# Blackcurrant breeding at JHI – where we are now and what's coming next

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### Plan



#### Progress to date

Existing varieties and the commercial landscape in the UK

New challenges

Breeding objectives and how they have changed

- Trial lines
  - The next raft of varieties for the processing and fresh markets
- Molecular breeding strategies
  - Genome sequencing
  - Marker-assisted selection

## JHI/MRS *Ribes* breeding

- Breeding at SCRI from 1960s
- GSK funding since 1990
  - Contracted until 2015
- First release Ben Lomond (1974)
- Subsequent releases (all Bens) increasingly successful commercially
  - Ben varieties now account for 99% UK production, ca. 50% global
- Emphasis on quality for processing, reflecting the funding source for the breeding programme
- Very wide genetic base variety and species collection maintained as part of Scottish Government Underpinning capacities programme
- New varieties **must** combine quality with agronomic performance











### **More varieties produced**

#### 1986

 Ca. 4 main varieties, Baldwin is widest-grown

2000

 Ca. 5 main varieties, Ben Lomond is most popular

2004

 Ca. 6 main varieties, Ben Alder is most popular

#### 2009

- Ca. 10 main varieties, Ben Hope is most popular
- 2014
- Ca. 10 main varieties, Ben Hope is most popular (just)







### Varieties – past and present



**`Baldwin' - > 100 years old,** mainstay of UK blackcurrant industry up to l980s



'Ben Lomond' – released from SCRI 1974, most popular variety in 1980s – early 90s





'Ben Starav' – released 2008



### The new standards.....

- 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



 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









## **Blackcurrant 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

#### 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





### **Attributes Ranking 2012**

Top 5 attributes for new variety selection are quality-related

From GSK Breeder's Guidelines

- Flavour is top criterion
  - Potential cultivars all screened at processor
    - + Some rejected as poor, or different to other 'Ribena' varieties
  - Better screening for flavour needed at early stages

• Yield/regularity of cropping is top agronomic trait

Pest and disease resistance has lower priority





#### **Breeding Programme Design**

- Identification of best parents
  - Combination of best quality traits and superior agronomic performance
  - Database development
- Identification of areas requiring improvement
  - Sources of characters to be improved identified within database
  - Knowledge of heritability of traits essential
    - » Eg. anthocyanins strong maternal influences
- Development of crossing schedule
  - Ca. 100 crosses every 2 years
  - Spread of cropping seasons









#### Plant resources within blackcurrant breeding programme

- Blackcurrant seedlings (unselected, Stage 1)
  - + >10k
- Blackcurrant single plant selections (Stage 2)
  - > 2000 including dedicated mite-resistant plot of
    > 500 selections
- Blackcurrant 5-plant selections (Stage 3)
  - + >400
- Trial lines
- + > 40 including 9 mite-resistant
- *Ribes* germplasm collection
  - Species, old varieties etc.
  - New genotyping techniques developed in *Ribes* have potential application in identifying useful traits within germplasm collection







- $\sim 100$  crosses made bi-annually
- $\sim 500$  selections evaluated annually
- 10 new lines selected for trials

#### Ranking

1

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6	6 not complying with AsA												
5	Yellow	High AsA (>145)											
4	Green	High AsA + High Brix (>13.5)											
3	Blue	High AsA + High Brix + Brown index (< 0.38)											
2	Red	High AsA + High Brix + Brown index (< 0.38)+ Blue index (>0.15)											
1	Purple	High AsA + High Brix + Brown index (<0.38)+ Blue index (>0.15) + field scores											

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## Winter chilling and climate change

- Potentially major limiting factor for blackcurrant production in some areas
- Differences in chill requirement identified, models developed (but need to be refined)
- Collaboration with Plant and Food NZ
  - Mapping population in 2 locations, correlation of post-chill responses
- Identification of genes/genetic regions
  that control differences in climate
  response







## **Ongoing work on climate effects**

- 2012-3 and 2013-4 we have been harvesting shoots from field at weekly/biweekly intervals to see if we can fit models to actual data
  - 4 cvs. (2 high chill, 2 low chill)
- Accompanied by bud samples for microarray/gene expression analysis
  - Alignment of gene expression with bud dormancy and development
- 2012/13 Continuously cold so little discriminatory power
- 2013/14 Lowest levels of chill in over 20 years









### New release – 9521-2 (prov. Ben Lawers)

- Early-mid (Lomond) season
  - after Ben Vane but before Ben Starav, at a time of potentially low fruit supply
- Typical yields 7 8 tonnes per hectare
- Not fully resistant to gall mite, but slow to become infected in a high pressure field situation
- Very low susceptibility to Botrytis
- Averaged Brix levels of 16.6 (though has been as high as 18.9)
- High levels of AsA
- Good flavour
  - `Fresh fruity blackcurrant'
- Low chilling requirement
- Exclusive to contract growers







- JHI 9918-3 (GSK 2008-6)
- Ben Hope x JHI 91130-1
- Mite resistant
- Mid-season
- Upright growth habit

#### AsA > 200 mg/100 ml



### JHI 9998-2 (GSK 2010-14)

- JHI 917-4 x 8828-18
- Early ripening, similar to Ben Vane
- Brix 15.8
- High yields of large berries (> 1g)







#### JHI 00-37-29 (GSK 2010-17)

- Ben Klibreck x JHI 8992-11
- Late season, possible Ben Tirran replacement
- AsA > 230 mg/100ml, Acy > 1, Brix > 16
- Berries > 1g



#### JHI 9918-1 (GSK 2008-6)

- JHI 91130-1 x Ben Hope
- Good yields
- Mid-late season, potential Ben Klibreck replacement
- AsA > 230 mg/100 ml
- Gall mite-resistant







### JHI 00-54-21

- Ben Hope x JHI 8837-11
- Late season
- Large berries
- ASA > 180 mg/100 ml



#### JHI 00-54-30

- Sister of 00-54-30
- Late season
- Avge berry size 1.23 g
- AsA > 190 mg/100 ml, better colour







### JHI 92105-13

- JHI \$36/2/21 x B1834
- Early-mid season
- Gall mite-resistant
- Sl. spreading habit
- AsA > 220 mg/100 ml, high colour

### JHI 92127-1

- JHI S36/3/51 x B1834
- Early-mid season
- Upright with strong branches
- Consistent cropping
- V high colour, AsA > 160 mg/100 ml









## **Ben Finlay**

- (JHI P10/9/13 x Ben Alder) x
  EMR B1834
- Gall mite-resistant
- Early-mid season
- AsA > 240 mg/100 ml
- High anthocyanins
- Registered for EU Rights





### **Fresh Market Types**

- JHI P8-5-24
- Berry size 1.29g
- Brix 13.9
- Green strig colour, storage at 4C quite good

#### Ben Maia

- Berry size < 1g, strong green strigs</p>
- Brix > 14









### **Fresh Market Types**

### JHI 01-33-1

- V large berries (avge. 1.42g)
- Good storage potential at 4C
- Brix avge. 16.48, has been up to 18

#### JHI 00-50-1

- Large berries (avge. 1.28g)
- Green strigs, outstanding storage potential
- Brix avge. 14.54





## **Selecting for berry size**

- Key trait for fresh and processing markets
- SNP markers associated with large berries identified
- Validation of markers on diverse breeding populations is in progress as part of EUBerry project
  - Joint work with InHort Poland
  - Phenotype data from 2014 harvest will be used to confirm effectiveness of markers
    - Other putative markers available









### **Future prospects**

- Range of new mite-resistant varieties with enhanced juice quality
- Better understanding of environmental effects on fruit quality and cropping
- More markers in the breeding programme
  - Berry size by end of 2014
  - Anthocyanins by end 2015
- Variety selection more closely linked to specific products







### **Ribes genomic resources**

- Genotyping by sequencing (GBS)
  - 1.58k new SNP markers identified
  - Map length increased by 33% to 780.7 cM
  - Model for mapping and identifying SNPs in crop species lacking reference genome
  - Further GBS in progress on NZ Dorain x Sefton population
- Shotgun sequencing of *Ribes* genome in progress
  - 50x MiSeq coverage

Russell, J., Hackett, C., Hedley, P., Liu, H., Milne, L., Bayer, M., Marshall, D., Jorgensen, L., Gordon, S. and **Brennan, R.** (2013). The use of Genotyping by Sequencing in blackcurrant (*Ribes nigrum*) - developing high-resolution linkage maps in species without reference genome sequences. *Molecular Breeding* DOI 10.1007/s11032-013-9996-8







### **Future challenges and opportunities**

- Move towards sustainable cropping
  - Climate change effects
    - Poor budbreak
    - + Frost damage
  - Reduced pesticide inputs (IPDM systems)
    - Emerging pest and disease problems, eg.
       *Phomopsis*, winter moth
- Molecular breeding offers increased efficiency and resilience within the programme for many of the traits of interest
- The JHI/MRS breeding programme is able to combine underpinning science and wide genetic resources with commercially-facing varietal production









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BBC `Harvest', August 2013 BBC



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