VIRULENCE OF *PUCCINIA STRIIFORMIS* POPULATION IN THE WEST OF ROMANIA

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ABSTRACT

In the last 50 years in Romania, the yellow rust attack was present with high intensity in 1961, 1967, 1978, 1985, 1988, 1991 and 2001. Although we have been studying at Oradea the appearance and evolution of *Puccinia striiformis* pathogen since 1998, only in 2001 we pointed out the presence of a significant attack on differential set. This study allowed the identification of wheat genes which were or weren't effective in protection against *Puccinia striiformis* races. All wheat genes were effective, except *Yr6* (?+2) from Heines Kolben, *Yr*7 from Lee and *YrA*+, from Anza cultivar. In Western Europe, the attack of *Puccinia striiformis* is stronger than in Romania. In addition, the number of virulent races in west of Romania is smaller. Considering the known expansion of new races to East, these results must be a warning for the breeders in Romania.The strong attack of yellow rust during the 2001 demonstrated that the cultivars Decan, Fundulea 4, Delia and Dropia are susceptible to pathogen races presented in the structure of *Puccinia striiformis* population. Other Romanian cultivars like Boema, Expres, Ardeal and G.K. Othalom (Hungarian), were resistant.

Key words: yellow rust, wheat.

INTRODUCTION

Puccinia striiformis Westend f.sp. *tritici*, which produces wheat yellow rust, is an obliged parasite, with a cyclic development in Romania because wintering conditions in this area are not optimal (Ittu et al., 1989). Although it has a reduced occurrence frequency, yellow rust could produce high damages as it happened in 1961, 1967, 1978 (Ceapoiu and Negulescu, 1983, 1985, 1988, 1991; Barbulescu et al., 1992).

In Hungary, contiguous to West of Romania, the yellow rust has become an important disease since 1985, especially in the South of the country, on Yugoslavian cultivars (Szunics, 1986).

Since 1932, Gassner and Straib (quoted by Stubbs, 1988) had shown that the race distribution of *Puccinia* depends on local cultivars and the change of cultivar structure will be followed by changes in the race composition. Thus, the 104 E 137 race, which occurred in North-West of Europe, has gradually moved to the East of the continent. Due to intensive wheat breeding towards the resistance to current races, the North-West of Europe is a center of new virulent race occurrence. In this area, some *Puccinia* races resistant to pesticides have also occurred by mutation (Ittu, 1996).

Long-term research led to the description of ten spreading areas in Europe and Asia and three in America, depending on the spectrum of races preponderant into populations (Stubbs, 1988). Romania is included in the fourth area, which spreads from the South-East of Europe to Middle-East and Egypt. The preponderant races of this area are 104 E 137, 6 E 16 and 82 E 16. Referring to these races, the same author showed that *Yr7* is the only gene which confer resistance to 104 E 137 race, 6 E 16 race is non-virulent on *YrA* gene from Anza cultivar and 82 E 16 race is virulent on *Yr10* gene from Moro cultivar.

The attack of *Puccinia striiformis* is influenced by environmental factors, as it is a pathogen which prefers low temperatures and high humidity. Thus, Johnson (1988) stated that the uredospores viability and emergence are strongly influenced by temperature, light and humidity. In Stubbs's opinion (1988), the optimum temperature for spores germination is 9-12°C, the minimum temperature is 0°C and the maximum one is 20-26°C.

More recent studies (Ash and Rees, 1994) have shown that the attack is maximal at 13°C, low at 25°C and below 13°C, under artificial inoculation, all cultivars were susceptible. These authors emphasize that the light intensity is very important in fungus proliferation.

To predict the development of yellow rust attack, research is presently targeted towards the elaboration of epidemic simulation models, taking into consideration the meteorological data, cultivar response, distance from the infection area, atmospheric concentration in carbon dioxide and ozone (Ittu, 1996).

Presently, a differential set of winter wheat cultivars with one or many resistance genes is

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used to study the *Puccinia striiformis* physiological races. A reduced number of resistance genes specific to various races, some of them dominant, other recessives or strongly influenced by environment and genetic background, were identified (Johnson, 1988). Some cultivars (Capelle Desprez, Maris Huntsman) include specific resistance genes, while other resistant cultivars (Holdfast, Little Joss) do not. The genes *Yr2*, *Yr6* and *Yr9* are recessive, at least in some combinations.

Other studies on *Puccinia striiformis* resistance genetics showed that the additive and dominance gene effects are important but depend on fungus pathotype (Ghannadha et al., 1995), the number of involved genes ranging between 1 and 4. Chen et al. (1995), by the testing crosses with a set of 21 aneuploids of Chinese Spring cultivar, located the gene *Yr2* on 7B chromosome, *Yr9* and *Yr10* on 1B and also postulated the existence of other genes on chromosomes 4A, 4B, D, 3A, 1A and 5D. Some of the most efficient genes originate from the related species or genera: gene *Yr15* from *Triticum dicoccoides*, *Yr 8* from *Aegilops comosa* and *Yr9* from *Secale cereale* by 1B/1R translocation (Stubbs, 1988; Johnson, 1988). The cultivar Capelle Desprez has a complex resistance, with specific and non-specific genes. The gene *Yr16* is located on 2D chromosome (Worland and Law, 1986) and on short arms of chromosomes belonging to homeologus 5 group, there are also other genes which confer resistance to *Puccinia striiformis* (Law et al., 1978).

Presently, many genotypes with durable resistance, are known: Capelle Desprez, Hybride de Bersee, Bounty, Andes, Anza, Little Joss. These cultivars, which include a gene or a combination of genes, could be used into breeding programs from other geographical areas, but with a certain risk due to changing the climatic conditions and pathogen races.

In Romania, most of cultivated varieties are *Yr1* and *Yr9* carriers, the origin of the genes being Nadadores an d respectively Aurora, Kaukaz or Fundulea 29 cultivars (Botezan et al., 1982; Ittu et al., 1995).

MATERIAL AND METHODS

The world distribution of *Puccinia striiformis* virulence genes is directly linked with performed in many locations has not detected any complete and durable resistance. Thus, monitoring the response of new cultivars to yellow rust and detecting changes in pathogen structure is essential.

Due to large spreading of rusts, an international program for airborne diseases research in small cereals has been initiated at the level of EU since 1997. Because the pathogen virulence varies in Europe depending on the resistance genes deployed and climatic conditions, the monitoring of airborne pathogens was organized by the COST 817 program at the level of whole Europe.

The rusts, including yellow rust, were monitored in Romania too, at Fundulea, Turda, Podu-Iloaiei and Oradea.

The paper presents the observation regarding the *Puccinia striiformis* manifestation in the West of Romania during 1998-2001. A differential set of 25 wheat genotypes which include various genes of resistance to *Puccinia striiformis* was used. Using this set allowed the identification of the spectrum and genetic diversity of pathogen populations (physiological races) which attack wheat. The differential set was sown in autumn, on two rows of 1 m length, at 30 cm distance between rows. To estimate the attack, the Cob modified scale was used, registering the infection type and attack intensity. The infection type depends on the necrosis size and sporulation degree and the attack intensity depends on maximum percentage of leaf covering by pustules.

The yellow rust attack estimation on wheat on-station yield trials was done by scores which synthetically describe the attack at the level of both leaf and whole plot.

RESULTS AND DISCUSSION

The strongest yellow rust attack of the last 20 years, was registered in 2001. Although, the yellow rust manifests only once in 5-6 years, the damage can be very important. This is why we have studied, at Oradea, since 1998, the disease occurrence, the *Puccinia striiformis* population structure and wheat resistance genes on which the races of pathogen are virulent or non-virulent.

In 1998, the spring was warmer than usual, with normal rainfall (65-88 mm/month) but with air relative humidity low enough (75-80%). Under these circumstances, the yellow rust occurred late, at the beginning of June. The disease did not occur on genotypes of differential set, but only on several lines belonging to leaf and stem rust differential sets.

Climatically, the spring of 1999 was almost similar with that of 1998. No obvious symptoms were noticed on yellow rust differential set, but symptoms were observed on several isogenic lines of the differential set for leaf rust and on NK 747 cultivar.

In 2000, the spring was extremely warm, with low rainfall and extremely low air atmospheric humidity (59-73) and the yellow rust did not occur.

The fact that during all three years, symptoms of *Puccinia striiformis* attack did not occur on any cultivar of the differential set could be explained by the late occurrence of spores into area (after 15th July) with very low intensity, when leaves were old enough or dry and by unfavourable climatic conditions for pathogen (2000 year).

April of 2000 was warmer as usual (monthly average temperature being of 10.8°C), extremely rainy (102.1 l/m^2) and with high atmospheric humidity (81%). Under these conditions, a strong yellow rust attack was noticed, inclusively on the differential set (Table 1).

At the first observations (30th May), *Puccinia striiformis* was noticed on suscep-tible check (Lovrin 855/99) and on Heines Kolben and Lee cultivars, the infection being of medium resistant (MR) type and the maximum intensity approximately equal (30% of the leaf covered with pustules). The wheat resistance genes which were inefficient to attack were *Yr6* (?+2) and *Yr7* from Heines Kolben and Lee.

The second observation was done in 13th June, when, necroses on Anza cultivar were registered. The type of infection was middle resistant on Heines Kolben and Anza cultivars, middle susceptible on Lee cultivar and on the check, the degree of leaf covering with pustules being obviously higher.

These data correspond to a narrow genetic structure of the fungus, respectively 1-2 races.

Thus, the previous researches performed by Ceapoiu and Negulescu (1983) who showed that in Romania, the most wide spread genes for virulence are those corresponding to resistance genes *Yr6* and *Yr7*, are confirmed. Recently, Ittu et al. (1989) have found that *Puccinia striiformis* has efficient virulence on *Yr7, Yr9,* and *Yr10* genes. In the fourth spreading area for *Puccinia striiformis*, which include Romania, the predominant races are 104 E 137, 6 E 16 and 82 E 16. Because *Yr7* is the only gene which confers resistance to race 104 E 137 and 82 E 16 is virulent on Moro (*Yr10*), it means that in 2001, the yellow rust attack was provoked by race 6 E 16. This race could be virulent or non-virulent on *YrA*.

Table 1. Efficiency of wheat resistance genes to the *Puccinia striiformis* attack at Oradea in 2001

Resistance genes	Differential set	Yellow rust attack			
		30th May		13th June	
		Infection type	Intensity	Infection type	Intensity
Yr1	Chinese 166	-	-	-	-
Yr2	Heine's VII	-	-	-	-
Yr2	Kalyansona	-	-	-	-
Yr3a, +	Vilmorin 23	-	-	-	-
Yr3a, +	Nord Desprez	-	-	-	-
Yr3b, Yr4b	Hybrid 46	-	-	-	-
Yr3c	Maris Huntsman	-	-	-	-
Yr5	*Triticum* sp. var. *album*	-	-	-	-
Yr6, Yr2	Heine's Peko	-	-	-	-
Yr6 (?+2)	Heine's Kolben	MR	30	MR	40
Yr6+7	Pavon 76	-	-	-	-
Yr7	Lee	MR	30	MS	45
Yr7+	Reichersberg	-	-	-	-
Yr 8	Compair	-	-	-	-
Yr9+	Slejpner	-	-	-	-
Yr10	Moro	-	-	-	-
Yr11	Joss Cambier	-	-	-	-
Yr14	Moulin	-	-	-	-
Yr17	VPM	-	-	-	-
CV	Carstens V	-	-	-	-
CV+	Hereward	-	-	-	-

YrA+	Anza	-	-	MR	40
So	Suwon 92/ Omar	-	-	-	-
Sd	Strubes Dickkopf	-	-	-	-
Sp	Speldings Prolific	-	-	-	-
Lovrin 855/99 (sensitive check)		MR	32	MS	57

It is known that the race 110 E 143 is virulent on *Yr7* gene and the race 4 E 0 is virulent on *Yr6*. Both races are preponderant in the Eastern Europe (former USSR) and it is possible that they might arrive in our area, under certain atypical climatic conditions.

Based on these data, we appreciate that the *Puccinia* population structure consists in races 6 E 16, 110 E 143 and E 0, virulent on *Yr6*, *Yr7* and *YrA+* genes. Comparing the results from Oradea with those presented by Bayles (1998), we ascertain that the *Puccinia striiformis* has a much stronger manifestation in the West of Europe (Table 2).

Additionally, in Romania, the number of virulent races is smaller (3) vs. France (9), Denmark (10), Holland (8) or England (8). Although, the data proceed from different climatically areas and years, knowing the tendency towards expansion of the new races to the East, these data must be a warning to breeders.

Table 2. Virulence of *Puccinia striiformis* local races in several European countries as compared with West Romania

Country	Race virulence														
	V1	V2	V3a	V3b V4b	V6	V7	V 8	V9	V10	V17	V_{CV}	V_{A}	V_{So}	V_{Sd}	V_{Sp}
France	62	100	100	84	51	0	0	92	0	0	0	16	84	100	0
Denmark	4	91	100	100	27	0	0	80	-	6	18	-	98	100	0
Holland	100	100	100	27	87	0	0	100	0	-	0	13	-	100	0
England	90	99	100	67	35	0	0	95	-	70	36	-	-	-	-
Romania (Oradea)	0	0	0	0	40	45	0	0	0	0	0	40	0	0	0

The yellow rust attack also intensely manifested on lines and cultivars tested in on-station yield trials. This allowed a good genotype characterization regarding the resistance to *Puccinia striiformis* attack, under natural infection (Table 3).

The first pustules occurred in spots, at the beginning of May, on wheat line Decan. This line proved to be the most susceptible one, finally reaching leaf rolling and premature drying of all leaves. The cultivar Dropia was also one of the most affected by the disease attack. Fundulea 4 and Delia cultivars, with similar pedigree proved to be very susceptible to disease. Although these cultivars include the *Yr9* resistance gene, originating from Fundulea 29, and another supplementary resistance factor (Ittu et al., 1995), they were strongly attacked due to action of another physiological race.

The cultivars Boema and G.K. Othalom showed no attack and, on line Expres we only noticed a reduced number of pustules, in one rep. The cultivar Ardeal also confirmed its resistance to yellow rust.

Table 3 . Reaction of several wheat genotypes to yellow rust attack in yield trials at Oradea in 2001

Genotype	Yellow rust attack intensity (notes)		
	30th May	13th June	Max. value
Boema	2.0	2.0	2
G. K. Othalom	2.0	2.0	2
Expres	2.2	2.2	3
Ardeal	2.5	2.5	3
Turda 2000	2.5	2.5	3
Farmec	2.5	2.5	3
Efect	2.7	2.8	4
Bezostaya	3.0	3.0	3
Lovrin 34	3.0	3.0	3
Falnic	3.0	3.0	4
Crina	3.0	3.2	4
Flamura 85	2.8	3.2	4

Romulus	3.0	3.3	4
Ariesan	3.2	3.3	4
Destin	3.5	3.5	5
Experiment average	*3.4*	*3.66*	*4.6*
Delabrad	3.7	3.7	4
Alex	3.7	3.8	5
Emul	4.2	4.2	6
Dor	4.2	4.3	7
Turda 95	4.0	4.7	6
G. K. Gobe	4.5	4.8	6
Dropia	4.7	5.3	8
Delia	4.8	5.7	7
Fundulea 4	4.7	6.3	7
Decan	5.7	6.7	8

CONCLUSIONS

The resistance genes which did not ensure protection of wheat against yellow rust attack in 2001 were: *Yr6 (?+2), Yr7* and *YrA+*.

The wheat genotypes with the best resistance to yellow rust were Boema and G.K. Othalom cultivars and the line Expres.

REFERENCES

ASH, G., J., REES, R., G., 1994. Effect of post-inoculation temperature and light intensity on expression of resistance to stripe rust in some Australian wheat cultivars. Austr. J. Agr. Res., 4 5, 7: 1379-1386.

BAYLES, R., 1998. Yellow rust of wheat. Annual report 1997 – COST 817. Population studies of airborne pathogens on cereals as a means of improving strategies for disease control. European Comm., Ed. H. Ostergard: 55-64.

BARBULESCU, Al. et. al., 1992. Evolution of some diseases and pest of grain industrial and forage crops in our country, during 1991 (in Romanian). Probleme de protectia plantelor, XX, 1-2: 67-83.

BOTEZAN, V., MOLDOVAN, V., MOLDOVAN, MARIA, 1982. Rezultate privind ameliorarea grâului în Transilvania. In: Contributii ale cercetarii stiintifice la dezvoltarea agriculturii. Redactia de Propaganda Tehnica Agricola, Bucuresti: 23-64.

CEAPOIU, N., NEGULESCU, FLOARE, 1983. Genetica si ameliorarea rezistentei la boli a plantelor. Edit. Academiei R.S.R.: 225-228.

CHEN, X., LINE, R., F., JONES, S., S., 1995. Chromosomal location of genes for resistance to *Puccinia striiformis* in winter wheat cultivars Heines VII, Clement, Moro, Tyee, Tres and Daws. Phytopathology, 85, 11: 1362-1367.

GHANNADHA, M., R., GORDON, I., L., CROMEY, M., G., McEWAN, J., M., 1995. Diallel analysis of the latent period of stripe rust in wheat. Theor. App. Gen., 90, 3-4: 471-476.

ITTU, MARIANA, SAULESCU, N., N., ITTU, Gh., MOLDOVAN, MARIA, 1989. New elements in the breeding strategy for disease resistance in wheat (in Romanian). Probleme de genetica teoretica si aplicata, XXI, 3: 123-147.

ITTU, MARIANA, SAULESCU, N., N., ITTU, Gh., 1995. Types and factors of resistance to diseases utilized in the wheat breeding programme (in Romanian). Anale I.C.C.P.T., LXII: 35-45.

ITTU, MARIANA, 1996. 9th Cereale Rusts & Powdery Mildews Conference (in Romanian). Lunteren, Olanda, 2nd-8th September 1996. Probleme de genetica teoretica si aplicata, XXVIII, 2: 135-140.

JOHNSON, R., 1988. Durable resistance to yellow (stripe) rust în wheat and its implications in plant breeding. Breeding strategies for resistance to the rust of wheat. Mexico, D. F., CIMMYT: 23- 28.

LAW, C., N., GAINES, R., C., JOHNSON, R., WORLAND, A., J., 1978. The application of aneuploid techniques to a study of simple rust resistance in wheat. Proceedings of the 5th Int. Wheat Gen. Symp., New Delhi: 427-436.

STUBBS, R., W., 1988. Pathogenicity analysis of yellow (stripe) rust of wheat and its significance in a global context. Breeding strategies for resistance to the rust of wheat. Mexico, D. F., CIMMYT: 23-38.

SZUNICS, L., 1986. Wheat resistance research team. Research results from the Agricultural Research Institute of the Hungarian Academy of Sciences, 1981-1985. Ed. L. Balla, Martonvásár: 66-72.

WORLAND, A., J., LAW, C., N., 1986. Genetic analysis of chromosome 2D of wheat. The location of genes affecting height, day-length insensitivity, hybrid dwarfism and yellow rust resistance. Zeitschrift für Pflanzenzüchtung, 96: 331-345.