

INFLUENCE OF THE *FUSARIUM OXYSPORUM* FUNGUS ON THE TRANSGRESSIVE POTENTIAL OF GROWTH TRAITS OF COMMON WHEAT

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Abstract. the purpose of the research was to establish the reaction of 7 parents, 4 pairs of F₂ hybrids of common winter wheat, obtained based on 4 pairs of reciprocal F₁ hybrids, and the transgressive potential of growth and development organs to the treatment of grains with *Fusarium oxysporum* culture filtrate. The pathogen was isolated from wheat plants with root rot symptoms and identified by macro- and microscopic methods. The culture filtrate (CF) was prepared on the basis of Czapek liquid medium. After treating the grains for 18 hours with CF, the seedlings were cultivated for 6 days, after which morphometric analyses of growth characters were performed. Plant distribution histograms were analyzed according to variant and character. The degree (Tg), the frequency (Tf) of transgressions were calculated and the important role of the plant-pathogen interaction mode, the parental factor in the spectrum of phenotypic classes and transgressive manifestations in segregating populations were found.

Keywords: *Fusarium oxysporum*, traits, transgressions, wheat.

INTRODUCTION

Interactions between plants and fungi can have beneficial or detrimental effects on host plants and can give rise to various changes at both the plant and the fungus levels. Plant fungal pathogens are economically important due to the threat they pose to the production and yield of agricultural crops.

The reduction or prevention of fungal diseases of plants depends on resistant crop varieties or fungicide treatment. Plant-fungi interactions need to be known to understand the mechanisms of fungal plant diseases, their prevention, and to improve plant productivity [1, 2].

The fungus *Fusarium oxysporum* Snyder et Hans. has a wide distribution both geographically and in terms of expansion on different host plants, which demonstrates the possession of a strong fermentative apparatus that gives it the possibility to utilize as many biochemical substrates as possible. It is a fungus with vascular activity, being better known for its ability to produce seed/grain rot at the

germination stage, root system, stem base and plant wilting [3].

Plant populations, like all living organisms, are the level of organization through which the species exists and realizes its biological potential under specific conditions. In this regard, there is little research on the influence of fungi on the population level of plants.

Due to the phenomenon of crossing-over in meiotic prophase I, which involves the exchange of fragments between homologous chromosomes, recombinant genetic material is obtained. It is this phenomenon that underlies the generation of a wide spectrum of genotypes with recombinant characters in the F_2 population, which offers broad opportunities for theoretical research and practical applications in biology and agriculture.

The success of genetic improvement is based on the knowledge and correct use of available germplasm, in order to identify the varieties to be used as parents in such a way that when crossed they generate an F_1 offspring with a high heterotic effect, allowing the emergence of transgressive variants that can be selected in segregating generations. According to the author [4], transgressive segregation consists of the production of F_2 offspring or subsequent generations with phenotypes that exceed the range of the parental populations from which they are derived.

According to the author [5], transgressive phenotypes are the result of positive or negative complementation of additive alleles, epistatic interactions of unique parental attributes, unmasking of recessive alleles from a heterozygous parent, or various combinations of these mechanisms.

The author [6] proposed that transgression occurs by crossing parents with similar values for the variable under study, but with different genes controlling the trait, which allows some F_2 individuals to contain new gene combinations with a greater or lesser number of genes that present a more favorable effect than that of the parents.

The aim of the present research was to elucidate the influence of the phytopathogen *F. oxysporum* on the spectrum of phenotypic classes in F_2 populations of common wheat, descendants of reciprocal F_1 hybrids, and the degree and frequency of transgressions of some growth and development characters.

MATERIALS AND METHODS

The study material consisted of 7 common winter wheat parents – Moldova 11 (M11), Moldova 16 (M16), Moldova 66 (M66), Cuialnic, Amor, Miranda, Centurion and 4 pairs of F_2 hybrids – descendants of reciprocal F_1 hybrids. The culture filtrate of the *F. oxysporum* isolate from wheat plant with signs of stem base rot was obtained on the basis of Czappek liquid nutrient medium (figure 1).

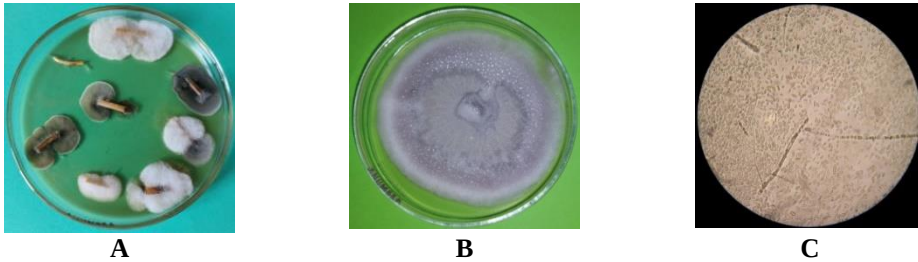


Figure 1. Isolation of the fungi from the stem base of: wheat (A); colony (B) and microconidia (C, 300x) of *F. oxysporum*

Wheat grains were treated for 18 hours with *F. oxysporum* CF. Morphometric analysis of the length of the embryonic radicle and the stem was performed on day 6 of seedling growth. The experiment was performed in replicates, 30 grains each for the parents and 120 – for the F₂ hybrids.

The degree of transgression (T_g) was calculated based on the formula: $T_g = [(C_h \cdot 100\%) : C_p] - 100$, where T_g – degree of transgression of the trait in percentage; C_h – maximum value of the trait in the F₂ generation hybrid (average of the 3 best plants); C_p – maximum value of the trait of the best parent (average of the 3 best plants).

The transgression frequency (T_f) was determined according to the formula: $T_f = (H \cdot 100\%) : N_h$, where T_f – transgression frequency in percentage; H – number of F₂ hybrid plants that exceed the best parent (average of 3 best plants) by the analyzed character; N_h – total number of F₂ hybrid plants analyzed [7].

When describing histograms, the following 3 basic characteristics were taken into account: **modality** – the number of "peaks" of the distribution (**unimodal** – with a single peak, **bi-**, **multimodal** – two or more "peaks"); **skewness** – the tendency of increasing or decreasing values: *skewed to the right* – a tendency of increasing the investigated characteristic and is called a positive distribution, *skewed to the left* – a tendency of decreasing the investigated characteristic – a negative distribution, the lack of skewness signifies a symmetric distribution; **flattening** – if the distribution is very flattened it means that the scores/values vary a lot, and if it is sharp – the scores/values vary little [8]. The data were statistically processed in the STATISTICA 7 software package.

RESULTS AND DISCUSSIONS

Radicle length. It was found that *F. oxysporum* CF produced both inhibition and stimulation of radicle growth in the F₂ M66 x Amor population. In the control variant it recorded 113.9 mm, and in the F. ox. CF variant – 91.3 mm, which means a decrease of 19.9%. At the same time, in the F₂ Amor x M66 population in the control variant, the radicle length was 56.4 mm, and under the influence of CF – 70

mm, thus showing growth stimulation by 24.1% (figure 2).

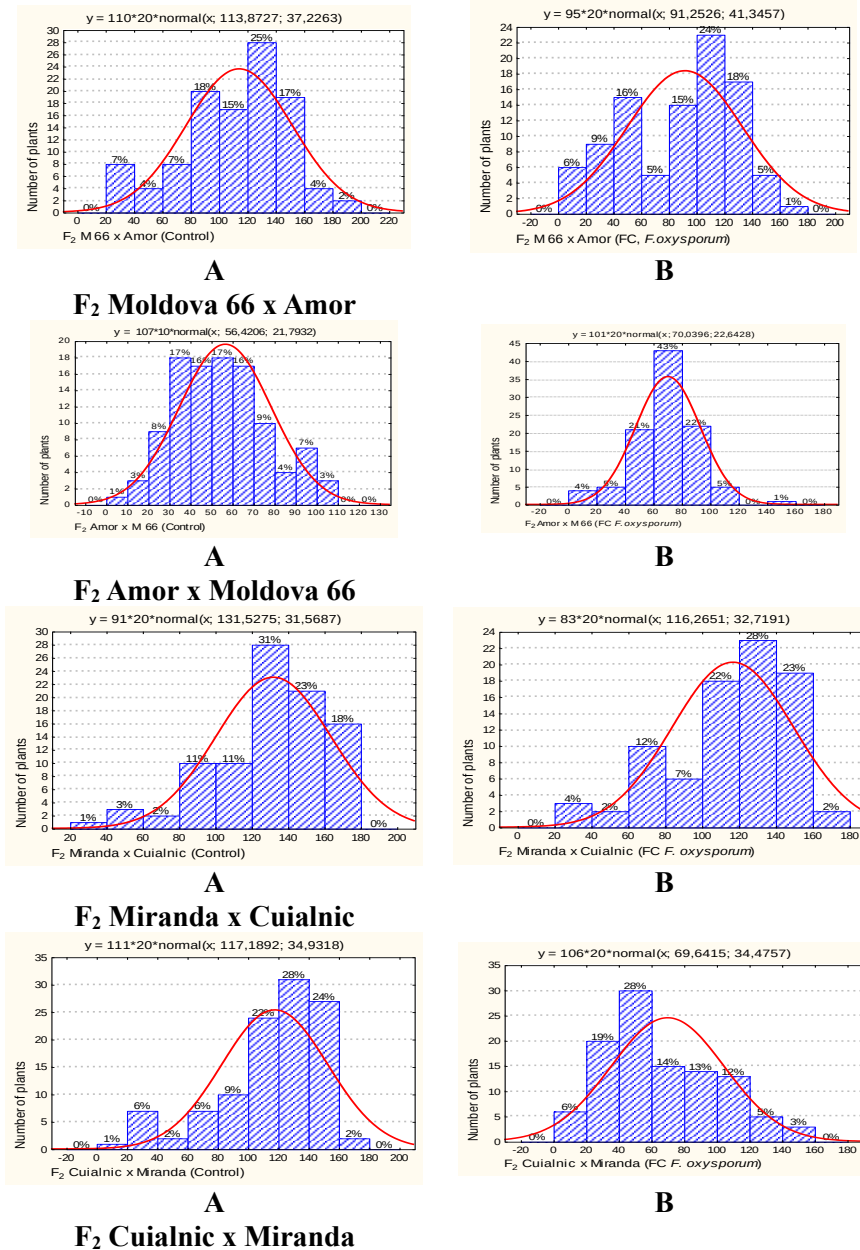


Figure 2. Spectrum of phenotypic classes (raicle length, mm) in F₂ populations of common wheat:

A – control, B – *F. oxysporum* FC

In the case of the F₂ Miranda Cuialnic and F₂ Cuialnic x Miranda hybrids, a decrease in radicle length under the influence of *F. oxysporum* CF was recorded by 11.6% and 40.6%, respectively. The data indicate that the reaction of wheat to *F. oxysporum* is specific, and the pattern of plant-pathogen interaction has the parental factor as a determinant in the creation of new genotypes.

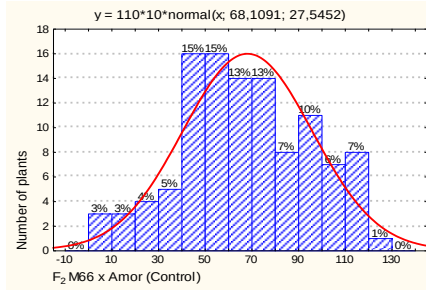
Disregarding the average values of the populations for the characters under study, which often camouflage different particularities and subcomponents within the system, we find that the pathogen influenced the profile of the distribution histograms of the phenotypic classes differently.

For example, under the pressure of the fungus *F. oxysporum*, in the F₂ M66 X Amor hybrid, a tendency for the population to decompose into 2 subpopulations with their own characteristics was observed - amplitude, maximum of value distribution, number of phenotypic classes, flattening. In the F₂ Amor x Moldova 66 population in the variant with *F. oxysporum*, no phenomena of decomposition of the initial population were observed, on the other hand, the maximum of value distribution with adjacent classes was narrower, which means lower variability.

Regarding the combinations F₂ Miranda x Cuialnic and F₂ Cuialnic x Miranda, it was observed that in the variant with *F. oxysporum* CF the rate of plants with high values of radicle length decreased compared to the control. For example, regarding the phenotypic classes 140-160 and 160-180 mm, in the combination F₂ Miranda x Cuialnic the summary rate of plants constituted 41 and 25%, respectively, of the control and *F. oxysporum* CF and in the reciprocal combination F₂ Cuialnic x Miranda – 26 and 3%, respectively, of the control and *F. oxysporum* CF variants.

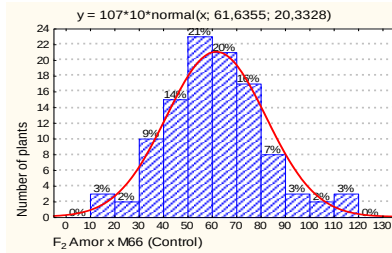
Stem length. A decrease in the character was found – by 11.1% in the F₂ M66 x Amor combination and a stimulation by 8.6% – in the F₂ Amor x M66 combination under the influence of the pathogen. Unlike the radicle, in the F₂ Amor x M66 combination, at the same time, in the variant with fungus, the spectrum of phenotypic classes was expanded (figure 3).

The character average of the combinations F₂ Miranda x Cuialnic, F₂ Cuialnic x Miranda in the variant with FC recorded +1.2% and -24.9%, respectively, in relation to the control. The F₂ Miranda x Cuialnic population was uneven in the control variant, but under the influence of the fungus, it slightly became uniform. In the F₂ Cuialnic x Miranda population, under the action of FC, the seedlings suffered a distribution tilted to the left, in the direction of low values.



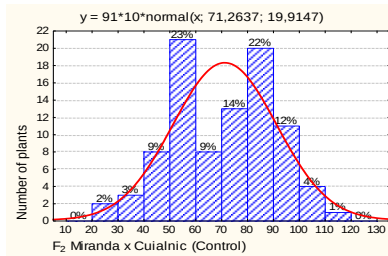
A

F₂ Moldova 66 x Amor



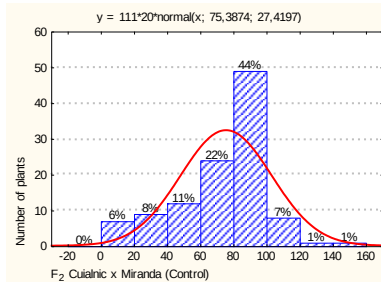
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F₂ Amor x Moldova 66



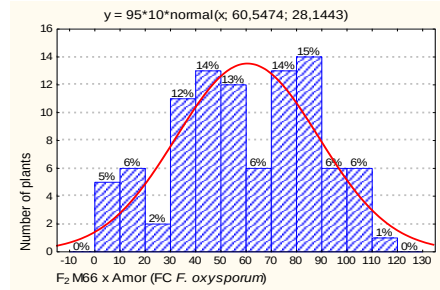
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F₂ Miranda x Cuialnic

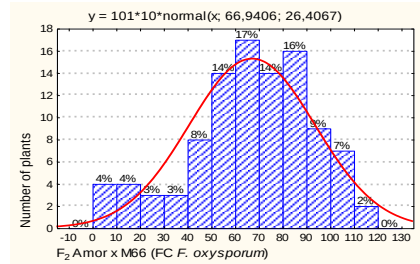


A

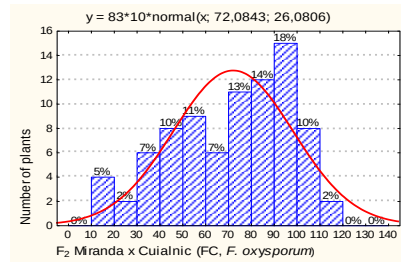
F₂ Cuialnic x Miranda



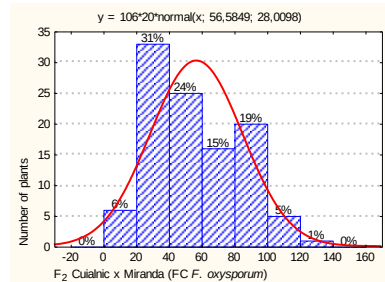
B



B



B



B

Figure 3. Spectrum of phenotypic classes (stem length, mm) in F₂ populations of common wheat:

A – control, B – *F. oxysporum* CF

The calculation of the degree (Tg) and frequency of transgressions (Tf) for the characters under study demonstrated the prevalence of negative transgressions in the case of the radicle and positive ones – in the stem (table).

Taking as a basis the postulate that transgressive phenotypes are determined mainly by the complementary action of allelic genes, we can admit that this mechanism can provide several positive "extreme" phenotypes for the less sensitive character (the stem) to the action of the phytopathogen, and at the same time - several negative "extreme" phenotypes for the sensitive character - the embryonic radicle, as demonstrated in previous research [9].

Starting from the practical interest in genotypes that manifest positive transgressions in the interaction with pathogens, in particular of sensitive characters but important for the vitality of the plant, we consider that the combinations F₂ Amor x Moldova 16, Cuialnic x Miranda, Centurion x Moldova 11 are promising, whose rate of positive segregants for radicle length on a background of biotic pressure varied within the limits of 3.77 ... 5.66%, the degree of positive transgression varying within the limits of 4.44 ... 11.09%.

Table 1. Degree (Tg) and frequency of transgressions (Tf) of some growth characters in the interaction of common wheat with *F. oxysporum*

F ₂ combination	Variant	The length of radicle		The length of stem	
		T _g	T _f	T _g	T _f
Amor x Moldova 66	Martor	-1,96	0,91	10,49	4,67
	FC <i>F. ox.</i>	-27,99	0,01	2,4	1,98
Moldova 66 x Amor	Martor	-43,14	0,01	17,05	12,73
	FC <i>F. ox.</i>	-4,83	1,05	0,90	1,05
Amor x Moldova 16	Martor	-3,70	1,80	12,73	4,72
	FC <i>F. ox.</i>	9,86	4,04	0,29	1,01
Moldova 16 x Amor	Martor	-3,70	1,80	15,76	5,41
	FC <i>F. ox.</i>	-5,13	0,02	5,80	2,83
Miranda x Cuialnic	Martor	-23,17	0,01	-16,3	0,02
	FC <i>F. ox.</i>	-2,35	0,96	9,03	9,62
Cuialnic x Miranda	Martor	1,78	3,67	10,14	7,34
	FC <i>F. ox.</i>	11,09	5,66	-10,65	0,01
Moldova 11 x Centurion	Martor	7,29	4,42	8,26	24,78
	FC <i>F. ox.</i>	-6,45	0,01	26,18	19,54
Centurion x Moldova 11	Martor	-24,70	0,02	-15,34	0,98
	FC <i>F. ox.</i>	4,44	3,77	25,09	27,12

CONCLUSIONS

1. It was found that treating common wheat grains with *F. oxysporum* culture filtrate led to inhibition or stimulation of embryonic radicle and stem growth.

2. Under the influence of the fungus, changes occurred in the profile of plant distribution spectra in F₂ segregating populations – the appearance of bi- or trimodal histograms, the orientation of the slope, flattening (expanded, contracted).

3. The F₂ combinations Amor x Moldova 16, Cuialnic x Miranda, Centurion x Moldova 11 are considered promising, whose degree and rate of positive segregants for radicle length on a background of biotic pressure varied within the limits of 3.77 ... 5.66%, 4.44 ... 11.09%, respectively.

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