

## Study of yellow rust infection on various winter wheat genotypes

László KISS – Szilvia VERES

Department of Agricultural Botany, Crop Physiology and Biotechnology, Institute of Crop Sciences, University of Debrecen, 138. Böszörményi út, Debrecen, Hungary E-mail: szveres@agr.unideb.hu

**Abstract:** Winter wheat (*Triticum aestivum* L.) is our most important cereal. During its production several pathogens can infect the population. In our two-year study susceptibility of 9 winter wheat genotypes against the pathogen *Puccinia striiformis* var. *striiformis* was investigated by three different nitrogen supply levels on a humous sandy soil type. Percentage frequency of yellow rust infection was lower in case of the genotypes Hystar, Mv. Csárdás, Mv. Magdaléna than in case of HK1307, 1304KV, Antonius or Hywin. Based on our results it can be stated that in the crop year 2016 the highest susceptibility towards the pathogen yellow rust was observed for the winter wheat variety GK Csillag. No consequent effect of nitrogen active substance treatments on yellow rust infection could be stated, different applied nitrogen dosages did not affect the infection rate of different genotypes to a statistically verifiable extent.

**Keywords:** wheat, yellow rust, infection, susceptibility, nitrogen

### Introduction

As a result of the production area of winter wheat the extent of yield loss due to pathogens is rather significant, which is combined with both weather conditions favourable for the infection of some pathogens, and the susceptibility of different genotypes towards pathogens. Yellow rust infection occurs in Hungary quite seldom, but in outbreaks (1977, 1985, 1994, 1995, 2000, 2001, 2014) (Békési and Viola 2000, Csősz et al. 1993, Csősz 2005, Limpert et al. 1994, Szunics et al. 1989) that is a consequence of the low temperature demand of the infectious pathogen (Szepessy 1977, Barabás 1987). Leaf rust, occurs worldwide wherever wheat is grown. Among the rusts, yellow (stripe) rust is the most serious in globally. Pustules are light yellow and occur on leaves in distinct straight-sided stripes about 1/16 inches wide and of regular length. The spores are yellow to orange in colour (Wellings 2011). Yellow rust is a highly destructive disease threatening wheat production and quality worldwide. This is mainly due to the pathogen's ability to mutate and multiply rapidly as well as to use its air borne dispersal mechanism from one field to another (Brown and Hovmöller 2002). In case weather conditions are favourable for the pathogen and the applied genotype is susceptible, the extent of yield loss may even range between 40 and 70% (I2). A number of genes controlling yellow or

stripe rust resistance in wheat has been identified (McIntosh et al. 2011, (I1)), but need to know more about the effect of several conditions.

Nitrogen (N) nutrition is thought to be an important environmental factor affecting quantitative resistance: high N is associated with increased severities of some foliar diseases such as cereal rusts and powdery mildew. Severe epidemics of yellow rust and substantial effects of N treatment on disease severity were observed by Bryson et al. (1995) and Paveley et al. (2005). Different mechanisms have been suggested to be involved in this response. Some studies suggest that increased crop density and canopy density associated with N fertilisation creates a more favourable microclimate for stripe rust development (Ash and Brown, 1991; Danial and Parlevliet, 1995)

Timing of nitrogen supply in wheat production is important, because in the early development stages (BBCH 30-50) wheat plants utilize the applied nitrogen, but their resistance against leaf diseases decreases in this stage (Nelson, 1982). Hornok and Pepó (2005) studied the resistance and yield of a winter wheat genotype in their experiment in case of the application of different pre-crops and plant protection technologies. Regarding the three studied crop years higher leaf rust infection rate was observed after wheat pre-crop. Unfavourable effects of different pre-crops (winter wheat, maize or pea) could be reduced

using intensive crop protection technologies. The studied genotypes showed susceptibility towards leaf rust (16.4%) in his experiment. According to the results of Vári and Pepó (2012) it can be stated that weather conditions that are more humid and warmer than the average are favourable for the occurrence and spread of the leaf rust pathogen. In case of an extensive plant protection experiment they found an infection rate of 24% for the pre-crop maize, and 31% for pea in case of the nutrient supply level of  $N_{200} + PK$ . Furthermore they concluded that pathogen infection parameters increased parallel to increasing nutrient supply levels. In the present study following objectives were set:

- Parameterisation of 9 studied winter wheat genotypes yellow rust (*Puccinia striiformis* var. *striiformis*) infection rates.
- Quantification of the effect of different nitrogen active substance dosage applications with regard to yellow rust infection rate in case of different winter wheat genotypes.
- Evaluation of the effect of different nitrogen supply levels on the yellow rust infected leaf area in case of different winter wheat genotypes.

### Materials and methods

Small plot field experiments were set up in October 2014 and 2015 with 9 winter wheat genotypes (1304 KV, HK1307, HB0304, Mv Csárdás, GK Csillag, Mv Magdaléna, Antonius, Hywin, Hystar) and 3 nitrogen supply levels ( $N_0 \text{ kg} \cdot \text{ha}^{-1}$ ,  $N_{30} \text{ kg} \cdot \text{ha}^{-1}$ ,  $N_{120} \text{ kg} \cdot \text{ha}^{-1}$ ) with 4 replications on humous sandy soil at the Nyíregyháza Research Institute of the University of Debrecen, Institute of Agricultural Research and Educational Farm. The studied 9 genotypes consist of landraces (1304 KV, HK1307, HB0304), widespread Hungarian varieties (Mv Csárdás, GK Csillag, Mv Magdaléna), hybrids (Hywin, Hystar), and an Austrian winter wheat variety (Antonius).

Before the evaluation leaf samples with visible symptoms were collected – 3 leaves per pot – and pathogens were identified with a microscope

type MOTIC SMZ 168. Disease scoring was executed in four replications. Percentage of yellow rust infected leaf area was determined. Degrees of yellow rust (*Puccinia striiformis* var. *striiformis*) severity was determined according to the modified Cobb-scale (Figure 1).

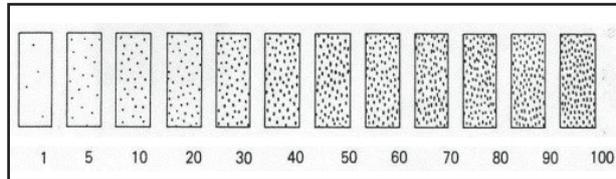


Figure 1. The modified Cobb-scale: severity of rust infection

Monitoring of yellow rust (*Puccinia striiformis* var. *striiformis*) was executed on the following dates:

- 9.06.2015. (on the figures marked as 2015.)
- 06.06.2016. (on the figures marked as 2016.)

During the experiment daily average temperature and daily amount of precipitation were recorded as well. Daily average temperature was over  $10 \text{ }^\circ\text{C}$  from the end of March in both studied crop years that was favourable for the pathogen development. In case of yellow rust germination and infection optimum of uredospores is between  $10\text{--}15 \text{ }^\circ\text{C}$  (I2), thus temperature was favourable for the infection of the pathogen already in the beginning – middle of April.

Regarding precipitation it can be stated that May was rather wet in both crop years (2015: 52.5 mm; 2016: 66.8 mm), that was favourable for the multiplication and spread of the pathogen.

For data analyses ANOVA tests were conducted using the Tukey's Multiple Range Test for mean separation. The analysis of all data was conducted using SigmaPlot for Windows Version 12.0 (Systat Software Inc., Germany) with the significant level determined at 95% confidence limit ( $p \leq 0.05$ ).

### Results

The effect of genotypes and nitrogen supply on the severity of winter wheat (*Triticum aestivum* L.) yellow rust (*Puccinia striiformis* var. *striiformis*) infection was studied on

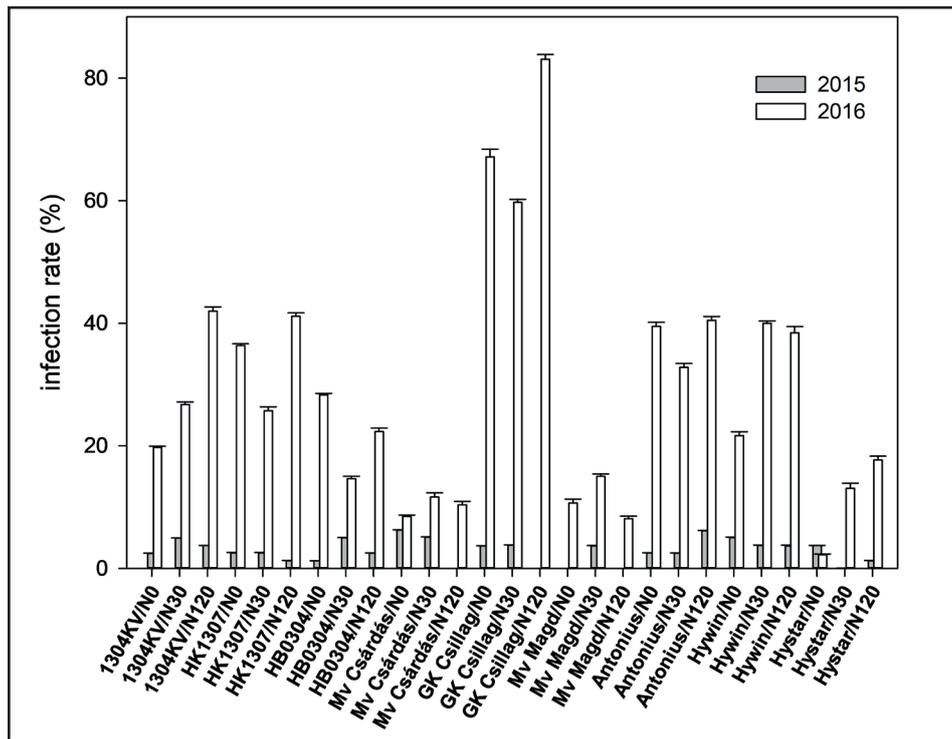


Figure 2. The effect of genotypes and nitrogen supply on the development of yellow rust (*Puccinia striiformis* var. *striiformis*) infection rate of winter wheat (*Triticum aestivum* L.) on humous sandy soil (Nyíregyháza, 2015-2016) n=4,  $\pm$ s.e. No significant differences between treatment and varieties at  $p \leq 0.05$  level

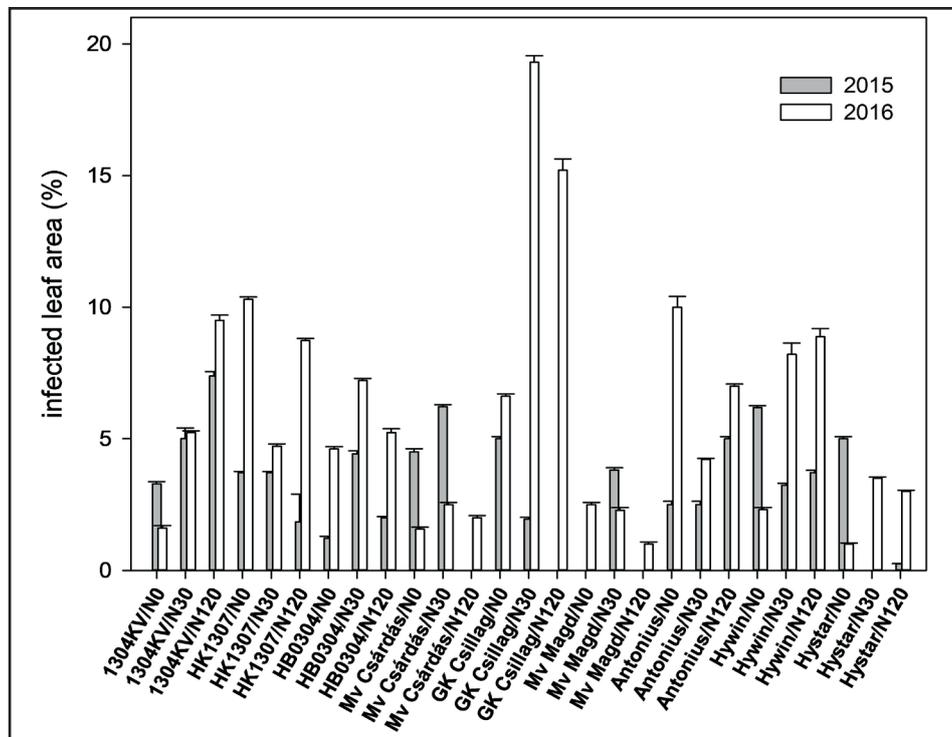


Figure 3. The effect of genotypes and nitrogen supply on the development of yellow rust (*Puccinia striiformis* var. *striiformis*) infected leaf area of winter wheat (*Triticum aestivum* L.) on humous sandy soil (Nyíregyháza, 2015-2016) n=4,  $\pm$ s.e. No significant differences between treatment and varieties at  $p \leq 0.05$  level.

humous sandy soil (*Figure 2*). Regarding the results of 2015 it can be stated that there was no significant difference between the infection frequency of the pathogen in case of different genotypes and nitrogen treatments. In the 2016 vegetation period the infection rate (%) was generally 3-4 times more, than in 2015. In the crop year 2016 no stable statistically verifiable difference was observed regarding the average of the nitrogen supply treatments. Infection rate of the studied Hystar, Mv Csárdás, Mv Magdaléna winter wheat genotypes was lower, than that of genotypes Antonius, Hywin, HB0304, HK1307 and 1304KV. Independent from nitrogen supply levels significantly higher infection rates were observed for the variety than in case of other genotypes or the respective nitrogen supply levels. However, this tendency could not be revealed in the crop year of 2015.

The yellow rust infected winter wheat leaf area rates (%) were also determined in the different crop years (2015, 2016) (*Figure 3*). In the crop year 2015 the infected leaf area rate was higher in case of the genotypes 1304 KV, Antonius, Hywin and Hystar by the nutrient treatment N120, than in case of the supply level N30. In 2016 the severity (%) was much higher in HK1307 and GK Csillag, than in 2015. Regarding the results of 2016 it can be concluded that the genotype GK Csillag showed higher susceptibility towards yellow rust than any other studied genotype. However, in case of the other studied genotypes and nitrogen supply levels no significant difference was found between the rate of infected leaf areas.

## Discussion

In the present study susceptibility of 9 winter wheat genotypes towards yellow rust (*Puccinia striiformis* var. *striiformis*) infection by the application of different nitrogen supply levels was studied under field conditions on a humous sandy soil type. The infection rate of the genotypes Hystar, Mv Csárdás, Mv Magdaléna was lower than that of the genotypes HK1307, 1304KV, Antonius and Hywin.

In the crop year 2016 the genotype GK Csillag showed the highest susceptibility towards yellow rust pathogen, but between other genotypes there were no statistically verifiable differences.

Some studies suggest that increased crop and canopy density due to N fertilisation means a more favourable microclimate for yellow rust development (Ash and Brown, 1991; Daniel and Parlevliet, 1995), thus increased nitrogen fertilization should increase the infection rate of yellow rust. In our study the increased nitrogen treatments did not affect the yellow rust infection frequency and infection rate, there was no statistically differences between the treatments. Other mechanisms suggested in the literature from studies on a range of pathosystems include changes in biochemical processes in the plant, such as a decrease in the content of phenol with an increase of nitrogen application (Király, 1964) and changes in crop canopy structure (Tompkins et al. 1992). Early studied declared, that increases in the severity of yellow rust (Huber and Watson, 1974) were observed with application of nitrate-N, but decreases were observed with ammonium-N, although both N forms would have been expected to increase canopy size.

Different sensitivity was found among the genotypes, breeding for resistance to yellow rust and developing new resistant cultivars became the main target in wheat breeding programs and considered as the most economical and effective way to eliminate the use of fungicides and reducing crop losses caused by the disease.

## Acknowledgement

Hereby we would like to express our acknowledgements for the support of 'Breeding of adaptive winter wheat strains with excellent milling parameters' (AGR\_P IAC\_13-1-2013-0002) project and EFOP-3.6.3-VEKOP-16-2017-00008 grant, which project is co-financed by the European Union and the European Social Fund.

## References

- Ash G.J., Brown J.F. (1991): Effect of nitrogen nutrition of the host on the epidemiology of *Puccinia striiformis* f. sp. *tritici* and crop yield in wheat. *Australas. Plant Pathol.*, 20:108-114. <https://doi.org/10.1071/APP9910108>
- Barabás Z. (1987): A búzatermesztés kézikönyve. Mezőgazdasági Kiadó, Budapest. 537 pp.
- Békési P., Viola J-né (2000): Minősített őszi búzafajták rezisztencia-vizsgálatának 2000. évi eredményei. *Gyakorlati Agrofórum*, 11(9): 36-37. DOI: 10.1556/Novenyterm.58.2009.4.4
- Brown J.K., Hovmöller M.S. (2002): Aerial dispersal of pathogens on the global and continental scales and its impact on plant disease. *Science*. 297(5581):537-41. DOI: 10.1126/science.1072678
- Bryson R.J., Sylvester-Bradley R., Scott R.K.S., Paveley N.D. (1995): Reconciling the effects of yellow rust on yield of winter wheat through measurements of green leaf area and radiation interception. *Asp. Appl. Biol.*, 42:9-18. [https://doi.org/10.1016/S1161-0301\(97\)00025-7](https://doi.org/10.1016/S1161-0301(97)00025-7)
- Csósz M., Matuz J., Mesterházy Á., Barabás Z. (1993) Field Testing Methods for Durable Resistance in Wheat to Stem Rust. In: Jacobs T., Parlevliet J.E. (eds) *Durability of Disease Resistance. Current Plant Science and Biotechnology in Agriculture*, vol 18. Springer, Dordrecht [https://doi.org/10.1007/978-94-011-2004-3\\_42](https://doi.org/10.1007/978-94-011-2004-3_42)
- Csósz M. (2005): Occurrence of necrotrophic leaf pathogens in wheat and their relation to symptom development in Hungary (2000-2002). *Acta Agrobotanica*. 58: 11-16. DOI: <https://doi.org/10.5586/aa.2005.002>
- Danial D.L., Parlevliet J.E. (1995): Effects of nitrogen fertilization on disease severity and infection type of yellow rust on wheat genotypes varying in quantitative resistance. *J. Phytopathol.*, 143:679-681. DOI: 10.1111/j.1439-0434.1995.tb00222.x
- Hornok M., Pepó P. (2005): Elővetemény és növényvédelem hatása az őszi búza fontosabb kórtani tulajdonságaira és termésére *Agrártudományi közlemények 2005/16. Különszám, Acta Agraria Debreceniensis* 84-89.
- Huber D.M., Watson R.D. (1974): Nitrogen form and plant disease. *Annual Review of Phytopathology*. 12: 139-65. <https://doi.org/10.1146/annurev.py.12.090174.001035>
- Limpert, E., J. Lutz, E.I. Remlein, J. Sutka & F.J. Zeller, (1994): Identification of powdery mildew resistance genes in common wheat (*Triticum aestivum* L.) III. Hungarian and Croatian cultivars. *J Genetics and Breeding* 48: 107-112. <https://doi.org/10.1051/agro:19930304>
- Király Z. (1964): Effect of nitrogen fertilization on phenol metabolism and stem rust susceptibility of wheat. *Phytopathologische Zeitschrift*. 51:252-61. DOI: 10.1111/j.1439-0434.1964.tb03432.x
- Nelson L. R. (1982): Effect of time of Nitrogen application on wheat yield and *Septoria nodorum* severity. *Agronomy Abstracts*. 7th Annual Meeting. American Society of Agronomy. Anaheim California. 26. DOI: [https://doi.org/10.1016/S0065-2113\(08\)60824-X](https://doi.org/10.1016/S0065-2113(08)60824-X)
- Paveley N., Foulkes J., Sylvester-Bradley R., Parker S., Lovell D., Snape J., Farrar J., Neumann S., Nason J., Ellerbrook C. (2005): Maximising disease escape, resistance and tolerance in wheat through genetic analysis and agronomy. Final report of a 57 month project that commenced in April 1999. The project formed the Home-Grown Cereals Authority contribution. HGCA Project Report 358, HGCA Project Number 2142. P 24
- Szepessy I. (1977): *Növénybetegségek*. Mezőgazdasági Kiadó, Budapest.
- Szunics L., Bartos P., Szunics Lu. (1989): Búzafajták sárgarozsda ellenállósága. *Növénytermelés*, 38:501-506. DOI: <https://doi.org/10.1023/A:1017588816724>
- Tompkins D.K., Wright A.T., Fowler D.B. (1992): Foliar disease development in no-till winter wheat: influence of agronomic practices on powdery mildew development. *Canadian Journal of Plant Science*. 72:965-72. <https://doi.org/10.4141/cjps92-121>
- Vári E., Pepó P. (2012): Két eltérő évjárat és az agrotechnikai tényezők hatása az őszi búza agronómiai tulajdonságaira tartamkísérletben. *Agrártudományi közlemények 2012/50.*, *Acta Agraria Debreceniensis*. 143-149. DOI: 10.1556/Novenyterm.60.2011.4.6

Wellings, C.R. (2011): Global status of stripe rust: a review of historical and current threats. *Euphytica*. 179: 129–141. doi: 10.1007/s10681-011-0360-y

**Web references**

I1: McIntosh R.A., Dubcovsky J., Rogers W.J., Morris C.F., Appels R., Xia X.C. (2011): <https://shigen.nig.ac.jp/wheat/komugi/genes/symbolClassList.jsp>, (downloaded: 13. 1. 2018.)

I2: <http://agroforum.hu/hirek/sargarozsda-eredete-es-elterjedese> (downloaded: 28.10.2018.)