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THE USE OF MARKER ASSISTED SELECTION (MAS) IN WHEAT IMPROVEMENT - A NEW POSSIBILITY FOR REGIONAL COOPERATION IN CENTRAL-EAST EUROPE

PURNHAUSER Laszlo

CEREAL RESEARCH NON-PROFIT COMPANY, SZEGED, HUNGARY

Wheat breeders continuously seek to develop new techniques, which can be used for introgression of desirable traits into new wheat cultivars. Breeding is interested in the improving the quality, as well as quantity of a crop. The main goals of wheat breeding are:

- Increasing the yield
- Improving the resistance to abiotic (e.g. to frost and drought) and biotic stresses (to viruses, bacteria, fungi and insects)
- Improving the quality (e.g. protein and gluten content, baking quality)
- However, there are difficulties for introducing new traits into plants like:
- the number of generations needed (to develop a wheat cultivar takes 10-12 years),
- many traits are quantitatively inherited (i.e. they are controlled by several genes),
- tests may be difficult, time consuming and expensive (e.g. to screen disease resistance artificial infection, and the maintenance of pathogen races are necessary),
- many traits are sensitive to genotype-environment interactions.

In recent years, DNA-based markers have shown great promise in lessening the time and expense in introgression the desirable genes into the new wheat cultivars.

Molecular markers are DNA sequences at specific positions on a chromosome, which are inherited in Mendelian manner, and therefore can be used as landmarks for genome analysis or the selection. The advantages of DNA markers are that they are not influenced by the environment; they are expressed in all tissues and can be scored at all stages of plant growth (early selection, even in seedling stage). Molecular markers are linked to economically important genes, can be efficiently used to select indirectly for the desirable alleles. This is the base of MAS. This technique is particularly useful for traits which are difficult to measure, such as bread making quality and Fusarium resistance. In

addition, in the resistance breeding, marker screening of DNA from seedlings needs a less time and space - than carrying out full-scale disease testing trials at each stage. Using MAS the breeder can accelerate the back-crossing of alleles or the pyramiding of several desirable alleles.

The principal DNA marker techniques the RAPD, AFLP SSR and SCAR which are based on the polymerase chain reaction (PCR), whereas RFLP is based on hybridization. PCR based techniques are breeder friendly as they are generally quick and easy to perform, and PCR requires only small amount of DNA.

In wheat many agronomically important genes are characterized; for several of them PCR based molecular markers are available (see for a review Gupta et al. 1999), e.g. for: d*isease resistance* (leaf rust, stem rust, yellow rust, powdery mildew, wheat streak mosaic, virus, common bunt, loose smut, eyespot, Fusarium head blight, karnal bunt), *pest resistance* (Hessian fly, cereal cyst nematode), s*tress tolerance* (aluminum toxicity, drought), q*uality traits* (kernel hardness, grain protein, LMW and HMW gluten content), and for other traits like vernalization, photoperiod sensitivity, dwarfing and fertility restoration.

Today MAS is ever integrating into the practical breeding worldwide. E.g. in the USA a national wheat MAS consortium is initiated including 12 wheat breeding and research programs across the US, in 2001. (www.maswheat.ucdavis.edu). They are breeding for improvements in quality (8 traits) and disease resistance (10 traits) in bread and pasta wheat including 99 lines and cultivars as recurrent parents. Generally each trait includes several genes (e.g. for leaf rust 7 resistance genes are included).

THE USE OF MAS AT THE CEREAL RESEARCH NON-PROFIT COMPANY (CRC), SZEGED, HUNGARY.

The CRC is the largest agricultural research institute in Hungary, breeding 31 different plant species including wheat, maize and sunflower. The more than 260 registered cultivars and hybrids are in production (90 of them are grown in 23 countries in the world) on about 1,5 million hectares. As for wheat, 30 bread and 3 pasta cultivars are in production. Yielding ability, disease resistance (rusts, powdery mildew, and Fusarium head blight), as well as the quality (bread and pasta making quality) are the most important breeding goals in wheat.

Several research projects are initiated on the field of MAS for resistance breeding including:

- Leaf, stem and yellow rust, powdery mildew and Fusarium head blight resistance in wheat
- Dwarf mosaic virus resistance in maize
- Plasmopara resistance in sunflower

New PCR based molecular markers for leaf resistance in wheat (Lr29 and Lr20) were developed. For MAS 8 resistance genes or QTLs are used in projects to transfer and/or to pyramidize them into 10 wheat

cultivars. Now, we also try to introduce MAS techniques for special traits important for bread making quality.

NEW POSSIBILITIES FOR REGIONAL COOPERATION IN CENTRAL-EAST EUROPE

In contrast to maize, wheat has low adaptation ability. So, wheat cultivars developed at climatic conditions quite different from that of Central-East Europe can hardly adapt here (early drought, hard winter, and different pathogenic races). It might be the reason why no wheat cultivars from USA or UK were successfully introduced in Hungary, however, several cultivars from the neighboring Yugoslavia (Sava, Rana, Baranjka), Slovakia (Viginta), Romania (Fatima 2) were successful in Hungary. And, Hungarian wheat cultivars were also registered, and are in production in these countries. While the multinational firms are conquering this region by their maize hybrids (85-90% in Hungary), the national wheat breeding has still a future. To keep this position new genetic sources and selection techniques have to be introduced.

Some abiotic (e.g. drought) and biotic stresses (e.g. leaf rust) can seriously reduce the yield and the quality (e.g. Fusarium head blight). These damages often can result 20-50% loss in the income. Although, the damages caused by diseases and insects can be successfully controlled by using the expensive and environmentally hazardous chemicals, still the genetic control (growing resistant cultivars) remains the most economic and environmentally safe solution for this problem. There are numerous disease resistance genes in wheat, however, due to mutations, pathogens can change their virulence, and they can infect cultivars which were formerly resistant to the disease. The change in the composition of pathogenic races is often so quick that the conventional resistance breeding can't cope with the problem. The MAS can help to develop new and unique solutions.

The advantages of MAS in resistance breeding:

- By a MAS based back-crossing program resistance genes from exotic sources can be transferred to adapted cultivars in shorter time.
- By pyramiding several effective resistance genes more durable resistance can be achieved for a given disease.
- By pyramiding resistance genes for different diseases (e.g. leaf, stem, and yellow rust, powdery mildew, Fusarium head blight and virus resistance) cultivars with complex resistance could be developed, drastically reducing the need for chemical control and increase profitability as well as food safety.

This is not an easy task. However, cooperation between geneticists, breeders, and pathologists of these neighboring countries in Central East Europe would greatly enhance this development.

* LASZLO PURNHAUSER, CEREAL RESEARCH NON-PROFIT COMPANY, SZEGED, HUNGARY