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Characteristics of the source material resistant to Fusarium head blight and root rot for the selection of winter wheat

Abstract. Diseases of winter wheat considerably reduce the yield and quality of grain. Losses of the gross grain harvest from them annually amount to 20-30%, and in epiphytotic years – 50%. An effective measure to limit the development of winter wheat diseases is the introduction of varieties that are resistant to their damage. Successful development of breeding work in this area is impossible without the use of a gene pool of stable forms. Among the genetic resources of wheat, there are genotypes described by resistance against several pathogens at the same time, and therefore have special value as sources of group resistance. There is a constant need to identify new sources and donors of resistance against pathogens, the search for which is an urgent area of research and requires constant screening of the gene pool. In the V. M. Remeslo Myronivka Institute of Wheat, work is constantly being carried out to create the initial breeding material of winter wheat, resistant to the main pathogens, which will be used by breeders in the future. According to the selection program for resistance against fusarium head blight and root rot, the following lines were created: Lutescens

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F. g. 163/19, Erythrospermum F. g. 164/19, Erythrospermum F. g. 166/19, Erythrospermum S. h. 177/19, Erythrospermum S. h. 175/19, which are used by breeders of the institute and have been transferred to the National Centre for Plant Genetic Resources of Ukraine. The line Erythrospermum F. g. 164/19 was selected according to the "duration of the growing season" indicator, with a growing season of 238 days, which is 3 days less than the Podolyanka standard variety. It belongs to the group of early-maturing forms. High TGW indicators were noted in the lines Erythrospermum F. g. 164/19 – 50.6 g, Erythrospermum F. g. 166/19 – 49.3 g, Erythrospermum F. g. 163/19 – 46.5 g, and Erythrospermum C. h. 177/19 – 47.3 g. In terms of productivity, the following lines exceeded the standard: Lutescens F. g. 163/19 – by 38.8 g/m^2, Erythrospermum C. h. 177/19 – by 39.6 g/m^2, Erythrospermum C. h. 175/19 – by 26.7 g/m^2. Lines Erythrospermum F. g. 166/19 and Erythrospermum C. h. 177/19 were distinguished by their high-protein content – 16.5% and 15.8%, respectively. The highest level of gluten content in grain was recorded in the line Erythrospermum F. g. 166/19 – 41.2%. The best lines in terms of sedimentation are: Lutescens F. g. 163/19 – 70 ml, Erythrospermum F. g. 164/19 – 67 ml, Erythrospermum F. g. 166/19 – 71 ml. It was established that the Lutescens line F. g. 163/19 showed elevated resistance against the causative agent of powdery mildew (damage – 1.0%) and septoria leaf blotch (damage – 3.0%). Fusarium head blight damage did not exceed 5.0%. Erythrospermum F. g. 166/19 was resistant to two pathogens (fusarium head blight, powdery mildew), while Erythrospermum F. g. 164/19 was resistant to fusarium head blight and septoria leaf blotch. The lines created under the program of resistance against root rot Erythrospermum C. h. 177/19 and Erythrospermum C. h. 175/19 showed relative resistance to this pathogen – 10.0% and 10.5% damage, respectively, and had high resistance to powdery mildew – 2.0% damage

Keywords: lines; diseases; damage; resistance; lodging; plant height; yield; grain quality

RELEVANCE

Grain crops during the growing season are affected by many types of pathogens, but there are some that occur very frequently. Diseases of winter wheat considerably reduce the yield and quality of grain. Losses of the gross grain harvest from diseases annually amount to 20-30%, and in epiphytotic years – 50% (S. V. Retman, 2009). An effective measure to limit diseases of winter wheat is the introduction of varieties that are resistant to their damage (Taranova *et al.*, 2020). Under favourable conditions for the development of diseases, such varieties do not reduce the yield of the crop. Chemical treatment of crops is not carried out or is used in small quantities. It is especially necessary to give preference to those varieties that have a comprehensive resistance to limiting major diseases. Selection from among the recommended varieties, relatively resistant or hardy against a complex of diseases, which are of economic importance.

The creation of sustainable varieties is recognized worldwide, the most effective, economically justified and environmentally safe method from the standpoint of environmental protection. Successful development of breeding work in this area is impossible without the gene pool of stable forms. Recently, against the background of the increase in the price of fungicidal preparations, on the one hand, and the ecological crisis of the biosphere, on the other hand, the search for new effective sources of resistance to diseases has become especially important (Kholod *et al.*, 2015; Lyfenko, 1988). Among the genetic resources of wheat, there are genotypes described by resistance against several pathogens at the same time, and therefore have special value as sources of group resistance (Kovalyshyna, 2012).

ANALYSIS OF RECENT STUDIES AND PUBLICATIONS

Pathogens of diseases that affect winter wheat plants in the early stages of development include root rot, specifically common fusarium, ophiobolus, cercosporellosis; diseases of the wintering period – snow mould and sclerotiniosis; diseases that appear and intensively develop in the period from germination to milky grain maturity – powdery mildew, septoria; diseases of the stem elongation period – milky-wax grain ripeness – brown rust; flowering period – milky-wax grain ripeness – fusarium head blight, alternariosis, helminthosporiosis, volatile and hard soot, olive mould, black spot and basal bacteriosis (Retman, 2009; Trybel *et al.*, 2010).

Fusarium head blight (*Fusarium graminearum* Schwabe*)* manifests itself in the earing phase and develops before harvesting. The disease is widespread, especially damaging in years with wet weather and moderate temperatures after the earing phase. The harmfulness of Fusarium pathogens largely depends on the phase of wheat plant development in which the damage occurs. Deep infection is especially dangerous, when the pathogen reaches the seed embryo due to damage to the ear in the early phases of development during the flowering period and before the grain is milky. In this case, the mycelium completely penetrates the grain, the seeds lose their germination. In spikes infected during this period, slender whitish grains are formed, often with a visible coating of mycelium on the surface of the grain. Such seeds almost completely lose their germination. At a late stage of infection, the affected grains, as a rule, do not differ in appearance from healthy ones, but carry a latent form of infection. Such grain stays in the batch of commercial grain and poses the greatest threat, since it is a source of infection for healthy seeds during storage. Damage to the ear leads to infection of grain, as a result of which the crop shortage reaches 45-73%, the sowing qualities of seeds deteriorate: the energy of germination and seedling can decrease by 24%, the TGW – by 39-72%. The empty ears of the affected spikelets sometimes reach 60%. In the affected grain, gluten density worsens, and the amount of protein decreases. In the presence of Fusarium grain during grinding, the quality of flour deteriorates, baked bread loses volume and porosity. Cracks appear in it, and the crumb has a brown tint. Grain affected by pathogens such as *F. sporotrishiella* and *F. graminearum* release strong mycotoxins and can cause poisoning in humans and animals (T. Yu. Gagkaeva *et al.*, 2011).

Several types of root rot can be distinguished on winter wheat: helminthosporium (causing agent *Helminthosporium sativum* Pamel., King Bakkel), fusarium (causing agents *Fusarium culmorum* Sacc., *Fusarium avenaceum* Sacc., *Fusarium oxysporium* Schlecht, *Fusarium sporotrichiella* Bilai, *Fusarium graminearum* Shwabe), ophiobolus (causing agent *Ophiobolus graminis* Sacc.), rhizoctonia (*Rhizoctonia cerealis* Vander Hoeven), cercosporellosis root rot (causing agent *Pseudocercosporella herpotrichoides* Fron), etc. Some of them can destroy a third, half, or even more of the winter wheat crop. They are one of the most widespread and harmful diseases of cereals. The area of their distribution almost coincides with the area of cultivation of ear crops. Root rot refers to ecological parasitic diseases. Their causative agents are facultative pathogens that affect plants weakened by unfavourable growing conditions (Kriuchkova, & Hrytsyuk, 2014).

Infectious root rots are caused by phytopathogenic microorganisms, which can be divided into three groups according to the type of nutrition: 1) specific, the causative agents of which are organisms inherent to a certain culture or this type of disease (phytophthora, ophiobolos, common root rot of cereals). Such diseases are usually primary. According to the method of nutrition, the causative agents of primary root rots can be biotrophs and necrotrophs or have a mixed type of nutrition; 2) non-specific, the causative agents of which are accompanying microorganisms – bacteria, nematodes, etc. These parasites enter the roots through various damages and their toxic secretions further weaken the plants, causing widespread neurotization of the roots and stem. Such fungi include representatives of the genera *Penicillium, Aspergillus, Cladosporium*, etc.; 3) mixed infections, when after damage to the root system by specific phytopathogens, it becomes possible for other types of fungi to penetrate them (fusarium-helmintosporium root rot of cereals). Infectious root rot is characterized by uneven spread of the disease. If crop rotations are saturated with repeated crops that are susceptible to diseases of crops, soil contamination progresses, which leads to frequent epiphytotics (Novokhatka,1990).

Due to the harmfulness of diseases, one of the vital tasks in the selection of soft winter wheat is to create a breeding material that is resistant to diseases. The main and necessary condition for any breeding work is the presence of sources and donors of the trait used for breeding. A distinctive feature of disease-resistant breeding is that genotypes identified as donors can quickly lose this property. This occurs due to changes in the virulence of pathogens and their overcoming of plant resistance genetic systems, i.e., there is a loss of effectiveness of known resistance genes (Kovalyshyna *et al.*, 2020a; Kovalyshyna *et al.*, 2020b). Therefore, there is a constant need to identify new sources and donors of resistance against pathogens, the search for which is an urgent area of research and requires constant screening of the gene pool.

The purpose of this study was to create a new selection material with group resistance against the main pathogens for use in selection work.

MATERIALS AND METHODS

The study was conducted under artificial inoculation with pathogens in field infectious nurseries of the Department of Plant Protection at the V.M. Remeslo Myronivka Institute of Wheat (MIP) of the National Academy of Agrarian Sciences of Ukraine according to generally accepted methods (Babayants *et al.*, 1988; Volkodav *et al.*, 2000; Trybel *et al.*, 2010; DSTU 3768:2010).

The artificial background of the causative agent of cercosporellosis was created as a result of spraying wheat plants in early spring in the budding phase with a mycelium suspension, for the development of which strains of the local population of the causative agent were used according to the generally accepted method (Grigorev, 1976). MV-EMESE variety was used as the susceptibility standard.

An artificial infectious background of fusarium head blight was created as a result of spraying winter wheat plants in the flowering phase with a suspension of spores isolated from the local population of the pathogen, according to the generally accepted method (L.T. Babayants *et al.*, 1988). The susceptible Natula variety was used as the susceptibility standard.

Experiments on the evaluation of varieties and collection samples of wheat for resistance to diseases, using artificial inoculation, were laid according to the schemes used in the system of state variety testing of agricultural crops (Volkodav *et al.*, 2000). The resistance of winter wheat plants against the causative agents of fusarium and cercosporellosis was assessed dynamically to determine the growth of the disease according to generally accepted methods (Trybel *et al.*, 2010). The main assessment is during the period of maximum development of diseases.

RESULTS AND DISCUSSION

Over 100 hybrid populations were investigated for resistance against causative agents of cercosporellosis root rot and Fusarium head blight in breeding nurseries F_3-F_5. The most resistant descendants were selected in combinations created with the participation of the following sources of resistance: against Fusarium head blight – Catalon, Co 75-50-71, TAM 139482/79, Nobeoka Bozu; root rot – Cappelle despres, Cartago, Roason.

According to the results of the study of constant lines of winter wheat of the selection nursery, twenty lines were transferred to the National Centre for Plant Genetic Resources of Ukraine (NCPGRU) in 2019, 5 of them were created under the selection program for resistance to Fusarium head blight and root rot: Lutescens F. g. 163/19, Erythrospermum F. g. 164/19 Erythrospermum F. g. 166/19, Erythrospermum S. h. 175/19, Erythrospermum S. h. 177/19.

These lines are superior to the Podolyanka standard variety in terms of resistance against the main pathogens, TGW and grain yield from the plot.

One of the key signs used to evaluate the material of winter wheat is the duration of the growing season. This indicator determines not only the yield level of the variety, but also its resistance to drought, diseases, and other stressful factors. The value of the "germination – maturation" period of samples of the breeding nursery of winter wheat was within 238-245 days. The duration of the growing season in the line Erythrospermum F. g.164/19 was 238 days, which is 5-7 days less than in the vulnerable varieties MV-EMESE (HUN), Natula (POL) and 3 days less than in the Podolyanka standard variety (Table 1).

Table 1. Characterization of lines of breeding nursery of soft winter wheat selection of MIP according to valuable economic traits, MIP, 2019.

Line or variety name	Growing season duration, days	Plant height, cm cm	TGW, g	Yield from the plot, g/m²	± to standard, g/m²
Resistant to fusarium head blight					
Natula (susceptible variety)	245	105.0	41.6	461.5	-53,0
Podolyanka (standard)	241	95.0	42.5	514.5	–
Lutescens F. g. 163/19	241	95.0	46.5	553.3	+38.8
Erythrospermum F. g. 164/19	238	85.0	50.6	522.1	+7.6
Erythrospermum F. g. 166/19	246	95.0	49.3	508.4	– 6,1
Resistant to root rot					
MV-EMESE (susceptible variety)	243	95.0	40.9	412.7	–101,8
Podolyanka (standard)	241	95.0	42.5	514.5	–
Erythrospermum C. h. 177/19	241	90.0	47.3	554.1	+39.6
Erythrospermum C. h. 175/19	242	80.0	43.6	541.2	+26.7
LSD_{05}			1.37	33.45	

An important feature of most winter grain samples is the presence of a link between plant height and lodging resistance. As the world breeding practices show, short-stemmed winter wheat samples with a plant height of 70.0-90.0 cm are sufficiently resistant to lodging, almost regardless of the thickness of the stem, and forms with a plant height of 90.0-100.0 cm have an average resistance to lodging. In terms of plant height, winter wheat lines created in the plant protection department are characterized by considerable variability (80.0-95.0 cm). According to the results of studying the material by plant height, 1 sample (Erythrospermum C. h. 175/19) with a plant height of 80 cm (semidwarf forms) was found, and 4 samples were included in the medium-sized group (85-95 cm). The stem height of 105 cm (tall forms) was inherent in the susceptible variety Natula (POL) (Table 1).

The TGW is an essential indicator of productivity, as well as a sign that characterizes increased drought resistance and heat resistance. The formation of grain with a high absolute mass is the resulting indicator of the formation of high and stable yields (Kyrpa, 2013). Growing conditions, precipitation, and temperature during the grain filling period, as well as biological features of the variety, are of decisive importance in the formation of grain with a high TGW. In experiments for this study, the average TGW of winter wheat samples was 44.9 g. According to the "grain size" indicator, the standard varieties had the following parameters: Podolyanka – 42.5 g, Natula – 41.6 g, MV-EMESE – 40.9 g. The largest grain was in the line distinguished by its resistance to fusarium head blight – Erythrospermum F. g. 164/19 – 50.6 g, a high TGW index was also noted in the line Erythrospermum C. h. 177/19 – 47.3 g. The TGW in other lines of winter wheat was also higher than that of the Podolyanka standard variety (Table 1).

According to yield data, the Lutescens F. g. 163/19, Erythrospermum C. h. 177/19 and Erythrospermum C. h. 175/19 significantly exceed the Podolyanka standard variety – by 38.8, 39.6, and 26.7 g/m^2, respectively.

The key features limiting the production of high-quality grain were and still are its protein and gluten content (B. Belderok *et al.*, 2000; K.A. Larchenko & B.V. Morgun, 2010). These indicators are closely related to each other, having a high (0.765) correlation coefficient (P. I. Bukrieva *et al.*, 2004). The protein and gluten content in grain characterize its quality, which is a crucial indicator when determining the price of grain. According to the current standard in Ukraine, the food grain can be attributed to those in which the protein content exceeds 10.5%, and gluten – 18% (DSTU 3768:2010).

One of the most informative parameters for determining the quality of wheat grain is the level of gluten content in it. Gluten is essential in the production of pasta, performing two main functions: it is a plasticizer, and it is also a substance that binds starch grains into a single mass. The former property of gluten contributes to the formation of the dough, while the latter preserves the shape given to the dough (H.P. Zhemela *et al.*, 2020). Factors such as the predecessor in the cultivation of the crop and the genotype of the variety have a substantial influence on the mass share of raw gluten (I.V. Pravdziva, *et al.* 2020).

A low percentage of protein content was found in the variety susceptible to fusarium head blight – Natula — 11.7%, and in the variety susceptible to root rot – MV-EMESE — 12.6%. These varieties also had a low level of gluten – 27.7% and 29.6%, respectively. A prominent protein content was found in the lines Erythrospermum F. g. 166/19 – 16.5% and Erythrospermum C. h. 177/19 – 15.8%, protein content at 14.9% was found in the grain of the lines Erythrospermum F. g. 164/19 and Erythrospermum C. h. 175/ 19. The highest level of gluten content in grain was recorded in the winter wheat line resistant to fusarium head blight – Erythrospermum F. g. 166/19 – 41.2%. In other lines, the content of the gluten indicator was at the standard level (Table 2).

Table 2. Results of incomplete technological analysis of winter wheat samples resistant to pathogens, MIP, 2019

Line or variety name	Protein content, %	Sedimentation rate, ml	Raw gluten content, %
Resistant to fusarium head blight			
Natula (susceptible variety)	11.7	52	27.7
Podolyanka (standard)	13.3	71	32.6
Lutescens F. g. 163/19	14.0	70	34.4
Erythrospermum F. g. 164/19	14.9	67	35.7

Table 2. Continued

Line or variety name	Protein content, %	Sedimentation rate, ml	Raw gluten content, %
Erythrospermum F. g. 166/19	16.5	71	41.2
Resistant to root rot			
MV-EMESE (susceptible variety)	12.6	59	29.6
Podolyanka (standard)	13.3	71	32.6
Erythrospermum C. h. 177/19	15.8	51	38.0
Erythrospermum C. h. 175/19	14.9	61	36.4

The index of sedimentation (swelling) is a complex indicator that judges the strength of grain (flour) (V. T. Koljuchyj, 2011). According to the data of this study, this indicator in winter wheat samples varied from 51 to 71 ml. The best lines in terms of this indicator (the sedimentation indicator is at 60-71 ml) are the lines resistant to fusarium head blight – Lutescens F. g. 163/19, Erythrospermum F. g. 164/19, Erythrospermum F. g. 166/19, and the line Erythrospermum C. h. 175/19, created under the root rot resistance program. In winter wheat varieties, which are standards of susceptibility to pathogens, a low sedimentation rate was found: Natula – 52%, MV-EMESE – 59%.

Determination of the sedimentation rate allows selecting promising material in the primary links of the breeding process and successfully conducting selection for grain quality, without increasing the volume of the source material. This indicator substantially depends on the genotype of the original forms and their combinational ability (L. M. Kononiuk *et al.*, 2014).

In nature, the plant is usually affected by several diseases at once, so there is a need to create varieties with group resistance. Evaluating the lines created under the resistance program against the pathogens of fusarium head blight, it was established that the line Lutescens F. g. 163/19 showed high resistance against the pathogen of powdery mildew (damage – 1.0%) and septoriosis of leaves (damage – 3.0%), but the damage from brown rust was 30.0%. Damage by fusarium head blight did not exceed 5.0%. The Erythrospermum F. g. 166/19 line was distinguished by resistance against two pathogens (fusarium head blight, powdery mildew), while Erythrospermum F. g. 164/19 – against fusarium head blight and septoria leaf blotch (Table 3).

Two best winter wheat lines, Erythrospermum C. h. 177/19 and Erythrospermum C. h. 175/19, were selected on an artificial infectious background of cercosporellosis root rot, which were relatively resistant to this pathogen (damage – 10.0% and 10.5%, respectively) and had high resistance to powdery mildew – damage 2.0%.

Table 3. Immunological characteristics of winter wheat samples for resistance against pathogens, MIP, 2019

Line or variety name	Disease damage, %				
	Fusarium head blight	root rot	powdery mildew	brown rust	septoria leaf blotch
Resistant to fusarium head blight					
Natula (susceptible variety)	15.0	-	15.0	70.0	10.0
Podolyanka (standard)	15.0	-	3.0	60.0	5.0
Lutescens F. g. 163/19	5.0	-	1.0	30.0	3.0

Line or variety name	Disease damage, %				
	Fusarium head blight	root rot	powdery mildew	brown rust	septoria leaf blotch
Erythrospermum F. g. 164/19	1.0	-	10.0	60.0	3.0
Erythrospermum F. g. 166/19	3.0	-	3.0	80.0	30.0
Resistant to root rot					
MV-EMESE (susceptible variety)	-	34.0	3.0	60.0	5.0
Podolyanka (standard)	-	34.0	3.0	60.0	5.0
Erythrospermum C. h. 177/19	-	10.0	2.0	80.0	20.0
Erythrospermum C. h. 175/19	-	10.5	2.0	30.0	40.0

CONCLUSIONS

According to the results of the study of constant lines of winter wheat from the breeding nursery, 5 lines created under the selection program for resistance against hard soot, fusarium head blight, and root rot were transferred to the National Centre for Plant Genetic Resources of Ukraine: Lutescens F. g. 163/19, Erythrospermum F. g. 164/19, Erythrospermum F. g. 166/19, Erythrospermum C. h. 175/19, Erythrospermum C. h. 177/19.

The line Erythrospermum F. g. 164/19 was selected according to the "duration of the growing season" indicator, with a growing season of 238 days, which is 3 days less than the Podolyanka standard variety. It belongs to the group of early-maturing forms.

High TGW indicators were established in the lines Erythrospermum F. g. 164/19 – 50.6 g and Erythrospermum C. h. 177/19 – 47.3 g.

In terms of yield, the standard was exceeded by the lines Lutescens F. g. 163/19 – by 38.8 g/m^2, Erythrospermum C. h. 177/19 – 39.6 g/m^2, Erythrospermum C. h. 175/19 – 26.7 g/m^2.

The lines Erythrospermum F. g. 166/19 and Erythrospermum C. h. 177/19 stood out with high-protein content – 16.5% and 15.8%, respectively. The highest level of gluten content in grain was recorded in the line Erythrospermum F. g. 166/19 – 41.2%.

The best lines in terms of sedimentation are: Lutescens F. g. 163/19 – 70 ml, Erythrospermum F. g. 164/19 – 67 ml, Erythrospermum F. g. 166/19 – 71 ml.

Based on the resistance against diseases on artificial infectious backgrounds of their pathogens, the following lines were selected: Lutescens F. g. 163/19 line with high resistance against the causative agent of powdery mildew (damage – 1.0%) and septoria leaf blotch (damage – 3.0%), damage from fusarium head blight did not exceed 5.0%. The Erythrospermum F. g. 166/19 line was distinguished by resistance against two pathogens (fusarium head blight, powdery mildew), while Erythrospermum F. g. 164/19 – against fusarium head blight and septoria leaf blotch. The lines created under the program of resistance against root rot, Erythrospermum C. h. 177/19 and Erythrospermum C. h. 175/19, showed relative resistance to this pathogen – 10.0% and 10.5% damage, respectively, and had high resistance to powdery mildew – 2.0% damage.

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Характеристика вихідного матеріалу, стійкого проти фузаріозу колоса та кореневих гнилей, для селекції пшениці озимої

Анотація. Хвороби пшениці озимої значно знижують урожайність та якість зерна. Втрати валового збору зерна від них щорічно становлять 20-30 %, а в епіфітотійні роки – 50 %. Ефективним заходом для обмеження розвитку хвороб пшениці озимої є впровадження стійких проти їхнього ураження сортів. Успішний розвиток селекційної роботи в цьому напрямку неможливий без використання генофонду стійких форм. Серед генетичних ресурсів пшениці є генотипи, що характеризуються стійкістю проти кількох збудників одночасно, а тому мають особливу цінність як джерела групової стійкості. Постійно існує потреба у виявленні нових джерел та донорів стійкості проти збудників хвороб, пошук яких є актуальним напрямом досліджень і потребує постійного скринінгу генофонду. У Миронівському інституті пшениці імені В. М. Ремесла постійно ведеться робота зі створення вихідного селекційного матеріалу пшениці озимої, стійкого проти основних збудників хвороб, які надалі використовуються селекціонерами. За програмою селекції на стійкість проти фузаріозу колосу та кореневих гнилей створені лінії: Лютесценс F. g. 163/19, Еритроспермум F. g. 164/19 Еритроспермум F. g. 166/19, Еритроспермум C. h. 177/19, Еритроспермум C. h. 175/19, які використовують селекціонери інституту і їх передано до НЦГРРУ. За показником тривалість вегетаційного періоду виділено лінію Еритроспермум F. g. 164/19 у якої вегетаційний період становив 238 діб, що на 3 доби менше, ніж у стандартного сорту Подолянка. Її віднесено до групи ранньостиглих форм. Високі показники маси 1000 зерен відмічені в ліній Еритроспермум F. g. 164/19 – 50,6 г, Еритроспермум F. g. 166/19 – 49,3 г, Еритроспермум F. g. 163/19 – 46,5 г та Еритроспермум C. h. 177/19 – 47,3 г. За урожайністю стандарт перевищували лінії Лютесценс F.g. 163/19 – на 38,8 г/м^2, Еритроспермум C. h. 177/19 – на 39,6 г/м^2, Еритроспермум C. h. 175/19 – на 26,7 г/м^2. З високим умістом білка вирізнилися лінії Еритроспермум F. g. 166/19 – 16,5 % і Еритроспермум C. h. 177/19 – 15,8 %. Найвищий рівень умісту клейковини в зерні зафіксовано в лінії Еритроспермум F. g. 166/19 – 41,2 %. Кращими за показником седиментації виділені лінії: Лютесценс F.g. 163/19 – 70 мл, Еритроспермум F.g. 164/19 – 67 мл, Еритроспермум F. g. 166/19 – 71 мл. Встановлено, що лінія Лютесценс F. g. 163/19 проявила високу стійкість проти збудника борошнистої роси (ураження – 1,0 %) та септоріозу листя (ураження – 3,0 %). Ураження колосу фузаріозом не перевищувало 5,0 %. Стійкістю проти двох збудників (фузаріоз, борошниста роса) вирізнилася лінія Еритроспермум F.g. 166/19, а проти фузаріозу й септоріозу листя – Еритроспермум F. g. 164/19. Лінії, створені за програмою стійкості проти кореневих гнилей Еритроспермум C. h. 177/19 і Еритроспермум C. h. 175/19, проявили відносну стійкі проти цього збудника – ураження 10,0 та 10,5 %, та мали високу стійкість проти борошнистої роси – ураження 2,0 %

Ключові слова: лінії; хвороби; ураження; стійкість; вилягання; висота рослин; урожайність; якість зерна