NARDI FUNDULEA, ROMANIA ROMANIAN AGRICULTURAL RESEARCH, NO. 41, 2024
www.incda-fundulea.ro; doi.org/10.59665/rar4135 First Online: February, 2024. DII 2067-5720 RAR 2024-84

Response of Thirteen Winter Wheat (*Triticum Aestivum*) Cultivars to Severe Stripe Rust (*Puccinia Striiformis* f. Sp. *Tritici*) Attack

Indira Galit[1*], Cristina-Mihaela Marinciu[1], Vasile Mandea[1], Gabriela Șerban[1], Iustina Lobonţiu[2], Zsuzsa Domokos[2], Gheorghe Bunta[3], Cecilia Bănăţeanu[4], Beniamin Andras[4], Cristina Meluca[5], Gabriela Gorinoiu[6], Nicolae N. Săulescu[1]

[1]National Agricultural Research and Development Institute Fundulea, Călăraşi County, Romania
[2]Research and Development Station for Cattle Breeding Târgu Mureş, Mureş County, Romania
[3]Agricultural Research and Development Station Oradea, Bihor County, Romania
[4]Agricultural Research and Development Station Livada, Satu Mare County, Romania
[5]Agricultural Research and Development Station Teleorman, Drăgăneşti-Vlaşca, Teleorman County, Romania
[6]Agricultural Research and Development Station Lovrin, Timiş County, Romania
[*]Corresponding author. E-mail: indira_galit@yahoo.com

ABSTRACT

Stripe rust caused by *Puccinia striiformis* f. sp. *tritici* has become an increasing threat for wheat crops worldwide. In Romania, stripe rust showed in 2023 increased adaptation to higher temperatures and different virulence at various sites. We analyzed the response to this new stripe rust variant of twelve winter wheat cultivars released by the National Agricultural Research & Development Institute Fundulea - Romania and one historical check, at six locations that reported higher attacks in 2023. Cultivars showed significantly different disease scores, ranging from resistant to very susceptible. Four of the five resistant cultivars were related and probably carry the same resistance gene(s) and only one had a different genealogy. All the other eight cultivars were medium-susceptible and susceptible. This underlines the need for more diversity of resistance to stripe rust in the breeding program. Resistance gene *Yr18*, present in two of the tested cultivars did not offer a sufficient protection against stripe rust. Average grain yield was significantly correlated with stripe rust scores averaged over the six sites (r=-0.85). However, cultivars with similar disease scores had different yields, as illustrated by large deviations from the regression of yields on stripe rust scores. These deviations might reflect differences in yielding potential and/or in tolerance to the disease. Cumulating these traits with genetic resistance deserves attention in breeding programs.

Keywords: stripe rust, wheat, grain yield, tolerance.

INTRODUCTION

The Stripe rust, caused by *Puccinia striiformis* f. sp. *tritici,*is now one of the most important wheat diseases that threaten food security (Hailu and Fininsa, 2007; Cotuna et al., 2019; Chen, 2020; Esmail et al., 2023). Increased frequency and intensity of stripe rust attacks has been observed worldwide, and recently in Romania too. The main factors causing this increase were identified as the appearance of more virulent and more aggressive new races, better adapted to higher temperatures, which circulated globally over long distances, as well as the increased chances for survival over winter, as a result of climate changes.

Many recent research results proved that spores travelling inter-continentally can cause epidemics (Brown and Hovmøller, 2002), and molecular studies demonstrated global migration of *Puccinia striiformis* f. sp. *Tritici* (Bai et al., 2021).

Severe stripe rust attacks were observed in wheat cultivars yield trials in six locations from different regions of Romania. Results suggested that the stripe rust races present in 2023 were better adapted to higher temperatures and showed variation of virulence at the respective sites (Galit et al., 2023).

In this paper analyzed the response of thirteen winter wheat cultivars to the new stripe rust variants present in the year 2023 in Romania.

Received 30 November 2023; accepted 19 February 2024.

MATERIAL AND METHODS

We analyzed the response to the attack of stripe rust in twelve winter wheat cultivars bred at NARDI Fundulea, along with the historical control Bezostaya 1, which were tested at six sites which reported higher attacks. These sites were located in Western Romania (ARDS Lovrin: 45°57’N latitude - longitude 20°46’E; ARDS Oradea: 47°02’N latitude - 21°54’E longitude; ARDS Livada: 47°52’N latitude - 23°08’E longitude) in the Center (RDSB Târgu Mureş: 46°32’N latitude - 24°33’E longitude) and in the South (ARDS Teleorman: 44°07’N latitude - 25°45’E longitude; NARDI Fundulea: 44°30`N latitude - 26°51`E longitude).

More details about material and methods used for obtaining the data presented in this paper can be found in Galit et al. (2023).

RESULTS AND DISCUSSIONS

The tested cultivars and the environments of the six testing centres were the main sources of variation for the recorded stripe rust scores (Table 1).

Table 1. ANOVA for scores of stripe rust attacks in thirteen wheat cultivars evaluated in six environments in the year 2023

Source of variation	SS	df	MS	F	P-value	F crit
Cultivars	170.33	12	14.19	9.01	1E-09	1.91
Environments	50.06	5	10.01	6.36	8E-05	2.36
Interaction C*E	94.43	60	1.573			
Total	314.83	77				

The effects of both sources of variation (cultivars and environments) were highly significant when tested against the interaction between cultivars and environments, while their interaction was small.

From the Table 2, which summarizes the stripe rust scores of the tested cultivars, one can see major differences between cultivars, both in average values over the six sites and the stability of these scores, as expressed by the variance. Average scores varied from 2.0 in cultivar FDL Consecvent to 7.3 in cultivar FDL Miranda, with most cultivars being characterized as “Medium susceptible” (average score from 4.0 to 5.0). Five cultivars were characterized as “Resistant”, with average scores between 2.0 and 3.0.

Table 2. Scores of stripe rust attack for winter wheat cultivars tested in 2023

Cultivar	Stripe rust score				Resistance group
	Average	Minimum	Maximum	Variance	
FDL Consecvent	2.00	1	4	1.600	Resistant
FDL E1	2.33	1	4	1.067	Resistant
FDL Abund	2.67	1	6	3.070	Resistant
FDL E2	2.83	1	5	1.767	Resistant
Otilia	3.00	2	4	1.200	Resistant
Voinic	4.33	3	7	2.267	Medium susceptible
FDL Columna	4.33	3	7	5.467	Medium susceptible
Pitar	4.67	3	6	1.467	Medium susceptible
Ursita	4.83	3	8	2.967	Medium susceptible
Glosa	5.00	3	7	2.400	Medium susceptible
FDL Concurent	5.00	2	7	2.800	Medium susceptible
Bezostaya 1	5.83	3	7	2.567	Susceptible
FDL Miranda	7.33	7	8	0.267	Susceptible

Averages with the same letter are not significantly different at P<5%.

Variation of rust scores was also different among the tested cultivars, the cultivar FDL Miranda having the most uniform scores at all sites (variance of 0.267), while FDL Columna had the most different scores (variance of 5.467). Stability of rust scores was not correlated with average scores as seen from the correlation coefficient (r=-0.014) and from the fact that small variance values were found in the most susceptible (FDL Miranda), but also in the resistant cultivars (Otilia, FDL Consecvent and FDL E1). This suggests that stability of expressed resistance to the stripe rust attack in different environments is an independent trait that deserves attention in breeding programs.

It is interesting to note that two cultivars known to carry the pleiotropic genes *Lr34/Yr18/Pm38*, namely Bezostaya 1 (Morgounov et al., 2012) and Glosa (Ciucă et al., 2015), were characterized as susceptible or medium susceptible, which suggests that the gene *Yr18* could not provide sufficient protection against the stripe rust races present in Romania in 2023.

Many of the tested cultivars are related, andthis can provide an insight into the genetics of stripe rust resistance of these cultivars.

Two of the most resistant cultivars were selected from a backcross with the cultivar OTILIA, which was noted as resistant many years ago, including in international testing in Turkiye. Our data showed that in 2023, FDL Consecvent and FDL Abund were less attacked than Otilia, and this suggests that they cumulated additional resistance gene(s) from the other parent (F00628G34), a breeding line derived from a cross involving triticale, used as a bridge for transferring useful genes from rye (Săulescu et al., 2011). This hypothesis is also supported by the fact that cultivar Ursita, selected from a cross involving the same line F00628G34 backcrossed with Glosa, was less attacked than the recurrent parent.

On the other hand, FDL Concurent, selected from the same cross as FDL Consecvent and FDL Abund, was attacked by stripe rust more than the other sister cultivars, as also seen from Figure 1.

FDL Concurent FDL Consecvent

Figure 1. Difference in stripe rust attack between two sister cultivars

The difference noted between these closely related sister cultivars suggests that the genetic control of the resistance coming from Otilia is simple, and therefore might be easily defeated by evolution of pathogen virulence. Another new line noticed as resistant (FDL E1) is also related to Otilia, and therefore may carry the same resistance gene(s). Otilia was also present in the genealogy of Voinic, but obviously this cultivar did not inherit the resistance to stripe rust of Otilia. The only resistant cultivar that is not related to Otilia (FDL E2) probably inherited stripe rust resistance from MV Nemere, a Hungarian cultivar which has as one of the parents a French breeding line. This information underlines the need for more diversity in the resistance genes used in the breeding programs.

Correlations between stripe rust attack and yield for each individual site, varied between -0.53 at Fundulea and -0.84 at Livada and slopes of regressions from -119 kg/ha at Fundulea to -691 kg/ha at Livada (Table 3). These values are higher than the ones found by Galit et al. (2023) for all twenty-five cultivars tested at each location. This is probably because most of the thirteen cultivars common to all trials were more related to each other than the complete set of twenty-five cultivars analyzed by Galit et al. (2023).

Table 3. Parameters of the equations describing the relationship between stripe rust scores and grain yield

Testing site	b kg/ha per unit stripe rust score	a kg/ha	Correlation between stripe rust scores and grain yield
Lovrin	-314.57	5969	r=-0.58
Oradea	-545.9	9961	r=-0.69
Livada	-690.8	9830	r=-0.87
Târgu Mureş	-569.0	8935	r=-0.69
Teleorman	-397.7	394	r=-0.75
Fundulea	-119.2	119	r=-0.53

The relationship between the stripe rust attack scores averaged over the testing sites and the average grain yield is described by a stronger correlation (r=-0.85) and by a regression slope b=-0.55 kg/ha per each one-point difference in the stripe rust score (Figure 2).

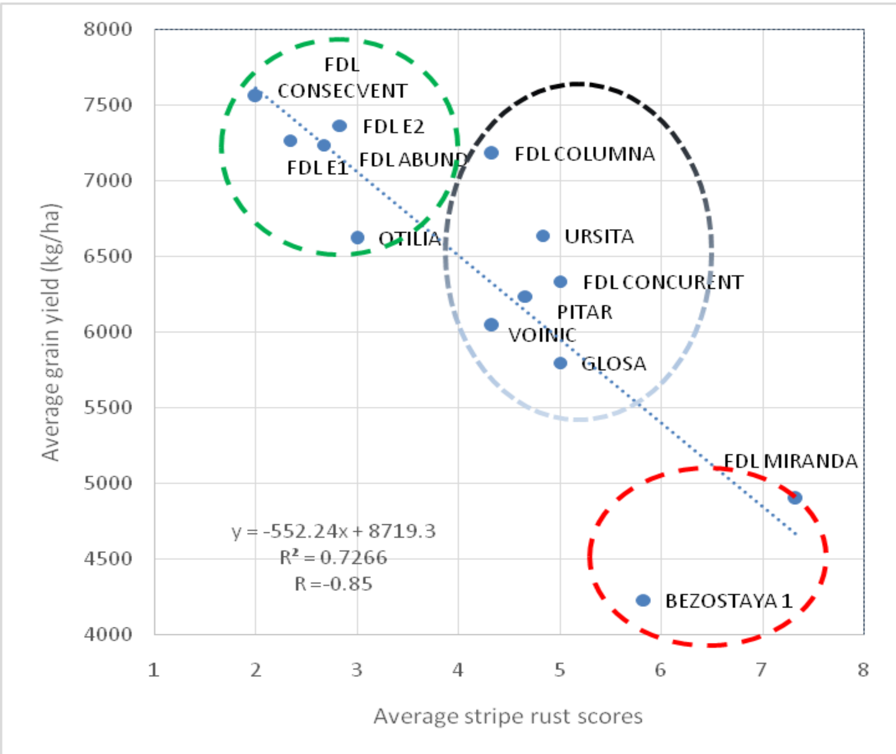

Figure 2. Relationship between the scores for stripe rust attack and grain yield, averaged over six sites

One can see that cultivars are clearly grouped according to their resistance to stripe rust, and this corresponds well with their grain yield. On the other hand, among the cultivars from each group, and especially among those from the medium resistant group, there are significant differences in yield at similar stripe rust scores, reflecting differences in yield potential and/or differences in their tolerance to the disease.

These are better described by the deviations from the regression of grain yield on scores of stripe rust attacks. Table 4 summarizes the deviations from the regression yield-stripe rust attack at each site, showing significant differences among cultivars.

The cultivars FDL Columna and Ursita, from the medium-susceptible group, had large positive deviations from the regression in all but one site, and FDL E2 and FDL Consecvent, from the resistant group, had positive deviations in four of the six sites. In contrast, Bezostaya 1 had negative deviations in all locations.

This suggests that the deviations from the regression of yield on stripe rust attack have a genetic component that might be used for protecting yield from this disease. Combining resistance with the ability for high positive deviations should deserve attention in wheat breeding programs.

Table 4. Deviations from the regression of grain yield on stripe rust scores (kg/ha per unit stripe rust score)

Cultivar	Environment					
	Lovrin	Oradea	Livada	Târgu Mureş	Teleorman	Fundulea	Average
FDL Columna	774	1395	1256	-769	321	843	637
Ursita	-301	734	789	789	606	242	476
FDL E2	1103	-310	-360	857	678	246	369
FDL Consecvent	49	177	313	1249	-80	-129	263
FDL Concurent	-564	1055	1466	-30	-311	-217	233
FDL Abund	-154	-101	192	190	369	306	134
Pitar	1130	-48	-73	-422	197	-281	84
FDL E1	445	-1303	408	-40	625	220	59
FDL Miranda	59	497	-1047	-203	694	-192	-32
Otilia	-680	-124	-465	879	-398	-210	-166
Voinic	-63	-187	-110	347	-1234	-429	-279
Glosa	-439	-488	-1830	-34	60	417	-386
Bezostaya 1	-1360	-1298	-538	-2814	-1526	-817	-1392

CONCLUSIONS

Thirteen wheat cultivars tested in locations with high stripe rust attack in 2023 showed significantly different disease scores, ranging from resistant to very susceptible. Four closely related cultivars (Otilia, FDL Consecvent, FDL Abund and FDL E1) and one cultivar with different genealogy were resistant, while all the others were medium-susceptible and susceptible. Resistance gene *Yr18*, present in two of the tested cultivars did not offer a sufficient protection against stripe rust. Average grain yield was significantly correlated with stripe rust scores averaged over the six sites (r=-0.85). However, cultivars with similar disease scores had different yields, as illustrated by large deviations from the regression of yields on stripe rust scores. These deviations might reflect differences in yielding potential and/or in tolerance to the disease and cumulating these traits with resistance deserves attention in breeding programs.

REFERENCES

Bai, Q., Wan, A., Wang, M., See, D.R., Chen, X., 2021. *Molecular characterization of wheat stripe rust pathogen (Puccinia striiformis f. sp. tritici) collections from nine countries*. International Journal of Molecular Sciences, 22(17), 9457.

Brown, J.K., and Hovmøller, M.S., 2002. *Aerial dispersal of pathogens on the global and continental scales and its impact on plant disease*. Science, 297(5581): 537-541.

Chen, X., 2020. *Pathogens which threaten food security: Puccinia striiformis, the wheat stripe rust pathogen*. Food Sec., 12: 239-251. https://doi.org/10.1007/s12571-020-01016-

Ciucă, M., Cristina, D., Turcu, A.G., Contescu, E.L., Ionescu, V., Săulescu, N.N., 2015. *Molecular detection of the adult plant leaf rust resistance gene Lr34 in Romanian winter wheat germplasm*. Cereal Research Communications, 43(2): 249-259.

Cotuna, O., Horablaga, M., Bostan, C., Sărățeanu, V., Agapie, A.L., 2019. *Response of some varieties and genotypes of triticale (Triticosecale wittm.) to the attack of puccinia striiformis west. Fungus in western Romania*. Research Journal of Agricultural Science, 51(2): 11-19.

Esmail S., Oma,r G., Mourad, A., 2023. *In-Depth Understanding of the Genetic Control of Stripe Rust Resistance (Puccinia striiformis f. sp. tritici) Induced in Wheat (Triticum aestivum) by Trichoderma asperellum T34*. Plant Dis., 107(2): 457-472. doi:10.1094/PDIS-07-22-1593-RE. Epub 2023 Feb 16. DOI: 10.1094/PDIS-07-22-1593-RE

Galit, I., Marinciu, C.M., Mandea, V., Șerban, G., Lobonţiu, J., Domokos, Z., Bunta, G.. Bănăţeanu, C., Andras, B., Meluca, C., Voica, M., Gorinoiu, G., Săulescu, N.N., 2023. *Rugina galbenă (Puccinia striiformis f. sp. tritici) - o ameninţare crescândă pentru culturile de grâu şi triticale* din *România [Stripe rust (Puccinia striiformis f. sp. tritici) - an increasing threat for wheat and triticale crops in Romania]*. An. INCDA Fundulea, XCI: 33-51.

Hailu, D., and Finisssa, C., 2007. *Epidemics of stripe rust (Puccinia striiformis) on common wheat (Triticum aestivum) in the highlands of Bale, southeastern Ethiopia*. Crop Protection, 26(8): 1209-1218.

Morgounov, A., Tufan, H.A., Sharma, R., Akin, B., Bagci, A., Braun, H. J., Mcintosh, R., 2012. *Global incidence of wheat rusts and powdery mildew during 1969-2010 and durability of resistance of winter wheat variety Bezostaya 1*. European Journal of Plant Pathology, 132: 323-340.

Săulescu, N.N., Ittu, G., Ciucă, M., Ittu, M., Şerban, G., Mustăţea, P., 2011. *Transferring useful rye genes to wheat, using triticale as a bridge*. Czech J. Genet. Plant Breed, 47: 56-62.