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# *Recent Advances in Wheat Breeding in Australia*

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# DAFWA Wheat Breeding Program

## *SubPrograms*

### **“Short Season” - Iain Barclay**

- early and midseason maturity
- drought tolerance and aluminium tolerance

### **“Long Season” - Robin Wilson & Chris Moore**

- late and midseason maturity
- disease resistance

### **“Backcross & Soft Wheat” - Robyn McLean**

- BC for rusts, sprouting and black point
- Also breeding Soft wheat (25%)

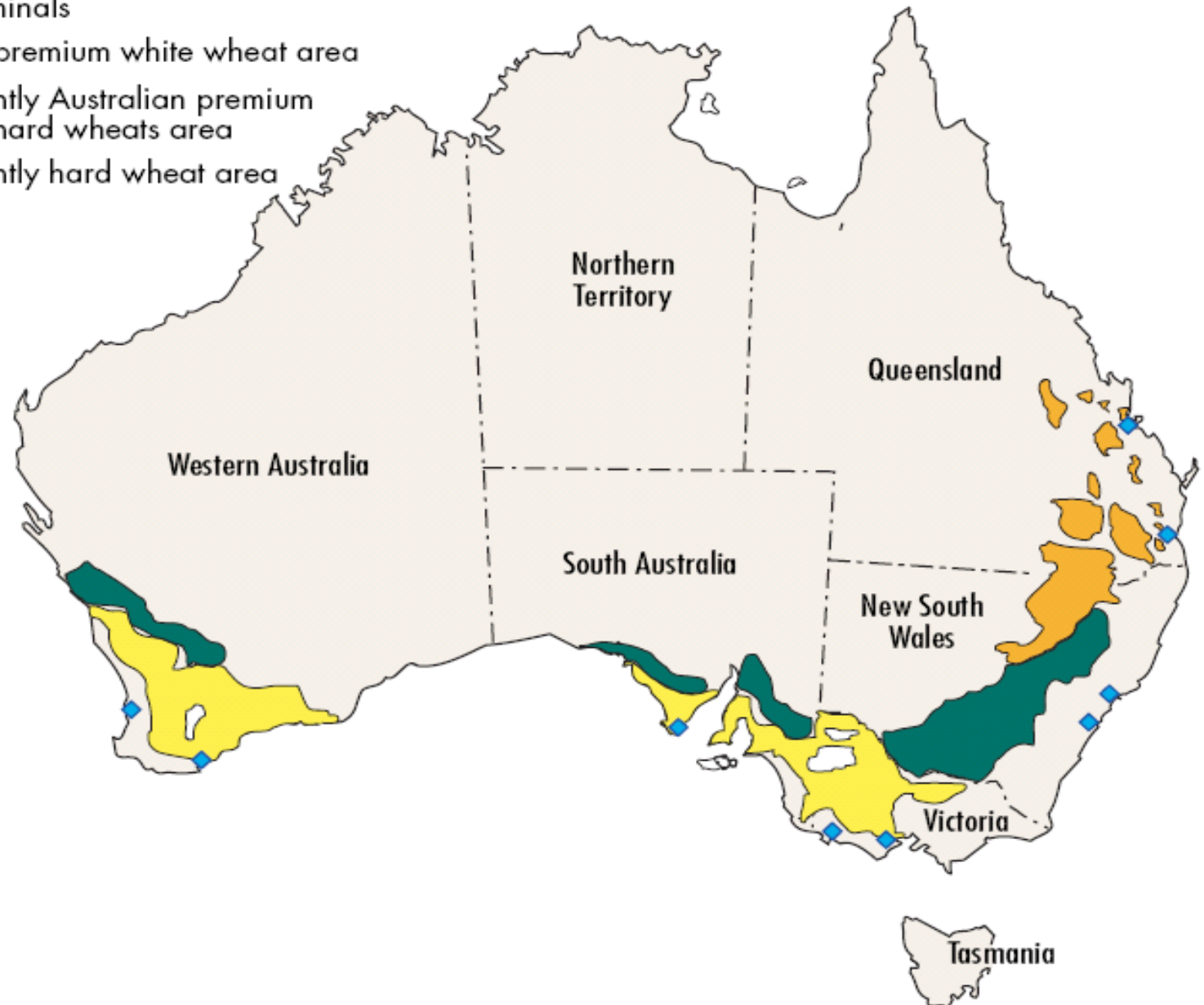


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# Australian Wheat Area

- ◆ Wheat terminals
- Australian premium white wheat area
- Predominantly Australian premium white and hard wheats area
- Predominantly hard wheat area

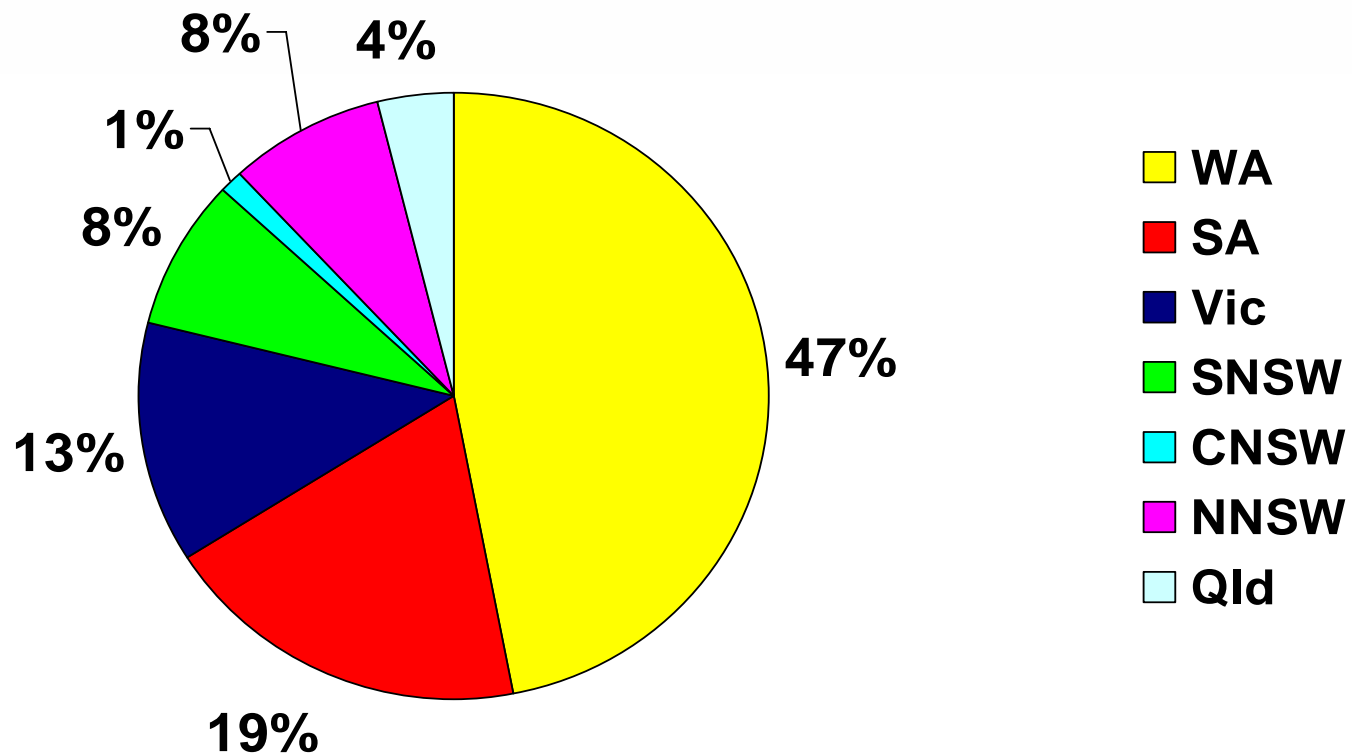




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# Australian Wheat deliveries for 05/06



**W.A. 8.2 mmt**

**Australia 17.4 mmt**





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# *Size of the Wheat Crop*



## *WA Wheat Production*

- **40-50% of Australian production**
  - **5 year average 6.8 mmt**
  - **Record wheat production in 2003/4 in WA of 10.5 million tonnes**
  - **Drought in 2006 – production around 5mt**



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# Market Situation



## *WA Wheat Exported by AWB Ltd. (single desk)*

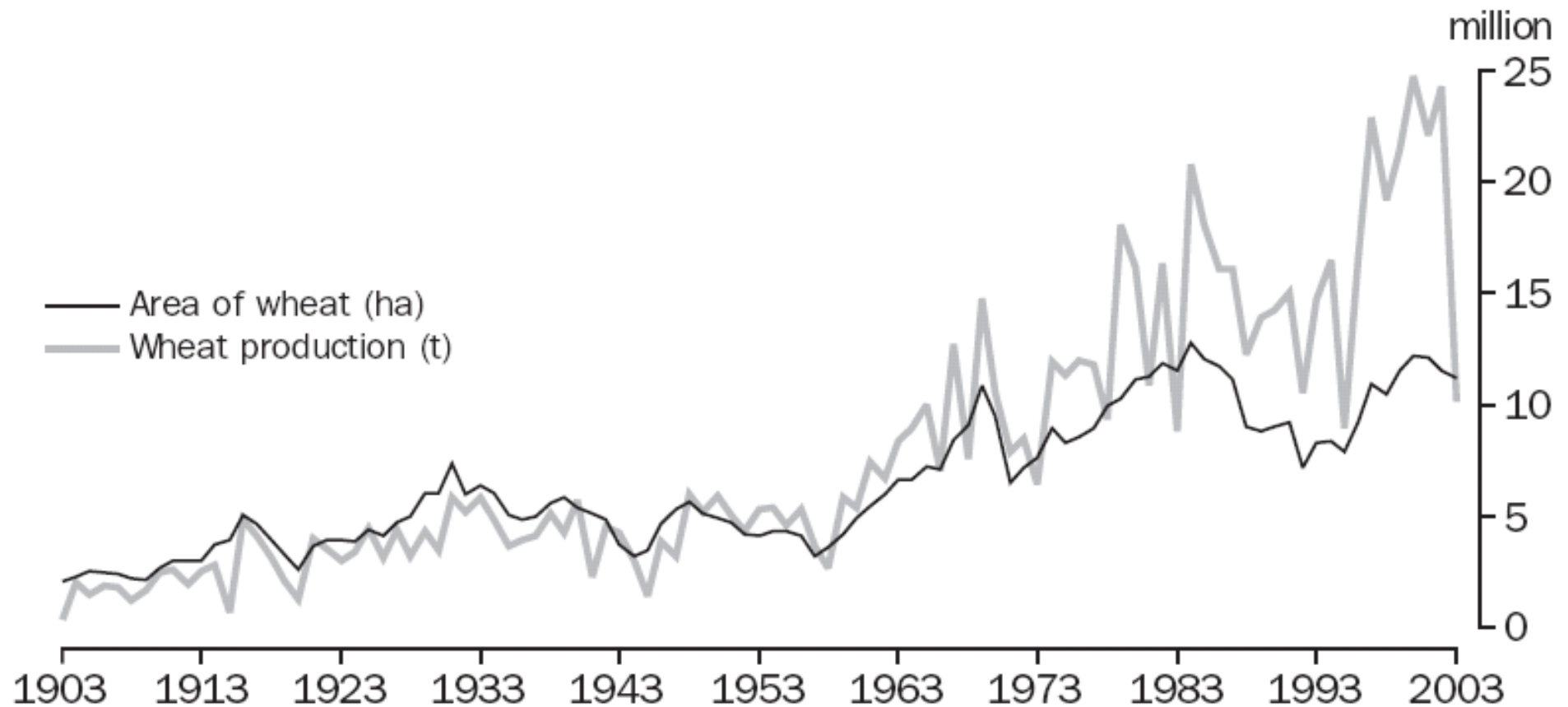
- **accounts for 50-60% of Australian Wheat exports**
- **95% of WA wheat is exported**  
(contrast to Eastern states which have a significant domestic market - 67% exported)
- **DAFWA wheat varieties sown on 81% of the WA crop area**
  - **45% Australian exports**
- **All wheat exported from Australia in 2006 was from WA**



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# Long term Wheat Production

## 14.14 WHEAT PRODUCTION — 1903 – 2003

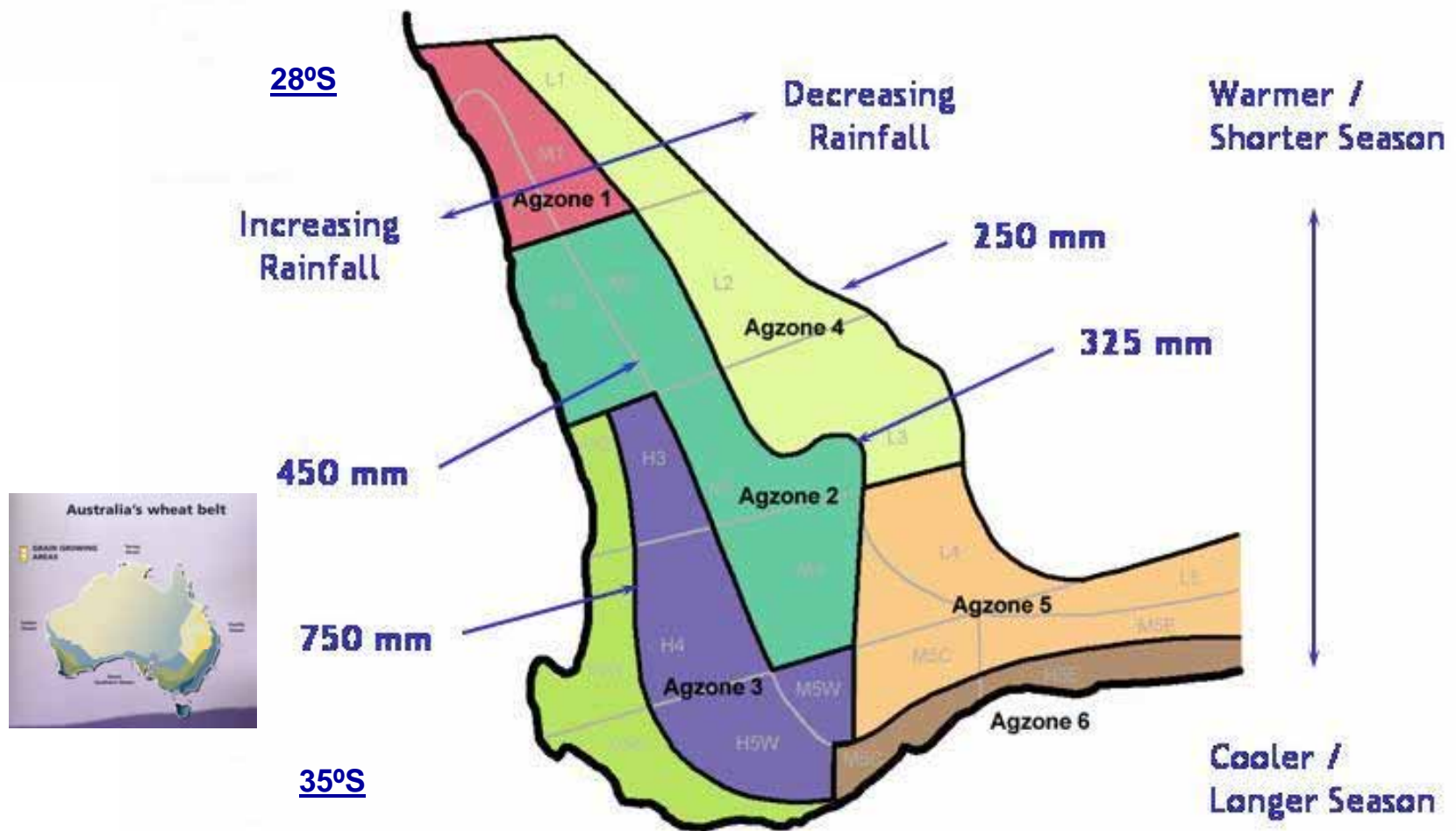


Source: *Agricultural Commodities, Australia (7121.0)*; Historical data available on request.



# WA Agricultural Zones

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# Environmental Challenges



- Grain filling during increasing temperature and decreasing rainfall
- Poor soils with low water holding capacity
  - Aluminium or Boron toxicity
  - Poor nutrition (N & P and some trace)
- Low yield potential



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# Wheat Breeding Objectives

- **Yield and adaptation**
  - Agronomic suitability
- **Quality**
  - Grade
  - Receival characteristics such as test weight, screenings, black point, low LMA etc
- **Disease resistance**
  - Three Rusts
  - Septoria nodorum blotch
  - Yellow spot
  - Septoria tritici blotch
  - Barley Yellow Dwarf Virus



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# Target Grades



In WA primary target are:

- Australian Hard (>11.5% protein)
- Australian Premium White (>10.0% protein)
- Australian Premium Noodle (average 10.5% protein)
- Australian Soft (<9.5% protein)

**AWB HARD WHEAT**  
minimum protein level of 11.5%

**AWB Hard Wheat** consists of specific, white, hard-grained wheat varieties selected for their superior milling and dough qualities.

**AWB Hard Wheat** is clean, dry and sound, producing high extraction flour of excellent quality and high water absorption.

Flour from **AWB Hard Wheat** is ideal for producing a wide range of baked products including European pan and hearth breads, Middle Eastern-style flat breads, Chinese-style yellow alkaline noodles and steamed products.

**AWB PREMIUM WHITE WHEAT**  
minimum protein level of 10%

**AWB Premium White Wheat** is made up of hard-grained white wheat varieties selected to ensure consistently high milling performance and flour quality at excellent extraction rates.

**AWB Premium White Wheat** flour is used to produce a wide variety of breads that include Middle Eastern flat and pocket breads such as balala, samosa, barbari, softbun and Indian specialty breads. It is also well suited for making many types of Asian baked products and noodles.

**AWB NOODLE WHEATS**

**AWB Noodle Wheats** are specially engineered to produce different types of flour for different varieties of soft and fresh noodles, including udon, white salted, Chinese, Ramen and Hokkien.

**AWB wheat** for udon noodles is made up of soft-grained wheat varieties that possess specific characteristics to ensure low flour ash, and a bright and creamy flour colour. A hardy-grained, high protein wheat is used to produce Ramen and Hokkien noodles with their characteristic yellow colour.

**AWB SOFT WHEAT**  
maximum protein level of 9.5%

**AWB Soft Wheat** is made up of unique white, soft-grained, 100% club wheat varieties, and accordingly is the only wheat product of its kind in the world. This high-quality wheat product is consistently clean and dry, milling readily at a straight-run extraction rate to produce excellent and versatile low-ash flour.

**AWB Soft Wheat** flour is ideal for making a wide range of confectionery and baked products including sweet biscuits, cookies, pastries, cakes, steamed buns and extensive snack foods.

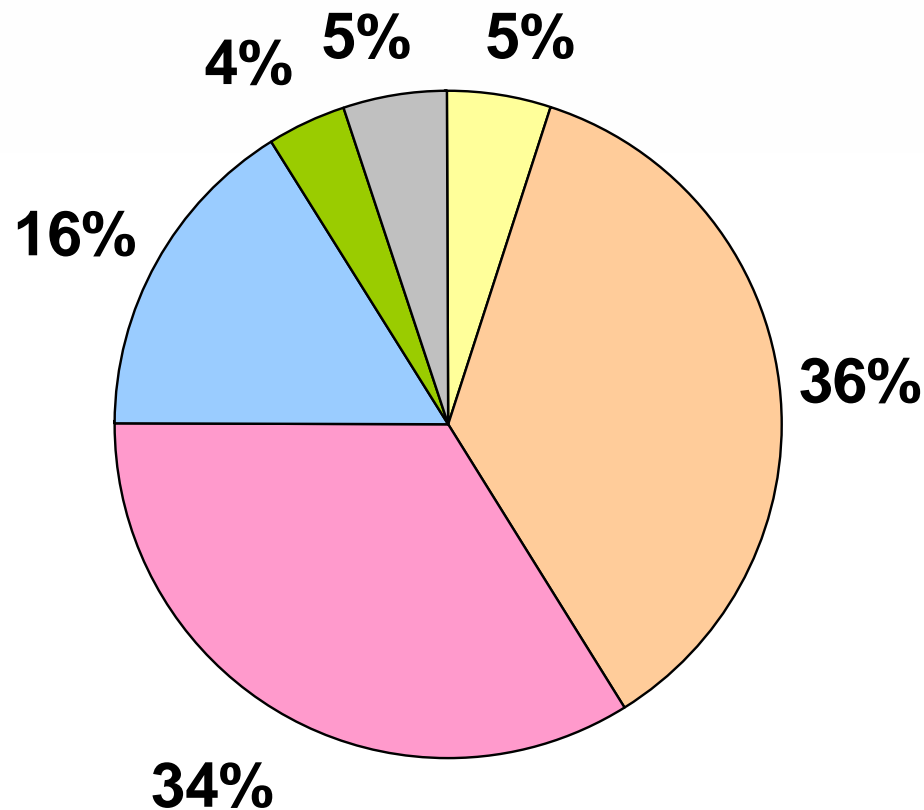


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# Quality Grades

## WA Deliveries by Grade 2005/06



■ AH ■ APW ■ ASW ■ ASWN ■ AGP ■ Other



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# DAFWA Wheat Breeding

- 4 Wheat Breeders
- 180,000 plots/year across 14 sites
- 3,000 crosses/year
- Program collaborators include:
  - cereal chemists
  - plant pathologists
  - molecular biologists
  - physiologists
  - biometrician
  - DH laboratory



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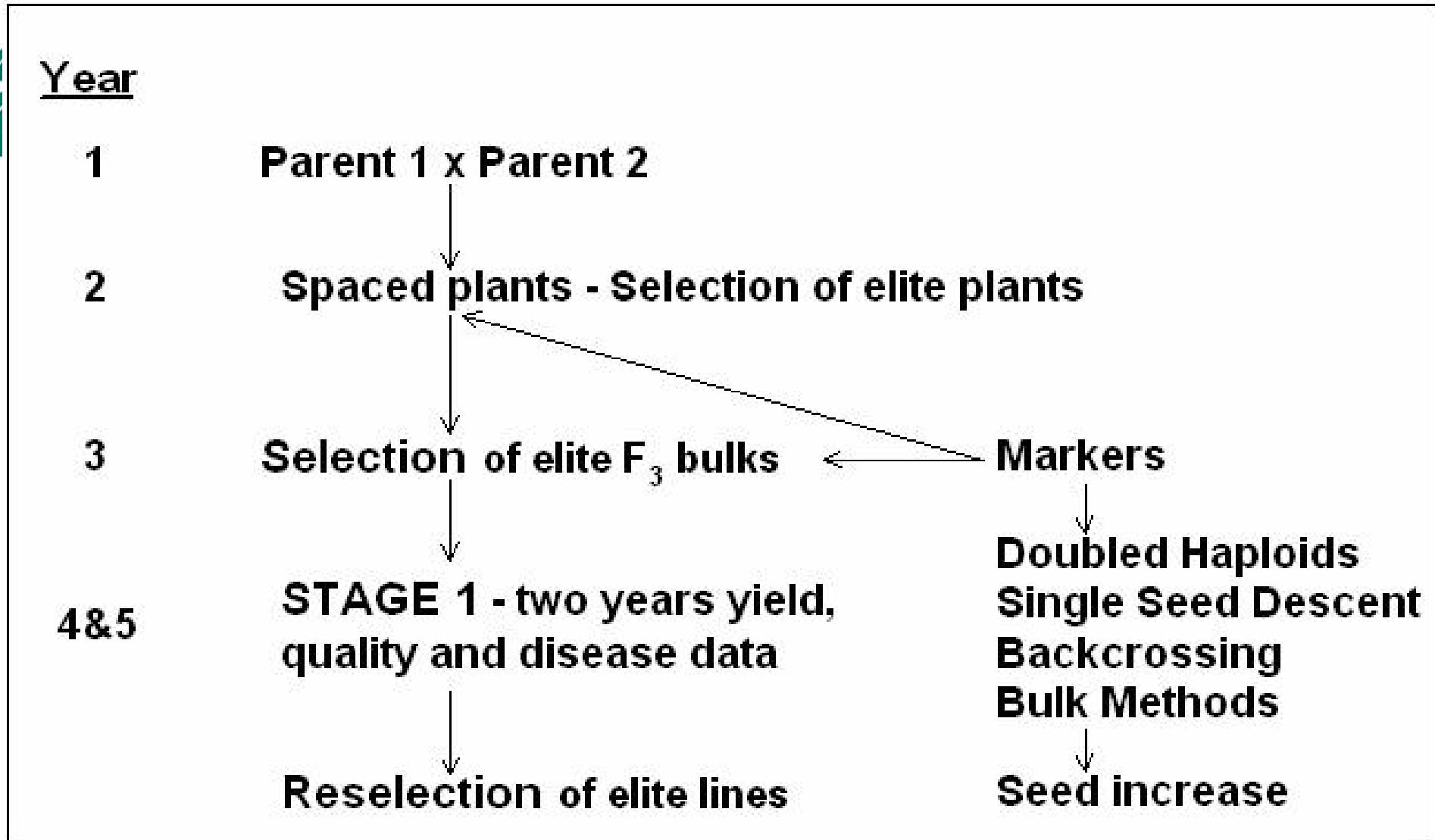
# Breeding Methodology

- **F2 Progeny**
- **Backcrossing**
- **Doubled haploids & Single Seed Descent**
  - routinely used
- **Marker Assisted Selection**



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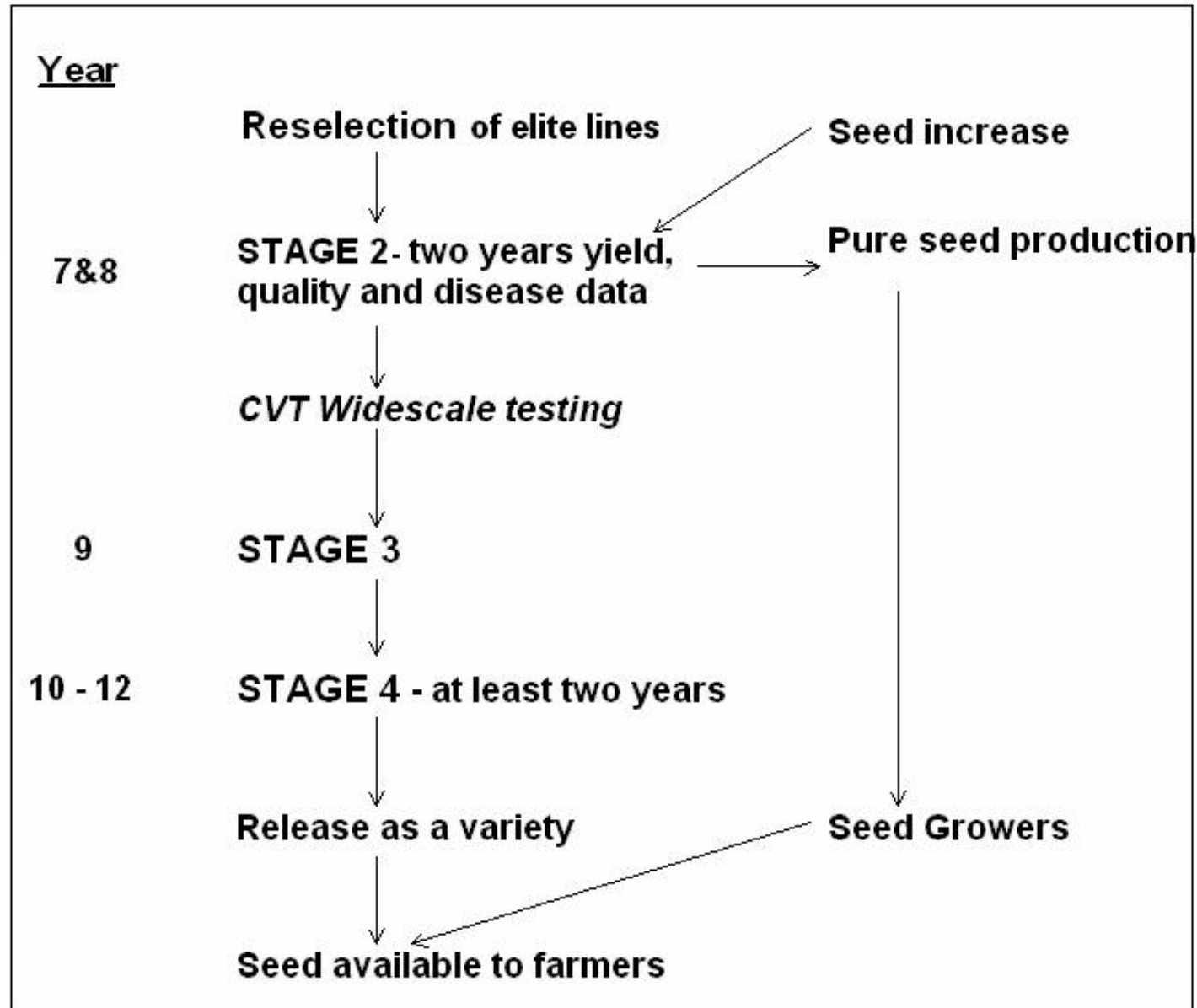
# Breeding Methodology





# Breeding Methodology

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# Wheat DH Production in WA



- Doubled Haploids have been used in the WA wheat breeding program since 1997
- Populations used for breeding and research
- Over 33,000 wheat DH lines have been produced using the wheat x maize method
- Produce 5,000 per year
- Research on anther culture
- Enhanced by F1 enrichment by molecular markers or rust tests prior to DH prodn



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# Agronomic suitability

- Aim to provide a range of maturities in each quality grade for different sowing dates
- Agronomic type
  - Height - mainly semidwarf - Wyalkatchem shortest (advantage in ease of stubble handling)
  - Non shattering -
  - Ease of harvest



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# Agronomic Suitability



- Agronomic type
  - Straw strength - again northern vars inclined to poorer straw strength as not exposed long before harvest
  - No preference for awns - just most parents are awned (awnless means if frosted the hay is more useful)
  - No preference for amount of tillers - let yield tell you which work (lower tillering seems to work in low rainfall though)
- Pre-harvest sprouting tolerance
  - Molecular markers helping us to select for this difficult character
- Freedom from LMA (Late Maturity Apha-amylase) - low falling no. without rain
- Frost tolerance - little genetic variation at present



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# Agronomic suitability

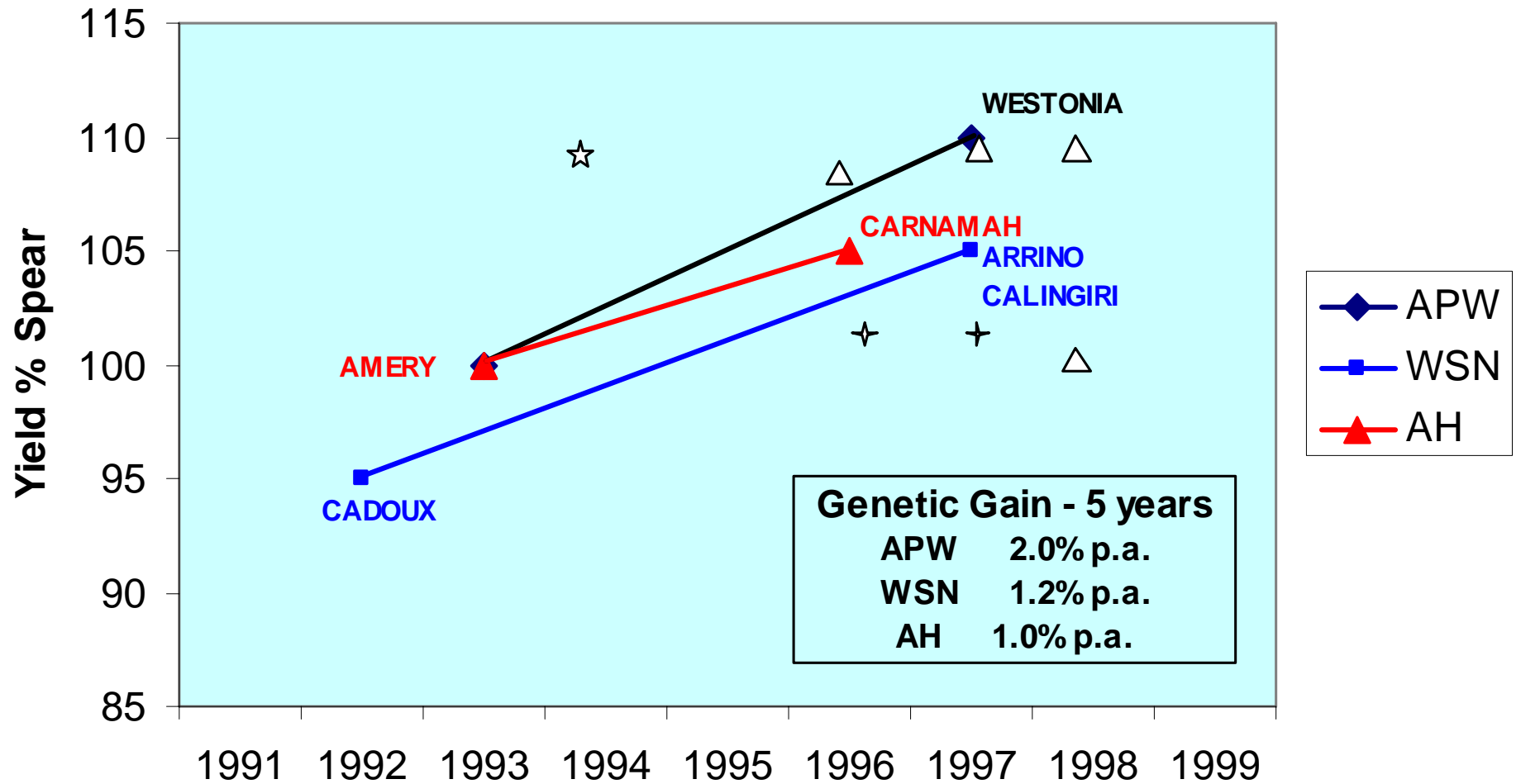
## When is it selected?

- F2 (Space plants) - maturity, height, non shattering adequate to good straw strength
- F3- onwards - ease of threshing
- Stage3 - Preharvest sprouting tolerance & LMA



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# Yield Genetic Gain - 5 years





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## Area sown (%) in WA to different wheat varieties



Wyalkatchem

Qual	2006	2005	2004	2003
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APW	29	27	20	5
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Calingiri

ASWN	17	19	24	23
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Carnamah

AH	8	12	18	26
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Arrino

APN	7	7	6	6
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Yitpi

AH	7	4	3	-
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Bonnie Rock

AH*	5	6	2	-
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Westonia

APW	5 <u>77%</u>	5	8	10
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All but Yitpi are from our program

DAFWA wheats 74% of all varieties in 2006



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# *Recent Advances in Wheat Breeding in Australia*



## Recent Advances

- **trial design**

breeding lines can be placed at more sites than previously without loss of precision with new un-replicated designs which can have partial replication (Stefanova & Clarke, 2006)

**GRDC**



Grains Research & Development Corporation





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# Site Selection and Trial Designs Optimizing Trials

- Seed for limited number of replicated trials?
  - More Replication at fewer sites?
  - More sites less replication?
- Designs available for partially replicated trials
  - E.g.  $1/3^{\text{rd}}$  of the trial replicated at each of 3 sites vs 2 reps at 2 sites

# Recent Advances in Wheat Breeding in Australia



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- **trial analysis**

- greater discrimination has been made by accounting for spatial trends over the trial
- trials are routinely analysed adopting
  - a spatial linear mixed model approach (Gilmour *etal*, 1997) and
  - multiplicative models (Smith *etal*, 2001) using ASREML.

# *Recent Advances in Wheat Breeding in Australia*



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- a **Plant Breeding database management system - “PBGenesis”**
  - designed by breeders
  - is used for all operations involved in running large breeding programs
  - has greater functionality than existing software packages
  - is presently being developed into a web-based system



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# Computerization



**Direct printing onto  
sample packets or  
harvest bags**





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# Computerization

**Bar coding harvest  
samples**



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- an **automated computer controlled seed preparation machine** - Agri-Pac Pty Ltd





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# *Recent Advances in Wheat Breeding in Australia*

**this automated computer controlled seed preparation machine**

- has been tested and used on breeding trials
- makes it possible to vary seed rate for each cell routinely
- enables routine use of different randomisations for each site of a set of breeding lines
- means less errors are made in the placement of entries in randomised trials.



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# *Recent Advances in Wheat Breeding in Australia*

- **application of new quality calibrations for Near Infrared Reflectance** for protein, flour yield and colour and water absorption
  - Used on all breeding lines before yield testing
  - these calibrations are further refined by growing a set of lines of very different quality beside the test material and processing them for quality and NIR to adjust the calibrations for that year

# Recent Advances in Wheat Breeding in Australia



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- **a new quality test** for micro-water absorption has been developed that allows this to be measured earlier in the program and on only 10grams of seed
- **Automation of preconditioning for milling tests** meant a greater throughput of samples



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# *Recent Advances in Wheat Breeding in Australia*

- **rust testing outside the wheat growing areas**
  - carried out on all lines prior to yield testing
  - using races possessing virulences not yet widespread, and
  - allowing timely inoculation



# *Recent Advances in Wheat Breeding in Australia*



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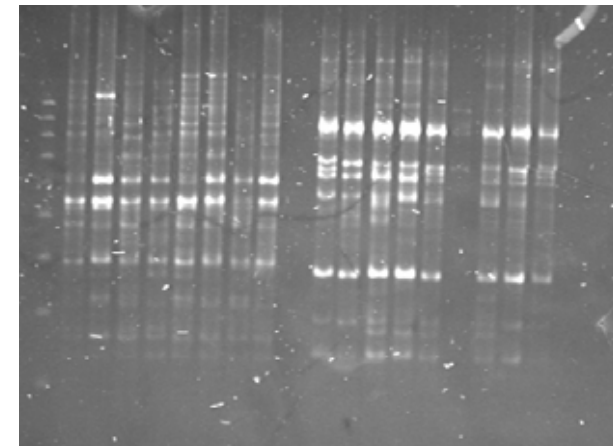


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# Recent Advances in Wheat Breeding in Australia

- **routine use of molecular markers**
  - at several stages in the program including F1 enrichment prior to backcrossing or production of doubled haploids
  - progress has been made for traits that are difficult to phenotype such as pre-harvest sprouting tolerance, or diseases such as BYDV





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# Recent Advances in Wheat Breeding in Australia

- **Utilisation of sources of abiotic stress tolerances**, eg waterlogging tolerance
  - strong linkage of our wheat breeding programs with the physiology group and international partners in India and China
  - project with India has identified good sources of waterlogging tolerance in varieties and the doubled haploid lines from the population used in this project
  - these are being used in the breeding programs in each country





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# *Suggestions for future work in wheat for Iraq*

- More progress will be made now with sorting out the agronomic or farm practice limitations than varieties
  - But need to be sure that you have an early and late planted option for each cereal (need balance between testing among cereals)
  - When these are sorted out selection for improved varieties will be important
- Consider other agronomic limitations eg
  - nutrition (toxicities and deficiencies - urgent need) or
  - coleoptile length or
  - time of sowing vs maturity (frost? or drought?)