The occurrence of *Sr31* and *Sr36* stem rust resistance genes in wheat cultivars registered in Hungary in the past 25 years

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ABSTRACT

Stem rust along with foliar diseases is a harmful pathogen causing strong yield reduction worldwide. Resistant cultivars provide efficient way for wheat growers to avoid yield losses. In our study, 200 wheat cultivars registered in Hungary in the past twenty five years, were investigated using molecular markers. A significant part of the cultivars carried the 1BL.1RS translocation, the source of *Sr31, Lr26, Yr9* and *Pm8* genes or the *Triticum timopheevi* introgression with *Sr36* gene. During this period, *Sr36* proved to be the strongest and durable stem rust resistance gene in Hungary. Resistance provided by the *Sr31* was also effective, although to a less extent than *Sr36*. The remainder of the resistance genes from 1BL.1RS demonstrated less (*Pm8*) or no appropriate (*Lr26* and *Yr9*) level of resistance. It seems that the introgression of alien chromosome translocations did not increase the choice of stem rust resistance genes in wheat cultivars registered in Hungary, as the use of efficient resistance genes became very biased. Among the two main wheat breeding programs in Hungary, the spread of *Sr31* resistance gene in cultivars of Martonvasar institute (West Hungary) had reached 90% (use of *Sr36* was marginal). Conversely, in the Szeged-institute (South-East Hungary) cultivars, *Sr36* reached the frequency of 50%, while *Sr31* was only exception there. There is an urgent need to incorporate several resistance genes against main diseases into the new wheat cultivars. To accelerate it, marker assisted selection provides new and efficient possibility.

INRODUCTION

The introgression of rye chromatin by chromosome translocations has increased the genetic diversity for several agronomic characters in wheat. The most frequently used translocations in wheat cultivar improvement programs is the 1BL.1RS, derived from ‘Petkus’ rye via Russian wheat cultivars ‘Kavkaz’ and Aurora’ (Zeller and Hsam, 1984). 1BL.1RS cultivars are worldwide in their distribution. From 1991 to 1995, 45% of 505 commercial cultivars of bread wheat from 17 countries (Rabinovich, 1998) and up to 50% of all wheat cultivars in China (Zhou et al., 2003) carried the 1BL.1RS translocation. The frequency of 1BL.1RS translocation went up to approximately 70% at one stage in CIMMYT’s spring wheat germplasm but has declined to about 30% in more recent advanced lines (Singh et al. 2006). In the past forty years, 1BL.1RS translocation has been widely used by breeders to enhance agronomic performance, particularly grain yield (Carver and Rayburn, 1995; Lelley et al., 2004). The 1BL.1RS wheats carry several disease resistance genes like *Sr31*. Another, very effective stem rust resistance gene is the *Sr36*, also derived from alien species *Triticum timopheevi* into common wheat (McIntosh and Gyarfas J, 1971) and it spread to several wheat cultivars in the world through cv. ‘Arthur’.

Isolates of *Puccinia graminis* f. sp. *tritici* with high virulence to *Sr31* were detected (TTKS race) in Uganda in 1999 (Pretorius et al., 2000), and pose a worldwide threat to wheat production in areas where *Sr31* resistance is important.

In this study, we aimed to determine the frequency of Sr31 and the Sr36 gene, among wheat cultivars registered in Hungary in the past 25 years period.

MATERIALS AND METHODS

In our study, 200 wheat cultivars registered in Hungary in the period of 1979 – 2003 were collected and tested for the presence of *Sr31* and *Sr36* gene. Most of the samples originated from the two main Hungarian wheat breeding institutions: Cereal Research Non-Profit Company, Szeged from South-East Hungary (GK cultivars) and the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar from West-Hungary (Mv cultivars) with 65 and 67 cultivars respectively. Rest of the cultivars originated from other Hungarian (11 cultivars) or surrounding countries: Austria (14), France (14), Yugoslavia (11), Croatia (4), Czech Republic (4), Germany (4), Ukraine (2), Netherlands (1), Romania (1) and Slovakia (2). This collection represents about 90% of wheat cultivars registered in Hungary in the past 25 year period.

Stem rust resistance data were derived from the annual bulletins of the National Institute for Agricultural Quality Control (OMMI), Hungary. These stem rust resistance tests were made by artificial inoculations lead by Dr. Pal Bekesi in the Plant Pathological Station of OMMI at Röjtökmuzsaj, Hung.

Molecular markers were used to detect the presence of *Sr36* as well as the wheat-rye translocation, 1BL.1RS, carrying *Sr31* and that of 1AL.1RS. Genomic DNA samples were extracted from a bulk of leaves from 3 plants according to the CTAB method essentially as described by (Rogers and Bendich, 1985). The presence of rye translocation was tested by the OPH20 RAPD marker (Francis et al., 1995), which is able to detect, however, can not distinguish any rye chromosome in wheat. To distinguish 1BL.1RS translocation from 1AL.1RS cultivars samples were further tested by the SCM9 microsatellite marker (Weng et al., 2007). The gwm271 microsatellite marker (Bariana et al., 2001) was used, with some modifications, to identify the *Sr36* stem rust resistance gene

RAPD amplifications were assayed by agarose (1.5%) gel electrophoresis, stained with ethidium bromide, and the amplified samples of microsatellite reactions were separated on a 5% denaturing polyacrylamide gel than visualized by silver staining.

RESULTS AND DISCUSSION

A significant part of the cultivars carried the 1BL.1RS translocation, the source of *Sr31*, *Lr26*, *Yr9*, *Pm8* genes or the *Triticum timopheevi* introgression with *Sr36* gene. The PCR analysis revealed that 52 cultivars (26.0% of total 200 cultivars) carried the 1BL.1RS and 31 cultivars (15.0%) had the *Sr36* gene. Considering the two important *Sr* genes together, by the year 1994, 61% of the registered cultivars were already protected against stem rust infection by at least one of the *Sr31* and *Sr36* resistance genes (Fig. 1).

Considering the origin of cultivars, a surprising difference was experienced in the incidence rate of 1BL.1RS cultivars between the two main Hungarian breeding institutions. The spread of *Sr31* resistance gene in cultivars of Martonvasar institute had reached 90% (in 1996-1997) then continuously decreased to 65%, while the use of *Sr36* was marginal (data not shown). Adversely, in the Szeged institute (GK) cultivars, *Sr36* reached the frequency of 50% (between 1997 and 2002), while *Sr31* was only exception there.

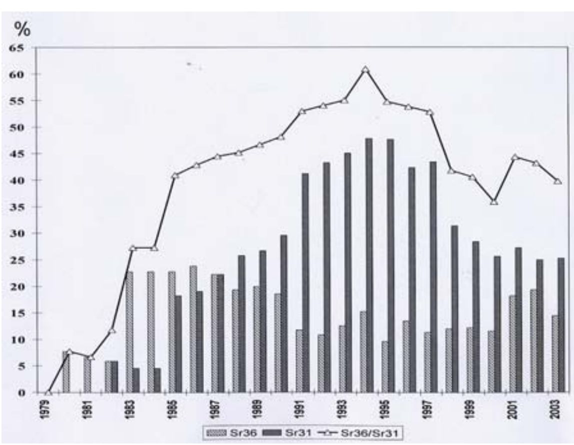

Fig. 1.. Occurrence of 1BL.1RS translocation (*Sr31*) and the *Sr36* resistance gene, as well as the percent rate of cultivars which are protected by any of the two stem rust resistance genes (line above columns) in wheat cultivars grown in Hungary from 1979 to 2003.

Out of the 57 foreign cultivars registered in Hungary, only 2 (from France) carried the 1BL.1RS (3,6%), and only those from Croatia and Yugoslavia carried *Sr36* resistance gene (2 of the 11 Yugoslavian, and all of the 4 Croatian cultivars). Only two cultivars from the total 200 (1 from Szeged and 1 from Martonvasar) carried both Sr31 and Sr36 genes, and also only two cultivars had the 1AL.1RS translocation (1%) – both from Martonvasar.

Most of the wheat cultivars (182 out of the 200) were tested for their stem rust resistance by artificial infections in field conditions from 1985 to 2004 (except the years of 1987 and 1995). In the group of cultivars having neither the *Sr31* nor the *Sr36* resistance genes the average degree of stem rust infection for all years tested proved 48%.

During this period, *Sr36* proved to be the strongest and durable stem rust resistance gene in Hungary (the average infection degree was only 3% in this group). Resistance provided by the *Sr31* was also effective, although to a less extent than that of *Sr36* - the average infection was only 15% for *Sr31*, about three times less than in the previous group. Other resistance genes from 1BL.1RS demonstrated less (*Pm8*) or no appropriate (*Lr26* and *Yr9*) level of resistance. These data show that the advantages of *Pm8*, *Lr26*, and *Yr9* genes were not apparent in Hungary during the era of second and third generation of 1BL.1RS cultivars. The reason of their spread might be due to their high stem rust resistance appeared in each year during the artificial disease tests, and to the steady use of these data in the selection work. Anyway, there was no serious stem rust epidemic during this period.

The reason for the great difference in the distribution of *Sr31* and *Sr36* by origin might come from the fact that, stem rust resistance was an easily selectable character for the breeder (rust resistance research and breeding has long traditions in Hungary). It was probably also the selection for stem rust resistance which caused a significant difference in the genetic background of the two main breeding institutions in Hungary. A great difference in the genetic background of Martonvasar and Szeged wheat cultivars was also proved by the use of molecular markers (unpublished results). To a breeding program where winter hardiness was especially important project (like in Martonvasar) the *Sr31* stem rust resistance gene from the winter hardy cv. 'Kavkaz' was more convenient than from the cv. Arthur (*Sr36*). In Szeged, having a slightly milder climate, where exploiting the high productivity of cultivars from the southern neighbouring countries was the primary important task at the beginning of their breeding project, *Sr36* was a more suitable resistance source than cvs. 'Aurora' and 'Kavkaz'. The first disease resistant and highly productive Szeged-cultivar, 'GK Kincsö' (registered in 1983) deriving from a cross between Arthur and Sava (from Yugoslavia) had a big impact on their wheat breeding program. Many of their new cultivars inherited *Sr36* from cv. 'GK Kincsö' (Csösz et al., 2001).

It seems that the introgression of alien chromosome translocations did not increase the diversity in stem rust resistance gene pool in wheat cultivars registered in Hungary, as the use of efficient resistance genes became very biased. The narrowed diversity may increase genetic vulnerability. It might open the door to new races of pathogens, i.e. TTKS (Ug99) race for *Sr31*. There is an urgent need to incorporate several resistance genes against major diseases into the new wheat cultivars. Marker assisted selection along with precise artificial field tests provide new and efficient possibilities for geneticists and breeders to achieve these goals.

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REFERENCES

Bariana, H.S., M.J.Hayden, N.U. Ahmed, J.A. Bell, P.J. Sharp, and R.A. McIntosh. 2001. Mapping of durable adult plant and seedling resistances to stripe rust and stem rust diseases in wheat. Australian Journal of Agricultural Research 52:1247-1255.

Carver, B.F., and A.L. Rayburn. 1995. Comparison of related wheat stocks possessing 1B or T1Bl-center-dot-1RS chromosomes - Grain and flour quality. Crop Science 35:1316-1321.

Csösz, M., P.Bartos, and A. Mesterhazy. 2001. Identification of stem rust resistance gene Sr36 in the wheat cultivar GK Kincso and in its derivatives. Cereal Research Communications 29:267-273.

Francis, H.A., A.R. Leitch, and R.M.D. Koebner. 1995. Conversion of a RAPD-Generated PCR product, containing a novel dispersed repetitive element, into a fast and robust assay for the presence of rye chromatin in wheat. Theoretical and Applied Genetics 90:636-642.

Lelley, T., C. Eder, and H. Grausgruber. 2004. Influence of 1BL.1RS wheat-rye chromosome translocation on genotype by environment interaction. Journal of Cereal Science 39:313-320.

McIntosh, R.A., and Gyarfas J. 1971. *Triticum timopheevi* as a source of resistance to wheat stem rust. Theoretical and Applied Genetics 66:240-248.

Pretorius, Z.A., R.P. Singh, W.W. Wagoire, and T.S. Payne. 2000. Detection of virulence to wheat stem rust resistance gene *Sr31* in *Puccinia graminis*. f. sp. *tritici* in Uganda. Plant Disease 84:203.

Rabinovich, S.V. 1998. Importance of wheat-rye translocations for breeding modern cultivars of *Triticum aestivum* L. Euphytica 100:323-340.

Rogers, S.O., and A.J. Bendich. 1985. Extraction of DNA from milligram amounts of fresh, herbarium and mummified plant-tissues. Plant Molecular Biology 5:69-76.

Singh R.P., D.P. Hodson, Y. Jin, J. Huerta-Espino, M.G. Kinyua, R. Wanyera, P. Njau and R.W. Ward. 2006. Current status, likely migration and strategies to mitigate the threat to wheat production from race Ug99 (TTKS) of stem rust pathogen (Review). CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 2006 1, No. 054

Weng, Y., P. Azhaguvel, R.N. Devkota, and J.C. Rudd. 2007. PCR-based markers for detection of different sources of 1AL.1RS and 1BL.1RS wheat-rye translocations in wheat background. Plant Breeding 126:482-486.

Zhou Y, He ZH, Liu JJ, Liu L. 2003. Distribution of 1BL/1RS translocation in Chinese winter wheat and its effect on noodle quality. In: Pogna NE, Romano M, Pogna E, Galterio G, eds. Proceedings 10th International Wheat Genetics Symposium, Paestum Italy, Vol. 3, 1419–1421.