















Immunological characteristic of Gherkins breeding materials towards resistance 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.

Keywords: 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:

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

where $\sum(a \cdot b)$ 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).

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).



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

Experimentally obtained data were processed using statistical methods of analysis – variational, correlation, and dispersal (Dospheov, 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).

Table 1. The reaction of *Cucumis sativus* L. genotypes to the intensity of downy mildew lesion under open ground conditions, 2011

Scale of assessment of resistance score	of lesion degree %	Number pieces	The original name of the sample
9	0	0	there is no
7	0.1–10	20	F1 Ajax – standard, Dzherelo – standard, Phoenix 640 – standard , F ₃ l ₂ (F ₁ Patriarh x F ₃ l ₂ D96a№2-96), F ₁ (F ₃ l ₃ Fansipak x F ₄ l ₁ Solovey), F ₃ l ₂ (F ₁ Ivolga x F ₃ l ₃ D96a№2-95), F ₄ l ₂ Semkross, F ₄ l ₂ Semkross, F ₄ l ₁ Semkross, F ₄ l ₂ Krak, F ₅ (F ₂ Regina x F ₁ Mazaj), F ₅ (F ₂ Regina x F ₁ Mazaj), F ₅ l ₁ (F ₂ Regina x F ₁ Mazaj), F ₅ l ₂ (F ₁ Maliia x Geim), F ₅ l ₁ Hermes Skerneytsky, F ₅ l ₃ (F ₁ Romans x F ₃ l ₃ D96a№2-95), F ₆ l ₁ Zasoliuvalny, F ₆ l ₁ Zasoliuvalny, F ₁ (Nizhynsky local x Era), F ₁ (Nizhynsky 12 x Nosivsky).
5	10.1–35	44	F ₁ Samorodok, F ₃ l ₁ Nastoyashchij polkovnik, F ₇ l ₄ Kozyrnaia karta, F ₄ l ₃ Danila, F ₄ l ₃ Muravej, F ₅ l ₂ Amur, F ₅ l ₂ Yemelia, F ₆ l ₃ Gepard, F ₆ l ₄ Polina, F ₆ l ₃ Podmoskovnye vechera, F ₁ l ₁ Gerkin, F ₃ l ₂ (F ₁ Buyan x F ₃ l ₃ D96a№2-96), F ₅ l ₂ (F ₁ Aurach x F ₃ l ₃ D96a№2-95), F ₅ l ₃ (F ₁ Fortuna x F ₃ l ₃ D96a№2-95), F ₁ (F ₃ l ₂ Fansipak x F ₃ l ₁ line P-1), F ₁ (F ₅ l ₁ Donia x line 23162 D96a№2-95), F ₁ (Gerkin x bush cucumber), F ₃ l ₁ (F ₁ Ivolga x F ₃ D96a№2-95), F ₃ l ₁ (F ₁ Ivolga x F ₃ D96a№2-95), F ₃ l ₁ Yulian, F ₄ l ₂ (F ₁ Mastak x F ₃ l ₃ D96a№2-95), F ₄ l ₁ Prestige, F ₄ l ₂ Krak, F ₄ Pervyj klass, F ₄ Tsygan, F ₄ l ₂ Tsygan, F ₄ (F ₁ Finist x Phoenix), F ₄ (F ₁ Phoenix x Finist), F ₃ l ₃ Odocheck, F ₅ (F ₂ Regina x Mazaj), F ₅ l ₂ Potomak, F ₅ l ₂ (F ₁ Maliia x Geim), F ₅ l ₂ (F ₁ Maliia x Geim), F ₅ l ₃ Syn polka, F ₅ l ₃ Syn polka, F ₆ l ₂ Zasoliuvalny, F ₁ Etap, F ₂ l ₁ (Geim x Nizhynsky 12), F ₂ l ₁ (Dzherelo x Nizhynsky 12), F ₂ (Era x Geim), F ₂ (Era x Geim), F ₂ l ₁ (Era x Nizhynsky 12), F ₁ (Geim x Nizhynsky local), F ₁ (Nosivsky x Nizhynsky Local).
3	35.1–50	42	F ₄ l ₂ zyd, F ₆ l ₃ Chistyie prudy, F ₃ l ₂ Denek, F ₄ l ₁ (F ₁ Denek x F ₃ l ₃ D96a№2-95), F ₁ (F ₄ l ₁ line P-1 x F ₃ l ₃ D96a№2-95), F ₁ (F ₈ l ₃ Donia x F ₁ l ₁ Dzherelo), F ₁ (F ₈ l ₃ Donia x F ₅ l ₁ Solovey), F ₁ (F ₅ l ₃ Ametyst x F ₄ l 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 ₁ l ₁ Melnitsa, F ₁ l ₁ Melnitsa, F ₂ l ₂ Bush cucumber, F ₃ (F ₁ Sultan x F ₃ l ₃ D96a№2-95), F ₄ l ₃ Krak, F ₄ Pervyj klass, F ₄ l ₂ Tsygan, F ₄ l ₁ Tsygan F ₄ (F ₁ Romans x F ₃ l ₃ D96a№2-95), F ₄ (F ₁ Romans x F ₃ l ₃ D96a№2-95), F ₄ l ₁ (F ₁ Romans x F ₃ l ₃ D96a№2-95), F ₃ l ₃ Odocheck, F ₆ l ₃ (F ₁ Masha x Geim), F ₁ Etap, F ₂ l ₁ (Nizhynsky 12 x 2316D96a№2-3), F ₂ l ₁ (Geim x Nizhynsky 12), F ₂ l 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 ₃ l 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 ₄ l ₂ Odogs, F ₄ l ₁ Zhelud, F ₄ l ₁ Regina plus, F ₅ l ₁ Kuznechik, F ₅ l ₃ Syn polka, F ₃ (Amur x Geim), F ₄ l ₂ (F ₁ Mar'ina roshcha x F ₃ l ₃ D96a№2-95), F ₁ (Gerkin x bush cucumber), F ₂ Hrustyashchij, F ₁ Gomes, F ₂ Gomes, F ₂ l ₁ Bush cucumber, F ₂ l ₁ Bush cucumber, F ₂ l ₂ Bush cucumber, F ₂ l ₂ Bush cucumber, F ₂ l ₂ Bush cucumber, F ₁ l ₁ Bush cucumber from Russia, F ₁ Bush cucumber from Russia F ₃ l ₂ Finist, F ₃ l ₁ Finist, F ₃ l ₁ Finist, F ₃ Tomast, F ₁ Filippok, F ₂ Filippok, F ₂ l ₁ Filippok, F ₃ l ₁ Filippok, F ₃ l ₂ Filippok, F ₃ Filippok, F ₃ Yulian, F ₃ Yulian, F ₃ Yulian, F ₃ (F ₁ Sultan x F ₃ l ₃ D96a№2-95), F ₅ l ₁ Tsezar, F ₆ l ₂ Tsezar, F ₂ (Dzherelo x Nizhynsky local), F ₂ l 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 ₁ l ₁ Dzherelo), F ₁ (Nizhynsky 12 x F ₁ l ₁ Dzherelo), Unknown hybrid, F ₈ l ₅ Kozyrnaya karta, F ₁ (Buyan F ₁ x Bush cucumber).

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 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 F₁ (Netherlands), during this period did not exceed the mark of 20-34% 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. The reaction of *Cucumis sativus* L. genotypes to the intensity of downy mildew lesion under open ground conditions, 2012

Scales of assessment		Number	The 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 ₇ 5 Chistyie prudy, F ₈ 2 Begio 1802, F ₉ 2 Fansipak, F ₄ 2 Nastoyashchij polkovnik, F ₅ 3 Odys, F ₆ 3 Amur, F ₅ 2 Mirabell, F ₅ 3 (F ₁ Mar'ina roshcha x F ₃ 3 D96a№2-95), F ₃ 3 (F ₁ Fortuna x F ₃ 3 D96a№2-95), F ₇ 4 Podmoskovnye vechera, F ₁ Zhelud, F ₅ 2 (F ₁ Denek x F ₃ 3 D96a№2-95), F ₅ Izyd, F ₃ 1 Pavlik, F ₅ 3 Krak, F ₄ 1 Semkross, F ₄ 3 Danila, F ₄ 3 (F ₁ Ivolga x F ₃ 3 D96a№2-95), F ₂ Rufus, F ₆ 4 Syn polka, F ₇ 2 Emelya, F ₇ 2 Emelya, F ₅ 1 (F ₁ Denek x F ₃ 3 D96a№2-95), F ₃ 1 Pavlik, F ₅ 4 Krak
5	10.1–35	68	F ₁ Samorodok, F ₅ 2 Zhelud, F ₅ 1 Romans, F ₇ 2 Polina, F ₅ 2 Mirabell, F ₅ 2 Mirabell, F ₆ 1 (F ₁ bee pollinating cucumber x F ₃ 3 D96a№2-95), F ₈ 5 Kozyrnaya karta, F ₄ 1 (F ₁ Saltan x F ₃ 3 D96a№2-95), F ₆ 2 Tsezar, F ₂ 1 Rufus, F ₂ Rufus, F ₂ Tytus, F ₂ 1 Gector, F ₂ Gerkin, F ₂ Gerkin, F ₂ 1 Gerkin, F ₄ 1 Nastoyashchij polkovnik, F ₅ 3 Odys, F ₅ 2 Odys, F ₅ 3 Regina plus, F ₅ 1 Regina plus, F ₇ 4 Chistyie prudy, F ₇ 3 Chistyie prudy, F ₇ 3 Chistyie prudy, F ₇ 2 Emelya, F ₇ 2 Emelya, F ₇ 6 Polina, F ₇ 4 Podmoskovnye vechera, F ₇ 4 Podmoskovnye vechera, F ₅ 1 (F ₁ Denek x F ₃ 3 D96a№2-95), F ₅ 1 (F ₁ Denek x F ₃ 3 D96a№2-95), F ₅ 1 Pervyj klass, F ₅ Pervyj klass, F ₅ Pervyj klass, F ₅ 2 (F ₁ Romans x F ₃ 3 D96a№2-95), F ₆ 5 (F ₁ Romans x F ₃ 3 D96a№2-95), F ₆ 4 (F ₁ Romans x F ₃ 3 D96a№2-95), F ₅ 3 Semkross, F ₅ 2 Semkross, F ₃ 2 Pavlik, F ₃ 1 Hrustyashchij, F ₃ 1 Hrustyashchij, F ₃ 1 Hrustyashchij? F ₃ 2 Bush cucumber, F ₄ 2 (F ₁ Ivolga x F ₃ 3 D96a№2-95), F ₄ 3 Finist, F ₄ 2 Finist, F ₄ 2 Yulian, F ₄ 1 (F ₁ Saltan x F ₃ 3 D96a№2-95), F ₄ 1 (F ₁ Saltan x F ₃ 3 D96a№2-95), F ₄ 1 (F ₁ Saltan x F ₃ 3 D96a№2-95), F ₄ 2 Mestnyj, F ₄ 2 Mestnyj, F ₄ 1 Mestnyj, F ₄ 1 (F ₁ Mastan x F ₃ 3 D96a№2-95), F ₅ (F ₁ Finist x Phoenix), F ₅ 2 Yanus, F ₅ 2 Yanus, F ₆ (F ₂ Regina x F ₁ Mazaj), F ₄ 1 Potomak, F ₄ 1 Potomak, F ₆ 3 (F ₁ Masha x Geim), F ₆ 2 Tsezar, F ₇ 4 (F ₁ Masha x Geim), F ₇ 4 (F ₁ Masha x Geim), F ₇ 3 (F ₁ Masha x Geim), F ₇ 2 Zasolochnyj, F ₇ 2 Zasolochnyj.
3	35.1–50	13	F ₉ 7 Ajax, F ₂ 1 Gector, F ₅ 2 Mazaj, F ₅ 1 Regina plus, F ₇ 5 Polina, F ₈ 6 Kozyrnaya karta, F ₃ 1 Pavlik, F ₆ 2 Tsezar, F ₃ 2 Bush cucumber, F ₃ 2 Bush cucumber, F ₃ Tomast, F ₅ (F ₁ Finist x Phoenix), F ₅ 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).

Table 3. The reaction of *Cucumis sativus* L. genotypes to the intensity of downy mildew lesion under open ground conditions, 2013

Scales of assessment of resistance	of lesion degree	Number	The original name of the sample
9	0	0	There is no
7	0.1–10	15	Phoenix 640 – standard, Dzherelo – standard , F ₅ l ₂ (F ₁ Bee pollinating cucumber x F ₃ l ₃ 96a№2-95), F ₆ l ₃ (F ₁ Denek x F ₃ l ₃ 96a№2-95), F ₄ l ₁ (F ₁ Saltan x F ₃ l ₃ 96a№2-95), F ₃ l ₂ Pavlik, F ₆ l ₅ Krak, F ₆ l ₃ Semkross, F ₅ l ₄ (F ₁ Ivolga x F ₃ l ₃ 96a№2-95), F ₇ l ₂ Tsezar, F ₃ l ₃ Patriarh, F ₁ (F ₈ l ₄ Kozyrnaya karta x Dzherelo), F ₆ l ₂ (F ₁ Bee pollinating cucumber x F ₃ l ₃ 96a№2-95), F ₁ {F ₆ l ₃ (F ₁ Fortuna x F ₃ l ₃ 96a№2-95)} x Dzherelo, Geim.
5	10.1–35	27	F1 Ajax – standard , F ₉ l ₆ Bejio 1802, F ₁₀ l ₆ Fansipak, F ₂ l ₁ Rufus, F ₃ l ₂ Gektar, F ₆ l ₃ Odys, F ₆ l ₂ Mirabella, F ₆ l ₄ (F ₁ Marina roshcha x F ₃ l ₃ 96a№2-95), F ₈ l ₄ Patriarh, F ₉ l ₅ Kozyrnaya karta, F ₆ lzyd, F ₅ l ₃ Danila, F ₇ l ₃ Potomak, F ₁ (F ₅ l ₃ Odys x Dzherelo), F ₁ {F ₆ l ₂ (F ₁ Bee pollinating cucumber x F ₃ l ₃ 96a№2-95)} x Dzherelo, F ₁ (F ₅ l ₄ Krak x Dzherelo), F ₅ l ₄ Krak, F ₁ (F ₆ l ₃ Potomak x Dzherelo), F ₁ {F ₆ l ₃ (F ₁ Fortuna x F ₃ l ₃ 96a№2-95) x Geim}, F ₁ (F ₅ l ₄ Krak x Geim), F ₄ l ₃ (F ₁ Ivolga x Geim x F ₃ l ₃ 96a№2-95), F ₁ {F ₅ l ₁ (F ₁ Romans x 57787 x F ₃ l ₃ 96a№2-95) x Phoenix 640}, F ₁ (F ₅ l ₄ Krak x Phoenix 640), F ₁ {F ₄ l ₃ (F ₁ Ivolga x F ₃ l ₃ 96a№2-95) x Phoenix 640}, F ₁ (F ₆ l ₂ Tsezar x Phoenix 640), F ₆ l ₃ Potomak, F ₁ {F ₆ l ₃ (F ₁ Masha x Geim) x Phoenix 640}, F ₁ (F ₅ l ₂ Zhelud x F ₈ l ₂ Bejio 1802).
3	35.1–50	20	F ₅ l ₃ Zhelud, F ₆ l ₂ (F ₁ Romans x F ₃ l ₃ D-96№2-95), F ₈ l ₆ Ajax, F ₅ l ₅ Polina, F ₃ l ₂ Tytus, F ₅ l ₂ Mirabella, F ₆ l ₃ (F ₁ Fortuna x F ₃ l ₃ 96a№2-95), F ₈ l ₅ Patriarh, F ₇ l ₃ (F ₁ Masha x Geim), F ₅ l ₃ Odys, F ₆ l ₃ Potomak, F ₁ {F ₆ l ₃ (F ₁ Masha x Geim) x Dzherelo, F ₆ l ₃ (F ₁ Masha x Geim), F ₁ (F ₅ l ₂ Zhelud x Phoenix 640), F ₁ {F ₆ l ₃ (F ₁ Fortuna x F ₃ l ₃ 96a№2-95) x Phoenix 640}, F ₈ l ₂ Bejio 1802, F ₅ l ₅ Bejio 1802, F ₉ l ₅ Fansipak, F ₁ (F ₇ l ₅ Ajax x F ₉ l ₅ Fansipak), F ₇ l ₅ Ajax.
1	50.1–100	7	Nizhynsky local – standard , F ₈ l ₇ Kozyrnaya karta, F ₁ (F ₅ lzyd x Phoenix), F ₅ lzyd, F ₅ l ₂ Zhelud, F ₆ l ₂ Tsezar, F ₁ (F ₆ l ₃ Potomak x Phoenix 640).

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), F₃l₂ (F₁ Patriarh x F₃l₂ D96a№2-96), F₁ (F₃l₃ Fansipak x F₄l₁ Solovey), F₃l₂ (F₁ Ivolga x F₃ D96a№2-95), F₄l₃ Semkross, F₄l₂ Semkross, F₄l₁ Semkross, F₄l₂ Krak, F₅ (F₂ Regina x F₁ Mazaj), F₅ (F₂ Regina x F₁ Mazaj), F₅l₁ (F₂ Regina x F₁ Mazaj), F₅l₂ (F₁ Maliia X Geim), F₅l₁ Hermes Skernevitsky, F₅l₃ (F₁ Romans x F₃l₃ D96a№2-95), F₆l₁ Zasoliuvalny, F₆l₁ Zasoliuvalny, F₁ (Nizhynsky Local x Era) and F₁ (Nizhynsky 12 x Nosivsky) (Table 1).

Table 4. Distribution Gherkins breeding material by 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	
		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

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 F₁, Dzherelo, Phoenix 640 (standards); breeding – F₇l₅ Chistye prudy, F₈l₂ Begio 1802, F₉l₂ Fansipak, F₄l₂ Nastoyashchij polkovnik, F₅l₃ Odys, F₆l₃ Amur, F₅l₂ Mirabell, F₅l₃ (F₁ Mar'ina roshcha x F₃l₃ D96a№2-95), F₃l₃ (F₁ Fortuna x F₃l₃ D96a№2-95), F₇l₄ Podmoskovnye vechera, F₇l₃ Patriarh, F₅l₂ (F₁ Denek x F₃l₃ D96a№2-95), F₅ lzyd, F₃l₁ Pavlik, F₃l₂ Pavlik, F₅l₃ Krak, F₅l₄ Krak, F₄l₁ Semkross, F₄l₃ Danila, F₄l₃ (F₁ Ivolga x F₃l₃ D96a№2-95), F₂ Rufus, F₆l₄ Syn polka, F₇l₂ Emelya, F₇l₂ Emelya, F₅l₁ (F₁ Denek x F₃l₃ D96a№2-95) (Table 2).

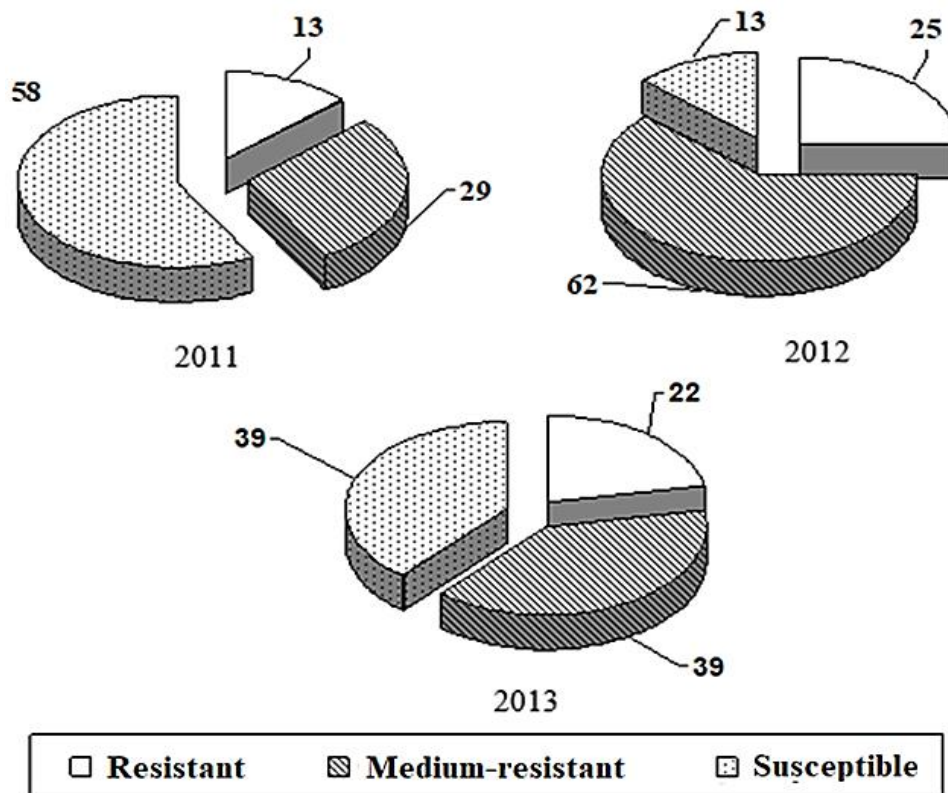


Fig. 2. Distribution of cucumber breeding material according to the expression of field resistance to downy mildew under conditions of natural infectious background, %

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, F₅l₂ (F₁ Bee pollinating cucumber x F₃l₃ 96a№2-95), F₆l₃ (F₁ Denek x F₃l₃ 96a№2-95), F₄l₁ (F₁ Saltan x F₃l₃ 96a№2-95), F₃l₂ Pavlik, F₆l₅ Krak, F₆l₃ Semkross, F₅l₄ (F₁ Ivolga x F₃l₃ 96a№2-95), F₇l₂ Tsezar, F₃l₃ Patriarh, F₁ (F₈l₄ Kozyrnaya karta x Dzherelo), F₆l₂ (F₁ Bee pollinating cucumber x F₃l₃ 96a№2-95), F₁{F₆l₃ (F₁ Fortuna x F₃l₃ 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) (Dospheov, 1985), which most effectively controls the natural evolutionary processes of shaping and regulates the aggressiveness of the *Pseudoperonospora cubensis* population in agrophytocenoses.

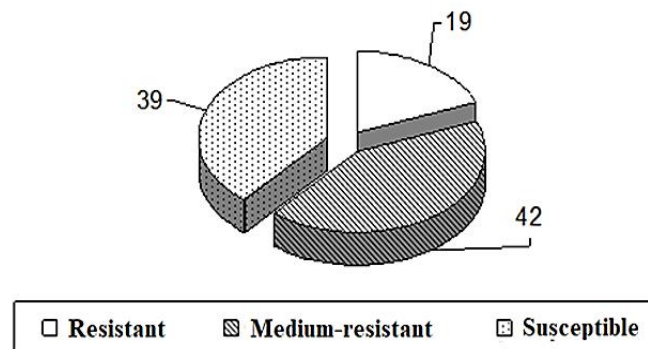


Fig. 3. Generalizing distribution of Gherkins breeding material regards the resistance to downy mildew (natural infectious background 2011-2013, %)

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 <i>tandem</i> 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.

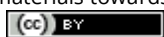
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