

Marker assisted breeding of organic heterogeneous wheat in Denmark

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Organic plant breeding started in Denmark 2006 with the attempt to develop Organic Heterogeneous Material (OHM) of wheat with baking quality, good weed competition and resistance to plant diseases, including common bunt.

We conclude that OHM is preferable over pure line varieties as a strategy for organic farming, as both yield and baking quality is more stable than in pure line varieties. There seems to be a synergy of baking quality and taste between the components of a mixture.

OHM can be composed by mixing of all offspring from crosses (original composite cross populations), but the mixture will be similar or slightly better than the average of the parents. It is therefore crucial to use only well adapted parents. If suboptimal parents are included, pure lines needs to be selected, and the OHM be composed only by selected offspring (complex variety mixture).

Some traits are difficult but not impossible to improve further after the OHM have been composed. Baking quality can be improved by Single seed NIR sorting (eg. BoMill Insight technology), colour sorting or by gravity sorting. However, at this point this can only increase gross grain protein content and seed hardness but will not improve gluten index. To compose mixtures with optimal gluten index above the average of the parents, we have developed SNP markers for gluten subunits to be used for MAS in order to compose mixtures with a diversity of HMWG subunits within the mixture.

Weed competition is best improved by visual assessment and selection for early vigour, and plant height before heading stage with due respect of the risk of lodging.

Cereal Cyst Nematodes (CCN, *Heterodera avenae*) is in Denmark mainly a problem in spring wheat and no varieties on the EU Catalogue are resistant. The market for special varieties with this trait is limited as farmers tend to use non susceptible crops in case of nematode infestation of a field. Therefore CCN resistance should be included in all spring wheat as a preventive rather than a curative measure. Marker Assisted Selection (MAS) is the best way for selection, as field phenotyping is difficult and expensive. We have therefore developed SNP markers the Cre1 resistance gene for this selection.

Common bunt needs special attention in organic breeding programs, as most varieties are susceptible. Only a few susceptible plants in an OHM is enough to maintain an infection, and close to all plants must therefore have resistance to the

virulence in the region. Virulence are present in Europe against most of the known resistance genes, and pyramiding genes are therefore the only safe way for durable resistance to common bunt. We have identified 59 resistance genes and developed SNP markers to 20 of them for MAS.

Leaf diseases such as mildew and in particular rust diseases can be devastating in organic farming. These diseases can be selected in the field based on leaf symptoms, but the experience indicates that if resistance is based on one or few vertical resistance genes, the varieties or OHM can turn susceptible within 1-3 years. Therefore, horizontal (adult plant) resistance genes or multiple vertical resistance genes must be included to maintain durability of the resistance. We therefore develop SNP markers for the most important rust resistance genes for MAS.

Funding organic plant breeding is difficult as the market is too small to fund the breeding. The OHM developed from this breeding program is therefore distributed via the member organisation Landsorten, based on home saved seed production to reduce cost for the seed production. Two OHMs have been officially registered, 'Mariagertoba ' and 'Popkorn', whereas other OHMs are produced in smaller amount without registration. By not selling seed, the activities of Landsorten is legal, and small seed lots can be distributed under the Article 3 exemption or research, trial and breeding purposes as a base for multiplication of home saved seed. Landsorten supports in this way a production of 1500ha of organic bred varieties in Denmark, England, Belgium and The Netherlands.

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