ECPGR Cereals Network and ECPGR Working Group on Barley

A pre-breeding workshop on cereals was held in Alnarp, Sweden on 24-25 November 2009. The workshop was organized by ECPGR, NordGen, Swedish University of Agricultural Sciences (SLU), Graminor, Norway, MTT Agrifood Research Finland and Oatly AB, Sweden, as part of the activities planned by the ECPGR Working Group on Barley during the present ECPGR Phase. Altogether 49 participants from 12 countries joined the first meeting on this increasingly important subject. As an outcome of this workshop, the present concept note was developed.

Pre-breeding for small grain cereals

- How to meet future challenges of food supply under a changing climate-

An enhanced exploitation of cereal crop genetic diversity through novel pre-breeding strategies and a fundamental reinforcement of the entire plant breeding chain is a vital part of a sustainable system for global food security. Taking the necessary time for breeding processes into account, action is urgently required.

Sustainable development, food supply and market demands

The future pressures on agriculture will be substantial. Demands on production from agriculture are expected to increase sharply in the 21st century with demands for cereals in particular expected to rise by 70 % from 2007 to 2050 (FAO, World Food Summit, 2007). This development is driven by foreseen demands on food supply from a forecasted world population of 9 billion people in 2050 and changing consumption patterns. In addition the need for biomass for bio-energy and bio-refineries is also expected to increase considerably. There are however, limited possibilities to increase the area of agricultural land substantially.

Moreover, Climate Change will reduce the global production potential with higher temperatures reducing the photosynthetic capacity for important crops, such as wheat and barley. Water is expected to become a limiting factor in many areas, and the pressure from devastating pathogens and pests will increase. In addition, there are strong environmental pressures to reduce inputs to agriculture such as energy, pesticides, water and nutrients that will impact on production capacity.

Apart from the production of food, feed and industrial raw material, agriculture is increasingly seen as necessarily providing, through the actions of the agro-ecological system, water protection, climate regulation, soil fertility, biodiversity and bioremediation. In addition, there is increasing consumer and end-user pressure for improvements in food and feed quality including the reduction of deleterious traits and the improvement of health benefits and functional food traits.

The seemingly impossible challenge is to produce more food, feed and other commodities but with reduced environmental impact whilst coping with a more variable and unpredictable climate.

Plant breeding and plant genetic resources

How future cereal production meets the challenges outlined above will be dependent on the development of varieties adapted to the changed conditions. The breeding of such suitable cereal varieties with high and stable yield, adequate quality traits and low environment impact, will in turn be dependent on the available appropriate genetic resources and the subsequent selection and trialling for adaptation to agronomic and market requirements.

Sustainable use of genetic diversity

Gene banks have often, through necessity, focused mainly on the immediate but long-term conservation aspects of plant genetic resource activities. However, there is an urgent need for active engagement with all stakeholders to enhance the utilization of plant genetic resources in order to assure the functionality of the entire "Genetic resource-chain":

There are considerable genetic resources for small grain cereals including collections of adapted varieties and genetic stocks carrying defined traits through to land-races and crop wild relatives. However, this richness of plant genetic diversity is greatly under-utilized, with important traits not being exploited and the potential value not being channelled back into societal benefit.

The conservation of genetic resources must be linked to their increased and sustainable use if they are to play a key role in climate change adaptation. Bottlenecks that need to be addressed include lack of information on genotypic and phenotypic level – e.g. need for evaluation for resistance to biotic and abiotic stresses of increasing importance. Data need to be easily accessible in standardized and searchable electronic formats enabling strong networks linking conservation, evaluation and plant breeding to be established to secure the necessary level of pre-breeding activities. Finally, long term commitments and funding from both public and private stakeholders are needed if this is to have a major impact on European food security.

Urgent need for *pre-breeding*

There is currently a major gulf between the operations of plant genetic resource collections and modern plant breeding that is potentially a major restriction in the development of cereal varieties that are needed to meet novel agronomic and environmental challenges. This disconnect can be bridged through a process known as pre-breeding that is based upon the characterization of genetic resources for traits of interest and then transferring these traits into suitable, agronomically adapted genetic backgrounds.

Pre-breeding in cereal crops for Europe for long-term goals must be performed in close collaboration between advanced and applied research institutes, genebanks as well as plant breeding entities in order to be sustainable and successful. Such partnerships will ensure that targets are chosen that meet the demands for climate adaptation and environmental policies – changed crop production systems, extended cultivation areas, improved water and nutrient use efficiency, improved resistance to pests and pathogens, etc. – and also the demands on increased production in combination with specific quality requirements of the market. Such partnerships will also help to develop the capacity building for breeding that is needed to counteract the competence erosion that has resulted from structural changes and low priority given to this area in recent years. Such capacity will be of paramount importance to balance the challenges that future agriculture has to meet, both in Europe and in developing countries.

Abiotic stresses – adapting to environmental changes

Tolerance to particular abiotic stresses such as drought, cold, salinity, heat, water logging, nutrient use efficiency and mineral toxicity has traditionally enabled cereal crops to cope with the prevalent local stresses with a balance of traits that were fine-tuned to optimize economic yields in their environments.

However, global warming is producing shifts in the prevalence of some abiotic stresses with drought being increasingly important, given the widely acknowledged effect of climate change on the amount of precipitation and its distribution over the growing seasons in Europe. In addition, ozone levels in the troposphere are expected to rise notably in the near future, affecting the amount of UV radiation that reaches the Earth surface in turn causing large increases of plant oxidative stress.

Therefore, it is expected that the agricultural areas of Europe will experience enhanced or novel abiotic stresses making it increasingly urgent to develop cereals that can withstand such environmental changes, in order to increase or even just to maintain current yield levels.

Biotic stress – coping with emerging diseases

Plant pathogens cause considerable yield losses in cereal production, reducing crop quality and threatening food safety. Disease prevention and control is thus a prerequisite for competitive cereal production with the breeding of genetically disease resistant crops being one of the most environmentally and economically desirable ways to manage plant diseases.

The prevalence of different plant diseases is changing due to changing environmental conditions, including global climate change, but also changes in agricultural production with trends towards larger areas planted to fewer and/or genetically more uniform varieties, reduced crop rotation and soil tillage, loss of biodiversity, changing use of pesticides, and global trade. In such a changing environmental and economical context, plant diseases will inevitably appear and compromise crop production in regions where they did not represent a problem before, as is already being seen with the emergence of a new strain of heat tolerant wheat yellow rust and increasing problems with Fusarium head blight and Ramularia leaf spot.

Understanding the host-pathogen biology is the first step towards minimizing the risks represented by plant diseases. Durable, both race non-specific and race-specific, resistance incorporated into high-yielding genotypes is the main method to manage diseases of cereals. New durable and efficient sources of resistance will have to be sought, in the case of cereals, from landraces and from wild relatives of the crops.

New tools to address the challenges

The recent progress in biotechnology has opened up enormous possibilities, both for introgression of specific traits and for base broadening in pre-breeding. Molecular techniques and bioinformatics allow more precise and faster selection methodologies as well as providing a much more detailed understanding of the underlying genetics. Such efficient tools are a crucial element in the modern plant breeding process to handle complex traits efficiently.

While costs of molecular genotyping are constantly decreasing and methods becoming more efficient, reliable and precise phenotyping is costly, time consuming and an increasing challenge. The strategy for the future should contain a broad knowledge of and access to modern technology, and combining the application of new tools and techniques with traditional and efficient plant breeding methods to achieve final goals rapidly.

Unlocking the genetic potential stored in genebanks is our responsibility towards future generations

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