Utilization of Wild Relatives and Primitive Forms of Wheat in Czech Wheat Breeding

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Abstract: In the Research Institute of Crop Production, Praha-Ruzyně, prebreeding for wheat lines with desired qualities, particularly disease resistance, is performed in cooperation with plant breeding organizations. Resistance to leaf rust (*Puccinia triticina*) and stem rust (*P. graminis*) was transferred from *Triticum timopheevi* to spring and winter wheat lines and three genes for resistance to stem rust, one for leaf rust, and one for powdery mildew were transferred from *T. monococcum* to bread wheat. A line derived from the *T. monococc*um cross was used in breeding the commercial cultivar Vlasta that shows outstanding powdery mildew resistance. Genes *Lr19* and *Lr24* (origin *Agropyron elongatum*), *Lr9* (origin *Aegilops umbellulata*) were transferred from hexaploid CIMMYT spring wheat lines and gene *Lr35* (origin *Thinopyrum intermedium*) from the German line W49 to progenies of crosses with registered cultivars. A line possessing *Lr19* was further used in Slovakia (Istropol) and an advanced line with *Lr19* was tested in State Variety Trials. Rust resistant lines were also derived from material from Israel with resistance from *Triticum tauschi*i (= *Aegilops squarrosa)*. Translocation from *A. ventricosa* possessing rust resistance genes *Lr37*, *Yr17* and *Sr38* was determined by molecular markers in registered foreign cultivars Apache, Bill, Clarus, Clever, Corsaire, Rapsodia and in the Czech cultivar Rheia.

Keywords: wheat; disease resistance; wild wheat relatives; primitive forms of wheat; *Puccinia triticina*; *P. graminis*; *Blumeria graminis*

The main objective of the utilization of wild relatives and primitive wheat forms in wheat breeding is the introduction of desirable traits, especially disease resistance, not possessed by bread wheat. The Czech wheat research and breeding program on the use of alien sources of resistance started about 50 years ago. It has often been a joint effort of specialists from the research institutes and plant breeding stations. Our paper summarizes the most important achievements of the program.

MATERIAL AND METHODS

Direct crosses with hexaploid wheats were carried out for the transfer of rust resistance from *Triticum timopheevi.* A tetraploid bridge was used to transfer rust and powdery mildew resistance from *T. monococcum*. Transfer of resistance genes derived from *Agropyron elongatum, Aegilops umbellulata, Triticum tauschii* and *Thinopyrum intermedium* was carried out from foreign hexaploid lines not agronomically suitable for the direct use in our wheat breeding.

Sources of resistance: *Triticum timopheevi*, originated from the Gene Bank, RICP Prague-Ruzyně, *T. monococcum* from the Zentralinstitut für Genetik und Kulturpflanzenforschung Gatersleben (Germany), and lines possessing resistance from *Ae. tauschii* from Israel. A spring line possessing *Lr9* from *Aegilops umbellulata* and spring lines with genes *Lr19* and *Lr24* from *Agropyron elongatum* were obtained from CIMMYT, Mexico. Line W49 with leaf rust resistance gene *Lr38* from *Thinopyrum intermedium* was obtained from Prof. F.J. Zeller (TUM München-Weihenstephan).

Transfers from hexaploid sources were carried out by crossing with cultivars possessing desirable agronomic characters. Selection for disease resistance and other desirable characters was carried out for the next 3–5 generations. Successful crossing with *Triticum timopheevi* was supported by application of 0.005% water solution of H_3BO_3. Transfer of resistance genes from *T. monococcum* was achieved via a tetraploid bridge formed by *T. durum*.

Selection for disease resistance was carried out in the greenhouse using suitable pathogen isolates.

The presence of alien genes was confirmed either by infection tests or using markers for the gene cluster *Lr 37, Sr38* and *Yr17* following Robert *et al*. (1999) and Seah *et al.* (2001).

RESULTS

Transfer of rust resistance from *Triticum timopheevi*

Ten ears of Kaštická osinatka were crossed with *Triticum timopheevi*. Eight grains were obtained from this cross and 40 kernels from the reciprocal cross. Sixteen plants were harvested from these hybrid seeds. Generation F1 was back-crossed with a pollen mixture from cvs. Kaštická osinatka and Uhřetická 100. In the next generations, selection for rust resistance and desired ear type was carried out. Of 630 preselected plants in F_3, a total of 170 progenies were tested in F_4 and in F_5 generations. The 22 progenies with the most resistance to stem and leaf rust were retested for resistance in the field and in the greenhouse. Their yield potential was also studied. The selected progeny displayed high stem and leaf rust resistance in the field and were also yellow rust resistant, like the parental cv. Kaštická osinatka. These resistant progenies were used in further breeding programmes of the Plant Breeding Station, Úhřetice (Zadražil & Bartoš 1964).

Transfer of rust and powdery mildew resistance from *Triticum monococcum*

Entries 1509/20, 1993/9 and 2126 of *Triticum monococcum* from Gatersleben were crossed with *T. durum* 3310 or 3574 and again back-crossed with *T. durum* or crossed with a hexaploid wheat (cvs. Yubileynaya 50 or Zlatka). After selfing and selection for resistance to a set of prevailing rust races and cytological control, hexaploid lines of winter as well as spring types were obtained. Three genes for stem rust resistance were transferred, among them two novel genes and one gene described earlier, *Sr35*. In addition, one gene for leaf rust resistance was identified in the developed material, located in chromosome 3A and provisionally designated *LrTm1*. The line Š13 derived from the cross with *T. monococcum* possessed powdery mildew resistance governed by a novel allele of the gene Pm1, designated by Hsam *et al*. (1998) as *Pm1b*. That line was used in the breeding of the commercial cultivar Vlasta, the powdery mildew most resistant Czech cultivar. (Valkoun *et al*. 1986a, b; Šíp *et al.* 1999).

Transfer of leaf rust resistance genes *Lr9, Lr19, Lr24* and *Lr38*

Transfer of leaf rust resistance genes *Lr19* and *Lr24* from *Agropyron elongatum* and *Lr9* from *Aegilops umbellulata* to lines of commercial winter wheat cultivars was carried out by crossing CIMMYT lines 2, 10, 60, 65, 90 and 91 with cvs. Mara, Viginta, Zdar and Regina. Two back-crosses and selection for leaf rust resistance and suitable agronomic traits followed. The best progenies were passed to plant breeders, namely *Lr9* in the background of the cv. Mara, *Lr19* in the background of the cv. Viginta or Zdar and *Lr24* in the background of the cv. Regina. Described progenies were resistant, medium resistant or medium susceptible also to stem rust (Stuchlíková 1993).

Leaf rust resistance gene *Lr38* transferred from *Agropyron elongatum* to the hexaploid line W49 by Wienhues (Zeller person. comm.) was crossed with the cv. Zdar. Most of the obtained progenies were leaf rust resistant or segregated for resistance. Selection for suitable agronomic traits was also carried out but the selected progeny had longer straw than cv. Regina and matured 1–3 days later. Leaf rust resistance in some progenies was also proved in a field trial in Switzerland (Bartoš *et al*. 1998).

Transfer *of Triticum tauschii* resistance from hexaploid lines from Israel.

Rust and powdery mildew resistance derived from *T. tauschii* was transferred from the hexaploid lines Israel 10 and Israel 11 into the progeny of crosses with the spring cv. Leguan.

Verification of the gene cluster *Lr37, Sr38* and *Yr17* in the registered cultivars

Resistance derived from *Aegilops ventricosa* (genes *Lr37*, *Sr38*, *Yr17*) was tested in selected cultivars registered in the Czech Republic using greenhouse tests of plants inoculated with suitable leaf and stem rust isolates and by means of molecular markers following Robert *et al.* (1999) and Seah *et al.* (2001). Both infection tests and molecular marker analyses demonstrated the presence of the above mentioned gene cluster in registered cultivars Apache, Bill, Clarus, Clever, Corsaire, Rapsodia and Rheia (Bartoš *et al.* 2004). Presence of the gene cluster in the cv. Complet (Ambrozková *et al*. 2002) was not verified.

DISCUSSION

Wild wheat relatives and primitive wheat forms are becoming the most important sources of disease resistance in wheat breeding. Of the total of 54 leaf rust resistance genes listed in an atlas of resistance genes (McIntosh *et al*. 1995), the majority of the recently described genes originated from wild wheat relatives or primitive forms of wheat. In the last five decades we have tried to contribute to the development of lines possessing disease resistance from such sources. The main problem was the application of the developed material in the further breeding. When prebreeding was closely linked with the breeding process and was carried out in a close cooperation between researchers and plant breeders, the likelihood that resistant strains would be utilized was higher than when the development of such resistance sources was undertaken as a separate research project. An important achievement was the application of the line Š13 derived from *T. monococcum* from which a very high powdery mildew resistance of the cv. Vlasta (Figure 1) is assumed to be derived. Another application of the developed winter wheat line Viginta/*Lr19* was created by the plant breeding company Istropol in Slovakia. The advanced leaf rust resistant line named Lutea was tested in the State Variety Trials in Slovakia but has not yet been registered. Our lines with *Lr9* (CIM 10/3 Mara) and *Lr24* (CIM 91/3 Regina) were applied for the validation of the relevant molecular markers in an international ring test (Blaszczyk *et al*. 2004). Although we have not transferred the gene cluster from *Aegilops ventricosa* to any registered cultivar, our application of molecular markers helped to identify the cluster in several registered cultivars and contribute to information useful for further rust resistance breeding .Our experience with tests of resistance genes *Lr19* and *Lr24* was also utilized in the joint project "Kontakt" with Slovak colleagues (Šliková *et al*. 2003, 2004). Rust and powdery mildew resistance tests of collections of wild wheat relatives and primitive wheats contributed to the description of many entries. Thus useful information for their application in the wheat breeding for disease resistance has been provided (Holubec *et al*. 1992, 1993, 1998; Hanušová & Holubec 1993; Havlíčková & Holubec 1995; Valkoun *et al*. 1985). It can be expected that with

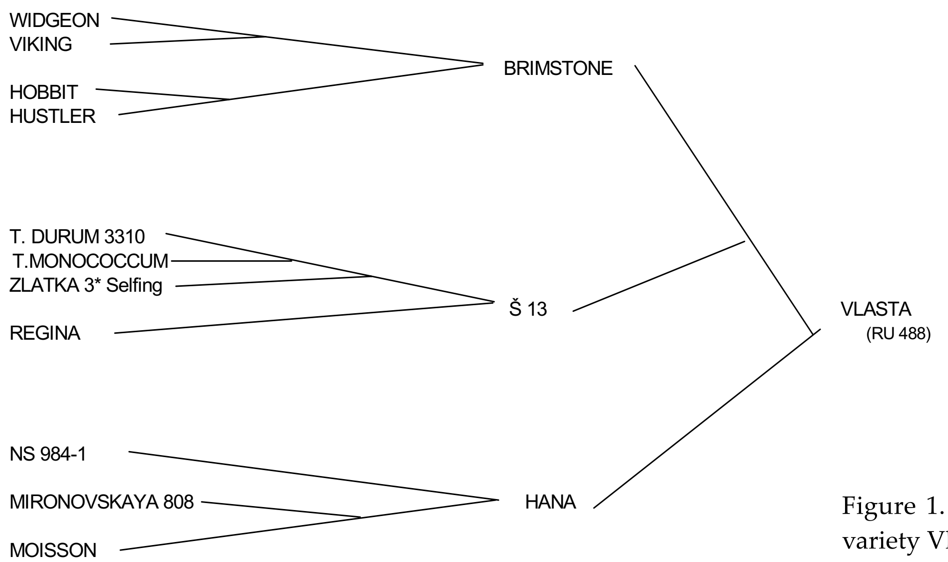

Figure 1. Pedigree of winter wheat variety Vlasta

the development of new breeding methods and sophisticated techniques the contribution of wild wheat relatives and primitive wheat forms to the disease resistance breeding will increase.

Acknowledgements. Supported by the Ministry of Agriculture of the Czech Republic, Projects Nos. 0002700602 and QD 1311.

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