EUBerry WP1 - Overview

Rex Brennan
WP1 leader

The James Hutton Institute

WP1 Structure

- `Improving berry varieties through the identification and utilisation of the best genetic resources'
- Three main sections:
  - Phenotyping and characterisation of pre-commercial berry germplasm
    - Existing database mining (P6, P7)
    - Assessment of pre-commercial material (P2)
  - Development of molecular tools for support and enhancement of berry fruit breeding
    - Strawberry (P6, P3 subcontractor)
    - Raspberry and blackcurrant (P3, P2)
  - Validation of the role of key genes in strawberry traits
    - Nutritional quality and flowering-related genes (P1, P5, P6)

WP1 philosophy

Identify the best germplasm currently available in the EUBerry region

D1.1

Identify the best germplasm available for breeders to address key issues

D1.2

Develop the best contemporary breeding and genetics tools for application by European fruit breeders

D1.3

Develop clear strategies for the breeding of superior cultivars

Improved sustainability of EU berry fruit production

D1.4, D1.5

Germplasm assessment and characterisation

- Mining of existing databases
  - RIBESCO (currants)
  - GENBERRY (strawberry)
    - Limited utility, as it uses botanical rather than agronomic/production-based descriptors
- Compilation of new database using field and lab observations across the EUBerry partners
  - Additional crops
    - Raspberry, blackberry, blueberry
  - Includes new breeding lines as well as cultivars

Sub-Task 1.1.1 Data mining of existing characterisation data

Partner 7 – MTT

The James Hutton

•The work of MTT (P7) was based on the information collected in the EU AGRI GEN RES project RIBESCO (2007– 2011)

•Quality information (more than 18 000 observations) of over 600 Northern and Central European accessions of **blackcurrant** that has been collected and included in the ECP/GR Ribes/Rubus Database

The data included morphological and agronomic traits, pathogen and winter resistance and some aspects of fruit quality. Groups of accessions were identified, based on

•Environmental adaptability
•Pest and disease resistance
•Yield components

The data were partly analysed separately as Central European subset (Poland, Germany) and North European subset (Estonia, Finland, Latvia, Lithuania, Sweden), some analyses were done by using the dataset as a whole.

Sub-task 1.1.2 Assessment of pre-commercial material

Partner 7 – MTT

The James Hutton Institute

Variety test created in COST 863 (planted in 2009)
Ben Dorain, Ben Gairn, Ben Hope, Ben Starav, Ben Tirran, Ben Tron, S 18/2/23, 8872-1, 9154-3; Tisel; Almiai, Dainiai, Gagatai, Joniniai, Tauriai; Mara; Mortti; New Finnish varieties (under DUS testing): Marski, Mikael, Vilma, Venny. Data included in the EUBerry database.

Traits evaluated

Vegetative scores	Vigour, Plant habit, Number of basal shoots
Phenology	Date of flowering, fruit ripening, uniformity of ripening Scoring
Stress resistance	Scoring winter, pest and disease injuries
Yield	Kg/plant , berry size: g/100 berries
Strigs length	Number of flowers, number of berries
Fruit quality:	Taste, Brix, Vitamin C, Titratable acids

Creation of database for cultivars and pre-commercial germplasm

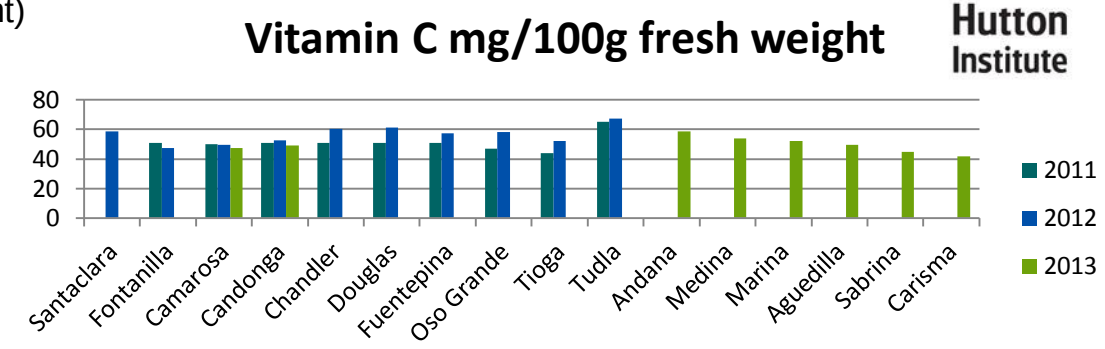
The James Hutton Institute

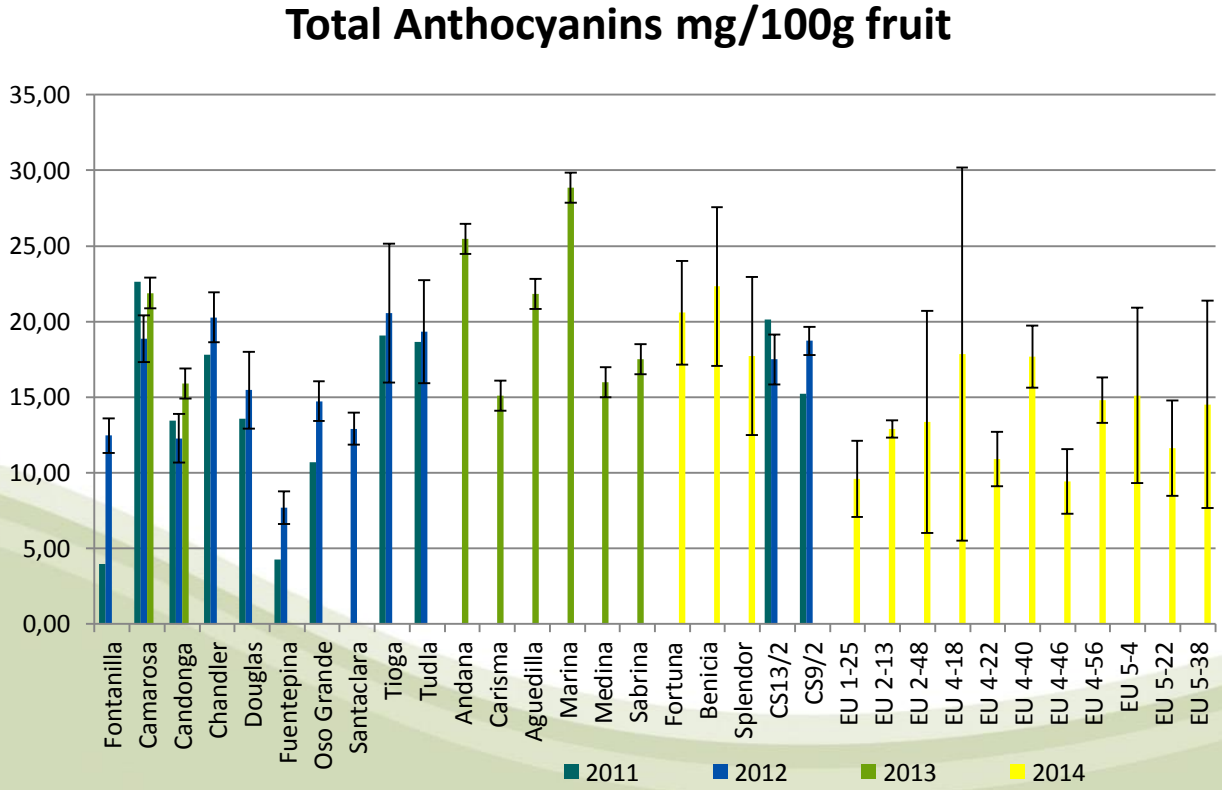
- Field and lab observations from 9 EUBerry partners
- Separated into regions within the EU territory
- Some crossover of cultivars between regions
- New database created and published on the web
- Utility for growers, breeders and researchers
  - Additional databases being finalised specifically for growers and breeders
- Further work required to produce a final version from the project
  - Some gaps inevitable – crop losses due to weather, etc.
  - Need to unify some measurements, eg. phenolic content

Task 1.1 Phenotyping and Characterisation of Pre-Commercial Berry Germplasm

Data included in Summary Gentoype Characteristics 6/06/2013

1)Yield (Early, Total, Second class, Fruit weight)
2)ºBrix
3)Firmness
4)External colour
5)Vitamin C
6)Acidity
7)Antocians
8)Total Phenols
9)Flavonoids
10)Antioxidant Capacity (TEAC)





Task 1.1 Phenotyping and Characterisation of Pre-Commercial Berry Germplasm

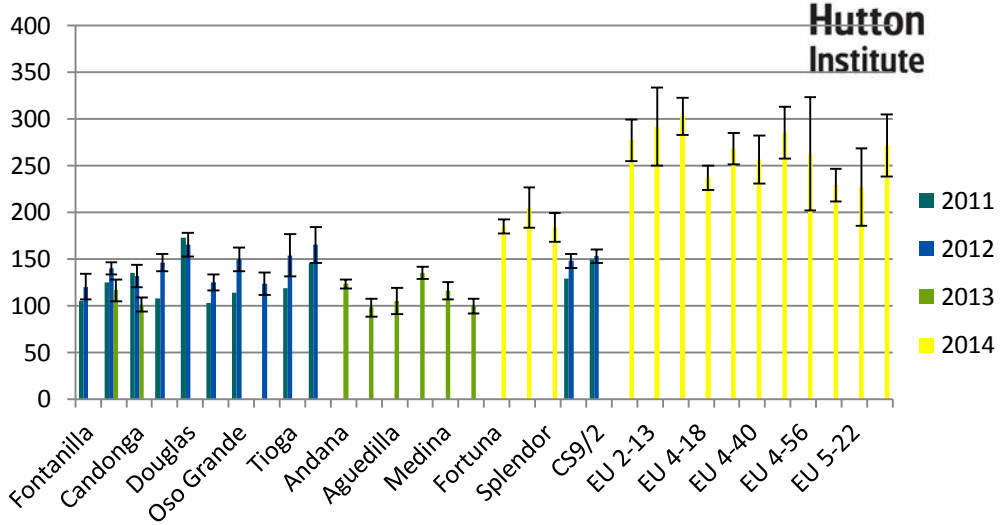
Pre-comercial Genotypes:

EU1-25 [‘Sabrosa’ x (‘Ventana’ x *F. chiloensis*)]
EU2-13 [‘Fuentepina’ x (‘Ventana’ x *F. chiloensis*)]
EU2-48 [‘Fuentepina’’ x (‘Ventana’ x *F. chiloensis*)]
EU4-18 [‘Sabrosa’ x (‘Camarosa’ x *F. chiloensis*)]
EU4-22 [‘Sabrosa’ x (‘Camarosa’ x *F. chiloensis*)]
EU4-40 [‘Sabrosa’ x (‘Camarosa’ x *F. chiloensis*)]
EU4-46 [‘Sabrosa’ x (‘Camarosa’ x *F. chiloensis*)]
EU4-56 [‘Sabrosa’ x (‘Camarosa’ x *F. chiloensis*)]
EU5-4 [‘Fuentepina’ x (‘Camarosa’ x *F. chiloensis*)]
EU5-22 [‘Fuentepina’ x (‘Camarosa’ x *F. chiloensis*)]
EU5-38 [‘Fuentepina’ x (‘Camarosa’ x *F. chiloensis*)]

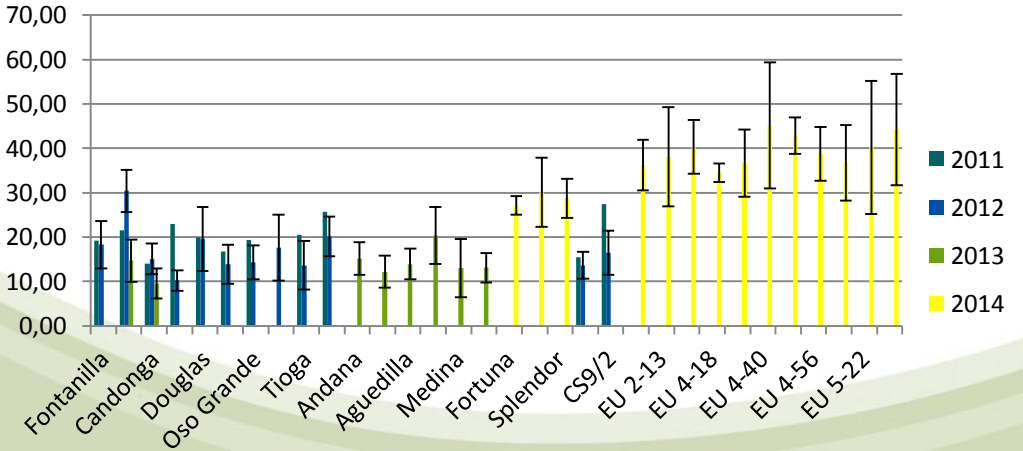
Reference Varieties

'Douglas', 'Fuentepina', 'Chandler', 'Tioga', 'Tudla', 'Candonga', 'Oso Grande', 'Camarosa', 'Fontanilla', 'Santaclara', ‘Fortuna’, ‘Sabrina’, ‘Splendor’

Total Phenols mg/100g fruit



Total Antioxidant Capacity µmol Trolox/g fresh weight



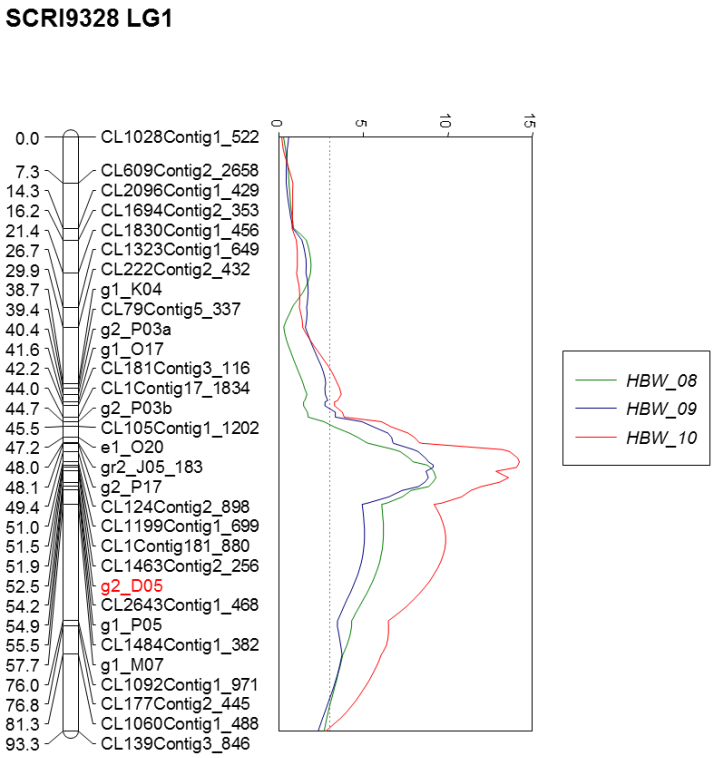
STRAWBERRY

Partner	Cultivar	External fruit characters				Sensory traits			Shelf-life					Internal quality		Nutraceutical compounds					Yield components			Disease resistance				Flowering habit	Climatic adaptation									
		Arbitrary scale 1-9												Brix	mg/100 g						g	g		Arbitrary scale1-9					Arbitrary scale1-9									
		Firmness	Skin color	Glossiness	Flesh color	Aroma	Taste	Volatiles	Glossiness	Resistance to bruising	Predominant fruit color	Calyx freshness	Resistance to fruit rot	Soluble solids	Vitamin C	Ellagitannins	Total antioxidant capacity	Total phenols	Total anthocyanins	Flavonoids	Fruit number per plant	Fruit size (weight)	Yield per plant	Verticillium	Antracnose plants	Antracnose fruits	Botrytis - fruits		Water use efficiency - field	Water use efficiency - artificial test	Plant tolerance to low temp. - field	Plant tolerance to low temp. - artificial test	Flower tolerance to low temp. - field	Flower tolerance to low temp. - artificial test	Plant tolerance to hot temp. - field	Plant tolerance to hot temp. - artificial test	Flower tolerance to hot temp. - field	Flower tolerance to hot temp. - artificial test
PI LIN/PM Italy	Adria (2011-2012-2013)	7	5	5	5	5	5							6.39			14.43	1671	275.5			20.3	1451	1	1	1	3	1					9					
	Alba (2011-2012-2013)	7	6	6	5	5	5							6.62			15.23	1647	352.16			21.7	1139	1	1	1	3	1					4					
	Artea (2011-2012-2013)	8	5	5	4	5	5							7.7			18.45	1968	270.94			20.2	994	1	1	1	3	1										
	Asia (2011-2012-2013)	6	7	6	4	6	6							7.08			16.64	3306	290.44			20.1	1065	1	1	1	2	1										
	Clery (2011-2012-2013)	7	5	5	5	6	6							7.03			15.97	1654	306.44			19.4	960	1	1	1	4	1					4					
	Cristina (2011-2012-2013)	5	5	7	4	6	6							7.58			12.67	1140	249.44			33.4	1094	1	1	1	3	1					9					
	Nora (2011-2012-2013)	7	5	5	4	5	6							7.76			15.96	1019	377.65			16.9	944	1	1	1	2	1										
	Romina (2011-2012-2013)	6	6	5	3	6	6							7.06			13.55	1474	427.18			18.1	931	1	1	1	3	1					4					
	Sveva (2011-2012-2013)	7	7	4	3	3	4							6.64			21.61	2177	364.63			23.1	767	1	1	1	4	1					9					
	Tecla (2011-2012-2013)	8	4	7	3	5	6							6.96			16.53	1604	324.32			27.2	871	1	1	1	4	1										
PO IO Poland	Honeoye (2012)	5	6	5	7									8.6	51.7						11	9.0	99		1	1		SD			5	5						
	Elsanta (2012)	3	5	6	5									9.7	57.7						5	13.2	59		1	1		SD			3	3						
	Elsanny (2012)	5	4	5	5									10.1	50.0						13	10.0	137		1	1		SD			5							
	Asia (2012)	7	6	7	7									10.5	46.0						9	10.4	91		1	1		SD			7							
	Candisa (2012)	7	6	5	6									12.4	59.7						36	9.8	351		1	1		SD			1							
	Lucy (2012)	7	6	7	6									9.1	52.0						15	15.4	226		1	1		SD			5							
	Palomar (2012)	9	4	7	5									9.2	59.0						1	10.2	10		1	1		SD			4							
	T-03021-12 GR (2012)	9	4	9	4									8.8	46.0		4.3	274	20.5		55	11.9	654		1	1		SD			8	5						
	T-03066-01 (2012)	9	4	7	4									8.5	62.5		4.9	290	43.0		57	9.7	556		1	1		SD			5	5						
	T-04022-01 (2012)	5	4	5	5									7.7	59.7		5.9	341	24.7		40	7.5	300		1	1		SD			3	1						
	T-04049-01 PV (2012)	5	4	7	6									8.2	59.5		5.2	313	21.6		36	11.7	420		1	1		SD			5							
	T-04052-06 PR (2012)	7	4	5	3									7.0	46.0		4.9	291	16.8		45	7.5	336		1	1		SD			5	7						
	Honeoye (2013)	5	6	5	7		3		5	4	7	5	3	8.4	59.3						25	9.2	201	7	1	1	5	SD			6	3			9		9	
	Elsanta (2013)	5	5	6	5		5		7	9	5	9	6	10.1	78.5		4.97	333	35.7	33.1	19	9.8	186	5	1	1	4	SD			7	1			9		9	
	Elsanny (2013)	6	4	4	5		6		5	6	5	5	4	9.6	58.4						22	9.3	207	3	1	1	3	SD			6				9		9	
	Asia (2013)	7	5	7	6		6		4	5	6	5	5	7.6	79.2						15	9.2	141		1	1	3	SD			6				9		9	
	Candisa (2013)	7	6	6	5		5		6	7	6	7	5	11.1	66.3						27	8.5	226		1	1	1	SD			7				9		9	
	Lucy (2013)	6	5	7	5		5		5	6	6	5	4	8.6	69.2						19	13.3	354		1	1	3	SD			6	5			9		9	
	Palomar (2013)	8	4	8	4		7		6	6	8	7	6	9.1	73.6						12	9.5	112	7	1	1	2	SD			7				9		9	
	T-03021-12 GR (2013)	9	4	9	4		9		9	9	4	9	6	8.6	39.5		4.58	312	21.8	18.66	26	11.7	308	3	1	1	2	SD			6	7			9		9	
	T-03066-01 (2013)	7	5	7	5		7		5	5	6	5	4	8.4	53.2						23	11.4	265	1	1	1	4	SD			6				9		9	
	T-04022-01 (2013)	5	5	5	6		6		4	6	7	5	6	8.1	48.1						32	7.7	243	4	1	1	4	SD			7				9		9	
	T-04049-01 PV (2013)	7	6	6	6		9		6	6	7	9	8	8.4	54.5						22	9.5	212	2	1	1	1	SD			6	3			9		9	
	T-04052-06 PR (2013)	8	3	5	3		7		4	3	5	5	2	9.6	37.0		4.66	343	20.03	26.3	26	10.3	264	1	1	1	3	SD			6	7			9		9	

Partner	Cultivar	External fruit characters		Sensory traits			Shelf-life			Internal quality			Yield components			Disease resistance			Pest resistance		Season of			Climatic adaptation			
		Arbitrary scale 1-9								Brix	mg/100 g			g	kg	Arbitrary scale 1-9											
		Firmness	Appearance	Aroma	Taste	Volatiles	Glossiness	Strig freshness	Resistance to fruit rot	Soluble solids	Vitamin C	Phenolic content	Fruit number per strig	Fruit size (weight)	Yield per plant	Powdery mildew	Antracnose	White pine blister rust	Blackcurrant gall mite	Two-spotted spider mite	Budbreak	Flowering	Yielding	Plant tolerance to low temp. - field	Plant tolerance to low temp. - artificial test	Flower tolerance to low temp. - field	Flower tolerance to low temp. - artificial test
P2 IO Poland	Bona (2012)				9					14,7	106			1,85	0,48						15.03	28.04	29.06				
	Gofert (2012)				7					22,3	267	473		1,26	1,24						16.03	30.04	12.07				
	Tihope (2012)				5					17,4	122			1,11	0,57						20.03	3.05	16.07				
	Sofiyewskaya (2012)				6					13,8	136			1,56	0,74						16.03	30.04	8.07				
	Ryasnaya (2012)				6					14,6	142			1,29	0,72						16.03	28.04	8.07				
	Tiben x Pax (*Ribes nigrum* L. x *Ribes grossularia*) 2012				4					18,6	113			0,63	0,93						18.03	4.05	18.07				
	Ores x Pax (1) (*Ribes nigrum* L. x *Ribes grossularia*) 2012				5					15,2	94			0,92	0,93						16.03	2.05	16.07				
	Ben Gairm x Pax (*Ribes nigrum* L. x *Ribes grossularia*) 2012				5					17,8	112			0,66	1,36						18.03	2.05	15.07				
	Ben Gairm (*Ribes nigrum* L. x *R. janczewski*) 2012				5					15,6	40			1,05	0,83						20.03	1.05	18.07				
	Ben Gairm (*Ribes nigrum* L. x *R.n. Europeum 7741*) 2012				5					17,4	89			0,95	0,72						20.03	4.05	18.07				
	Ores (*Ribes nigrum* L. x *R. sanguineum*) 2012				6					15,3	157			0,81	0,86						20.03	5.05	20.07				
	Ores x Pax (3) (*Ribes nigrum* L. x *Ribes grossularia*) 2012				5					15,6	106			0,94	0,71						17.03	2.05	16.07				
	Bona (2013)	7	8	3	9	not tested	5	7	5	16,39	95	4,95	3	1,61	1,00	1	3	7	not tested	not observed	18.03	28.04	26.06				
	Gofert (2013)	5	7	5	8		5	5	3	19,39	288	4,37	8	1,52	1,85	3	5	1			19.03	1.05	15.07				
	Tihope (2013)	5	7	7	5		7	7	5	14,39	129	3,90	7	1,81	1,97	1	3	1			22.03	3.05	18.07				
	Sofiyewskaya (2013)	3	5	7	5		7	3	3	18,04	207	4,28	10	1,14	1,40	5	5	3			19.03	2.05	18.07				
	Ryasnaya (2013)	5	5	5	5		5	5	3	14,78	148		8	1,25	1,14	1	3	5			19.03	30.04	16.07				
	Tiben x Pax (*Ribes nigrum* L. x *Ribes grossularia*) 2013	7	3	7	5		3	5	5	15,52	185	5,17	6	0,64	1,02	1	3	3			21.03	4.05	17.07				
	Ores x Pax (1) (*Ribes nigrum* L. x *Ribes grossularia*) 2013	5	5	5	6		5	5	3	15,04	300	3,85	6	0,81	0,44	1	5	3			19.03	3.05	17.07				
	Ben Gairm x Pax (*Ribes nigrum* L. x *Ribes grossularia*) 2013	5	3	5	5		5	3	5	15,87	123	5,29	5	0,72	0,44	1	5	5			23.03	2.05	17.07				
	Ben Gairm (*Ribes nigrum* L. x *R. janczewski*) 2013	7	3	7	6		5	5	3	14,51	122	4,66	7	0,72	0,35	1	5	5			22.03	3.05	17.07				
	Ben Gairm (*Ribes nigrum* L. x *R.n. Europeum 7741*) 2013	5	5	7	5		5	5	5	14,47	100	4,00	5	0,83	0,64	1	7	3			23.03	3.05	17.07				
	Ores (*Ribes nigrum* L. x *R. sanguineum*) 2013	5	3	7	6		5	3	5	14,17	206	5,03	6	0,78	0,91	1	3	3			22.03	2.05	17.07				
	Ores x Pax (3) (*Ribes nigrum* L. x *Ribes grossularia*) 2013	5	5	5	5		5	5	5	12,93	194	4,66	7	0,93	0,52	1	5	3			21.03	3.05	17.07				

Development of marker-assisted breeding strategies

- Strawberry
  - P6 (INRA/CIREF), P5 (IFAPA), P3 (subcontractor, EMR), P8 (Bioforsk)
- Raspberry
  - P3 (JHI)
- Blackcurrant
  - P3 (JHI), P2 (InHort)

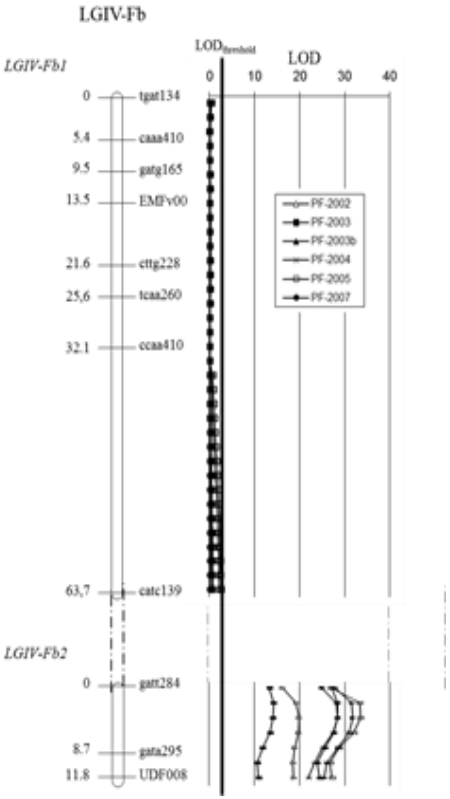


Aims of MAB work

- Develop populations, linkage maps
  - Some pre-existing
- Identify potential markers
  - SNPs, SSRs, DaRT
- Validate markers in other germplasm
- Make markers available to other breeders

Fragaria

- Putative markers for:
  - Everbearing trait (P6)
  - Colour (P6)
  - Disease resistance
    - *Verticillium* wilt (P3 subcontract)
    - *Sphaerotheca* (P3 subcontract)
    - *Phytophthora* (P3 subcontract, P8)



QTL mapping of *Phytophthora cactorum* resistance in *Fragaria vesca (P8)*

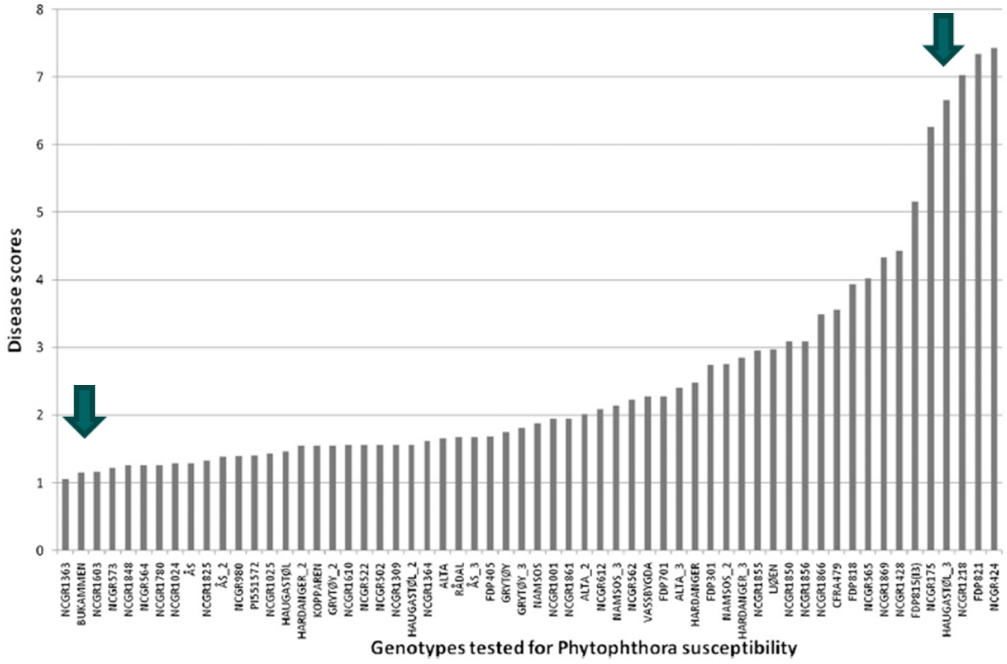
The James Hutton Institute

- Crown rot caused by the oomycete *Phytophthora cactorum* is a very problematic disease in strawberry.
- No chemical controls for this very persistent and long lived organism.
- Project was initiated by The Norwegian Institute for Agriculture and Environmental Research together with the EUBerry contributions to better understand the interaction between the pathogen and one of its hosts – the diploid (woodland) strawberry (*Fragaria vesca*).

Bioforsk

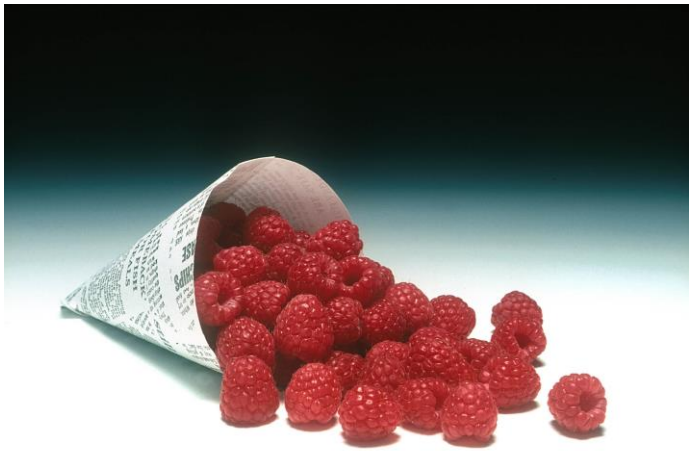
Mapping *P. cactorum* resistance

- Diploid *Fragaria vesca* accessions were tested for *P. cactorum* susceptibility using the survival test of Eikemo *et al.* (2010).
- F_2-population with Norwegian parents `Bukammen' (resistant) x 'Haugastøl3' (susceptible)
- The parents, the F_1-hybrid and 92 F_2-genotypes were phenotyped using the survival test and genotyped by genotyping-by-sequencing.
- A linkage map has been produced with JoinMap and the QTL-analysis was done with MapQTL.



Rubus and *Ribes*

- *Rubus*
  - Berry size, shelf life
  - Compositional traits
    - Sensory components
  - Antioxidant capacity
- *Ribes*
  - Berry size
  - Anthocyanin content



Marker availability

Trait	Marker type	Marker details	Availability/source	Deployment	Published details
Verticillium wilt tolerance	SSR	11 QTL, stable over at least 2/3 years in the field, each of small effect	Not available at present, derived from Redgauntlet and Hapil	Used in EMR breeding programme	Publication awaiting submission
Powdery mildew resistance	SSR	Multiple QTL, some stable over 3 years of field testing in multiple sites	Not available at present, derived from Redgauntlet and Hapil, Emily and Fenella, Elvira and BSP14 (F. chiloensis)	Used in EMR breeding programme	Manuscript in preparation
Phytophthora fragariae resistance	SSR	Multiple race-specific resistances	Freshforward, NL (not available)	Unknown	Manuscript is promised by end of 2014

Functional Genomics

- Validation of the role of key genes in strawberry traits
- Flowering-related genes
  - Transgenic lines under evaluation (P1, P6)
- Nutritional quality-related genes
  - Ascorbic acid (P1)
  - γ-decalactone and mesifurane (sensory links) (P5)
  - Anthocyanin synthase (P1)

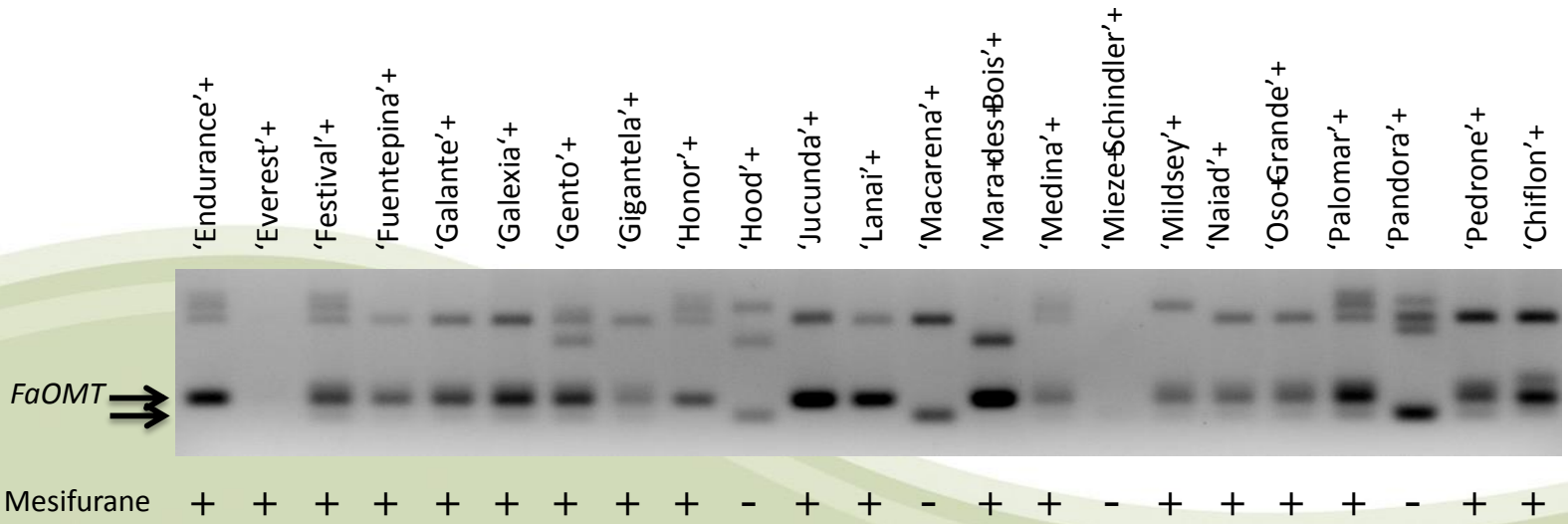
D 1. 5. Validation of markers for fruit volatile content prediction in strawberry

The James Hutton Institute

Marker for Mesifurane

68 cultivars and species have been genotyped and volatile content measured (still in progress for 16 of them)

The developed marker in the gene *FaOMT* is able to predict mesifurane production with a 93,6 % accuracy



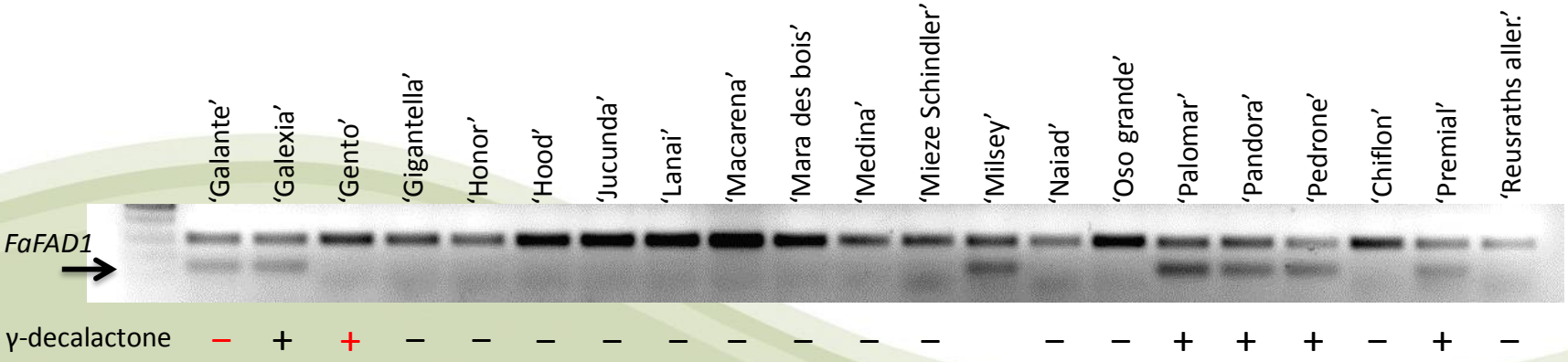
D 1. 5. Validation of markers for fruit volatile content prediction in strawberry

The James Hutton Institute

Marker for γ-decalactone

68 cultivars and species have been genotyped and volatile content measured (still in progress for 16 of them)

The developed marker in the gene *FaFAD1* is able to predict γ-decalactone production with a 94.23% accuracy



WP1 Summary

- Working databases produced for various stakeholder groups within the European berry industry
  - Completion requires further input before the end of 2014
  - Some discussion needed on continuation (if any)
- Enhanced linkage maps and trait associations identified in all crops
- Markers becoming available for various traits in *Fragaria* and *Rubus*
  - Validation in progress, further work required in *Ribes*
- Gene effects on flowering and quality traits better understood
  - Transgenic and non-transgenic options

Acknowledgements

- Germplasm resources
  - Saila Karhu and colleagues (P7)
  - Beatrice Denoyes and colleagues (P6)
  - Edward Zurawicz and colleagues (P2)
- Molecular breeding
  - Beatrice Denoyes and colleagues (P6)
  - Julie Graham, Joanne Russell and colleagues (P3)
    - Richard Harrison *et al.* (EMR)
  - Jahn Davik and colleagues (P5)
- Functional genomics in strawberry
  - Bruno Mezzetti and colleagues (P1)
  - Jose F Sanchez Sevilla and colleagues (P5)
  - Beatrice Denoyes and colleagues (P6)