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ORIGINAL ARTICLE

Variability of the initial breeding material of cucumber by resistance to downy mildew and main traits

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It was found that in samples from the resistant group, compared to the susceptible group, the difference between the average values of the reaction norm range for parameters such as the total cropping capacity is 4 times greater, the cropping capacity for the first decade of fruiting is 2.4 times, and the duration of the mass fruiting period is 2.3 times. It was determined that the initial breeding material (linear) of Gherkin-type cucumbers selected for resistance had an average range (Cv=10-20%) and a high range (Cv <20%) range of variability in 24 main valuable approbatory and economic traits, which are in demand in production, allowing mobile solutions to the main demands that consumers of the final product variety or hybrid make to breeders. It was found that the initial parental (male) form against the background of different resistances of the maternal one is the leading carrier and transmitter of the resistance trait in downy mildew to the hybrid generation F_1 with an intermediate and positive character of its dominance. It was determined that a rise in the main parameters of the harmfulness of downy mildew under field conditions directly affects the decrease in cucumber indicators such as total cropping capacity (by 52-55%), commercial cropping capacity (by 47-56%), the duration of the fruiting period (by 37-42%), the number of fruits on the plant at the end of the first decade of mass fruiting (by 38%) changes the biochemical composition of fruit in the direction of increase in their dry matter content by 41-45%. With the help of correlation analysis among the 30 main economic and approbatory traits, a group of inert (21 pieces) was identified, with which the breeder can work individually, without caution that an artificial change in their characteristics in the breeding process for downy mildew resistance can negatively affect the final result of the breeding process for other traits.

Keywords: Cucumber, diseases, prevalence, phytopathological complex, immunity, selection, variety, hybrid.

Introduction

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

For this purpose, it is primarily 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 types of phytopathogens 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 (Badr & Mohamed, 1999; Blinova, 2005; Gorbatenko, Holodnyak & Shvartau, 2011).

So, at present, a comprehensive assessment of breeding material (in a broad aspect) 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 Gherkin-type cucumber is highly relevant and priority for domestic agricultural science (Chaban, 1993; Skripnik & Lopotun, 2003).

Scientists have determined that the breeding of cucumbers for disease resistance should be carried out stepwise, that is, by gradually giving the breeding material resistance to the most common pathogens-by analogy with the spontaneous formation of this protracted sign in natural populations of these organisms (Efimov, Sklyarevskaya, & Olhovskaya, 1978; Nalobova, 2005).

World experience proves that it is the use of such a theoretical approach that makes it possible to most effectively distinguish among the breeding material of cucumber of Gherkin type the initial material that is highly resistant to downy mildew against the background of a consistently high expression of other valuable traits and successfully use it in breeding programs to solve the most relevant problems of increasing its commercial production (Nalobova, 2008).

Individual traits, inherent in any living organism, are interconnected and form the so-called 'correlation pleiad or dendrite', which regulates all the processes of its vital activity. At the same time, the tightness and direction of relationships between traits in this structure are fully responsible for the degree of object integration in the environment. An important specific feature of such correlation structures is that they represent certain groups (correlation Pleiades), each of which combines the most strongly related traits. This allows scientists to more effectively control the effectiveness of the breeding process, especially at its final stages (Koshnikovich, Sherbinin, & Timoshenko, 2008).

The structure of these relationships in the adaptive breeding of vegetable crops, including cucumbers, is very important, because they allow the breeder to indirectly judge the direction and tightness of the influence of one selective (working) trait on others (Nalobova, 2005).

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:

$P=(a/N) \bullet 100$ ....(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:

$R=(\Sigma(a \bullet b)/N \bullet K) \bullet 100$ ....(2)

where ∑(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 of 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 F_1 (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, Sherbinin & Timoshenko, 2008; Chistyakova & Biryukova, 2012).

Experimentally obtained data were processed using statistical analysis-variational, correlation, and dispersal (Dospehov, 1985; Bondarenko & Yakovenko, 2001; Chistyakova & Biryukova, 2012; http://www.statstutor.as.uk/resources/uploaded/ pearsons.pdf).

The economic effect of growing Gherkin type cucumber samples in the field with different resistance characteristics to downy mildew was determined according to a typical technological map for growing this vegetable crop (Bolotskih, 1988; Bondarenko & Yakovenko, 2001).

Based on the above, the purpose of this block of research was to determine the level of variability (stability) of the main traits of cucumber of Gherkin type in obtaining new initial forms that can meet different consumers' needs and tastes of the created final breeding innovative product-variety or hybrid.

The characteristic of the variability level of the main traits in the newly created initial material of Gherkin type cucumber was studied according to the "Methods of examining varieties for Difference, Uniformity and Resistance (DUR)" (Ermakov, 1987), chemical assessment of fruit quality (dry matter content, sugars, nitrates) was carried out according to the "Methods of biochemical plants research" (Ohorona prav na sorti roslin, 2004).

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

The main object for this research area was the initial breeding (linear) material of Gherkin type cucumber of nursery gardens of preliminary and competitive variety testing. In the future, all obtained experimental data on a complex of essential economic characteristics (5 pieces) and 22 approbatory traits were processed by variational analysis (Dospehov, 1985).

Under the weather, climatic and economic conditions that have developed today in Ukraine, an important stage in cucumber breeding is creating hybrids and varieties based on specially selected initial material based on resistance to the most common diseases, yield, and technological qualities. Of particular breeding value are the initial forms which harmoniously combine in their genotypes resistance to diseases with the maximum possible combination of a complex of valuable traits with the genetic ability to transmit the specified complex of traits to hybrids when crossing with the maximum possible heterotic effect (Gorohovskij & Berlin, 2009).

Studies of N.I. Medviedieva, V.F. Pivovarov, E.G. Dobrutska and N.M. Balashova (*cited* by Nalobova, 2005) revealed that cucumber resistance to downy mildew by a genetic basis is a polygenic trait that is inherited recessively.

In order to confirm or refute this fact, under conditions of the Left-Bank Forest-Steppe of Ukraine, we have analyzed the results of the crossing of the initial material of Gherkin type cucumber of different resistance to downy mildew and the obtained hybrid generation F_1.

With the help of these studies, we have found out the specificity of the dominance of downy mildew resistance trait in F_1 hybrids at different crossing combinations of different in the resistance initial (parental) material.

Thus, the parental pairs involved in the hybridization process had different resistance to this disease under conditions of the natural infectious background of 2013-at the level of scores 7-1 of the immunological scale (Table 1).

The degree of dominance (*Hp*) of the resistance trait to downy mildew in Gherkin type cucumber F_1 hybrids was determined by the formula 3:

$$Hp = \frac{F_1 - MF}{HF - MF}, \quad \text{....(3)}$$

Where F_1 is an average indicator of the resistance trait in the hybrid combination;

MF is an average value of the resistance trait in parental components;

HF is the maximum value of the trait of the best parental form (40, 89).

Values of *Hp*: from -∞ to -1 is negative overdominance of a trait (-OD); from -1 to -0.5-negative dominance (-D); from -0.5 to 0.5-intermediate dominance (ID), from 0.5 to 1-positive dominance (D), from 1 to+∞-positive overdominance, or heterosis (OD). At *Hp*=± 1-complete dominance of better (+) or worse (-) expression of trait value (Tockij, 2002).

The scale that we used to analyze the relationships between pairs of basic approbatory and economic traits was as follows: from 0 to 0.19-the relationship between traits is very weak; from 0.2 to 0.39-weak; from 0.40 to 0.59-average; from 0.60 to 0.79-strong; from 0.80 to 1.0-very strong, linear or direct (http://www.statstutor.as.uk/resources/uploaded/ pearsons.pdf).

We believe that just this gradation calibration of the correlation assessing scale for the tightness of determining relationships between breeding traits, in contrast to the standard scale proposed by B.O. Dospekhov (Dospekhov, 1985), "which is recommended for analyzing the results of field research, of mainly technological direction", which most optimally levels the uncontrolled influence of abiotic and biotic stressors and, accordingly, more impartially reveals the peculiarities of the genetic framework of relationships between plant traits it is in genetic and breeding research.

Thus, of particular interest to us was studying the tightness and direction of relationships between the block of main approbatory and economic traits of Gherkin type cucumber, at which the breeder's research work aims, with the trait parameters of resistance to downy mildew. The main interest for indirect selection paired with relationship tightness at a level not lower than strong and very strong (correlation coefficient from 0.60 to 1.0) (Osnovnye metody fitopatologicheskih issledovanij, 1974; Koshnikovich, Sherbinin, & Timoshenko, 2008).

Results

As a result of studying the variability of the five main economic traits in 27 initial cucumber samples (lesion degree, intensity of disease spread, total crop capacity, crop capacity for the first decade of fruiting, duration of the mass fruiting period), the following statistical characteristics were obtained: variation coefficient (Cv), limits of trait expression (LV=v_{min} ÷ v_{max}) and the average value of the normal range of the genotype reaction ($\overline{X}_{Am}=(v_{max}+v_{min})/2$).

According to the studies results of the initial breeding material (innovative product), the lesion degree of samples (27 numbers) by downy mildew ranged from 2.5 to 79.2% over the years.

At the same time, the whole experimental material of cucumber according to the range of reaction expression of the resistance trait to downy mildew is divided into two nominal subgroups: resistant (scores 7, 5) and susceptible (scores 3, 1 of the immunological scale) by the type 50 ÷ 50, or resistance is present ÷ absent. The results of such a comparative assessment of the 5 main economic characteristics variability both for the entire general totality of samples and for the corresponding immunological subgroups arranged according to the downy mildew resistance reaction expression are shown in Table 1.

Table 1: Results of assessing the variability of a complex of basic economic characteristics in different by resistance expression subgroups of Gherkin type cucumber,%.

Traits	The general totality of samples (27 pieces)		Subgroups			
			Resistant (scores 7, 5)		Susceptible (scores 3, 1)	
	CV	LV	LV	$\overline{X}_{Am}$	LV	$\overline{X}_{Am}$
Downy mildew, the degree of development,%	49	2.5 ÷ 79.2	2.5 ÷ 34.1	18.3	44.0 ÷ 79.2	61.6
Downy mildew, the intensity of spread,%	29	10.0 ÷ 100.0	10.0 ÷ 64.4	37.2	50.0 ÷ 100.0	75.0
Total crop capacity, t/ha	39	3.8 ÷ 44,6	20.0 ÷ 44.6	32.3	3.8 ÷ 11.9	7.85
Crop capacity for the first decade of fruiting, t/ha	48	2.6 ÷ 12.4	7.8 ÷ 12.4	10.1	2.6 ÷ 6.0	4.3
Period of mass fruiting, days	29	10.0 ÷ 45.0	34.0 ÷ 45.0	39.5	10.0 ÷ 25.0	2.3

Note: A_m is the average value of the reaction norm range of the trait.

From the results obtained, it can be seen that according to these main economic traits, all of the initial material was not genetically aligned. Therefore, the variation coefficients (CV,%) of all the main economic traits mentioned above in the initial forms and standards were very high and ranged from 29 to 49%.

Comparison of the average values of the reaction norm range (Am) of these traits in two selective totalities grouped by the presence or absence of resistance to the downy mildew trait allowed us to find the following fact.

In the group of susceptible samples (genotypes), an average of reaction norm range (Am) of such an indicator as the degree of disease development exceeded this indicator in the resistant group more than 3.4 times, by the trait of the intensity of the disease spread more than 2 times.

So, in samples (genotypes) of resistant and susceptible groups, the difference between the average values of the reaction norm range of such traits as total crop capacity was 4 times more significant, the crop capacity for the first decade of fruiting-2.4 times, by the trait of the mass fruiting period-1.7 times, respectively.

Consequently, the variability range from cucumber samples of the susceptible group according to traits such as the degree of development and the intensity of the spread of downy mildew was the largest, by the indicator of total crop capacity, the absolute value of this trait for the first decade of fruiting, and the duration of the mass fruiting period-the smallest.

This allows us to conclude that the samples of different resistance groups differ in the following way-the general reaction norm of such main economic traits as total crop capacity, crop capacity for the first decade of fruiting, the duration of the mass fruiting period for each group is constant, and the phenotypic difference in the extreme values of these traits between groups becomes most noticeable as indicators such as development degree and the intensity of downy mildew spread grow.

For breeding practice, this proves the possibility of successful selection of initial forms-sources of high resistance and crop capacity among the breeding material at the final stages of its creation.

In the future, we present a summary of more detailed immunological characteristics by years of the initial breeding material, divided according to resistance expression under field conditions into 4 immunological groups (scores 7-1 of the immunological scale) (Table 2).

Table 2: Immunological characteristics of the initial material of Gherkin-type cucumber, natural infectious background (2011-2013).

General totality of samples (27 pieces), their numbers of the selection catalogue of the Institute of Vegetables and Melons growing of NAAS	Accounting date-end of the first decade of mass fruiting degree of disease development,%		resistance, scores
	LV	Am	
No.s: 57713, 57770, 57729, 57703, 57396, 57803, 57851, 1240, 57707, 57826, 57756, 57711, 57797, 57774	2,5 ÷ 10,0	7,5	7
No.s: 57759, 1806, 57767, 1797, 57862, 57836	12,5 ÷ -31,1	18,6	5
Phoenix 640, Ajax F_1, Dzherelo (standards of resistance)	8,5 ÷ 34,1	25,6	7-5
Nizhynsky local (standard of susceptibility), susceptible hybrid populations from collection samples Pavlik, Fansipak, Krak	44,0 ÷ 79,2	35,2	3-1

Stably high field resistance over the years of research (the degree of the disease development-up to 10%, score 7 of the immunological scale) was found by 14 initial cucumber breeding lines with the numbers of the Institute's catalog No.s: 57713, 57770, 57729, 57703, 57396, 57803, 57851, 1240, 57707, 57826, 57756, 57711, 57797 and 57774.

Stable average resistance to downy mildew (the degree of the disease development-up to 35%, score 5 of the immunological scale) was shown by 6 lines selected for resistance and a complex of other valuable traits (catalog No.s: 57759, 1806, 57767, 1797, 57862 and 57836).

As a standard of susceptibility, we used the local Nizhynsky variety. To increase the representativeness of the analyzed sampling by traits variability, a group of nonresistant forms-selections of different generations of hybrid populations of 3 collection samples-was additionally involved in the initial material.

At the same time, the whole contrasting sampling (initial material, standards) by the level of reaction expression of the resistance to downy mildew was analyzed by us according to a complex of 24 standard approbatory (morphological, biochemical) traits and indicators of the sample's resistance to downy mildew-lesion degree (X_{23}) and the intensity of disease spread (X_{24}) (Shirokij unificirovannyj klassifikator SEV, 1980; Ermakov, 1987; Ohorona prav na sorti roslin, 2004): in a leaf, these traits were: its length (X_1), blade size (X_2), blistering (X_4), wavy edges (X_5), length (X_6) and width of the upper lobe (X_7); in a plant- sex-expression (X_8), the number of female flowers per first node (X_9), lesion degree (X_{23}), the intensity of disease spread (X_{24}); in a fruit-its shape (X_{10}), intensity of green colouring (X_3), length (X_{11}), diameter (X_{12}), presence of pubescence (X_{13}), stripes (X_{14}), spots (X_{15}), fruit stalk length (X_{16}), bitterness (X_{17}), weight (X_{18}), number of fruits on the plant (X_{19}) during the period of maximum disease development on a susceptible standard (Nizhynsky local), dry matter content (X_{20}), monosaccharides (X_{21}) and nitrates (X_{22}) (Table 3).

According to literature data, it has been established that the initial material with short cylindrical fruits of dark green color, with a hard skin and fruits pubescence of black color, has the most significant value for breeding to create short-fruited короткоплідних early ripening varieties and hybrids of cucumber of Gherkin type (Nalobova, 2008). Such samples are the most popular for various types of processing (canning, pickling), because even after heat treatment or fermentation, they have an attractive commercial shape and quality for consumption.

According to the research results, it was found out that all the selected initial breeding material of cucumber of Gherkin type (27 samples) had 24 main necessaries in breeding and production valuable approbatory, economic traits and parameters of resistance to downy mildew an average (Cv=10-20%) and high (Cv ≥ 20%) variability level. No trait showed high stability (low variability, *Cv* up to 10%) within the analyzed totality (Table 3).

The average variation (Cv=10-20%) was typical for the width of the upper leaf lobe (X_7), fruit shape (X_{10}), fruit length (X_{11}), fruit weight (X_{18}), dry matter content in fruit (X_{20}), monosaccharides content in fruit (X_{21}).

The following main traits varied enormously (Cv ≥ 20%) within the studied initial breeding material:

in a leaf-its length (X_1), blade size (X_2), blistering (X_4), and wavy edges (X_5); in a plant-*sex-expression* (X_8), the number of female flowers per the first node (X_9), indicators of resistance to the downy mildew-lesion degree (X_{23}), the intensity of disease spread (X_{24}); in the fruit-its diameter (X_{12}), presence of pubescence (X_{13}), stripes (X_{14}), spots (X_{15}), fruit stalk length (X_{16}), bitterness at the base (X_{17}), the amount on the plant (X_{19}) on the date of maximum disease development on the susceptible standard (Nizhynsky local), nitrate content (X_{22}).

Table 3: Characteristics of the variability of a primary traits complex (X_1-X_{24}) in the initial material of Gherkin type cucumber, generalized for 2011-2012.

Plant organ, trait (X_i), value of its variation coefficient (Cv),%		
insignificant, up to 10	average, 10-20	significant, more than 20

--	Leaf-X_7; Fruit-X_{10}, X_{11}, X_{18}, X_{20}, X_{21}	Leaf-X_1, X_2, X_4, X_5; Plant in general-X_8, X_9; Fruit-X_{12}, X_{13}, X_{14}, X_{15}, X_{16}, X_{17}, X_{19}, X_{22}; Indicators of resistance to downy mildew-X_{23}, X_{24}

So, the calculated statistical characteristics affirmed a comprehensive genetic polymorphism of the initial breeding material of this vegetable crop in a complex of essential characteristics. Today, this allows mobile and efficiently solve most of the demands that consumers of the final product (variety or hybrid) make for breeders soon.

Along with this, the analysis results of the newly created initial material of Gherkin type cucumber according to the essential characteristics for practical breeding and production showed the following distribution of valuable initial forms identified for resistance to downy mildew (Table 4).

Table 4: Results of assessing the variability level of initial cucumber material by the level of resistance and the main traits complex.

Trait	**The number of samples,%** **Trait gradation** **(Shirokij unificirovannyj klassifikator SEV..., 1980; Ermakov, 1987; Ohorona prav na sorti roslin, 2004)**			
Leaf length (X_1)	from 5,3 to 11,5 cm			
Leaf blade size (X_2)	Small 24	Medium 72	Big 4	
The intensity of green fruit coloring (X_3)	Weak 20	Moderate 48	Strong 32	
Leaf blistering (X_4)	Weak 20	Moderate 64	Strong 16	
Waviness of leaf edges (X_5)	Absent 4	Weak 16	Moderate 72	Strong 8
The length of the upper lobe (X_6)	Small (up to 12 cm) 96		Medium (12-15 cm) 4	
The width of the upper lobe (X_7)	Small (up to 15 cm) 44	Medium (16-20 cm) 52	Big (more than 20 cm) 4	
Plant: *sex-expression* (X_8)	♂ and ♀ flowers equally 84		♀ flowers predominate 16	
The number of female flowers per node (X_9)	From 1 to 3 pieces 84		Over 3 pieces 16	
Fruit shape (X_{10})	Spindle-shaped 36		Cylindrical 64	
Fruit length (X_{11})	Short (6-10 cm) 44		Medium (11-20 cm) 56	
Fruit diameter (X_{12})	Medium (2,1-3,5 cm) 84		Big (more than 3,6 cm) 16	
Black or white fruit pubescence (X_{13})	Absent 48	Insignificant 40	Moderate 12	
Presence of stripes on a fruit (X_{14})	Absent 12		Present 88	
Spots on a fruit (X_{15})	Absent 36		Present 64	
Fruit stalk length (X_{16})	Small (up to 2 cm) 60		Medium (2,1-5,0 cm) 40	
Fruit: bitterness at the base (X_{17})	Absent 96		Present 4	
Fruit weight (X_{18})	65-100 g			
An additional number of fruits per plant (X_{19}) at the end of the mass fruiting phase-compared to the susceptible standard-Nizhynsky local	3-9 pieces			
Dry matter content in a fruit (X_{20})	3,91-5,8%			
Monosaccharides content in a fruit (X_{21})	1,32-2,17%			
Nitrates content in fruit (X_{22})	69-224 mg/kg			

Lesion degree (X_{23}) of the sample by downy mildew, score of the immunological scale	Low (7)	Average (5)	High (3-1)
	60	36	4
Lesion of the sample (X_{24}) by downy mildew, score	Low (0-1)	Average (2)	High (3-4)
	8	52	40

Consequently, the degree of downy mildew lesion (X_{23}) in 60% of the initial material selected for this trait at the end of the first fruiting decade was low, which corresponded to score 7 of the immunological scale of accounting, and in 36%-average (score 5 of this scale).

72% of the genotypes identified for resistance had the average size of the leaves blades (X_2), vigorous-intensity of fruits green color (X_3)-32%, moderate leaves blistering (goffering) (X_4)-64%, moderate waviness of the leaves edges (X_5)-72%, small (up to 12 cm) length of the upper leaves lobe (X_6)-96%, the average width (16-20 cm) of the upper leaves lobe (X_7)-56% of the sample, respectively.

Among the initially studied material, 16% of the selected resistant initial forms had a predominantly female flowering type (X_8). At the same time, 16% of cucumber genotypes selected for resistance to downy mildew had the number of female flowers on the first node (X_9) more than 3 pieces.

By the shape trait (X_{10}), sampling of 64% of initial resistant forms had a fruit of the cylindrical shape; it is short (6-10 cm) length (X_{11})-44%, and an average (2.1 to 3.5 cm) diameter (X_{12})-84% of the selected genotypes.

In 40% of the initial forms selected for resistance, black pubescence in fruits (X_{13}) was insignificant. The stripes on the fruit (X_{14}) were absent in 12% of the selected initial material, spots on a fruit (X_{15})-in 36%.

Fruits in 60% of the genotypes selected for resistance to downy mildew had a small length of the stalk of the fruit (up to 2 cm) (X_{16}) and bitterness at the base of the fruit (X_{17}) were absent in 96% of the newly created initial forms.

The given characteristics of the level of variability made it possible to select for breeding programs (primarily taking into account the traits of resistance to downy mildew) the initial breeding material of different quality according to the complex of main approbatory and economic characteristics to attract it to the process of creating modern domestic competitive varieties and hybrids of gherkin cucumber.

Therefore, according to the results of our research in the final stage of the breeding process, together with the breeders, we selected a promising initial form (bee-pollinated line of Gherkin type cucumber P 57/745-11) of Gherkin type cucumber, which, against the background of high expression of several critical economic characteristics, has high resistance to downy mildew under conditions of a natural infectious background.

Bee-pollinated cucumber line of Gherkin type P 57/745-11. The line is early ripening (before the first harvest-42 days). The total yield under Bohairic growing conditions is 20.4 t/ha, commercial-18.3 t/ha, for the first fruiting decade-8.9 t/ha. Marketability-84%. The line is resistant to downy mildew (score 7 on the REV scale) and medium-resistant to bacteriosis (score 5). The tasting evaluation of fresh fruits is 4.8 scores. Plants are mainly of the female flowering type; the fruit is up to 9 cm long and has a cylindrical shape, the pubescence is complex and black. The average weight of commercial fruit is 60 g.

As a valuable sample of the gene pool and a promising initial parent component for creating future heterotic hybrids, in 2013, this line was transferred for registration to the National Center for Plant Genetic Resources of Ukraine (V.Ya. Yuriev Institute of crop production of NAAS). Now it has received the registration number of the national catalog UL3700411.

The created line is a valuable maternal form and is involved in heterotic breeding to create new domestic cucumber hybrids of Gherkin type for open ground.

Thus, the experimental data obtained proved that the initial material selected by a complex of essential traits fully meets the modern demands made by the market for short-fruited varieties and Gherkin-type cucumber hybrids under the conditions of their cultivation on the open ground of the Left Bank Forest-Steppe of Ukraine.

The results of the analysis of the development of downy mildew development in F_1 hybrids and parental forms in our experiments have shown that the initial forms obtained by crossing contrasting to the initial forms of this disease in the obtained F_1 hybrids, resistance depended on the combination of parental components. Thus, in hybrid populations No. 1-6, it had an intermediate character (p = from -0.5 to 0.5), and in combinations No. 7, 8 it was positive (p = from 0.5 to 1).

As can be seen from the analysis of hybrid combinations No. 1, 2, when crossing the medium-resistant to downy mildew maternal form (score 5 of the immunological scale) with the susceptible (score 3) and highly susceptible (score 1) parental form, the obtained F_1 hybrids inherited the resistance (susceptibility) of the parental component.

Table 5: Characteristics of the resistance trait to the dominance of the resistance trait of downy mildew in Gherkin-type cucumber F_1 hybrids under natural infectious conditions (open ground, 2013).

S.No.	Hybrid combination F_1 (♀ x ♂), catalogue number of the Institute of Vegetables and	Degree (R) of diseases development, percentage/immunological scale						Average indicator of initial forms, MF	Indicator of the best parental form, HF	Degree of dominance of the resistance trait, HP
		F_1		♀		♂				
		%	score	%	score	%	score	%	%	

	Melons growing of NAAS								
1	58258	39,0	3	21,1	5	45,0	3	33,0	21,1	-0,50
2	57982	49,0	3	13,7	5	75,0	1	44,4	13,7	-0,15
3	58076	34,5	5	62,5	1	13,7	5	38,1	13,7	0,15
4	58012	10,0	7	7,5	7	13,7	5	10,6	7,5	0,20
5	58156	15,0	5	25,0	5	10,0	7	17,5	10,0	0,33
6	57987	27,5	5	55,0	1	15,6	5	35,3	15,6	0,40
7	58040	42,5	3	62,5	1	37,5	3	50,0	37,5	0,6
8	58150	15,0	5	25,0	5	13,7	5	19,4	13,7	0,76

When a highly susceptible maternal form (score 1) was involved in crossing with a medium resistant parental component (score 5) (combinations 3, 6), the hybrids obtained inherited the resistance of the paternal form (score 5).

In hybrid combinations No. 4 and 5, which were obtained by crossing resistant (score 7) and medium resistant (score 5) to initial parental forms of downy mildew, the F_1 hybrids obtained inherited resistance to this maternal form disease.

When both parental forms that were not resistant to downy mildew (scores 3 and 1) were involved in the crossing (combination 7) or both forms with the same level of average resistance (score 5 of the immunological scale) (combination 8), the hybrids obtained had a positive dominance of the resistance level of the parent component.

From the experimental material given, it is clearly recognized that it is the initial parental (male) form against the background of differences in resistance of the maternal one that is the primary carrier and transmitter of the resistance trait to downy mildew to the hybrid generation F_1 with an intermediate and positive character of its dominance.

When selecting the initial material, considering the previously established specificity of the relationship in the pathosystem «pathogen-plant environment» and the determined nature of the trait inheritance of prolonged cucumber resistance to downy mildew as resistance sources (donors), we recommend using parental components with high (score 7) and average expression (score 5) of resistance to this disease.

Based on the conducted correlation analysis results, we have established the directions and tightness of the relationships of the main economic traits complex of the initial material (27 samples) of Gherkin-type cucumbers with their resistance parameters downy mildew under field conditions.

Thanks to correlation analysis, we have identified a genetic block (framework) of pairs of economic traits, the relationship with resistance parameters turned out to be different in direction, but reliably strong and very strong ($p=0.60 \div 1.0$, $r_{critical}=0.48$, $\alpha=0.01$ (Osnovnye metody fitopatologicheskih issledovanij, 1974)) (Table 6).

Table 6: Correlation relationships between the complex of main traits and resistance parameters to downy mildew of Gherkin-type cucumber, 2011-2013.

Relationship characteristics	Pairs of traits, No ÷ No, (correlation coefficients *, r/determination, D)
	REVERSE
strong (r=0,6-0,79)	1 ÷ 7 (-0,65/0,42); 2 ÷ 7 (-0,61/0,37); 1 ÷ 4 (-0,72/0,52); 2 ÷ 4 (-0,74/0,55); 1 ÷ 5 (-0,69/0,47); 2 ÷ 5 (-0,75/0,56) 1 ÷ 27 (-0,62/0,38)
	DIRECT
strong (r=0,6-0,79)	1 ÷ 28 (0,67/0,45), 2 ÷ 28 (0,64/0,40)
very strong (r=0,8-1,0)	1 ÷ 2 (0,88/0,77)

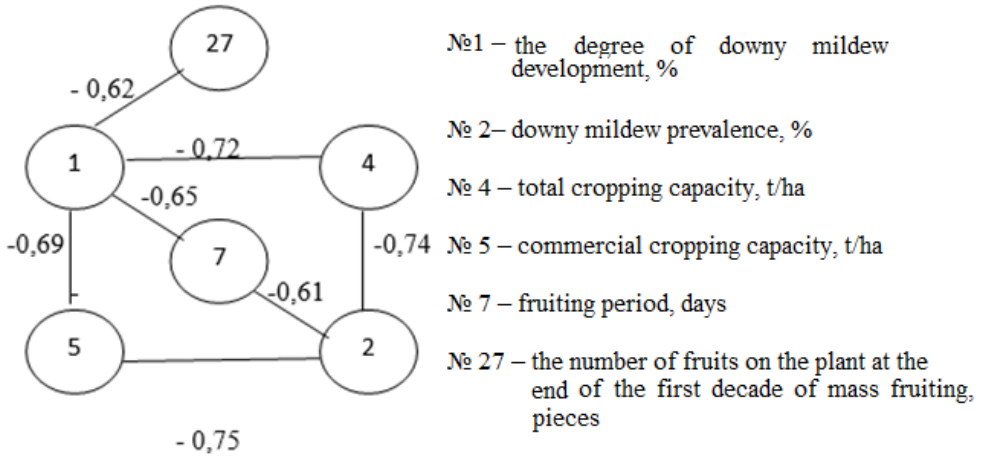

Fig. 2. Correlation pleiad of reversal relationship between resistance parameters to downy mildew (Y_i) and a complex of other traits (X_j) in Gherkin type cucumber, 2013.

The data obtained show that severe plant lesions due to downy mildew (lesion score 3-4) led to a significant loss of moisture in plant tissues and, accordingly, an increase in the dry matter content in fruits.

The calculated coefficients of determination for these pairs of traits, shown in Table 3, statistically prove that the direct contribution of the study of biological stress factors to the overall formation process in cucumber of this biochemical trait is 41 to 45%.

So, according to this block of studies, it was found that an increase in the main parameters of downy mildew harmfulness under field conditions directly affects the decrease in cucumber indicators such as total cropping capacity (by 52-55%), commercial cropping capacity (by 47-56%), the duration of the fruiting period (by 37-42%), the number of fruits on the plant at the end of the first decade of mass fruiting (by 38%), change the biochemical composition of fruits in the direction of increasing their dry matter content by 41-45%.

In contrast, the following traits pairs revealed a robust direct influence on each other: the degree of downy mildew development,% (trait No. 1)-the content of dry matter in fruits,% (№ 28); downy mildew prevalence,% (No. 2)-the content of dry matter in fruits,% (No. 28), which is very important for breeders and producers of processed products (Fig. 3).

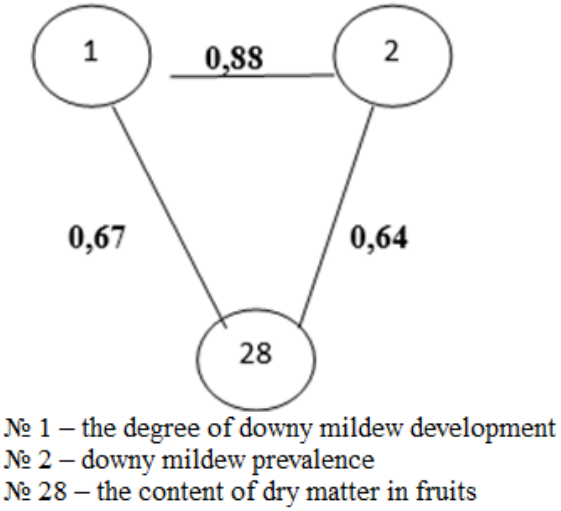

Fig. 3. Correlation pleiad of direct relationship between resistance parameters to downy mildew (Y_i) and the content of dry matter in cucumber fruits of Gherkin type (X_{28}), 2013.

We have established such economic characteristics as the duration from the beginning of the mass germination phase to the beginning of the first fruit harvest, days (No. 8), leaf blade length, cm (No. 9), leaf blade size, cm (No. 10); intensity of the green colouring of the fruits, scores (No. 11); leaf blistering, scores (No. 12); waviness of the leaf edges, scores (No. 13), the length of the upper leaf lobe, cm (No. 14); the length of the lower lobe, cm (No. 15); sex expression in the plant (No. 16), the number of female flowers in the plant, pieces (No. 17), the shape of the fruit, scores (No. 18), fruit length, cm (No. 19), the diameter of the fruit, cm (No. 20), the intensity of pubescence (No. 21), the presence of stripes (No. 22) and spots on the fruit (No. 23), the length of the fruit stalk (No. 24), the presence or absence of bitterness (No. 25), weight, g (No. 26), the content of monosaccharides,% (No. 29), remnants of nitrates (No. 30) didn't show strong and very strong correlation relationship with the indicators of downy mildew resistance and are inert to changes in the parameters of downy mildew resistance.

This means that the breeder can work with this group of traits individually, without caution that artificial changes in their characteristics during the breeding process to resist downy mildew can negatively affect the final result of the breeding process.

Conclusion

It was found that in samples from the resistant group, compared to the susceptible group, the difference between the average values of the reaction norm range for parameters such as the total cropping capacity is 4 times greater, the cropping capacity for the first decade of fruiting is 2.4 times, and the duration of the mass fruiting period is 2.3 times. It was determined that the initial breeding material (linear) of Gherkin-type cucumbers selected for resistance had an average (Cv=10-20%) and a high (Cv <20%) range of variability in 24 main valuable approbatory and economic traits, which are in demand in production, which allows mobile solutions to the main demands that consumers of the final product variety or hybrid make to breeders. It was found that it is the initial parental (male) form against the background of different resistance of the maternal one that is the main carrier and transmitter of the resistance trait to downy mildew to the hybrid generation F_1 with an intermediate and positive character of its dominance. It was determined that a rise in the main parameters of downy mildew harmfulness under field conditions directly affects the decrease in cucumber indicators such as total cropping capacity (by 52-55%), commercial cropping capacity (by 47-56%), the duration of the fruiting period (by 37-42%), the number of fruits on the plant at the end of the first decade of mass fruiting (by 38%) changes the biochemical composition of fruits in the direction of increase in their dry matter content by 41-45%. With the help of correlation analysis among the 30 main economic and approbatory traits, a group of inert (21 pieces) was identified, with which the breeder can work individually, without caution that an artificial change in their characteristics in the breeding process for downy mildew resistance can negatively affect the final result of the breeding process for other traits.

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