Breeding Advances in Development of Biofortified Wheat

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Introduction

- Dietary deficiency of essential micronutrients such as zinc (Zn) and iron (Fe) poses serious health problems for more than 3 billion worldwide (WHO, 2012)
- Genetic biofortification to improve micronutrient levels in bread wheat could greatly reduce micronutrient malnutrition problems among resource-poor people.
- CIMMYT is working with national and international partners to develop and disseminate micronutrient-rich, high yielding, rust resistant wheat varieties to target countries.
- Adoption of high Zn wheat varieties will be driven by its improved agronomic properties and resistance to new strains of yellow and stem rusts.

Materials and Methods

- By 2005, the highest level of Zn and Fe in wheat was found in landraces and wild relatives of wheat, such as *Triticum dicoccum, Aegilops taushii* and *Triticum spelta*.
- A targeted breeding program was initiated at CIMMYT in 2006 to develop wheat germplasm with 8 ppm more Zn than the mean 25 ppm level achieved in widely grown varieties.
- High Zn-containing advanced lines were routinely tested for resistance to rusts in Mexico and Ug 99 races of stem rust at KARI-Njoro, Kenya.

Breeding Advances

G x E trials: The first proof of concept results from the CIMMYT-derived high Zn lines tested in target environments identified high Zn candidate varieties with durable resistance to rusts (Velu et al. 2012).

High heritability: Multi-site analysis revealed high heritability (H^2 = 0.7) and high genetic correlations between locations for Zn, suggesting the potential opportunity to select high Zn candidates across varying environmental conditions.

No trade-off: there was hardly any correlation between grain Zn and grain yield, suggesting that enriched grain Zn can be combined in elite genetic backgrounds with no yield penalty (Velu et al. 2012).

High-throughput screening methods: The x-ray fluorescence (XRF) based high-throughput non-destructive technique has been developed to screen a large number of breeding lines for grain Zn and Fe (Paltridge et al. 2012).

Molecular markers: Two large effect QTLs were stably detected for increasing grain Zn in chromosomes 3AL and 2Bc (centromeric region), interestingly, 2Bc QTL had pleiotropic effect for increased thousand-kernel weight (TKW) (Fig 1).

Candidate varieties: Multi-site evaluation of candidate lines in target countries identified one of the extra-early candidate variety (CROC_1/AE.SQUARROSA (210)//INQALAB91..) for South Asia (Fig 2) and a normal maturing Ug 99 resistant variety (DANPHE #1*2/SOLALA) derived from a stem rust resistant Ethiopian wheat variety “Danda’a” (Fig 3).

On-farm or PVS trials: The most promising varieties (>75% of the Zn target level; competitive yields; and better resistance to rusts) are being evaluated in large scale multi-location yield trials and on-farm participatory variety selection trials (PVS) in South Asia. The first release of biofortified wheat is expected in India by 2014-15.

Acknowledgements

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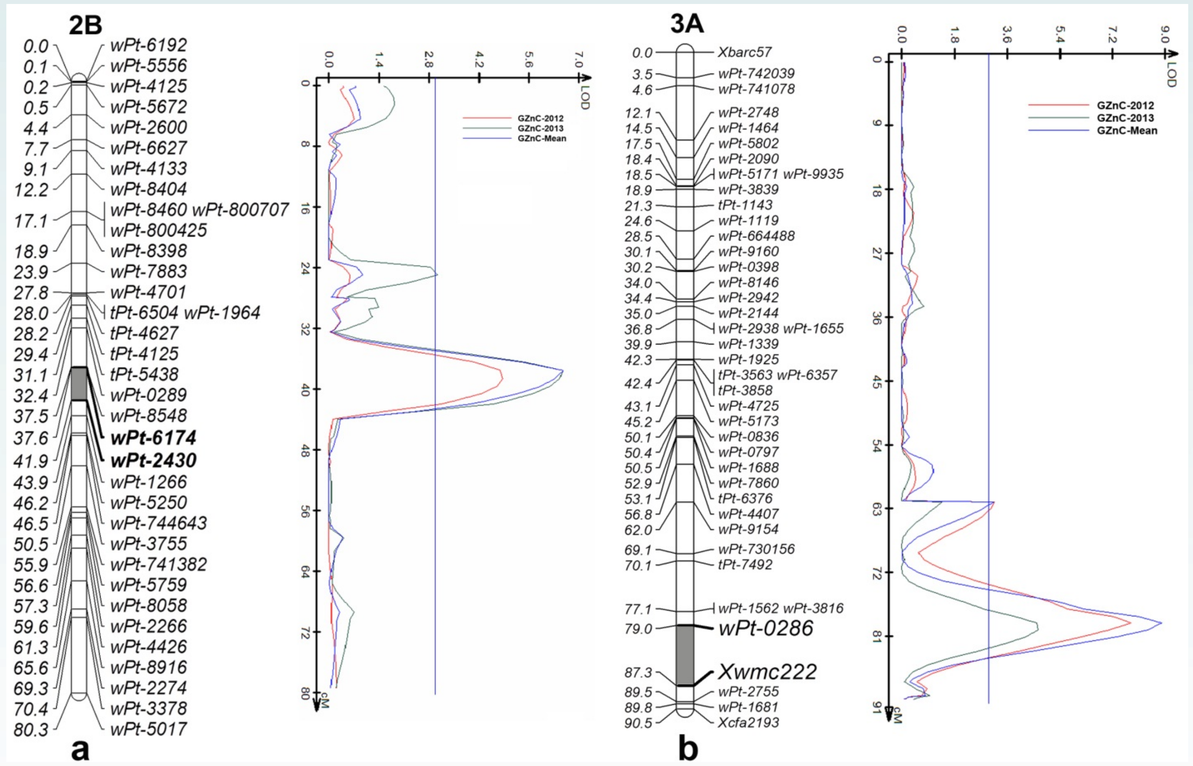

Figure 1 Major effect QTLs with highly significant LOD values for increasing grain Zn on (a) 2B and (b) 3A (QTL regions are indicated by *gray rectangles)*.

Figure 2. Extra-early high Zn wheat variety (CROC_1/AE.SQUARROSA (210)//INQALAB91*2/KUKUNA/3/PBW343*2/KUKUNA) for North-East India and southern part of Pakistan.

Figure 3. High Zn version of Danda’a variety, Ciudad Obregón, Mexico.

Conclusions

- Preliminary results suggest good prospects of identifying biofortified wheat varieties with wide adaptation, resistance to emerging strains of biotic stresses and tolerance to climate change induced abiotic stresses.
- There is promising, substantial genetic diversity available for enhancing grain Zn and Fe concentrations. This genetic variation is being intensively exploited by wheat breeding programs to improve both the concentration and bioavailability of Zn in modern wheat cultivars.

References

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