Pulse Improvement: Chickpea and Field Pea

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CLIMA/DAFWA
Content

• Pulse (Field Pea & Chickpea) importance
• Chickpea
  – Breeding aims
  – Current approaches
  – Future
• Field Pea
  – Breeding aims
  – Current approaches
  – Future
Value to Human and Soil Health

• Dietary health
  – Protein content: pea (26%) chickpea (23%)
  – Vitamins and minerals

• Role in cereal-dominated cropping system
  – Roots colonized by nitrogen-fixing Rhizobia
  – Disease and weed break
Pulse area and production in WA

Area (000 ha)

Field pea
Faba bean
Chickpea
Albus lupin
Lentil

# Field Pea and Chickpea Area & Production

<table>
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<tr>
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<th>FP</th>
<th>Ch</th>
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<tbody>
<tr>
<td><strong>Area (1000 ha in 2007)</strong></td>
<td></td>
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<tr>
<td><strong>Australia</strong></td>
<td>293</td>
<td>306</td>
</tr>
<tr>
<td><strong>WA</strong></td>
<td>50</td>
<td>0.8</td>
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<tr>
<td><strong>Production (1000 MT in 2007)</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Australia</strong></td>
<td>313</td>
<td>466</td>
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<tr>
<td><strong>WA</strong></td>
<td>55</td>
<td>0.2</td>
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Goal: Integrated Gene Management

Consistency & profitability, and, hence, sustainability of cereal-legume systems in a drying, variable climate with escalating input costs
Chickpea (Cicer arietinum L.)
2n=2x=16
Self-pollinating
Progenitor: C. reticulatum
in SE Turkey
Chickpea Importance

• Third most important pulse after Phaseolus bean and pea
• Global production 2006 = 8.2 m t
• South Asia followed by Mediterranean region
• India = Largest producer & importer
• Australia = 10th largest Ch producer
• Average yield (global) = 772 kg/ha
• Australian yields = 1553 kg/ha
Chickpea Seed Types

Kabuli

Desi
Major breeding objectives

- Improved yield potential and stability
- Water productivity = *more crop per drop*
- Improved Ascochyta blight resistance
- Tolerance to herbicide
- Maintained disease/pest resistance:
  - *PRR, PB, RLN, BGM and virus*
- Improved tolerance to chilling
- Tolerance to high soil boron and salinity
- Appropriate phenology for regional environments
- Pod shatter resistance
Chickpea Ascochyta blight
Breeding Methods: Chickpea

• Bulk-pedigree
• Single seed descent
• Backcross
• Pollen selection
• Hybrids: male sterility
• Marker-assisted selection
• Genetic transformation
Integrated Chickpea Gene Map

Millan et al. 2006
Lack of diversity in cultivated chickpea

• Bottlenecks in evolution
  – Few polymorphisms - Gene mapping slow

• Need sources of
  – Water Productivity
  – Drought-avoidance traits (residual moisture)
  – Res. to AB, PB & BGM
  – Herbicide tolerance

• Sources
  – Land races & wild species
  – Mutation breeding
  – Genetic transformation
Recent Advances

• Novel genetic variation identified for:
  – Salinity and Boron tolerance
• Ascochyta Blight resistance
  – Parental material with partial resistance
  – STMS Markers for QTLs for partial resistance
• Doubled haploids
Accelerated Improvement of Desi Chickpea: An International Alliance of UWA/DAFWA/ICRISAT/COGGO

• Elements
  – Germplasm resources, infrastructure and expertise of ICRISAT joins hands with the DAFWA resources and scientific input from CLIMA
  – Pre breeding based at ICRISAT with evaluation and development in WA
  – Fast tracking: 3 generations in India, summer growing in WA and use of high multiplication site, Kununurra
  – Synergy; development of cold tolerant germplasm at CLIMA
  – Expanding network: Punjab Agric University, Ludhiana joins hands to enhance selection for WA conditions
Accelerated Improvement of Desi Chickpea: An International Alliance of UWA/DAFWA/ICRISAT/COGGO

- **Output (3 years)**
  - 2000 fixed lines with ascochyta resistance already in WA for evaluation with over 3000 new lines being evaluated in India
  - F4 segregating generation developed through pollen selection for chilling tolerance in field for single plant selection
  - Potential releases in demo trial in 2008 and plans to enter
- **Excellence**
  - Communication: Within WA and International
  - Industry participation: COGGO input at all levels
  - Linkage with CLIMA based research and development of new projects
Future: Integrated Gene Management

• Yield and Water productivity:
  - Broaden genetic base with crossable wild relatives with Adv. backcross QTL

• AB: QTLs tagged with STMS markers
  - MAS for QTLs & Wide crossing with wild + bridge sp.

• Herbicide tolerance: Mutation breeding & GM

• Salinity and soil boron toxicity:
  - Classical

• Chilling tolerance:
  - Pollen selection; ?MAS, + wide crossing

• Pod borer: Wide crossing with wild + bridge sp.; & GM
Field Pea

*Pisum sativum L.*

2n=2x=14

Self-pollinating
Field Pea: Importance

- Global production 2006 = 10.6 million MT
- 25% pea consumed as fresh green
- Second most important pulse after Phaseolus
- Canada (21%), France (15), China (11) & Russia (10) = Largest producers of dry pea
- Australia = 8th largest producer
- Average yields:
  - Global 1570 kg/ha: Australia 1068 kg/ha
Field pea types

White

Marrowfat

Dun

Blue

Maple
Field Pea: Major breeding objectives

- Improved yield potential and stability
  - Water productivity = More crop per drop
- Standing ability and harvestability
- Disease/pest resistance to
  - Blackspot
  - Pea weevil
- Tolerance to herbicide
- Tolerance to high soil boron
- Maintained resistance to
  - Downy mildew
  - Powdery mildew
- Pod shatter resistance
- Improved tolerance to frost and drought, particularly at podding
Advances in FP breeding

• Semi-leafless *afila* type with local adaptation
• Stem strength variation and SP selection
• Slow steady progress in partial resistance to black spot
• Pea weevil resistance transferred from *P. fulvum*
• GM protocol routine & incl. weevil resistance
• Doubled haploid production
• Generation advancement protocol (GAP)
Breeding Methods: FP

• Pedigree
• Single seed descent
• Bulk-pedigree
• Backcross
• Recurrent selection
• Hybrids: male sterility
• Marker-assisted selection
• Genetic transformation
Future: Integrated Gene Management

- Water productivity: Wide crossing crossable wild sp.
- AB:
  - Recurrent phenotypic selection
  - GM - Antifungal gene/s
- Stem strength
- Markers for pea weevil resistance
- Herbicide tolerance
‘Peas on Earth’

Thanks