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TRITICI EM. MARCHAL IN MOBILE NURSERIES**

**PROUČAVANJE VIRULENTNOSTI *ERYSIPHE GRAMINIS DC. EX MERAT F.SP.*
TRITICI EM. MARCHAL POMOĆU POKRETNIH RASADNIKA**

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SCREENING THE VIRULENCE OF *ERYSIPHE GRAMINIS* DC. Ex Merat f. sp. TRITICI Em. Marchal IN MOBILE NURSERIES*)

In 1989 and 1990, we tested in mobile nurseries the virulence of causal agent of powdery mildew during the spring vegetation of wheat in Novi Sad and Kragujevac. The different virulence spectra were determined and the least frequent alleles were V-3b, V-4a and V-9. Mobile nurseries are suitable for collecting and screening the population at different intervals.

Key words: *Erysiphe graminis*, screening, virulence, wheat, nurseries, Serbia

Introduction

Erysiphe graminis tritici = (*Blumeria graminis tritici*), the causal agent of powdery mildew in wheat, occurs regularly in Yugoslavia. Infection intensity varies depending on wheat variety, climat conditions and agricultural practices (S m i l j a k o v i ć, 1966).

The necessary predisposition for rational wheat breeding for resistance to powdery mildew, is to know the virulence of the pathogen and the sources of resistance. The screening of virulence is usually done by testing the cleistothecia isolates, proliferated by sexual reproduction (K o s t i ć and P r i b a k o v i ć, 1981, 1985; S t o j a n o v i ć and P o n o š, 1988, 1990). However, it is very important to know the structure of the population and to make the quantitative analyses of its virulence in the course of the vegetation (W o l f e and M i n c h i n, 1976).

In our country, the population of the causal agent of powdery mildew has not been screened in mobile nurseries so far.

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Material and Methods

In the course of 1989 and 1990, trials were established in two locations: Novi Sad and Kragujevac. In each location, there were two mobile nurseries which were located at a safe distance (A and B).

The varieties and lines of wheat with known resistance gene Pm (Table 1) were sown in plastic cups. Until the one-leaf stage (8 days after sowing), the cups were kept in chambers, and after that period they were taken out in wheat field. After 48 to 72 hours, the plants were taken back into the chambers with optimum conditions for the plants and pathogen development.

Tab. 1. — Varieties and lines of wheat used to test the virulence of *Erysiphe graminis tritici* in the mobile nurseries

Sorte i linije pšenice korišćene za ispitivanje virulentnosti *Erysiphe graminis tritici* pomoću pokretnih rasadnika

Variety or line Sorta ili linija	CI	Resistance gene Gen otpornosti	Location Lokacija	Corresponding virulence Odgovarajuća virulentnost
Axminster/ ⁸ CC	14114	Pm 1	7 AL	V-1
Ulka/ ⁸ Cc	14118	Pm 2	5 DS	V-2
Idaed/ ⁸ Cc	14119	Pm 2 ⁺	5 DS	V-2 ⁺
Asosan/ ⁸ Cc	14120	Pm 3a	1 AS	V-3a
Chul/ ⁸ Cc	14121	Pm 3b	1 AS	V-3b
Sonora/ ⁸ Cc	14122	Pm 3c	1 AS	V-3c
Khapli/ ⁸ Cc	14123	Pm 4a	2 AI	V-4a
Hope/ ⁸ Cc	14124	pm 5	7 BL	V-5
Mich. Amber/ ⁸ Cc	14033	Pm 6	2 B	V-6
Trances	14189	Pm 7	—	V-7
Kavkaz	—	Pm 8	1 B	V-8
Amigo	—	Pm 9	—	V-9

Eight to 10 days after the inoculation, the seedlings reaction was scored according to the exhibited infection type on the scale from 0 to 4, (0-2 immune and 3-4 susceptible) (M a i n s and D i e t z, 1930) and the exhibited infection intensity from 0 to 100%

The mobile nurseries were used from March till the end of May. The plants sowing time and taking out and back were identical for both locations.

Results and Discussion

Tables 2 and 3 show the differences in virulence spectra of *Erysiphe graminis tritici* in different locations and years. The lines which contained genes Pm 1, Pm 2⁺, and Pm 6 showed the first phenotypic virulence, because these genes are inefficient to numerous isolates (S t o j a n o v i ć et al., 1991). Other genes were also inefficient, especially the recessive gene Pm 5 (L o w and W o l f e, 1966). Consequently, the new sources of resistance should be introduced to such investigations to have as wide as possible virulence spectrum, individually, some major resistance genes may be inefficient, but in

T a b. 2. — Virulence spectrum of *Erysiphe graminis tritici* in the mobile nurseries in Kragujevac
 Spektar virulentnosti *Erysiphe graminis tritici* u pokretnim rasadnicima u Kragujevcu

Taking out date Datum Izn ošenja	Date of screening Datum očltavanja	Set A B	Pm genes — Pm geni											
			1	2	2a	3a	3b	3c	4	5	6	7	8	9
			1989.											
13.03.	27.03	A	Without disease — Bez bolesti											
		B	Without disease — Bez bolesti											
24.03.	7.04	A	Without disease — Bez bolesti											
		B	Without disease — Bez bolesti											
		A	A	A	V	A	A	A	A	A	V	A	A	A
3.04.	18.04.	B	A	A	A	A	A	A	A	A	A	A	A	V
		A	V	V	V	V	V	V	V	V	V	V	V	V
24.04.	6.05.	B	V	V	V	V	V	V	V	V	V	V	V	V
		A	V	V	V	V	V	V	V	V	V	V	V	V
4.05.	17.05.	B	V	V	V	V	V	V	V	V	V	V	V	V
			1990.											
22.03.	2.04.	A	Without disease — Bez bolesti											
		B	Without disease — Bez bolesti											
		A	Without disease — Bez bolesti											
30.03.	12.04.	B	A	A	A	A	A	A	A	A	V	A	A	A
		A	V	A	A	A	A	A	A	A	A	A	A	A
10.04.	25.04.	B	V	A	A	A	A	A	A	A	V	A	A	A
		A	V	V	V	V	V	V	V	A	V	V	V	A
19.04.	4.05.	B	V	V	V	V	V	V	V	V	V	V	V	A
		A	V	V	V	V	V	V	V	V	V	V	V	A
25.04.	10.5	B	V	V	V	V	V	V	V	V	V	V	V	A
		A	V	V	V	V	V	V	V	V	V	V	V	—
4.05.	17.05.	B	V	V	V	V	V	V	V	V	V	V	V	—

V = virulence — virulentnost
 A = avirulence — avirulentnost

their own or with minor genes interactions, they may be sources of good resistance. Therefore, the accumulation of more resistance genes in a single wheat variety is an important factor in the control of wheat for this pathogen (Bennett, 1984). Jorgensen and Jensen (1972) reported that the wheat line with CI number 12633 has Pm 2 and Pm 6 genes. According to numerous researchers, this line is highly resistant and widely used in breeding programs all over the world (Bennett, 1984). In our conditions, it was also highly resistant line (Smiljaković, 1966; Javor, 1981; Stojanović and Ponoš, 1988).

Differences existed in the same location, between two (A and B) nurseries located at a safe distance. In Kragujevac, powdery mildew was reported on lines which had Pm 2+ and Pm 6 genes at the location A while only the variety Amigo (Pm 9) was attacked by powdery mildew at the location B on April 18, 1989. At the same time, the lines which

T a b. 3. — Virulence spectrum of *Erysiphe graminis tritici* in the mobil nurseries in Novi Sad
Spektar virulentnosti *Erysiphe graminis tritici* u pokretnom rasadniku u Novom Sadu

Taking out date Datum iznošenja	Date of scoring Datum očitavanja	Set A B	Pm genes — Pm geni											
			1	2	2+	3a	3b	3c	4	5	6	7	8	9
			1989											
13.03.	27.03.	A	Without disease — Bez bolesti											
		A	A	A	A	A	A	A	A	A	A	A	A	V
24.03.	7.04.	B	V	A	A	A	A	V	A	V	V	V	A	A
		A	V	A	A	A	A	V	A	V	V	V	A	A
3.04.	18.04.	B	V	A	V	V	A	V	A	V	V	V	A	V
		A	V	V	V	V	V	V	A	V	V	V	V	V
24.04.	6.05.	B	V	V	V	V	A	V	V	V	V	V	V	V
		A	V	V	V	V	V	V	A	V	V	V	V	V
4.05.	17.05.	B	V	V	V	V	V	V	A	V	V	V	V	V
			1990.											
		A	A	A	V	A	A	A	A	A	V	V	V	A
22.03.	2.04.	B	A	A	V	A	A	A	A	V	V	V	V	A
		A	V	V	V	A	V	A	V	V	V	V	V	A
30.03.	12.04.	B	V	V	V	A	A	V	A	V	A	A	V	A
		A	V	V	V	V	A	V	A	V	V	V	V	A
10.04.	25.04.	B	V	V	V	A	A	V	A	V	V	V	A	A
		A	V	V	V	V	V	V	V	V	V	V	V	V
19.04.	4.05.	B	V	V	V	V	V	V	V	V	V	V	V	A
		A	V	V	V	V	V	V	V	V	V	V	V	V
25.04.	10.05.	B	V	V	V	V	V	V	V	V	V	V	V	V
		A	V	V	V	V	V	V	V	V	V	V	V	V
4.05.	17.05.	B	V	V	V	V	V	V	V	V	V	V	—	—

V = virulence — virulentnost
A = avirulence — avirulentnost

had Pm 2+, Pm 3a and Pm 9 genes had different reactions in the mobile nurseries A and B in Novi Sad. Even higher differences on this location were observed on April 7, 1989, when Amigo was the only susceptible variety in A, while the lines with Pm 1, Pm 3c, pm5, Pm 6 and Pm 7 genes were susceptible in B. Such differences, which occurred in 1990 as well, may be explained by the existence of different alleles for virulence alleles and by the effect of variety and microclimatic conditions on the occurrence of powdery mildew.

The parasite population had wider virulence spectrum in Novi Sad than in Kragujevac. According to the spectrum of reactions of differential varieties in Kragujevac and Novi Sad, there are seven and thirteen virulence formulae, respectively. The smaller number of virulence formulae than that formed by sexual reproduction (Stojanović et al., 1991) is explainable by the fact that it is not possible to make population

differentiation in mobile nurseries, because conidia of different origin or those having the same alleles for virulence alleles for all Pm genes, occupy the differential plants at the same time. In such cases, there exists only one virulence spectrum where all Pm genes have phenotypic susceptibility.

Alleles for virulence V-1, V-2+, V-3a, V-3c, V-5, V-6, V-7 and V-8 had the highest frequency in the population, while V-3b, V-4a and V-9 had the lowest (Figure 1). These results are in agreement with our previous results which showed the high efficiency of Pm 3b and Pm 4a genes (Stojanović and Stojanović, 1989). At the beginning of the vegetation, there were no virulence alleles for Pm 9 gene, but they appeared later, when inoculum and disease spread in wheat crop. According to Heun (1987), Pm 3b and Pm 9 genes were efficient in southern parts of Germany as well as in New York (Namuco et al., 1987). According to our investigations, V-6 allele had the highest frequency, and then followed V-1, V-2+, V-5, V-7 etc. According to Leah and Murphy (1986), V-3a virulence had the highest frequency in the pathogen population of North Carolina.

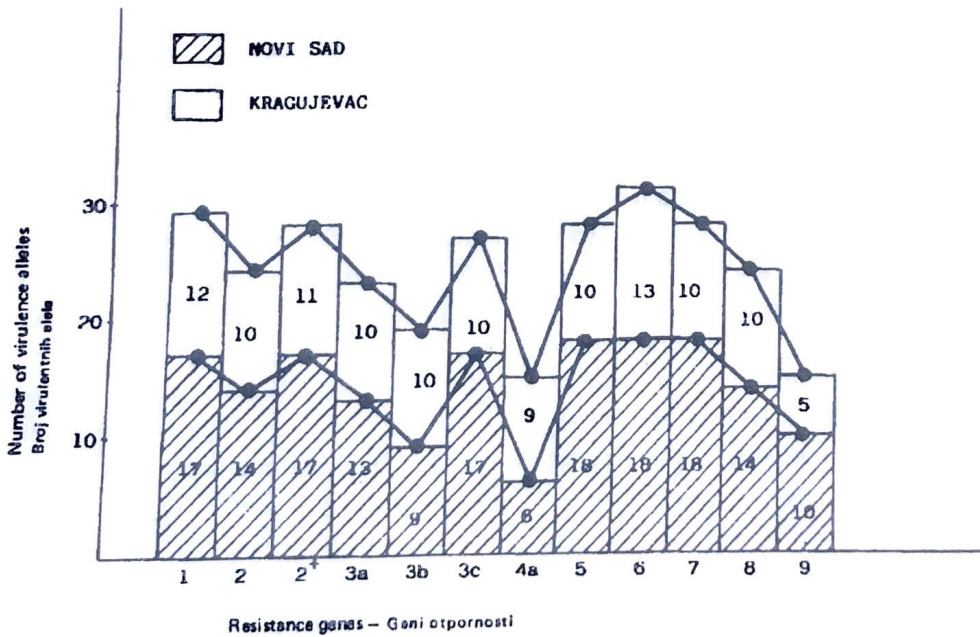


Fig. 1. — Frequency of virulence alleles of *Erysiphe graminis tritici* in mobile nurseries in 1989 and 1990

Učestalost alela virulentnosti *Erysiphe graminis tritici* u pokretnim rasadnicima u 1989. i 1990. godini

All examined isogenic wheat lines and varieties were susceptible, but the infection had different intensity (Table 4 and 5). The lines with Pm 3 and Pm 4a genes and the variety Kavkaz (Pm 8) had the low infection intensity in 1989, while in 1990, the variety Amigo (Pm 9) had such reaction. Pm 8 is inefficient gene, because in 1989 it had over

T a b. 4. — Severity of infection of *Erysiphe graminis tritici* in mobile nurseries in 1989
 Intenzitet zaraze *Erysiphe graminis tritici* u pokretnim rasadnicima u 1989. god.

No. Red. broj	Pm gene Pm gen	Scoring data — Datum očitavanja																			
		27.03.				7.04.				18.04.				6.05.				17.05.			
		KG		NS		KG		NS		KG		NS		KG		NS		KG		NS	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1.	1					0	t	0	0	5	t	90	50	60	t	60	50	60	t		
2.	2					0	0	0	0	0	0	40	40	60	10	40	20	70	0		
3.	2 ⁺					0	0	t	0	0	10	50	30	50	30	40	10	50	10		
4.	3a	Bez bolesti				0	0	0	0	0	10	50	30	50	10	60	20	20	70		
5.	3b	Bez bolesti				0	0	0	0	0	0	20	30	20	0	60	30	5	5		
6.	3c					0	t	0	0	5	30	60	60	30	30	60	50	20	70		
7.	4a					0	0	0	0	0	0	20	t	0	0	30	30	0	0		
8.	5					0	t	0	0	5	t	60	30	40	30	40	50	20	80		
9.	6					0	t	5	0	5	10	80	50	60	20	60	50	70	30		
10.	7					0	t	0	0	70	10	70	50	90	20	60	60	10	90		
11.	8					0	0	0	0	0	0	10	5	10	t	20	20	10	t		
12.	9					t	0	0	t	0	10	60	50	80	40	60	60	90	90		

KG — Kragujevac
 NS — Novi Sad

90% alleles for virulence (Stojanović et al., 1991). The genotypes in mobile nurseries were very virulent. They proved to be suitable collection and examination of the population in different intervals (Eyal et al., 1973). Such investigations are important because the pathogen population changes during the wheat vegetation. Wolfe and Minchin (1976) find the mobile nurseries necessary for the successful analysis of pathogen population dynamics, but field sampling is indispensable for fast results. The differences between the infection intensities of two distant nurseries in the same location were also screened. Sometimes, the differences are negligible, while in some lines, they are clearly expressed such as on lines with Pm 3b gene (in Novi Sad) and Pm 4a gene (in Kragujevac).

In both years, the occurrence of first *E. graminis tritici* pustules was earlier in Novi Sad than in Kragujevac. According to Smiljaković (1966), in the region of Serbia, the fungus overwinters in form of mycelia and forms 8–10 conidia generations in spring. According to the same author, the first powdery mildew occurred in the beginning of March. In the mobile nurseries, the first infection occurred at the end of March, which differs greatly from the first disease occurrence in nature. Such results could be expected because a long period has to pass between the primary infection and the presence of conidia in the air due to the unfavourable conditions for infection, incubation and fructification of the parasite in the middle of March. The average infection intensity in all mobile nurseries, lines, years and periods in 1989 was higher in Kragujevac than in Novi Sad, while in 1990 it was higher in Novi Sad. The mean infection intensity was higher in 1989 than in 1990, because of unfavourable conditions for parasite development in

T a b. 5. — Severity of infection of *Erysiphe graminis tritici* in mobile nurseries in 1990
 Intenzitet zaraze *Erysiphe graminis tritici* u pokretnim rasadnicima u 1990. god.

No. Red. broj	Pm gene Pm gen	Scoring data — Datum očitavanja																
		2.04.		12.04.		4.05.		25.04.		10.05.		17.05.						
		KG A	NS B	KG A	NS B	KG A	NS B	KG A	NS B	KG A	NS B	KG A	NS B					
1.		0	0	0	0	t	t	t	5	30	20	15	30	40	50	40	50	70
2.		0	0	0	0	t	0	0	t	30	20	10	t	5	30	40	20	60
3.	2 ⁺	t	t	0	0	0	0	0	5	50	15	15	5	5	40	40	50	60
4.	3a	0	0	0	0	t	0	0	t	60	10	5	40	30	30	30	30	60
5.	3b	0	0	0	0	0	0	0	0	5	t	t	5	10	25	20	30	80
6.	3c	0	0	0	0	t	0	0	t	20	10	5	t	40	30	35	20	50
7.	4a	0	0	0	0	0	0	0	0	10	5	t	t	t	10	10	10	80
8.	5	0	5	0	0	0	0	0	t	40	10	10	t	30	60	40	10	50
9.	6	5	5	0	t	0	0	t	t	30	15	t	30	50	30	50	50	70
10.	7	t	5	0	0	10	0	0	t	20	20	15	60	60	80	70	50	80
11.	8	t	5	0	0	5	5	0	t	20	25	15	60	60	70	60	80	80
12.	9	0	0	0	0	0	0	0	0	0	t	0	0	—	15	10	—	30

KG — Kragujevac
 NS — Novi Sad

1990, first of all insufficient rainfall during the spring. The rainfall which occurs in the period when seedlings are taken out, negatively affects the sowing of air-borne conidia, because they are washed off the leaves.

o n c l u s i o n s

The first phenotypic virulence was recorded at the beginning of April on lines which contained genes Pm 1, Pm 2+, and Pm 6. In both years, the occurrence of powdery mildew was earlier in Novi Sad than in Kragujevac.

The population in Novi Sad had wider spectra of virulence than that in Kragujevac. The reaction of differential varieties in Kragujevac and Novi Sad showed the existence of seven and thirteen virulence formulae, respectively.

The virulence alleles, V-1, V-2+, V-5, V-6 and V-7 showed the highest frequency, while V-3b, V-4a and V-9 showed the lowest.

In 1989, the average infection intensity in all mobile nurseries, all Pm genes and all periods, was higher in Kragujevac, while in 1990 it was higher in Novi Sad. The differences of infection intensity depended on year, location, local climatic conditions and alleles of resistance and virulence. Due to unfavourable conditions, the infection intensity was lower in 1990 than in 1989. The low infection intensity was scored on the lines with Pm 3b and Pm 4a genes in both years, while in 1989 it was scored on the variety Kavkaz (Pm 8) and in 1990 on the variety Amigo (Pm 9).

The virulence of the population of the causal agent of powdery mildew can be successively tested in mobile nurseries in various time intervals. Such investigations should be continued in our country in more location and with an additional resistance source.

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