Blackcurrant Breeding and Research at The James Hutton Institute

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Fruit Breeding Group

The James Hutton Institute

Blackcurrant Breeding at JHI

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

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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 <u>10.07 t/ha</u> 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 <u>10.2 t/ha</u> 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

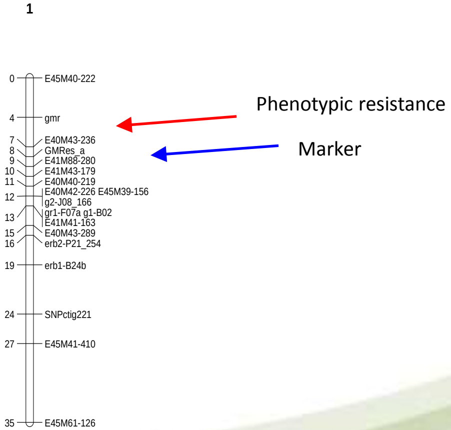
- Rapid identification of genetically superior individuals in breeding populations
- Can be utilised in situations where:
  - Assessment in field takes a long time
    - Pest resistance (some)
  - Assessment can only be done on mature plants over time
    - Fruit quality
- Basic research costs relatively 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 BC_9+

- 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

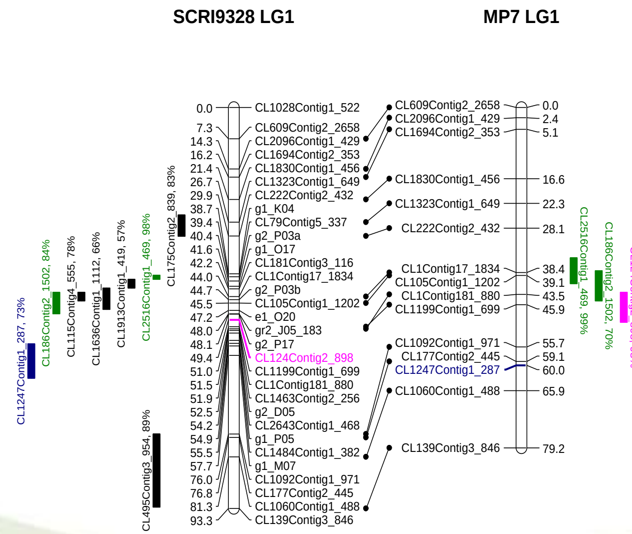
JHI 9154-4

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

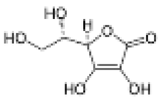
- Associated molecular markers identified
  - Validation in progress for markers linked to berry size and total anthocyanins

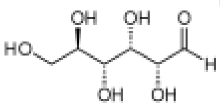


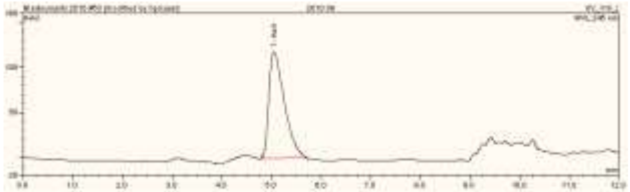
Trait associations – fruit quality traits II

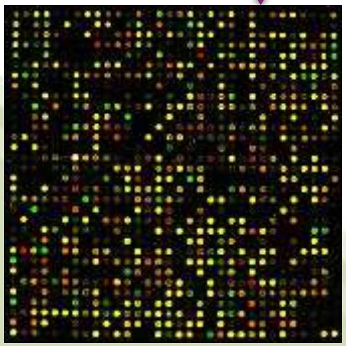
- **Use of gene expression data from ripening fruit linked to metabolomic analyses**

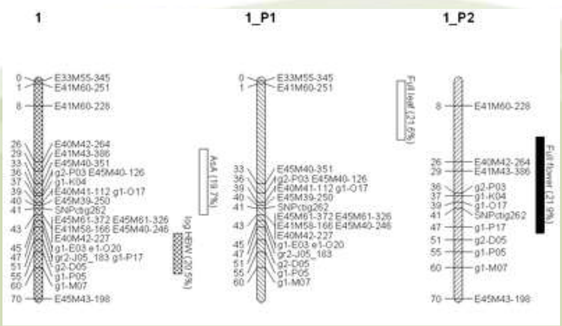
  - Fruit quality analysed at various stages
  - Gene expression monitored across stages using Agilent microarrays
  - Key genes mapped, markers identified for the various quality and nutritional traits
  - Environmental influences on gene expression











Reduction of seedling numbers using marker-assisted breeding

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Marker for berry size
Est. 2013

Marker for gall mite resistance
2012

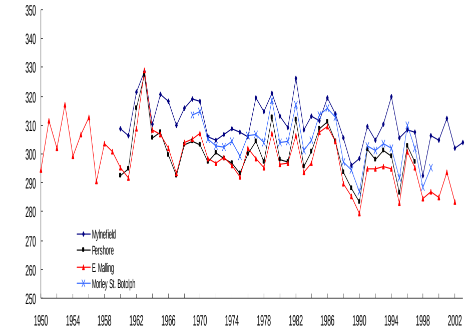
Markers for anthocyanins, sugars, vitamin C
Est. 2015

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

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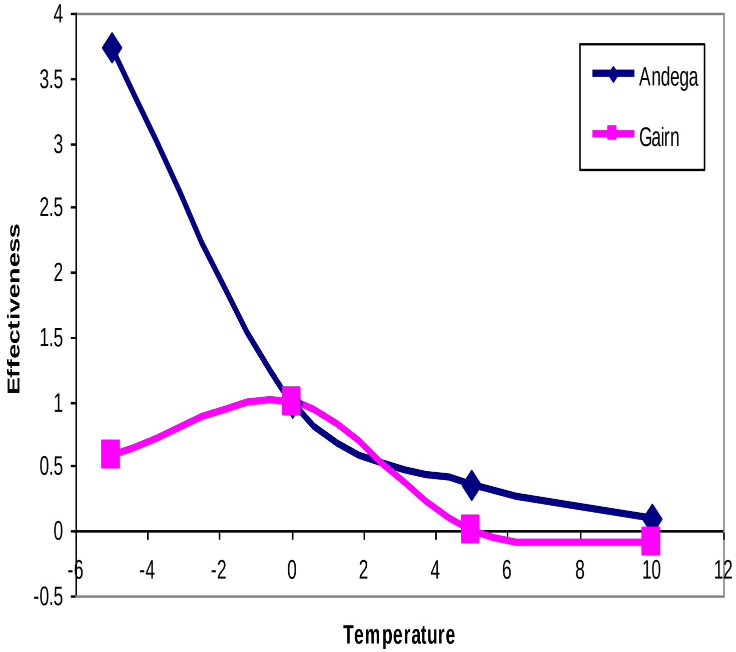
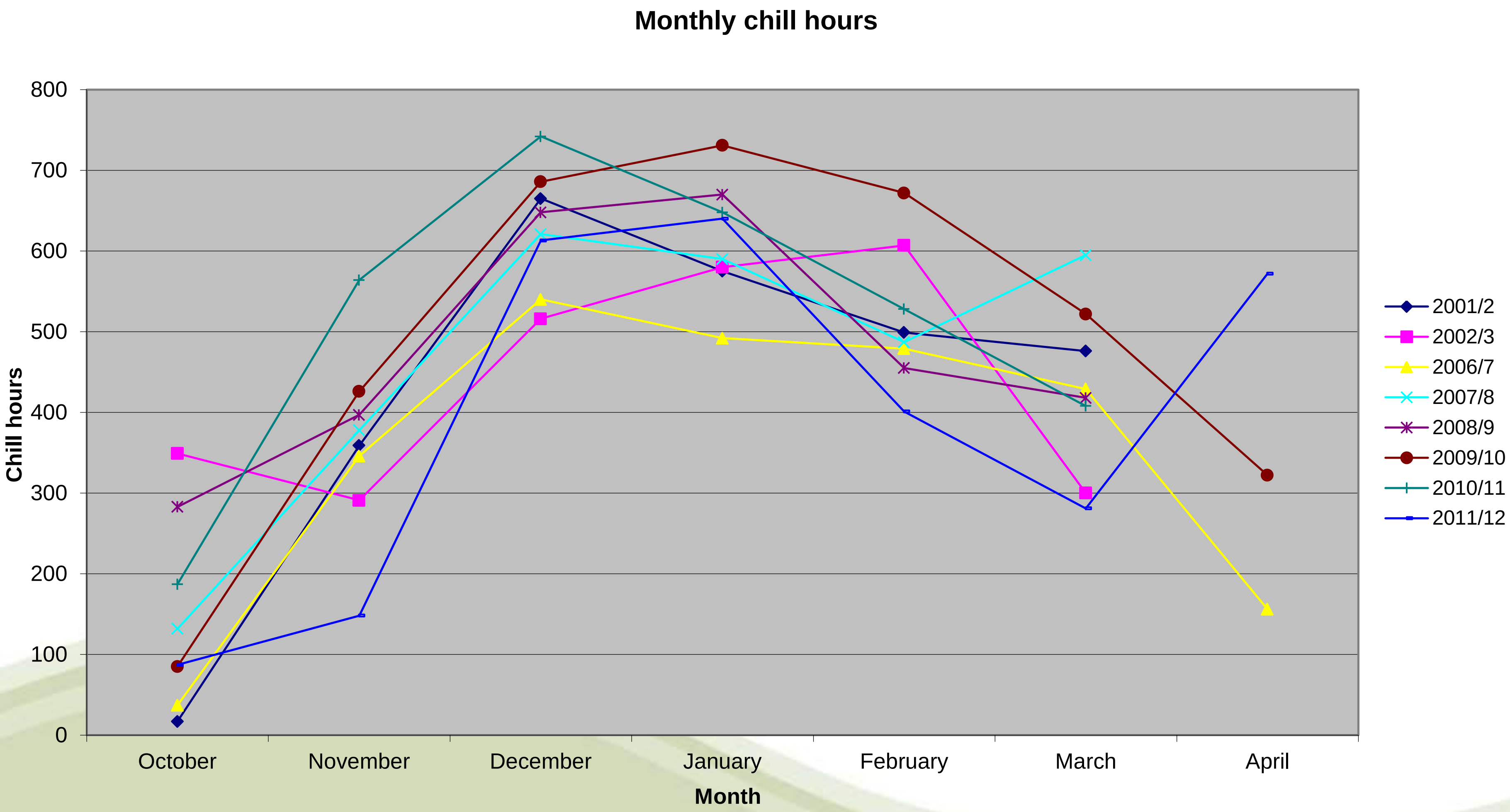
Future-proofing berryfruit
CLIMAFRUIT

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)



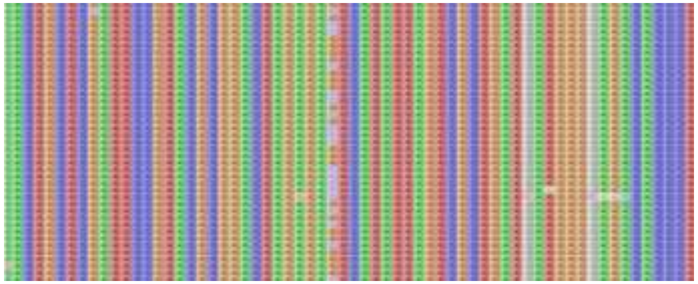
Population of `Ben Dorain' (high chill' ex. Scotland) x `Sefton' (low chill, ex. NZ)



Monthly chill hours
Chill hours
0
100
200
300
400
500
600
700
800
October
November
December
January
February
March
April
Month
2001/2
2002/3
2006/7
2007/8
2008/9
2009/10
2010/11
2011/12

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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UK Collaborators

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