 Fortuna x F_3I_3 D96a№2-95), F_7I_4 Podmoskovnye vechera, F_1 Zhelud, F_5I_2 (F_1 Denek x F_3I_3 D96a№2-95), F_5 Izyd, F_3I_1 Pavlik, F_5I_3 Krak, F_4I_1 Semkross, F_4I_3 Danila, F_4I_3 (F_1 Ivolga x F_3I_3 D96a№2-95), F_2 Rufus, F_6I_4 Syn polka, F_7I_2 Emelya, F_7I_2 Emelya, F_5I_1 (F_1 Denek x F_3I_3 D96a№2-95), F_3I_1 Pavlik, F_5I_4 Krak
5	10,1–35	68	F_1 Samorodok, F_5I_2 Zhelud, F_5I_1 Romans, F_7I_2 Polina, F_5I_2 Mirabell, F_5I_2 Mirabell, F_6I_1 (F_1 bee pollinating cucumber x F_3I_3 D96a№2-95), F_8I_5 Kozyrnaya karta, F_4I_1 (F_1 Saltan x F_3I_3 D96a№2-95), F_6I_2 Tsezar, F_2I_1 Rufus, F_2 Rufus, F_2 Tytus, F_2I_1 Gector, F_2 Gerkin, F_2 Gerkin, F_2I_1 Gerkin, F_4I_1 Nastoyashchij polkovnik, F_5I_3 Odys, F_5I_2 Odys, F_5I_3 Regina plus, F_5I_1 Regina plus, F_7I_4 Chistyie prudy, F_7I_3 Chistyie prudy, F_7I_3 Chistyie prudy, F_7I_2 Емеля, F_7I_2 Emelya, F_7I_6 Polina, F_7I_4 Podmoskovnye vechera, F_7I_4 Podmoskovnye vechera, F_5I_1 (F_1 Denek x F_3I_3 D96a№2-95), F_5I_1 (F_1 Denek x F_3I_3 D96a№2-95), F_5I_1 Pervyj klass, F_5 Pervyj klass, F_5 Pervyj klass, F_5I_2 (F_1 Romans x F_3I_3 D96a№2-95), F_6I_5 (F_1 Romans x F_3I_3 D96a№2-95), F_6I_4

Table 2 (continuation)

Scales of assessment		number	Original name of the sample
of resistance	of lesion degree		
scores	%	pieces	
9	0	0	
5	10,1–35		(F_1 Romans x F_3I_3 D96a№2-95), F_5I_3 Semkross, F_5I_2 Semkross, F_3I_2 Pavlik, F_3I_1 Hrustyashchij, F_3I_1 Hrustyashchij, F_3I_1 Hrustyashchij, F_3I_2 Bush cucumber, F_4I_2 (F_1 Ivolga x F_3I_3 D96a№2-95), F_4I_3 Finist, F_4I_2 Finist, F_4I_2 Yulian, F_4I_1 (F_1 Saltan x F_3I_3 D96a№2-95), F_4I_1 (F_1 Saltan x F_3I_3 D96a№2-95), F_4I_1 (F_1 Saltan x F_3I_3 D96a№2-95), F_4I_2 Mestnyj, F_4I_2 Mestnyj, F_4I_1 Mestnyj, F_4I_1 (F_1 Mastan x F_3I_3 D96a№2-95), F_5 (F_1 Finist x Phoenix), F_5I_2 Yanus, F_5I_2 Yanus, F_6 (F_2 Regina x F_1 Mazaj), F_4I_1 Potomak, F_4I_1 Potomak, F_6I_3 (F_1 Masha x Geim), F_6I_2 Tsezar, F_7I_4 (F_1 Masha x Geim), F_7I_4 (F_1 Masha x Geim), F_7I_3 (F_1 Masha x Geim), F_7I_2 Zasolochnyj, F_7I_2 Zasolochnyj.
3	35,1–50	13	F_9I_7 Ajax, F_2I_1 Gector, F_5I_2 Mazaj, F_5I_1 Regina plus, F_7I_5 Polina, F_8I_6 Kozyrnaya karta, F_3I_1 Pavlik, F_6I_2 Tsezar, F_3I_2 Bush cucumber, F_3I_2 Bush cucumber, F_3 Tomast, F_5 (F_1 Finist x Phoenix), F_5I_1 Yanus.
1	50,1–100	1	**Nizhynsky local – standard**

As noted above, the lesion degree (R) of cucumber samples by downy mildew under open ground conditions as of early-mid – July ranged in the general totality at the level of 2.5 to 75%, and the intensity of the disease spread (P) – from 24 to 100 % (Table 3).

Thus, as of the end of the first or second decade of July, we did not find very highly resistant breeding samples of Gherkins (score 9 of the immunological scale) to downy mildew under open ground conditions during the years of research (Table 4).

We registered field resistance at the level of 7 scores to this disease in 2011 in 20 cucumber samples (13 %) from the general totality (collection, hybrid material, multiple self-pollination – lines of different generations),

namely: F1 Ajax (standard), Dzherelo (Standard), Phoenix 640 (standard), F_3I_2 (F_1 Patriarh x F_3I_2 D96a№2-96), F_1 (F_3I_3 Fansipak x F_4I_1 Solovey), F_3I_2 (F_1 Ivolga x F_3 D96a№2-95), F_4I_3 Semkross, F_4I_2 Semkross, F_4I_1 Semkross, F_4I_2 Krak, F_5 (F_2 Regina x F_1 Mazaj), F_5 (F_2 Regina x F_1 Mazaj), F_5I_1 (F_2 Regina x F_1 Mazaj), F_5I_2 (F_1 Maliia X Geim), F_5I_1 Hermes Skernevytsky, F_5I_3 (F_1 Romans x F_3I_3 D96a№2-95), F_6I_1 Zasoliuvalny, F_6I_1 Zasoliuvalny, F_1 (Nizhynsky Local x Era) and F_1 (Nizhynsky 12 x Nosivsky) (Table 1).

Table 3

Reaction of *Cucumis sativus* L. genotypes to the intensity of downy mildew lesion under open ground conditions, 2013

Scales of assessment		Number	Original name of the sample
of resistance	of lesion degree		
score	%	pieces	
9	0	0	There is no
7	0,1–10	15	**Phoenix 640 – standard, Dzherelo – standard,** F_5I_2 (F_1 Bee pollinating cucumber x F_3I_3 96a№2-95), F_6I_3 (F_1 Denek x F_3I_3 96a№2-95), F_4I_1 (F_1 Saltan x F_3I_3 96a№2-95), F_3I_2 Pavlik, F_6I_5 Krak, F_6I_3 Semkross, F_5I_4 (F_1 Ivolga x F_3I_3 96a№2-95), F_7I_2 Tsezar, F_3I_3 Patriarh, F_1 (F_8I_4 Kozyrnaya karta x Dzherelo), F_6I_2 (F_1 Bee pollinating cucumber x F_3I_3 96a№2-95), F_1{F_6I_3 (F1 Fortuna x F3I3 96a№2-95)} x Dzherelo, Geim.
5	10,1–35	27	**F1 Ajax – standard,**F_9I_6 Bejio 1802, $F_{10}I_6$ Fansipak, F_2I_1 Rufus, F_3I_2 Gektar, F_6I_3 Odys, F_6I_2 Mirabella, F_6I_4 (F_1 Mar'ina roshcha x F_3I_3 96a№2-95), F_8I_4 Patriarh, F_9I_5 Kozyrnaya karta, F_6 Izyd, F_5I_3 Danila, F_7I_3 Potomak, F_1 (F_5I_3 Odys x Dzherelo), F_1 {F_6I_2 (F_1 Bee pollinating cucumber x F_3I_3 96a№2-95)} x Dzherelo, F_1 (F5I4 Krak x Dzherelo), F_5I_4 Krak, F_1 (F_6I_3 Potomak x Dzherelo), F_1 {F_6I_3 (F_1 Fortuna x F_3I_3 96a№2-95) x Geim}, F_1 (F_5I_4 Krak x Geim), F_4I_3 (F_1 Ivolga x Geim x F_3I_3 96a№2-95), F_1 {F_5I_1 (F_1 Romans x 57787 x F_3I_3 96a№2-95) x Phoenix 640}, F_1 (F_5I_4 Krak x Phoenix 640), F_1 {F_4I_3 (F_1

Table 3 (continuation)

Scales of assessment		number	Original name of the sample
of resistance	of lesion degree		
score	%	pieces	
9	0	0	
			Ivolga x F_3I_3 96a№2-95) x Phoenix 640}, F_1 (F_6I_2 Tsezar x Phoenix 640), F_6I_3 Potomak, F_1 {F_6I_3 (F_1 Masha x Geim) x Phoenix 640}, F_1 (F_5I_2 Zhelud x F_8I_2 Bejio 1802).
3	35,1–50	20	F_5I_3 Zhelud, F_6I_2 (F_1 Romans x F_3I_3 Д-96№2-95), F_8I_6 Ajax, F_5I_5 Polina, F_3I_2 Tytus, F_5I_2 Mirabella, F_6I_3 (F_1 Fortuna x F_3I_3 96a№2-95), F_8I_5 Patriarh, F_7I_3 (F_1 Masha x Geim), F_5I_3 Odys, F_6I_3 Potomak, F_1 {F_6I_3 (F_1 Masha x Geim) x Dzherelo, F_6I_3 (F_1 Masha x Geim), F_1 (F_5I_2 Zhelud x Phoenix 640), F_1 {F_6I_3 (F_1 Fortuna x F_3I_3 96a№2-95) x Phoenix 640}, F_8I_2 Bejio 1802, F_5I_5 Bejio 1802, F_9I_5 Fansipak, F_1 (F_7I_5 Ajax x F_9I_5 Fansipak), F_7I_5 Ajax.
1	50,1–100	7	**Nizhynsky local – standard,** F_8I_7 Kozyrnaya karta, F_1 (F_5 Izyd x Phoenix), F_5 Izyd, F_5I_2 Zhelud, F_6I_2 Tsezar, F_1 (F_6I_3 Potomak x Phoenix 640).

An average resistance at the level of 5 scores of the immunological assessment scale we found in 44 samples (29 %) of the general totality, respectively. Eighty-eight samples or 58% of all breeding material that we studied in 2011 belonged to the "susceptible" group (scores 3-1) (Fig. 2, Table 1, 4).

According to our research, in 2012, out of the entire general totality (110 samples) of Gherkins under open ground conditions, 28 samples (or 25 %) were classified as resistant (score 7).

This group includes breeding material, namely: collection samples – Ajax F_1, Dzherelo, Phoenix 640 (standards); breeding – F_7I_5 Chistye prudy, F_8I_2 Begio 1802, F_9I_2 Fansipak, F_4I_2 Nastoyashchij polkovnik, F_5I_3 Odys, F_6I_3 Amur, F_5I_2 Mirabell, F_5I_3 (F_1 Mar'ina roshcha x F_3I_3 D96a№2-95), F_3I_3 (F_1 Fortuna x F_3I_3 D96a№2-95), F_7I_4 Podmoskovnye vechera, F_7I_3 Patriarh, F_5I_2 (F_1 Denek x F_3I_3 D96a№2-95), F_5 Izyd, F_3I_1 Pavlik, F_3I_2 Pavlik, F_5I_3 Krak, F_5I_4 Krak, F_4I_1 Semkross, F_4I_3 Danila, F_4I_3 (F_1 Ivolga x F_3I_3 D96a№2-95), F_2 Rufus, F_6I_4 Syn polka, F_7I_2 Emelya, F_7I_2 Emelya, F_5I_1 (F_1 Denek x F_3I_3 D96a№2-95) (Table 2).

Table 4

Distribution of the general totality of breeding material of Gherkin type cucumber by the level of resistance to downy mildew (natural infectious background, end of the first decade of mass fruiting)

Year	Unit of measurement	Immunological group			In total
		Resistant	Medium-resistant	Susceptible	
	scores	7	5	3–1	
	%	0,1–10	10,1–35	35,1–100	
2011	pieces	20	44	88	152
	%	13	29	58	100
2012	pieces	28	68	14	110
	%	25	62	13	100
2013	pieces	15	27	27	69
	%	22	39	39	100
In total	pieces	**63**	**139**	**129**	**331**
	%	**19**	**42**	**39**	**100**
Correlation		**1**	**2**	**2**	**5**

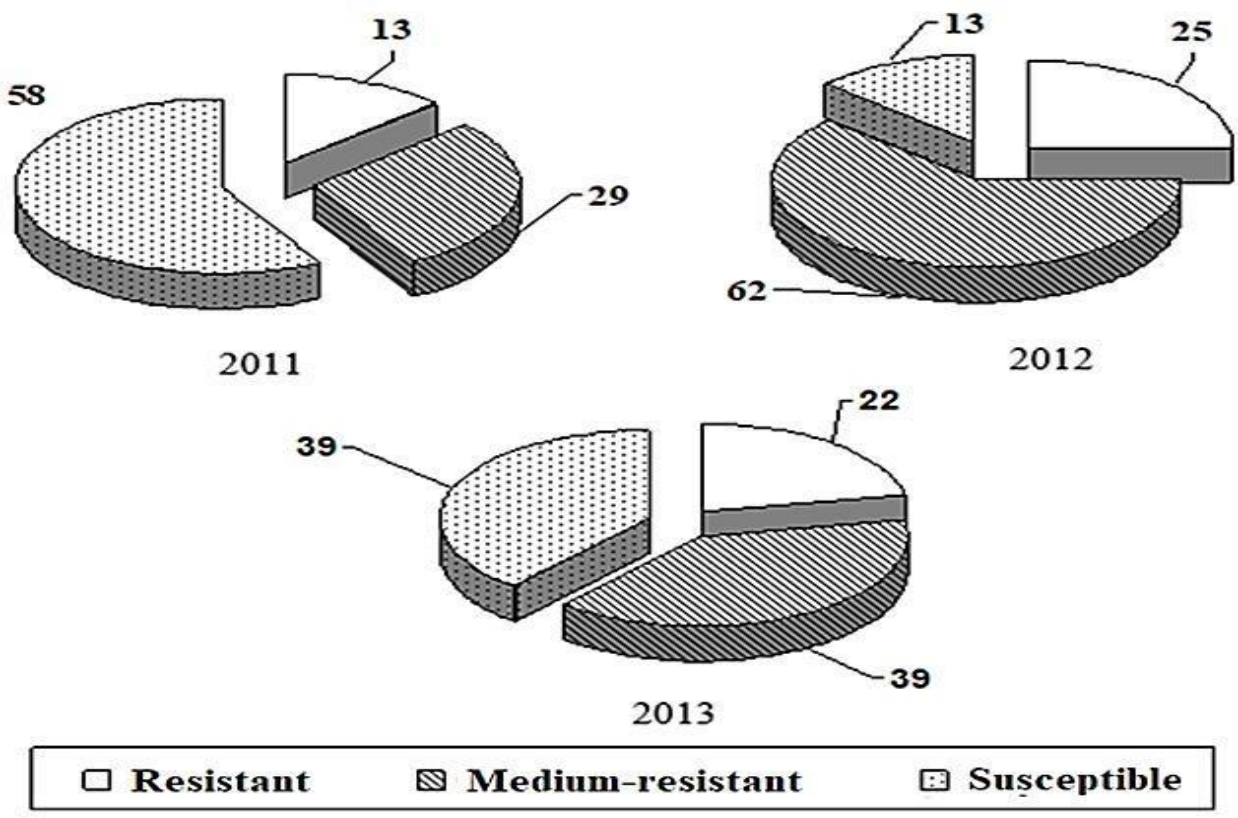

Fig. 2. Distribution of cucumber breeding material according to the expression of field resistance to downy mildew under conditions of natural infectious background, %

According to the studies results of 2012, we assigned 68 samples (62%) to the "medium resistance" group (score 5 of the immunological scale), and 14 samples (13%) we assigned to the susceptible group (scores 3-1 of the scale) (Fig. 2, Table 2, 4). A sampling of 17 samples (10.6%) from the analyzed general totality (69 samples) showed high resistance (score 7 of the immunological scale) in 2013 (Table 4).

This group includes collection and breeding samples of Gherkins, namely: Phoenix 640, Dzherelo, Geim, F_5I_2 (F_1 Bee pollinating cucumber x F_3I_3 96a№2-95), F_6I_3 (F_1 Denek x F_3I_3 96a№2-95), F_4I_1 (F_1 Saltan x F_3I_3 96a№2-95), F_3I_2 Pavlik, F_6I_5 Krak, F_6I_3 Semkross, F_5I_4 (F_1 Ivolga x F_3I_3 96a№2-95), F_7I_2 Tsezar, F_3I_3 Patriarh, F_1 (F_8I_4 Kozyrnaya karta x Dzherelo), F_6I_2 (F_1 Bee pollinating cucumber x F_3I_3 96a№2-95), F_1{F_6I_3 (F_1 Fortuna x F_3I_3 96a№2-95)} x Dzherelo (Table 3). In 2013 27 samples (39 %) from the entire analyzed totality were included in the group of medium-resistant samples (score 5 of the immunological scale). Twenty-seven genotypes (39 %) of all breeding material studied this year we assigned to the susceptible group (scores 3-1) (Fig. 2, Table 3, 4).

Thus, according to the generalizing results of the three-year immunological assessment, we will note that a sampling of 63 samples that, under the conditions of natural infectious background, showed high resistance (score 7) to downy mildew over the years was used annually at most actively by breeders for selection both for resistance and for a complex of other characteristics (Fig. 3).

Samples (139 pieces or 42 %), which showed medium resistance (score 5 of the immunological scale), were the most polymorphic and, by their composition, were a mixture of high-, medium - and low-resistance genotypes in different proportions.

We carried out the tandem selection of the best forms among the samples of this group annually, which harmoniously combined in their genotypes the trait of protracted resistance to downy mildew with a complex of other critical economic characteristics (Vitchenko & Meleshkina, 1991; Kilchevskij & Hotyleva, 2008). In our opinion, it is this group of samples that acts as the flexible, adaptive buffer (the middle zone of σ-sigma curve of the normal distribution of the resistance trait) (Dospehov, 1985), which most effectively controls the natural evolutionary processes of shaping and regulates the aggressiveness of the *Pseudoperonospora cubensis* population in agrophytocenoses.

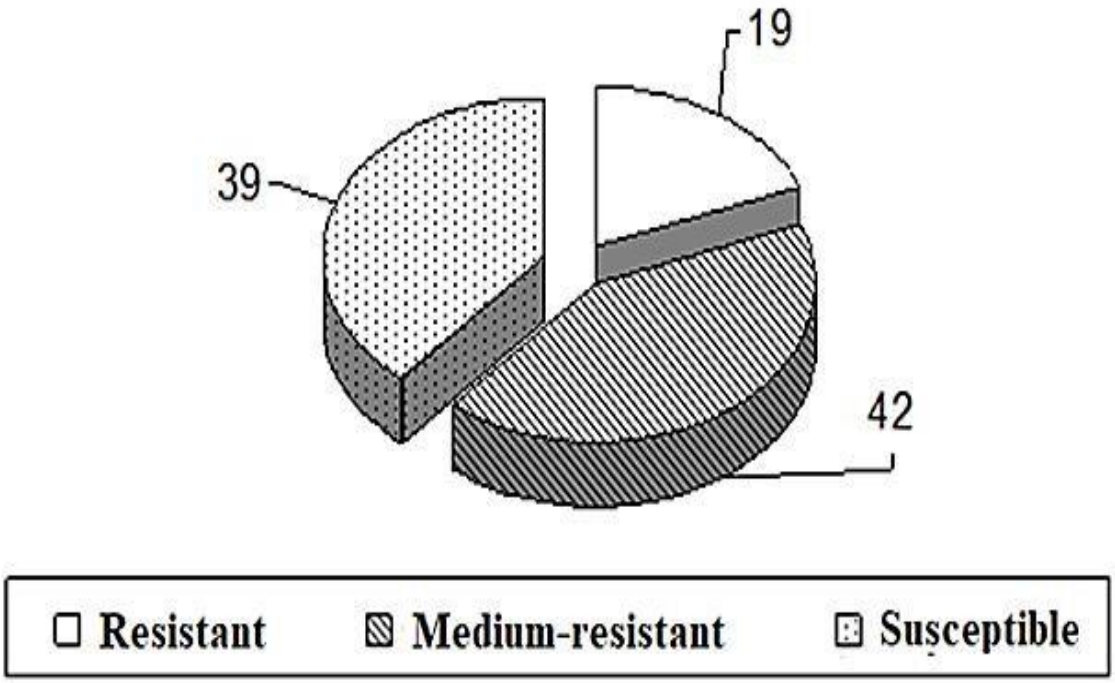

Fig. 3. Generalizing distribution of Gherkins breeding material regards the resistance to downy mildew (natural infectious background 2011-2013, %)

The whole last selective totality of the studied breeding material, represented by 129 samples (39.0 %), is classified as susceptible to downy mildew by the type of immunological reaction(scores 3, 1) (Table 4, Fig. 3). According to scientists' recommendations, samples with low expression of resistance trait to downy mildew were annually withdrawn from the breeding process (Nalobova, 2003; Shkalikov et al., 2005; Koshnikovich et al., 2008). Thus, based on the obtained summary immunological characteristics among the available breeding material, we determined the intensity of selection of downy mildew-resistant forms (genotypes) of Gherkins under conditions of natural infectious background (Plotnikova, 2007; Kirichenko & Petrenkova, 2012) (Fig. 4). Complete information on the degree (R) and intensity of downy mildew lesion (P) of cucumber breeding material studied in 2011-2013 was provided annually, in the form of an information database, to scientists of the laboratory of pumpkin plant breeding of the Institute of Vegetables and Melons growing of NAAS. So, from the above experimental material, we can draw the following generalizing conclusions. According to the level of resistance to the most common disease in the region – downy mildew, a phytoimmunological characteristic of 331 breeding samples of Gherkins was obtained, which was used annually in breeding studies in the form of a database.

NATURAL INFECTIOUS BACKGROUND The susceptibility trait to downy mildew is studying, selecting, and rejecting breeding material (collection, selection – a hybrid, linear, initial) of cucumber of Gherkin type. Conducting *tandem* selection of resistant forms with their simultaneous assessment by a complex of other valuable features (Plotnikova, 2007; Lebeda & Cohen, 2011)
2011 According to susceptibility and other traits, we rejected up to **60 %** of the breeding material (Table 1, 4)
2012 According to susceptibility and other traits, we rejected up to **40** % of the breeding material (Table 2, 4)
2013 According to susceptibility and other traits, we rejected up to **25** % of the breeding material (Table 3, 4)

Fig. 4. Scheme of assessment and stepwise selection of Gherkins initial material by the resistance trait to downy mildew

We registered that a sampling of 63 breeding samples (19%) is of practical interest for breeding programs by the resistance trait to downy mildew, the lesion degree of which by the causative agent of this disease at the end of the first decade of mass fruiting (critical phase of ontogenesis) did not exceed 10% (resistance score 7 of the REV immunological scale). For a group of 139 samples (42%) that showed medium resistance (score 5 of the REV scale) under conditions of natural infectious background, we recommended conducting an annual tandem selection of forms that are most harmoniously able to combine the trait of resistance to downy mildew with a complex of other valuable traits in their genotypes.

Conclusions

We obtained an immunological characteristic of 331 breeding samples (collection, hybrid, linear, initial material) of Gherkins of Ukrainian and World breeding according to the level of downy mildew resistance under natural infectious background. We selected groups of 63 samples (or 19 %) of cucumber– promising sources of genetic resistance to downy mildew, the lesion degree of which under the field conditions at the end of the first decade of mass plants fruiting did not exceed the value of 10 % (score 7 of the immunological scale). We identified a group of 139 samples (42 %),

which revealed suitability for purposeful tandem selection of promising sources to harmoniously combine high downy mildew resistance in their genotypes in a complex with other valuable for selection and production traits.

References

1. Blinova, T.P. (2005). Ispolzovanie provokacionnogo fona v selekcii ogurca na ustojchivost k lozhnoj muchnistoj rose. Ovoshebahchevye kultury i kartofel. Tiraspol, Tipar (in Russian)

2. Bolotskih, O.S. (1988). Operacijni tehnologiyi virobnictva ovochiv. Kyiv, Urozhaj (in Ukrainian)

3. Bondarenko, G.L. & Yakovenko, K.I. (2001). Metodika doslidnoyi spravi v ovochivnictvi i bashtannictvi. Harkiv: Osnova (in Ukrainian)

4. Bondarenko, S.V. & Solodovnik, L.D. (2012). Polimorfizm kolekcijnogo ta selekcijnogo materialu ogirka kornishonnogo tipu za kompleksom oznak. Ovochivnictvo i bashtannictvo, 58, 50–57. (in Ukrainian)

5. Bondarenko, S.V. (2011). Ogirok: suchasnij fitosanitarnij stan ta metodi zahistu vid hvorob. Visnik HNAU im. V.V. Dokuchayeva. Series "Tehnichni, silskogospodarski, ekonomichni nauki", 6(1), 32–42 (in Ukrainian)

6. Bondarenko, S.V. (2012). Urazhenist ogirka nespravzhnoyu boroshnistoyu rosoyu (Pseudoperonospora cubensis Rostow). Proceed. Int. Sc. Conf. "Ovochivnictvo Ukrayini. Naukove zabezpechennya i rezervi zbilshennya virobnictva tovarnoyi produkciyi ta nasinnya", Merefa, 2012. NAAN, IOB. Harkiv, Pleyada, 12–14 (in Ukrainian)

7. Bondarenko, S.V. (2013). Imunologichnij rozpodil selekcijnogo materialu ogirka kornishonnogo tipu za rivnem trivaloyi stijkosti do peronosporozu. Proceed. Int. Sc. Conf. "Pidvishennya stijkosti roslin do hvorob i ekstremalnih umov seredovisha v zv'yazku iz zadachami selekciyi", Harkiv, 2013. Institut roslinnictva im. V.Ya. Yur'yeva. Harkiv, Pleyada, 47. (in Ukrainian)

8. Bondarenko, S.V. (2013). Rezultaty ocenki ustojchivosti k peronosporozu linejnogo materiala ogurca kornishonnogo tipa. Proceed. Int. Sc. Conf. "Selekciya i tehnologichni innovaciyi v ovochivnictvi, rezervi zbilshennya virobnictva produkciyi ta nasinnya", Merefa, 2013. NAAN, IOB. Harkiv, Pleyada, 17–18 (in Russian)

9. Bondarenko, S.V., Chernenko, V.L. & Sergienko, O.V. (2013). Rezultaty ocenki ishodnogo materiala ogurca kornishonnogo tipa po

priznaku ustojchivosti k peronosporozu (Pseudoperonospora cubensis (Berk. & M.A.Curtis) Rostovtsev). Ovochivnictvo i bashtannictvo, 59, 251–264 (in Russian)

10. Bondarenko, S.V., Stankevych, S.V., Matsyura, A.V., Zhukova, L.V., Zabrodina, I.V., Rysenko, M.M., Golovan, L.V., Romanov, O.V., Romanova, T.A., Novosad, K.B., Klymenko, I.V., Ye.Yu. Kucherenko, Ye.Yu., Zviahintseva, A.M. (2021). Major cucumber diseases and the crop immunity. *Ukrainian Journal of Ecology*, 11 (1), 46-54. DOI: 10.15421/2021_7

11. Bondarenko, S.V., Stankevych, S.V., Zhukova, L.V. et al. (2021). Zonal pathogenic community formation of gherkin hybrid cucumber under open ground conditions. *Ukrainian Journal of Ecology*, 11 (2), 327-339. DOI: 10.15421/2021_118

12. Bondarenko, S.V., Stankevych, S.V., Zhukova, L.V. et al. (2021). Immunological characteristic of Gherkins breeding materials towards resistance to downy mildew. *Ukrainian Journal of Ecology*, 11 (3), 240-247. DOI: 10.15421/2021_167

13. Bondarenko S., Stankevych S., Zhukova L., et al. (2021). Increase in cucumber cropping capacity and resistance to downy mildew. *Ukrainian journal of ecology*. №11 (10) P. 48–54. DOI: 10.15421/2021_318

14. Bondarenko S.V., Stankevych S.V., Polozhenets V.M., Nemerytska L.V., Zhuravska I.A. (2022). Downy mildew of cucumber of Gherkin type and immunological potential of breeding material: monograph. Zhytomyr: Ruta Publishing House, 109.

15. Bondarenko S., Romanova T., Romanov O., Stankevych S. (2022). Diagnostics, prevalence and harmfulness of the main cucumber diseases of gherkin type. Modern trends in the development of agricultural production: problems and perspectives: monograph. Edited by S. Stankevych, O. Mandych. Tallinn: Teadmus OÜ, 55-71.

16. Buriev, H.Ch. et al. (2004). Ustojchivost sortoobrazcov ogurca k boleznyam. Zashita i karantin rastenij, №6, 47 (in Russian)

17. Chaban, V.S. (1993). Epifitotiya nespravzhnoyi boroshnistoyi rosi ogirka na Ukrayini ta mozhlivi shlyahi yiyi podolannya. Zahist i karantin roslin, 40, 18–19 (in Ukrainian).

18. Chernenko, V.L. et al. (2013). Osobennosti vzaimosvyazi osnovnyh kachestvenyh i kolichestvennyh priznakov s vredonosnostyu peronosporoza u ogurca kornishonnogo tipa. Visnik HNAU im. V.V. Dokuchayeva. Series “Fitopatologiya ta entomologiya?, 10, 179–185 (in Russian)

19. Chernenko, V.L., Sergienko, O.V. & Bondarenko S.V. (2014). Zavisimost hozyajstvenno-cennyh priznakov ogurca kornishonnogo tipa ot ustojchivosti k peronosporozu. Zashita i karantin rastenij, 10, 44–45. (in Russian)

20. Chistyakova, L.A. & Biryukova, N.K. (2012). Ocenka selekcionnyh linij ogurca na ustojchivost k peronosporozu i muchnistoj rose. Gavrish, 1, 38– 41 (in Russian)

21. Dhillon, N.P.S., Pushpinder, P.S. & Ishiki, K. (1999). Evaluation of landraces of cucumber (Cucumis sativus L.) for resistance to downy mildew (Pseudoperonospora cubensis). Plant Genetic Resources Newsletter, 119, 59–61.

22. Dospehov, B.A. (1985). Metodika polevogo opyta (s osnovami statisticheskoj obrabotki rezultatov issledovanij). Moscow, Agropromizdat, 351 (in Russian)

23. Gannibal, F.B., Gasich, E.L. & Orina, A.S. (2011). Ocenka ustojchivosti selekcionnogo materiala krestocvetnyh i paslyonovyh kultur k alternariozam. Metodicheskoe posobie. Sankt-Peterburg, GNU VIZR Rosselhozakademii (in Russian)

24. Gorbatenko, I.Yu., Holodnyak, O.G. & Shvartau, V.V (2011). Ogirok. geni stijkosti. Kyiv, Logos (in Ukrainian)

Gorohovskij, V.F. & Berlin, O.S. (2009). Selekciya pchelo-opylyaemogo ogurca na ustojchivost k boleznyam. Zbirnik naukovih prac SGI, 13 (53), 119–126 (in Russian)

25. Kartashov, I.A. & Kazakova, V.S. (1988). Izuchenie ustojchivosti k boleznyam sortov ogurca dlya industrialnoj tehnologi vozdelyvaniya. Zashita rastenij ot vreditelej, boleznej i sornyh rastenij. Stavropol, 57–59 (in Russian)

30. Kilchevskij, A.V. & Hotyleva, L.V. (2008). Geneticheskie osnovy selekcii rastenij. Obshaya genetika rastenij. Minsk, Belorusskaya nauka (in Russian)

31. Kirichenko, V.V. & Petrenkova, V.P. (2012). Osnovi selekciyi polovih kultur na stijkist do shkidlivih organizmiv: navchalnij posibnik; NAAN. Harkiv, In-t roslinnictva im. V.Ya. Yur'yeva (in Ukrainian)

32. Koshnikovich, V.I., Sherbinin, A.G. & Timoshenko, N.N. (2008). Peronosporoz ogurca. Novosibirsk, ZAO "Novosibirskij poligrafkombinat" (in Russian)

33. Lebeda, A. & Cohen, Y. (2011). Cucurbit downy mildew (*Pseudoperonospora cubensis*) – biology, ecology, epidemiology, host-pathogen interaction and control. *Eur. J. Plant. Pathol*., 129, 157–192.

34. Mitchell, M.N. et al. (2011). Genetic and pathogenic relatedness of *Pseudoperonospora cubensis* and *P. humuli*. *Phytopathology*, 101, 805–818.

35. Nalobova, V.L. (2003). Immunologicheskaya harakteristika kollekcionnogo ta selekcionnogo materiala ogurca. Izvestiya Nacionalnoj akademii nauk Belarusi, 1, 42–44 (in Russian)

36. Nalobova, V.L. (2005). Selekciya ogurca na ustojchivost k boleznyam. Minsk: Belprint Russian)

37. Nalobova, V.L. (2008). Podbor ishodnogo materiala dlya selekcii korotkoplodnyh sortov i gibridov ogurca kornishonnogo tipa. Ovoshevodstvo, 14, 105–110. (in Russian)

38. Plotnikova, L.Ya. (2007). Immunitet rastenij i selekciya na ustojchivost k boleznyam i vreditelyam. Moscow, Kolos (in Russian)

39. Shihmatova, O.V. (2006). Ocenka obrazcov dlya selekcii ogurca na ustojchivost k peronosporozu. Kartofel i ovoshi, 6, 28 (in Russian) Shkalikov, V.A. et al. (2005). Immunitet rastenij. Moscow, Kolos (in Russian)

40. Skripnik, H.B. & Lopotun, N.L. (2003). Poshuk dzherel stijkosti proti zbudnika nespravzhnoyi boroshnistoyi rosi ogirka. Zahist i karantin roslin, 49, 168–174. (in Ukrainian)

41. Strajstar, E.M. (1991). Sozdanie ishodnogo materiala dlya selekcii ogurca na ustojchivost k lozhnoj muchnistoj rose i drugie cennye priznaki. Thesis of Doctoral Dissertation. Leningrad (in Russian)

42. Tockij, V.M. (2002). Genetika. Odesa, Astroprint, 578–580 (in Russian)

43. Vitchenko, E.F. & Meleshkina, T.N. (1991). Vyvedenie sortov i gibridov ogurca, ustojchivyh k peronosporozu. Selekciya, semenovodstvo i agrotehnika ovoshnyh kultur. Novosibirsk (in Russian)

44. Yarovii, G.I. (2006). Dovidnik z pitan zahistu ovochevih i bashtannih roslin vid shkidnikiv, hvorob ta bur'yaniv. Harkiv, Pleyada (in Ukrainian)

45. Yevtushenko, M.D. et al. (2004). Imunitet roslin. Kyiv, Kolobig (in Ukrainian)