Next steps for perennial grain crops in Australia

Matt Newell, Richard Hayes, Mark Norton, Len Wade, Phil Larkin

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PROFITABLE PERENNIALS™ FOR AUSTRALIAN LANDSCAPES

New studies

Yet to be studied:

- Physiology of root systems – of perennial selections [PhD student]
  - Root mass and dynamics
  - water and nutrient dynamics and partitioning
- Forage management effects
- The physiology of summer survival
  - dormancy, dehydration tolerance
- Forage and grain quality
  - Grain quality assessment initiated (CSIRO)
- Other fungal diseases
  - yellow spot, nodorum, tritici, FHB
- Root and crown diseases
  - take-all, crown rot, common root rot, CCN, RLN

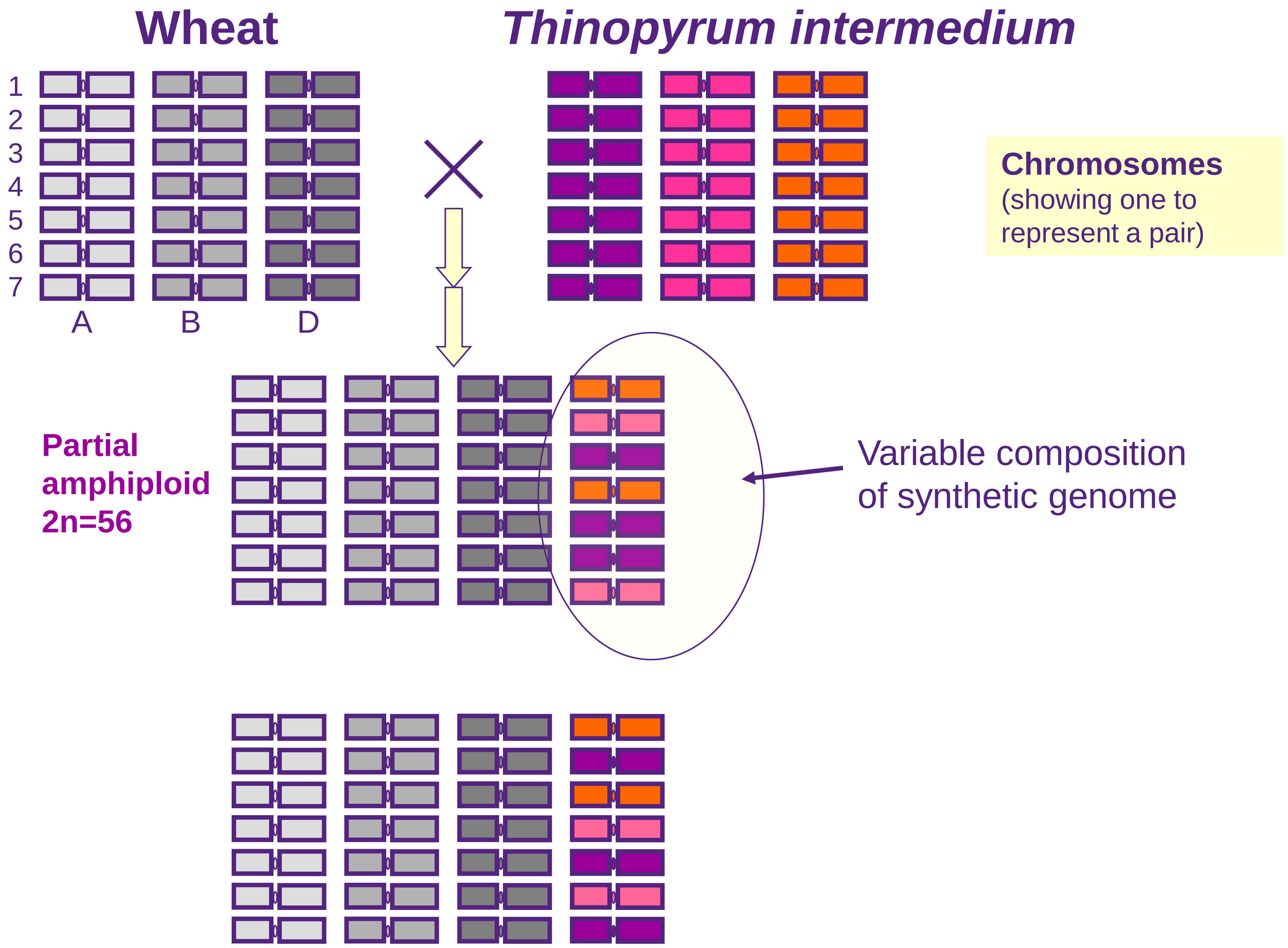
Prospects for ongoing breeding of perennial wheat

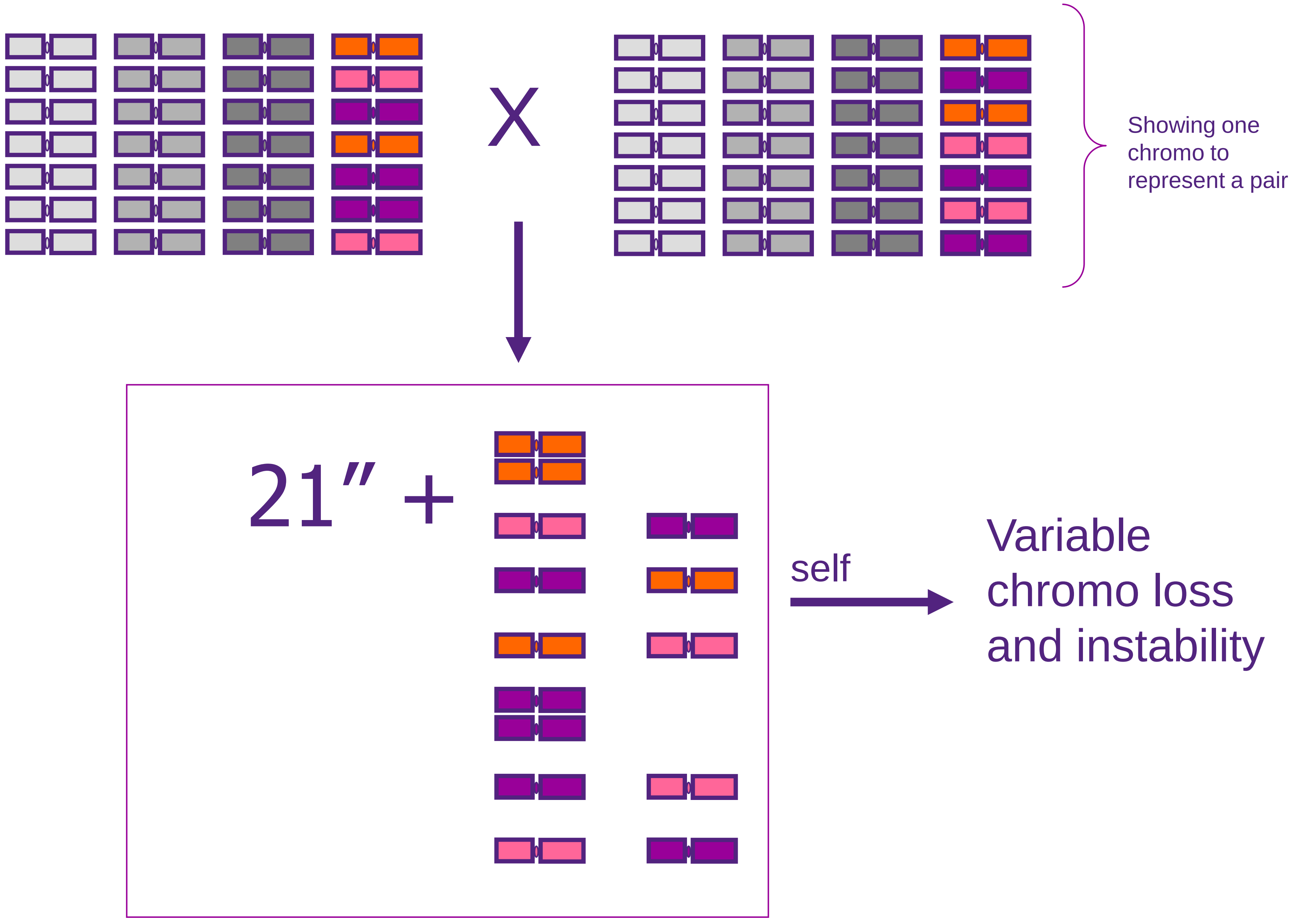
- From what we have learned it seems sensible to breed deliberately at the amphiploid level for adequate perenniality

- It is greatly preferable to use a diploid perennial donor

- Comparison to triticale at 6x (ABR) or 8x (ABDR) level

- If the donor is a allopolyploid (mixed genomes) such as *intermedium* or *ponticum*, then the extra “genome” is synthetic and variable making subsequent interbreeding chaotic and inefficient ….


Wheat
Thinopyrum intermedium
1
2
3
4
5
6
7
A
B
D
Chromosomes
(showing one to represent a pair)
Partial amphiploid 2n=56
Variable composition of synthetic genome


X
Showing one chromo to represent a pair
21” +
self
Variable chromo loss and instability

Allo-polyploid donor makes subsequent breeding at the amphiploid level very difficult

- You make or collect a series of foundation lines, AABBDDXX, where X is a synthetic genome
  - Very difficult to recover stable 2n=56 progeny
  - Examples of such difficulties:
    - intercrossing Zhong lines (Banks et al 1993)
    - Ot38 x Zhong lines
    - OK72 x Ot38 (derivatives of *ponticum and intermedium)*

- Intercrossing synthetic octoploids makes a mess

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Elongatum breeding

- ***Elongatum*** amphiploid breeding:
  - The WSU program has demonstrated that the E genome is sufficient
  - Select adapted naturalised populations of *L. elongatum* (2n=14)
  - Cross to various 4x or 6x adapted wheats
  - Chromosome double F1 plants (colchicine)
  - Stabilise AABBEE and AABBDDEE lines through selfing
    - Possibility that the genome balance ABE might be more robustly perennial than ABDE
  - Should be able to create many *foundation* breeding lines which are mutually compatible yet with genetic diversity to drive the breeding program

Elymus scaber breeding

Elymus scaber, Common wheatgrass

- ***Elymus*** amphiploid breeding [Matt Newell postgrad project]
  - Assessment of five diverse accessions of *Elymus scaber*
  - An Australian endemic perennial Triticeae grass
  - Widely adapted
  - *E. scaber* appears to be a allo-hexaploid (2n=42), genomes SYW
  - Some forms are 2n=9x=63
  - Interestingly it is ~95% apomictic

- *Elymus scaber* x wheat (4x or 6x, highly crossable genotypes)
- Chromosome double the F1 hybrids
  - Because 9x forms of scaber exist and are stable, possibility that ABSYW or ABDSYW might also be stable
  - Hybrids have been produced between wheat, barley and rye with other Elymus species

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Other breeding options

- Select increased grain yield and grain size within perennial grass
  - *Secale montanum*
  - Wheatgrass species
- Engineer grain size genes into perennial grass, e.g.
  - RNAi of wheat glucan water dikinase (GWD) gene (Ral et al 2010)
  - Overexpress wheat ExpA6 gene (Lizana et al 2010)
  - Overexpress rice GS3 gene (Li et al 2010)
  - Overexpress Brassica wri1 gene (Liu et al 2010)
  - Overexpress grain sucrose synthase gene
  - Apetala2 (lec 2 is an AP2)
  - Tomato Sw4.1 ABC transporter (Orsi and Tanksley, 2009)

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An international research possibility…

sowing an idea you will hear more of on Thursday

Molecular control of perenniality in grasses

- Use the power of the genomic tools of *Brachypodium* to find genes controlling perenniality in the Triticeae
- Iain Wilson (CSIRO) and John Vogel (USDA) showing interest in exploring the molecular genetics of perenniality with us
  - *B. distachyon* is an erect annual grass
  - There are also perennial species of the genus including *pinnatum, sylvaticum, glaucovirens, mexicanum, arbuscula, retusum, rupestre* and *phoenicoides*.
  - They can be intercrossed and hybrids were vigorous and long-lived
  - With some annual x perennial crosses there might be prospect of mapping perenniality
  - The perennial species can be sequenced and compared to the annual to find candidate genes for perenniality.