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**Perennial wheat breeding: Current germplasm and a way forward for breeding and global
cooperation**

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Abstract

The Australian perennial wheat team has collected and assessed a wide range of global germplasm derived from wheat x perennial-relative crosses (Hayes et al, 2012 and unpublished). Some lines were able to perennialize in one or both field environments where they were grown and a few were able to regrow through four seasons. Without exception the only wheat-derived lines that could perennialize contained seven or more pairs of chromosomes from the perennial parent. The donor perennial parents included *Thinopyrum ponticum* (2n=70, decaploid), *Th. intermedium* (2n=42, hexaploid) and *Th. elongatum* (2n=14, diploid). This has led us to conclude that the best near-term prospect for a perennial wheat-like grain crop is a full or partial amphiploid, containing the full set of tetraploid (AABB) or hexaploid (AABBDD) wheat chromosomes plus one genome (XX) from the donor. When the perennial donor is a polyploidy, the extra genome is usually a synthetic genome, consisting of a mixture of chromosomes from the polyploid parental genomes. This creates a significant difficulty in that each time a primary partial amphiploid is produced, the synthetic genome may consist of a different mix of donor chromosomes, and therefore interbreeding of these primary partial amphiploids may result in poor fertility and loss of the perennial donor chromosomes. That in turn would be problematic in trying to establish a breeding program. Consequently we would advocate a breeding program based on a diploid perennial donor, such as *Th. elongatum* (EE). This is analogous to triticale breeding. The amphiploids produced could be AABBEE (analogous to hexaploid triticale, AABBRR) or AABBDEEE (analogous to octoploid triticale, AABBDDRR). We would further advocate a multinational effort to produce many primary amphiploids using locally adapted wheat parents and diverse accessions of *Th. elongatum*; the primary amphiploids would be shared amongst participating groups, and intercrossed to permit subsequent selection of robust, productive, locally adapted perennials. The analogy with triticale is instructive also in suggesting that many generations of selection may be required before full fertility, high yielding types can be recovered.