Blackcurrant Breeding and Research at The James Hutton Institute

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Plan

• Breeding programmes and cultivar releases to date
  ➢ Processing and fresh market

• New techniques for selecting the plants we need
  ➢ Marker–assisted breeding strategies

• Emerging challenges
  ➢ Environmental effects eg. reducing levels of winter chilling

Can we improve on the cultivars we already have?
Blackcurrant Cultivars

- Ben Avon
- Big Ben
- Ben Dorain
- Ben Gairn*
- Ben Vane
- Ben Finlay*
- Ben Klibreck
- Ben Maia
- Ben Starav
- Ben Como*
- Ben Chaska+
- Ben Hope

* First commercial UK cv. with resistance to BRV
* First commercial UK processing cv. with resistance to gall mite
+ First UK cvs released in USA
Breeding Objectives

Fruit quality

- High Brix/acid ratio
- Low total acidity
- Anthocyanins
  - Delphinidins preferentially selected
- Vitamin C (AsA)
  - > 140 mg/100 ml
- Sensory traits
- Berry size
  - 1g minimum

Agronomic

- Environmental resilience
  - Winter chill levels
    - < 2000 h/7.2°C
- Pest resistance for low-input growing
- Acceptable crop yield
  - > 6 t/ha
  - Juice yield also quantified
Fresh Market Blackcurrants

- Increasing interest
  - Predominantly related to health benefits

- Different requirements and breeding objectives
  - Often different cultural practices
    - Hand harvesting
    - Grown on wires in some areas
  - Large berries preferred
    - 2g +
  - Green strigs preferred
  - Aiming for berries suitable for eating fresh
    - Higher Brix/acid ratios

Big Ben
Recent releases

**Ben Starav** (Ben Alder x ([E29/1 x (93/20 x S100/7)] x [ND21/12 x 155/9]))

- Consistently high yields (mean **10.07 t/ha** in trials), medium berries, low-medium chilling reqt., high Brix and juice yield, very high anthocyanin content

**Ben Klibreck** (Ben More x C2/13/15) x (Ben More x Ri-74020-16)

- High yields (mean **10.2 t/ha** in trials), medium berry size, good growth habit, moderate/high chilling reqt., high vitamin C and anthocyanin content
New release – Ben Finlay

- Gall mite-resistant
- Parentage: [(SCRI P10/9/13 x Ben Alder) x EM B1834-67]
- High yields, suitable for low-input growing
- Vigorous growth habit
- Early-midseason, medium sized berries
- Excellent flavour
- High Vitamin C
- Medium-low chilling requirement
Trial seedlings from JHI breeding programme

**JHI 9253-1**
- Complex cross involving elite lines from Scotland, Sweden and England
- Late mid season cv.
- Tall vigorous growth
- Good yields at Ben Hope/Alder levels
- High AsA, v. good anthocyanins

**JHI 92127-1**
- Complex cross incl. Ben Lomond, Ben Rua etc.
- Early mid season
- Yields good in trials in 2009 & 2010
- Very stocky upright growth, with dense foliage
- High anthocyanins, medium AsA
- Good ‘hangability’ (only 10% drop after 14 days)
Breeding techniques

- Expensive to run breeding programmes:
  - Lengthy timescales
    - Some traits take a long time to screen for, others are impossible to screen on a high-throughput basis
  - Field/glasshouse costs

- Timescales need to be reduced and efficiency needs to be increased
  - Time to cv. currently 12-15 years

- More extensive phenotyping in field, glasshouse and CE rooms

- Establish link between genotype and phenotype
Molecular Breeding

- Rapid identification of genetically superior individuals in breeding populations

- Can be utilised in situations where:
  - Assessment in field takes a long time
    - Pest resistance (some)
  - Assessment can only be done on mature plants over time
    - Fruit quality

- Basic research costs relatively high, deployment costs low

- No environmental effects

- Must be associated with detailed evaluations of performance in field

- Marker-assisted selection possible by linking of genotype with phenotype

- Simple traits so far, more complex traits in development
Gall mite marker

- Gall mite still a v. serious problem
  - Pesticide withdrawals, plantation lifespan, etc.

- Resistance available from Ce gene from gooseberry (cf. EMR)
  - Material at JHI now at BC3+

- Field infestation plot for screening new lines from breeding programme
  - 4 years

- Resistance mapped on genetic linkage map, associated marker identified
  - Accuracy > 95% across mapping population, cvs., trial lines etc.

- Converted to PCR-type (high throughput)
  - Can test 2-3k seedlings p.a.

- Marker now routinely deployed in JHI breeding programmes as a selection tool
  - Field infestation plot removed
  - Separate plots of exclusively resistant material initiated
  - Material tested for other programmes, eg. ISK, Poland
Mite-resistant lines in commercial trials

New cv. release: Ben Finlay

JHI 9968R-1
91130-1 x JHI S36/1/100

JHI 92015-13
(JHI C7/4/24 x Ben Gairn) x EMR B1834-19

JHI 9154-4
Ben Dorain x EMR B1834-120
Trait associations – fruit quality traits I

- Measurements across reference mapping population (ca. 300 plants) for 4 years at JHI
- Individual traits placed on genetic linkage map
  - Fruit size
  - Anthocyanins
- Associated molecular markers identified
  - Validation in progress for markers linked to berry size and total anthocyanins
Trait associations – fruit quality traits II

- Use of gene expression data from ripening fruit linked to metabolomic analyses
- Fruit quality analysed at various stages
- Gene expression monitored across stages using Agilent microarrays
- Key genes mapped, markers identified for the various quality and nutritional traits
- Environmental influences on gene expression
Reduction of seedling numbers using marker-assisted breeding

Marker for gall mite resistance Est. 2012

Markers for berry size Est. 2013

Markers for anthocyanins, sugars, vitamin C Est. 2015

Reduced seedling numbers – but increased relevance to industry needs

Faster field selections and cv. releases
New challenges (& opportunities)

- Disease problems eg. *Phomopsis*
- Environmental effects on blackcurrants
  - Winter chilling reductions
    - Increased frost risk
  - Water use efficiency
  - Effects on fruit quality
Genetic resources relating to winter chill

- Use of low-chill germplasm (ex. NZ) for environmental resilience
- Phenotyping of germplasm (selection for low chill)
- Mapping population grown in NZ and Scotland (from 2012)

Population of ‘Ben Dorain’ (high chill’ ex. Scotland) x ‘Sefton’ (low chill, ex. NZ)
Conclusions

- Can we improve on the cultivars we already have?
- **Definitely yes**

-Targets for the future:
  - Environmental resilience and cropping consistency
  - Cultivars and end-user needs more exactly aligned
  - Increased quality, particularly health-beneficial components
  - Improved resistances for low-input growing

-Tools to help us achieve our aims:
  - Marker-assisted breeding
  - Smart phenotyping linked to the genetics
  - Good collaborations with industry and academic partners
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