# STAŢIUNEA DE CERCETARE DEZVOLTARE AGRICOLĂ TELEORMAN

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# Cultivar and environment on the impact of yellow rust (*Puccinia striiformis*) in Triticale

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## INTRODUCTION

*Triticale (×Triticosecale Wittmack), a synthetic intergeneric hybrid between wheat (Triticum sp.) and rye (Secale sp.) has gained considerable importance in the past decades. It combines desirable traits of both parents (Salmanovicz et al., 2013), the high yield potential and high grain protein content of wheat with the disease resistance and environmental tolerance of rye to abiotic stress conditions such as aluminum toxicity, drought, salinity, acidic or waterlogged soils (Kuleung et al., 2004).*

*Triticale was long considered very resistant to rusts (Schevchenko and Karpachev, 1985) but later, several rust epidemics caused by Puccinia species have been reported in triticale (Bekele et al. 1985; Haesert et al.1987; Wilson and Shaner 1989a,b; Iliev et al. 1990; Zwer et al. 1992; Zamorski 1994; Schinkel, 2002; Sodkiewicz and Strzembicka, 2004; Mergoum et al., 2009; Mikhailova et al., 2009). Among these, yellow (stripe) rust (Puccinia striiformis, Pst), emerged in the past decades as a real economic threat in triticale (Wiese, 1987; Singh and Saari 1991; Guedes-Pinto et al., 1996).*

*In Romania, Pst, which is generally more adapted to the humid and cooler environments ($3^0C$ - 15°C), occured rather sporadicaly in the past (Ittu et al., 1989) and was rarely seen on triticale. However, a 91,7% attack of Pst on untreated plots of triticale was registered in 2018 (Goga, 2019) and attacks varying from 10 to 90% were reported on triticale in Western Romania (Cotuna et al, 2019, 2023). In 2023 symptoms of disease were observed on triticale in 2023, even in the South of Romania since March (Voica et al., 2023), and heavy attacks were reported in triticale in North-West and in Transylvania (Galit et al., 2023). Results presented by Galit et al. (2023) suggested that the stripe rust races present in 2023 were better adapted to higher temperatures.*

*Foto.1. Attack of the pathogen Puccinia striiformis*

## MATERIAL AND METHODS

*Triticale released cultivars and breeding lines originating from the breeding program of NARDI Fundulea were tested in 2022-2023 and 2023-2024 seasons in yield trials with balanced square lattice design with twenty-five entries and three replications, on five or ten $m^2$ harvestable plots without irrigation and using the usual crop management. Out of the eight locations which performed the trials, in three locations stripe rust was strong enough to have impact on grain yield, as expressed by a correlation between disease scores and yield r > 0.3 in at least one year. These locations included ARDS Livada (47°52'N latitude - 23°08'E longitude), RDSB Târgu-Mureș (46°32'N latitude- 24°33'E longitude) and ARDS Teleorman (44°07'N latitude - 25°45'E longitude). We included in the analysis twenty-three cultivars which were tested in both years.*

*In 2023-2024 at Tg. Mureș and Teleorman preliminar yield trials with one replicat ion, including new lines selected at ARDS Teleorman were organized in the same conditions.*

*Intensity of Puccinia striiformis was visually scored in the field under natural infection and uncontrolled conditions, on a scale between 1-9, where 1(resistant) and 9 (susceptible) (McNeal et al., 1971) and grain yield was expressed as kg $ha^{-1}$ at 14% moisture.*

*Table 2. ANOVA for stripe rust score and grain yield in the six analyzed yield trials*

| Source of Variation | Stripe rust score | | | Grain yield | | |
|---|---|---|---|---|---|---|
| | df | MS | F | MS | F | F crit |
| Cultivars | 22 | 6.570 | 5.038 | 5386448 | 5.887 | 1.639 |
| Environments | 5 | 159.176 | 122.060 | 1.54E+08 | 168.078 | 2.296 |
| G*E interaction | 110 | 1.304 | | 914853.8 | | |

*Table 3. Correlation between stripe rust scores registered in the six analyzed trials*

| | Livada23 | Livada24 | TgM23 | TgM24 | TR23 | TR24 |
|---|---|---|---|---|---|---|
| Livada 23 | 1 | | | | | |
| Livada 24 | **0.52** | 1 | | | | |
| Tg. Mures. 23 | **0.62** | **0.81** | 1 | | | |
| Tg. Mures 24 | **0.47** | **0.52** | **0.55** | 1 | | |
| Teleorman 23 | **0.58** | **0.49** | **0.51** | **0.62** | 1 | |
| Teleorman 24 | 0.37 | 0.24 | 0.32 | 0.29 | -0.09 | 1 |

*Table 5. Deviations from the regression of grain yield on stripe rust score (kg/ha)*

| CULTIVAR | Yield trial | | | | | |
|---|---|---|---|---|---|---|
| | Livada 2023 | Tg Mures 2023 | Teleorman 2023 | Livada 2024 | Tg Mures 2024 | Average (kg/ha) |
| ZARAZA | 3100 | 707 | 359 | 1034 | 362 | 1112 |
| T14187 | 1921 | 130 | 607 | 1857 | 1024 | 1108 |
| PLAI | 2024 | 84 | -377 | 1413 | 553 | 739 |
| T15038 | 575 | 121 | 614 | 974 | 591 | 575 |
| TF2 | 2811 | 127 | -760 | 453 | -637 | 399 |
| FDL CORDIAL | 304 | 90 | 578 | 652 | 353 | 396 |
| T16026 | -155 | -844 | 188 | 1668 | 612 | 294 |
| UTRIFUN | 443 | 125 | -260 | 995 | 145 | 290 |
| STIL | 27 | 56 | -412 | 1013 | -40 | 129 |
| T16322 | 740 | -833 | 408 | -309 | -49 | -9 |
| ZORI | -1431 | 119 | 208 | 943 | -260 | -84 |
| T14225 | -483 | -236 | 308 | 31 | -228 | -122 |
| PISC | 517 | 126 | -111 | -1390 | -553 | -282 |
| ODA FD | -1282 | 111 | -99 | 527 | -701 | -289 |
| T16007 | 84 | -914 | 386 | -974 | -372 | -358 |
| CASCADOR | 761 | 103 | 101 | -2088 | -945 | -414 |
| FDL ASCENDENT | -1404 | 50 | 204 | -1077 | -71 | -460 |
| T15183 | -1373 | 86 | -767 | -192 | -241 | -497 |
| TULNIC | -806 | 96 | 239 | -1135 | -932 | -508 |
| HAIDUC | -23 | 126 | -348 | -1800 | -674 | -544 |
| TITAN | -1875 | 112 | 141 | -848 | -659 | -626 |
| NEGOIU | -1242 | 127 | -788 | -1741 | 482 | -633 |
| ZVELT | -2766 | 108 | -269 | -928 | 378 | -695 |
| | | | | | LSD 5% | 248 |

*Table 1 Average temperatures and rainfall at three locations in 2023 and 2024*

| Specification | | LIVADA | | Tg. MUREȘ | | TELEORMAN | |
|---|---|---|---|---|---|---|---|
| Month | Decade | Temp. ($^0C$) | Rainfall mm | Temp. ($^0C$) | Rainfall mm | Temp. ($^0C$) | Rainfall mm |
| MARCH 2023 | I | 5,4 | 4.0 | 7.2 | 9.0 | 6.1 | 6.0 |
| | II | 5,9 | 14.2 | 7,2 | 12.5 | 6.4* | 10.0 |
| | III | 7,9 | 8.9 | 9,4 | 208.2 | 7.8 | 8.0 |
| | **Mean/Sum** | **6,4** | **27.1** | **7,9** | **229.7** | **6,8** | **24.0** |
| APRIL 2023 | I | 6,4 | 20.4 | 8,2 | 22.7 | 5.2 | 36.0 |
| | II | 11,6 | 9.8 | 12,0 | 6.8 | 11.1 | 10.0 |
| | III | 10,9 | 43.1 | 13,0* | 29.5 | 11,0 | 9.0 |
| | **Mean/Sum** | **9,6** | **73.3** | **11,1** | **64.0** | **9,1** | **55.0** |
| MAY 2023 | I | 14,4 | 6.3 | 14,3* | 8.0 | 13,5 | 8.0 |
| | II | 15,2 | 10.9 | 15,9 | 5.0 | 15.2 | 5.5 |
| | III | 19,4 | 2.5 | 18,4* | 15.5 | 18.4 | 40.5 |
| | **Mean/Sum** | **16,3** | **19.7** | **16,2** | **28.5** | **15,7** | **54.0** |
| MARCH 2024 | I | 9.2 | 9.8 | **8.98** | **15.0** | **7.0** | **3.0** |
| | II | 7.5 | 15.2 | 6.77 | 30.0 | 7.4 | 27.5 |
| | III | 11.2 | 15.0 | 11.1 | 5.0 | 11.3 | 19.0 |
| | **Mean/Sum** | **9.3** | **40.0** | **9.0** | **50.0** | **8.6** | **49.5** |
| APRIL 2024 | I | 14.8 | 9.0 | 14.6 | 3.0 | 15.7 | 2.0 |
| | II | 12.5 | 16.5 | 13.6 | 31.0 | 16.1 | 13.0 |
| | III | 12.1 | 16.1 | 12.1 | 32.0 | 13.4 | 19.0 |
| | **Mean/Sum** | **13.1** | 41.0 | **13.4** | **66.0** | **15.1** | **34.0** |
| MAY 2024 | I | 17.3 | 8.4 | 16.1 | 22.0 | 15.7 | 12.5 |
| | II | 15.9 | 6.5 | 14.7 | 21.0 | 15.0 | 4.5 |
| | III | 19.1 | 15.3 | 17.7 | 18.0 | 19.0 | 15.0 |
| | **Mean** | **17.4** | **30.2** | **16.1** | **61.0** | **16.6** | **32.0** |
| Temperatures higher than optimum for pathogen development | | | | | | | |

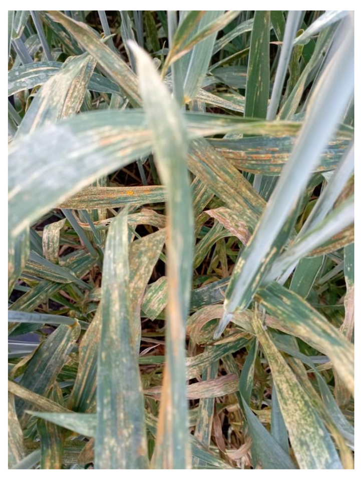


*Foto.2. Attack of the pathogen Puccinia striiformis*

*Table 4. Stripe rust scores and grain yield of twenty-three triticale cultivars, averaged over six trials (3 locations x 2 years)*

| Stripe rust score | | | Grain yield (kg/ha) | | |
|---|---|---|---|---|---|
| CULTIVAR | Averaged over six trials | Variance | CULT IVAR | Averaged over six trials | Variance |
| ZARAZA | 2.5 | 2.7 | ZARAZA | 7113 | 3323765 |
| T16026 | 4.3 | 9.1 | T14187 | 5046 | 8576397 |
| T16007 | 4.5 | 7.1 | PLAI | 4999 | 7664827 |
| TF2 | 4.7 | 9.9 | T16026 | 4797 | 8070712 |
| PLAI | 4.8 | 7.8 | TF2 | 4658 | 6577465 |
| T14225 | 4.8 | 8.6 | T16007 | 4409 | 8016503 |
| T16322 | 5.0 | 8.0 | T16322 | 4396 | 9331511 |
| FDL ASCENDENT | 5.3 | 8.3 | T15038 | 4277 | 7327029 |
| TITAN | 5.5 | 7.9 | T14225 | 4245 | 8347209 |
| T15183 | 5.5 | 7.5 | FDL CORDIAL | 3918 | 8998532 |
| STIL | 5.8 | 10.2 | UTRIFUN | 3898 | 5528266 |
| ZVELT | 5.8 | 9.4 | FDL ASCENDENT | 3745 | 9068583 |
| FDL CORDIAL | 6.0 | 8.0 | STIL | 3732 | 8889848 |
| ZORI | 6.2 | 10.6 | T15183 | 3595 | 7772520 |
| T14187 | 6.2 | 6.2 | ZORI | 3563 | 6235490 |
| HAIDUC | 6.3 | 9.5 | TITAN | 3480 | 7784520 |
| PISC | 6.3 | 8.3 | PISC | 3366 | 7248143 |
| UTRIFUN | 6.3 | 9.5 | ZVELT | 3283 | 8171507 |
| T15038 | 6.5 | 6.7 | ODA FD | 3254 | 7044529 |
| NEGOIU | 6.7 | 9.1 | TULNIC | 3032 | 7295462 |
| ODA FD | 6.7 | 9.1 | CASCADOR | 3023 | 7304757 |
| TULNIC | 6.7 | 7.1 | HAIDUC | 2983 | 8355543 |
| CASCADOR | 7.2 | 7.8 | NEGOIU | 2876 | 6961149 |
| LSD 5% | 1.36 | | LSD 5% | 1138 | |

*Foto.3. Attack of the pathogen Puccinia striiformis*

**Table 6. Correlations between weather data and the impact of stripe rust on Triticale yield (estimated by the correlation between stripe rust score and grain yield)**

| *Month* | Average temperature $^0C$ | Rainfall mm | Ratio Rainfall/Temperature |
|---|---|---|---|
| March | 0.24 | 0.26 | 0.19 |
| April | 0.61 | -0.76 | -0.67 |
| May | 0.28 | -0.25 | 0.27 |

*Figure 1. Relationship between stripe rust attack and grain yield at Tg. Mureș*

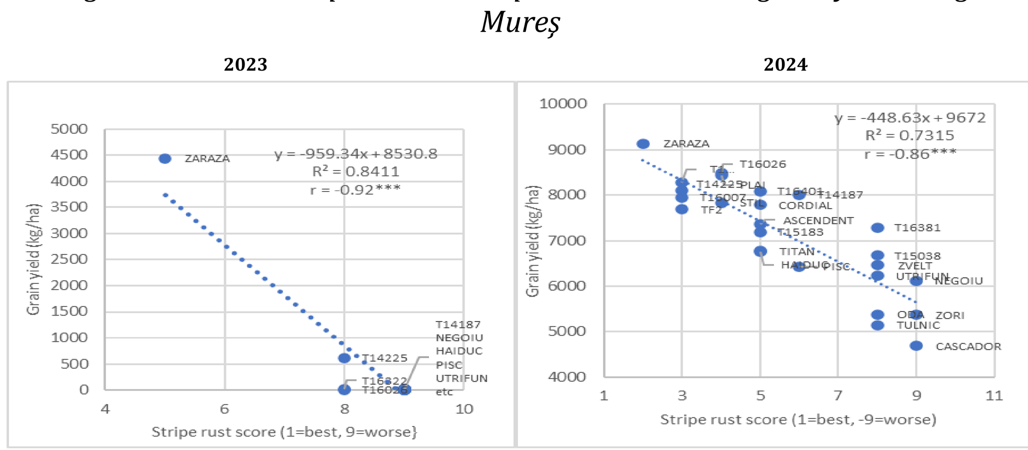



*Figure2. Relationship between stripe rust attack and grain yield at Livada*

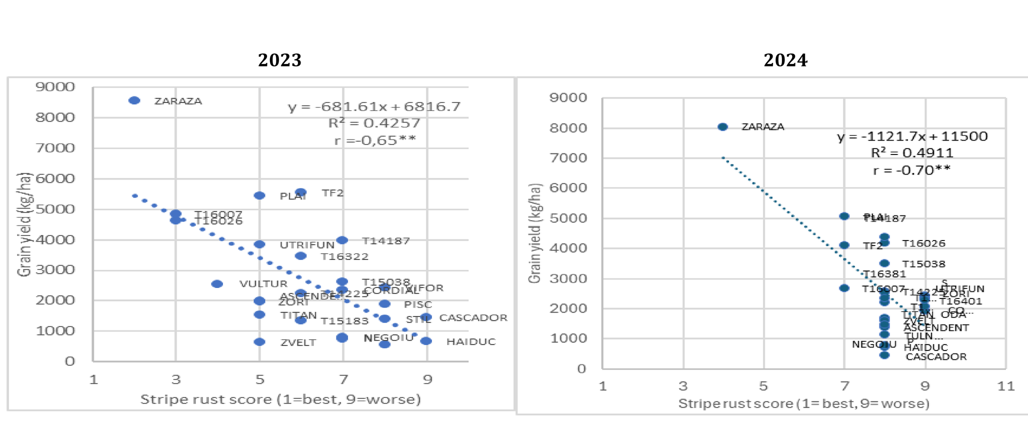



*Figure 3. Relationship between stripe rust attack and grain yield at Teleorman*

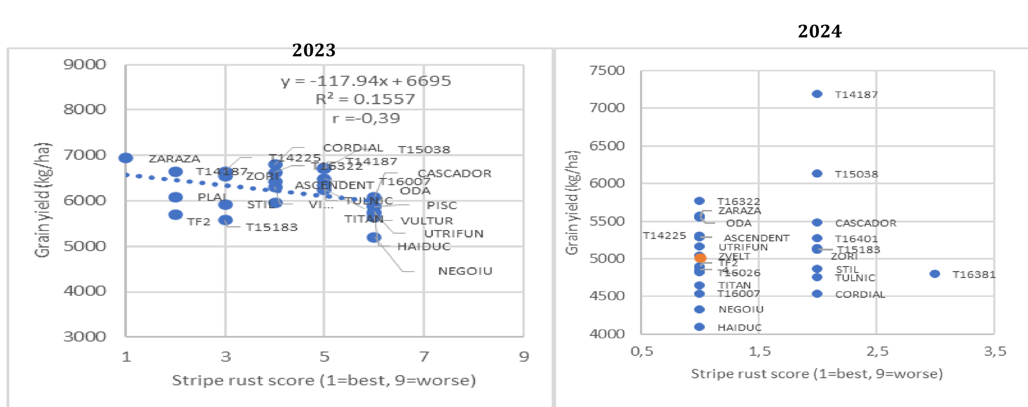



*Figure 4. Relationship of stripe rust scores and grain yield in preliminary yield trials with Triticale lines selected at ARDS Teleorman*

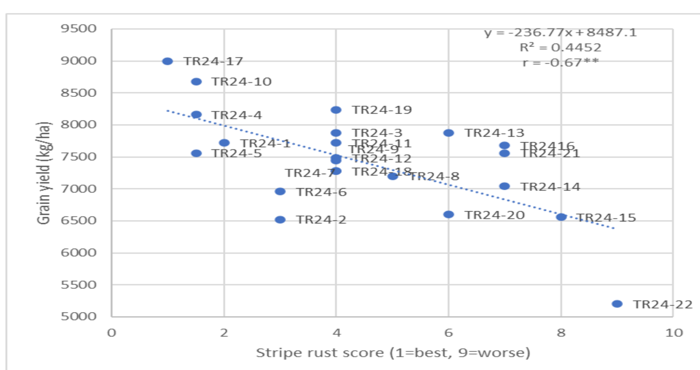
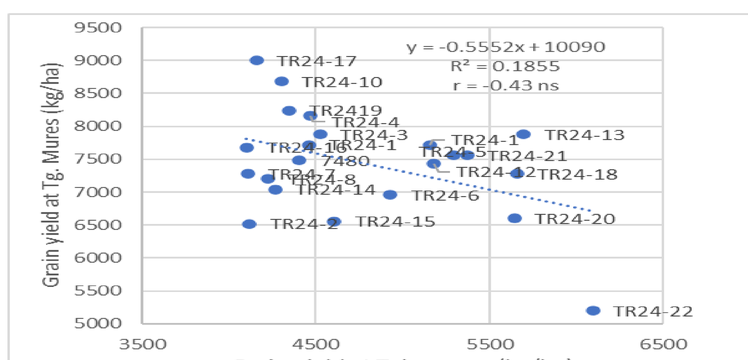



*Figure 5. Comparison between yields obtained in preliminary yield trails at Teleorman and Tg. Mureș by new lines selected at ARDS Teleorman*




## CONCLUSIONS

*Twenty-three triticale cultivars and twenty-five new lines tested in locations with high stripe rust attack in 2023 and 2024 showed significantly different disease scores, ranging from resistant to very susceptible. Best resistance to Puccinia striiformis was observed in cultivar ZARAZA and in five of the new lines. In five yield trials performed in 2023 and 2024, stripe rust had significant impact on grain yield explaining between 15 and 92% of the yield variation and in one trial susceptible cultivars did not produce any grains.*

*We observed large yield differences between cultivars scored similarly for rust attack, suggesting differences in partial resistance and/or tolerance to the disease. These differences suggest that their exploitation can be, along with exploiting available sources of strong resistance genes, an additional breeding objective for reducing rust induced yield losses,.*

*The impact of stripe rust on yield was associated with lower temperatures and higher rainfall in April, which explained more than one third of the variation in coefficients of correlation between stripe rust and yield.*