67. Tagung der Vereinigung der Pflanzenzüchter und Saatgutkaufleute Österreichs
21.-23. November 2016, HBLFA Raumberg-Gumpenstein, Irdning, Österreich

The leaf rust resistance gene *Lr22a* does not alter other disease resistances, yield or bread making quality

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Abstract

Worldwide, leaf rust is one of the most important disease on wheat. Leaf rust epidemic occur each year in Switzerland, leading to yield reduction. Some leaf rust resistance gene are linked with, more or less, unwanted side effect. For example, *Lr9* could lead to yield reduction, *Lr34* cause a leaf type necrosis and *Lr19* is linked with yellow flour. The efficacy and unintended effects of new resistance genes must be examined before utilising the latter in a breeding programme. In the case of wheat, it is necessary to verify that the resistance gene is still effective and has no negative side effect on other disease resistances, yield or baking quality. The *Lr22a* gene confers resistance to leaf rust at the adult stage (adult-plant resistance), and microsatellite markers linked to it have been identified. To date, this gene is relatively rarely used, and is still effective under Swiss conditions.

Lr22a was introgressed from the spring wheat cultivar 'AC Minto' by 6 backcrosses (BCs) into the susceptible spring wheat cultivars 'CH Campala' and 'CH Rubli'. The presence of *Lr22a* was examined at each BC step using the microsatellite markers *wmc503* and *gwm261*.

The BC lines CH Campala-6BC and CH Rubli-6BC were compared with their original cultivar in multi-location yield trials for four (2012 to 2015) and two (2012 to 2013) years respectively. Simultaneously, resistance to stripe rust (*Puccinia striiformis*), powdery mildew (*Blumeria graminis*), leaf and glume blotch (*Phaeosphaeria nodorum*), Septoria leaf blotch (*Mycosphaerella graminicola*) and Fusarium head blight (*Fusarium graminearum*) were tested using artificial infections. Protein content and Zeleny sedimentation index were determined for each location. The seed harvested from all locations was used for dough- and bread making-quality tests (farinograph, extensograph and Rapid-Mix-Test). The similarity of the resulting two backcross lines (BC lines) CH Campala-6BC and CH Rubli-6BC with their recipient cultivars was verified using a 15K SNP Array.

The number of polymorph SNPs between the BC lines and their their recipient cultivars was low comparing with the number of polymorph SNPs between the two cultivars. As expected, the original cultivars and their essentially derived lines containing *Lr22a* (BC lines) were very similar in heading time, plant height and morphological traits. Overall, the BC lines showed significantly improved resistance to leaf rust in all trials. In years and at locations with strong leaf rust pressure, we measured a significant yield reduction (up to 13.7%) in the original varieties compared with the improved BC lines.

Resistance to other diseases was very similar (less than 0.5 point difference). In one trial, few stem rust (*Puccinia graminis*) symptoms on the backcross line CH Campala-6BC have been observed. No significant (or very small) differences were observed for protein content, Zeleny index, and rheological or baking parameters. In conclusion, for both genotypes tested, *Lr22a* gene is effective against leaf rust, with no associated negative effects. Nevertheless, we recommend associating this gene with one or more other effective leaf rust resistance genes in order to ensure its durability.

Keywords

Adult plant resistance · marker assisted selection · *Triticum aestivum*

Table 1: Number of polymorph SNPs in a 15K SNP Array

Line/cultivar comparison	Polymorph SNPs
CH Rubli *vs* CH Rubli-6BC	234
CH Campala *vs* CH Campala-6BC	106
CH Campala *vs* CH Rubli	4145

References

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Table 2: Mean performance values of BC-lines compared to their original cultivar mean values

Trait	BC-Lines	CH Campala, CH Rubli	*P*-value
Grain yield (dt ha^{-1})	55.3	54.7	0.530
Thousand kernel weight (g)	41.8	41.6	0.715
Specific weight (kg hL^{-1})	80.8	80.4	0.158
Heading date (days from Jan 1^{st})	162.4	162.4	0.861
Plant height (cm)	87.6	88.1	0.541
Lodging (1-9)	1.4	1.4	0.178
Mildew (1-9)	4.3	3.9	0.028
Stripe rust (1-9)	2.5	2.8	0.073
Leaf rust (1-9)	1.4	5.1	0.048
Stem rust (1-9)	2.7	2.0	
Septoria leaf blotch (1-9)	4.1	4.2	0.926
Fusarium (1-9)	3.4	3.6	0.081
Falling Number (s)	340	34.3	0.849
Protein content (%)	14.2	13.9	0.034
Zeleny (mL)	59.4	59.3	0.860
Wet gluten (%)	30.0	26.7	0.268
Farinograph, water absorption (%)	60.4	59.0	0.319
Farinograph, stability (min)	5.2	4.9	0.273
Farinograph, degree of softening (FU)	107.3	98.5	0.116
Rapid-Mix-Test, volume (mL)	504.0	503.0	0.934
Bread making test, box (mL)	500.5	497.0	0.955
Extensograph, resistance at 5 cm (EU)	201.5	197.0	0.464
Extensograph, extensibility (mm)	370.8	424.3	0.173