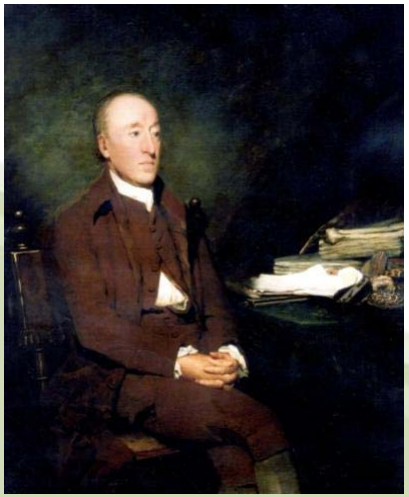
The Application of KETs to AgriFood – An Academic Perspective

Robert D. Hancock

The James Hutton Institute

The James Hutton Institute

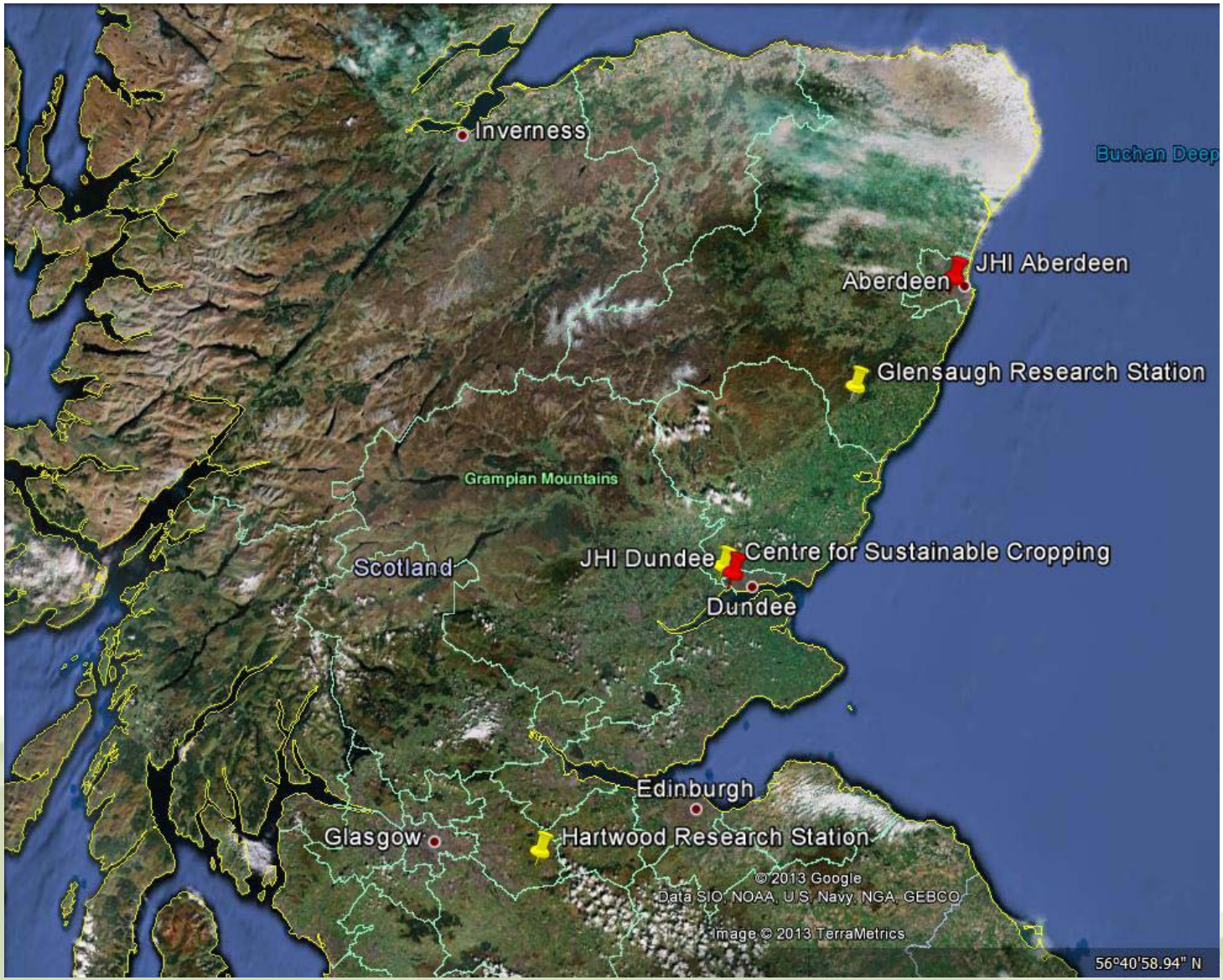
- Formed in 2010 via merger of the Macaulay Land Use Research Institute (Aberdeen) and Scottish Crop Research Institute (Dundee)
- Combines strengths in crops, soils, land use and environmental research
- More than 600 staff (450 scientists and 150 support staff) and 120 PhD students
- One of the largest research centres in the UK
- One of the Scottish Government's main research providers (environmental, crop and food science)
- Extensive links with industry and end users
- Has a major role in the Scottish knowledge (bio)economy.



James Hutton (1726 – 1797)
was a leading figure of the Scottish Enlightenment, an eighteenth century golden age of intellectual and scientific achievements centred on Edinburgh

Hutton's career covered medicine and chemistry before becoming a farmer, studying the latest agricultural techniques, and finally a leading geologist

JHI Locations



JHI: Interactions and Global Reach

JHI Facilities Provide the Infrastructure for KET Development

JHI Aberdeen

Extensive inorganic and organic chemistry analytical facilities
Advanced controlled environment rooms
Houses national soils archive
Fleet of off-road vehicles for field research

JHI Dundee

Fully equipped laboratories
Metabolomics suite, Functional genomics facility,
Imaging and microscopy suite, Genome technology suite
9000 m^2 glasshouse facilities
18 growth rooms + 41 CE cabinets
200 ha farmland

JHI Facilities Provide the Infrastructure for KET Development

Hartwood Research Station

Rotational grassland livestock farm – 350 ha
Sustainable management systems

Glensaugh Research Station

Upland livestock farm – 900 ha
Environmental change network site

Centre for Sustainable Cropping

Experimental platform for sustainable crop varieties and management
42ha field site, 6 year rotation

Where is JHI Positioned in the AgriFood Sector?

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Environment

Monitoring
Soils
Water
Catchments

Systems
Breeding
Sustainability
Substrates
Water use

Phenology
GIS
Meteorology
Modelling

N use
Polytunnels
LEDs
PV

→

Crop

Foods
Cereals
Potato
Soft fruit
Herbs

Treatments
Heat
Mechanical
Pressure
Ultrasonic

Oil Crops
Apple
Brassicas

Solvent
Microwave
Sterilisation
Filtration
Legislation

→

Processed

Foods
Whiskey
Beers
Ready Meals
Juices
Soft Drinks

Processes
Fortification
Shelf life
Rancidity

Fresh cut
Bread
Mash
Crisps
Snacks
Functional

MAP/CAP
Packaging
NPD

→

Consumer

Characteristics
Appearance
Taste
Texture
Aroma

Safety
Nutrition
Health
(claims)
Interventions
USP
Preference
Provenance
Authenticity

Key Enabling Technologies in a Translational Pipeline

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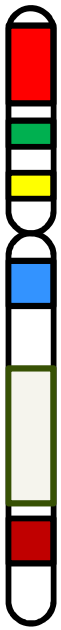
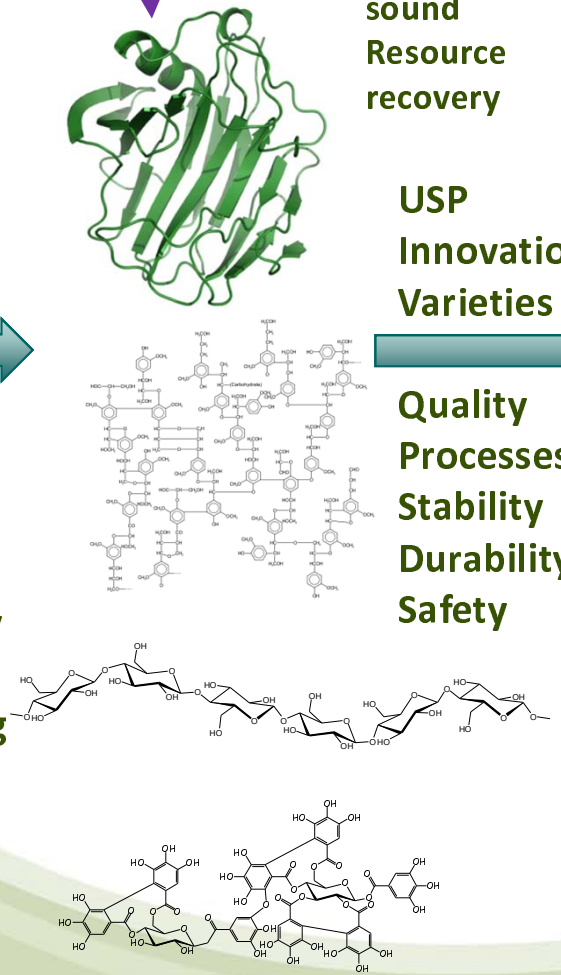


GBS,
'Omics,
Bioinf.,
Visualisation,
Network
construction

Genome
Analysis,
Diversity,
Evolution,
Exploitation
Systems &
networks

Green Biotech,
Remote
sensing,
Agri platforms
App
development

Molecular
physiology,
Gene
discovery,
Biochemistry
'Omics
Chemotyping



SMART screens
and sensors
µwave/ ultra-
sound
Resource
recovery

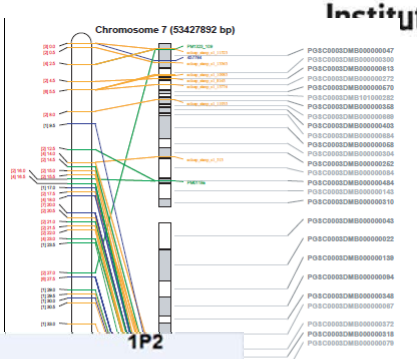
USP
Innovation
Varieties

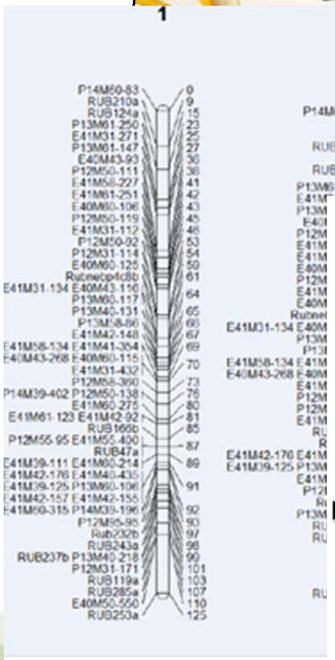
Quality
Processes
Stability
Durability
Safety

- Food
- Drink
- Fuel
- Pharma
- Functional Ingredients
- Policy

KETs Underpinning JHI Translational Research

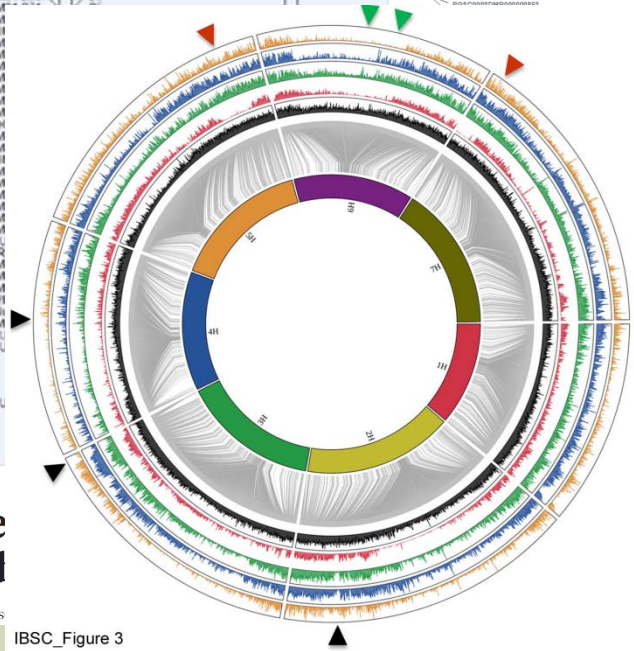
Genetics and Genomics





A physical, gene
sequence assemb

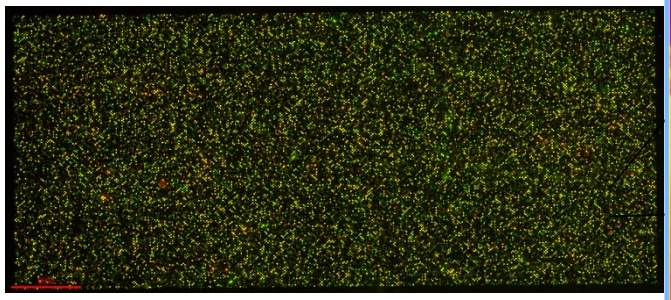
The International Barley Genome Sequencing Cons

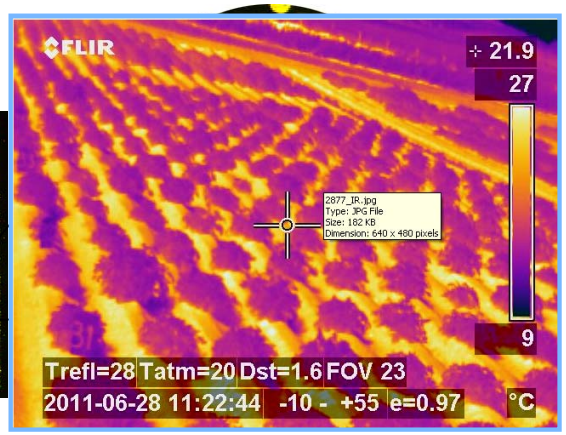


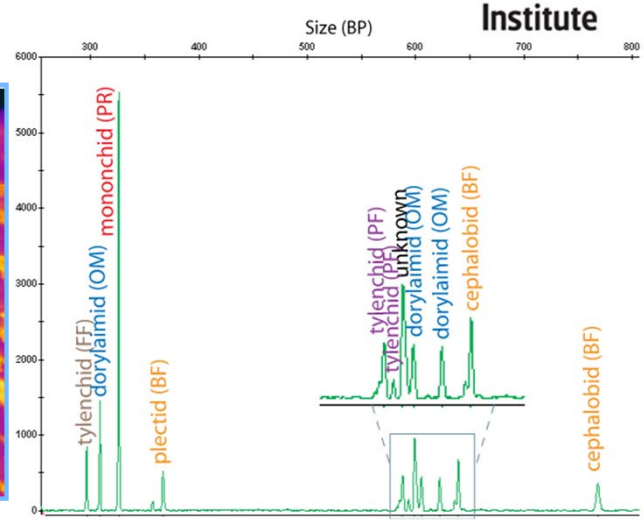
IBSC_Figure 3

KETs Underpinning JHI Translational Research

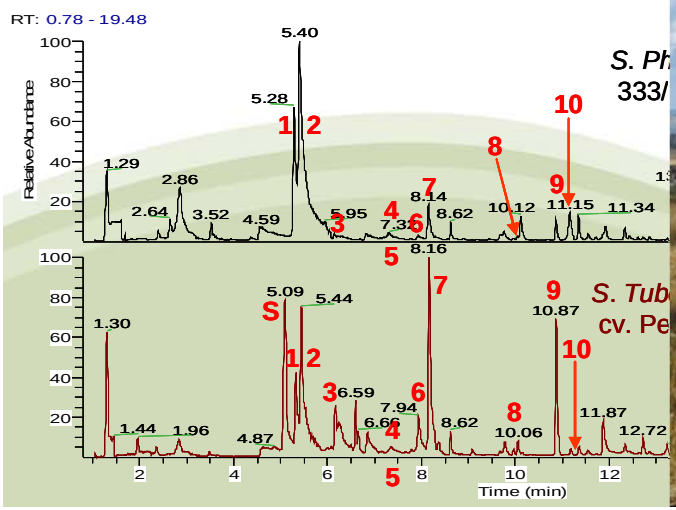
Phenotyping

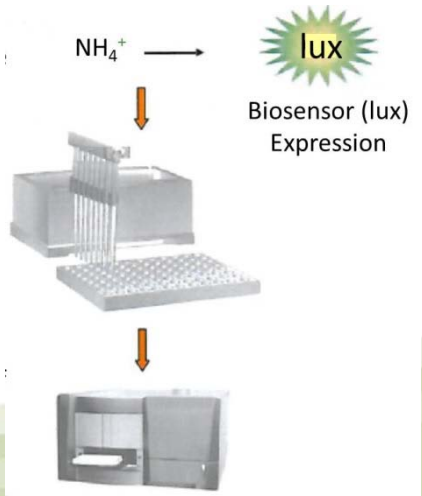






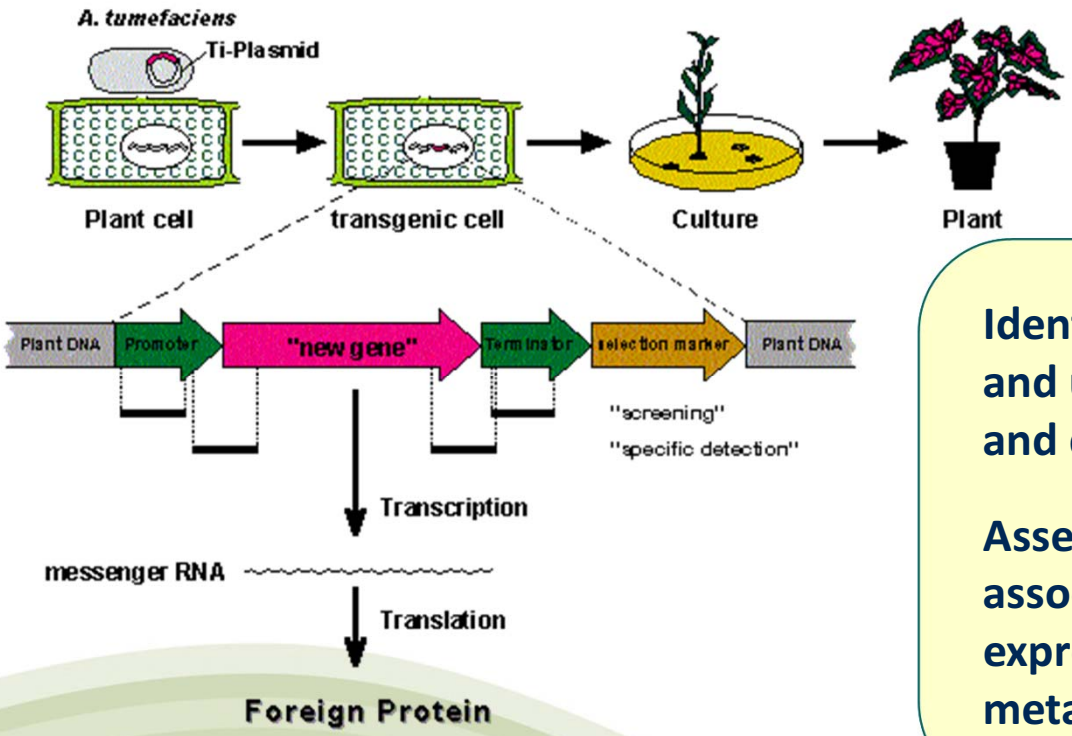
Molecular → **Trait** → **Environment**





KETs as a Tool for Policy Development

Assessing unintended effects in GM potatoes



Identification of intended and unintended alterations and degree of equivalence

Assess potential hazards associated with newly expressed gene products and metabolites

"Omics" analysis

Multi-partner FP6 project 'SAFEFOODS'

KETs as a Tool for Policy Development

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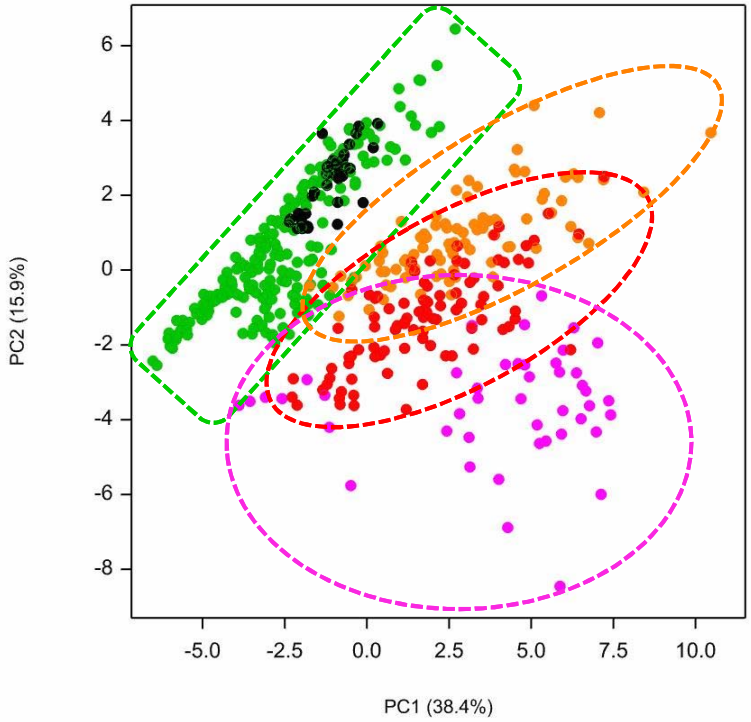
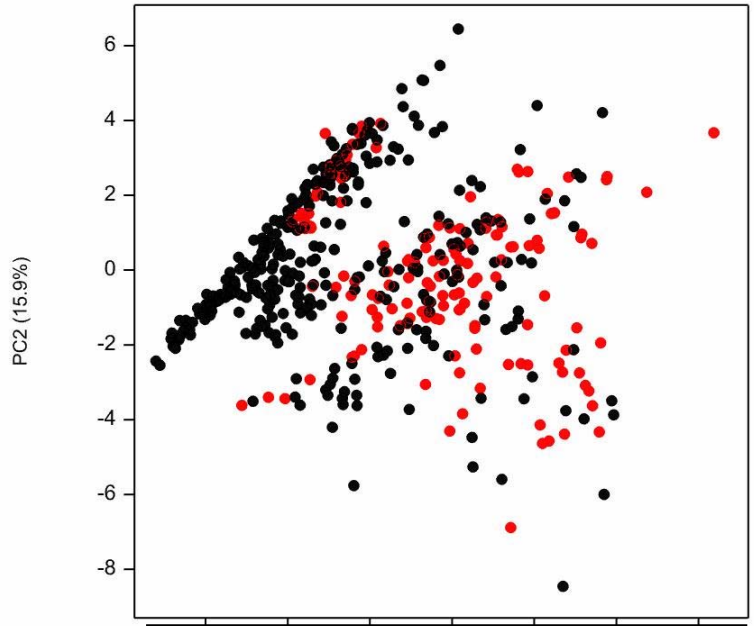
Pattern dominated by location



No pattern

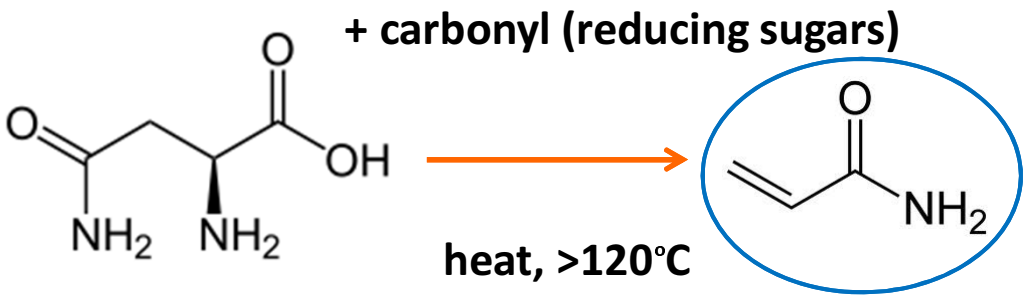


Cannot distinguish GM from non-GM

- ○ Polish Site (GM, Non-GM)
- ○○○ South African Sites (All GM, Non-GM)
- ○ UK Site (Conv & Org Inputs)

○ Non-GM		○ GM	
'BlightMOP'	UK	'PVY^{r}'	Poland
'QLIF'	UK	*'Bt'*	S. Africa
'PVY^{r}'	Poland		
'Bt'	S. Africa		

The Application of KETs to Industry Problems



Neurotoxin, potential carcinogen, major concern in cooked potato products

Used segregating germplasm to select lines that differed in asparagine, reducing sugars levels & acrylamide forming potential (AFP)

Line	Reducing Sugars	Asparagine	Acrylamide
93.Q.12 322	57.46	45.19	1797.72
92 MT 66 214	115.06	94.46	4455.62
12601ab1	32.64	46.93	1827.88
Stirling	179.18	69.50	6631.29

The Application of KETs to Industry Problems

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		93.Q.12 322 = Low Asn, Low RS, Low Acrylamide																				92 MT 66 214 = High Asn, High RS, High Acrylamide																			
Gene Code	UniRef based putative functional annotation	Asparagine	AsparticAcid	Glutamine	Glutamicacid	GABA	Alanine	Glycine	Valine	Leucine	Isoleucine	Threonine	Serine	Proline	Methionine	Phenylalanine	Ornithine	Lysine	Histidine	Tyrosine	Tryptophan	Asparagine	AsparticAcid	Glutamine	Glutamicacid	GABA	Alanine	Glycine	Valine	Leucine	Isoleucine	Threonine	Serine	Proline	Methionine	Phenylalanine	Ornithine	Lysine	Histidine	Tyrosine	Tryptophan
number of +ve correlations		100	32	3430	923	267	4253	3070	2473	709	1021	3726	1399	143	1314	2399	256	183	1588	1536	890	89	71	1037	1731	1934	20	8	116	136	228	15	24	1847	42	256	10	1419	301	1222	314
number of -ve correlations		36	27	1768	1320	460	1844	530	937	86	215	890	417	55	243	726	224	23	251	457	71	63	20	41	3398	3781	25	2	18	42	52	123	34	1074	14	71	42	563	21	327	145
GENE11355	Asparagine synthetase [glutamine-h	0.80	0.23	0.72	0.05	0.10	0.67	0.70	0.80	0.80	0.84	0.77	0.71	0.56	0.78	0.78	0.74	0.82	0.80	0.81	0.75	0.73	0.37	0.20	0.24	0.57	0.19	0.26	0.72	0.71	0.76	0.57	0.72	0.65	0.74	0.80	0.49	0.80	0.79	0.77	0.72
GENE29127	L-asparaginase	0.15	-0.42	0.57	-0.78	0.51	0.61	0.41	0.45	0.10	0.23	0.49	0.31	0.12	0.35	0.44	0.23	-0.03	0.25	0.35	0.20	-0.31	-0.16	0.27	-0.33	-0.74	0.25	0.59	-0.01	-0.17	-0.20	0.10	0.13	-0.20	-0.32	-0.34	0.14	-0.49	-0.12	-0.40	-0.45
GENE22356	Asparaginyl-tRNA synthetase, chloro	0.38	-0.27	0.71	-0.57	0.43	0.74	0.63	0.63	0.40	0.48	0.66	0.49	0.22	0.55	0.62	0.44	0.30	0.50	0.55	0.42	0.07	0.35	0.72	-0.84	-0.61	0.50	0.40	-0.07	-0.32	-0.30	0.25	0.13	-0.55	-0.15	-0.14	0.30	-0.46	-0.06	-0.45	-0.42
GENE22431	Asparaginyl-tRNA synthetase, chloro	0.62	-0.11	0.75	-0.28	0.17	0.76	0.69	0.74	0.64	0.68	0.76	0.62	0.34	0.69	0.71	0.57	0.59	0.71	0.69	0.73	-0.04	0.12	0.63	-0.74	-0.66	0.32	0.37	-0.15	-0.39	-0.38	0.19	0.06	-0.49	-0.32	-0.28	0.16	-0.51	-0.09	-0.52	-0.51
GENE13832	Aspartate aminotransferase	0.11	0.11	0.18	-0.59	0.58	0.19	0.10	0.17	0.07	0.11	0.20	0.02	-0.18	0.27	0.21	0.09	0.07	0.13	0.15	0.04	0.03	0.35	0.44	-0.89	-0.43	0.37	0.20	-0.23	-0.34	-0.35	0.08	-0.03	-0.71	-0.09	-0.14	0.14	-0.41	-0.21	-0.45	-0.33

United Biscuits

TESCO

ESA

ConAgra Foods
Food you love

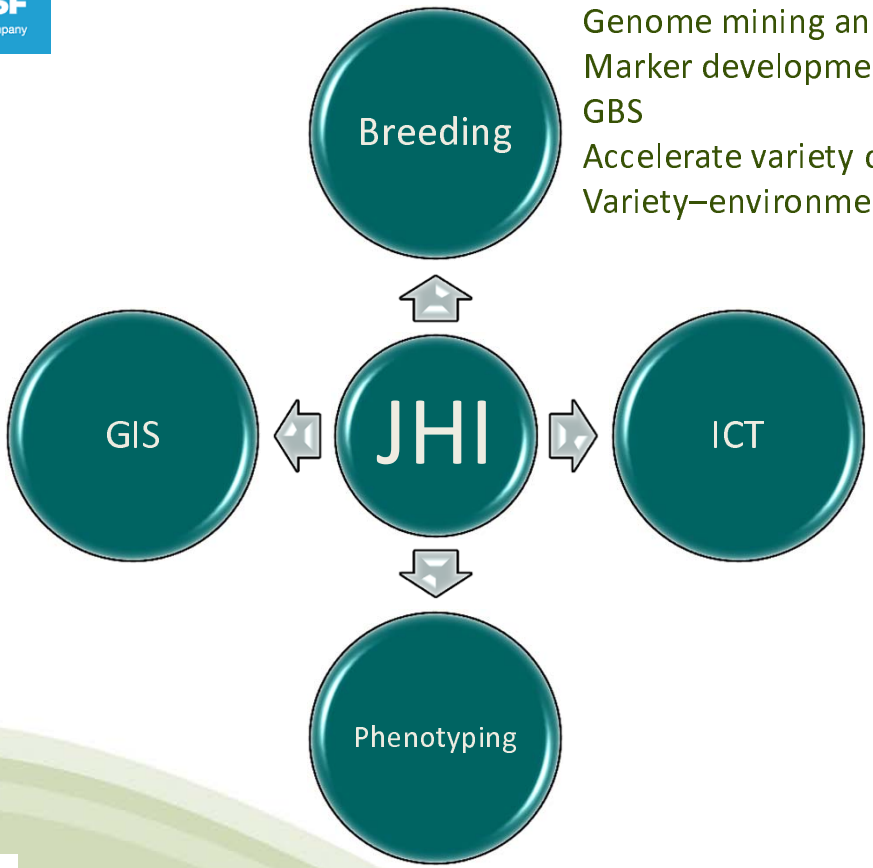
KETTLE BRAND

EUPPA
European Potato Processors' Association

POTATO COUNCIL

QTL Interval Mapping
Genetic Mapping
Marker Mapping
Transcriptomics & Physical Mapping
Chromosome Location (cM)
0
20
40
60
80
0
1
2
3
4
QTL
Chromosome VI SNP Map
0
1
2
3
4
5
6
7
8
9
10
12
13
14
15
c2_30508 c2_27607
c2_30632
c2_27606 c2_30557 c1_15726
c1_9229 c2_30509 c2_43944 c2_30596
c2_54010
c1_10889
c2_3091 c2_3127
c2_3135
c2_27556 c1_11418
c2_55554 c2_38323
c2_3104 c2_27570
c2_27620
c2_36708
c2_56259
c2_3146 c2_56971 c2_53506 c2_35592
Marker Assisted Breeding
Asn synthetase @ 9cM
0052
0266
0596
0337
0890
Chromosome VI Superscaffolds

AgriFood KETs: Mapping onto Industry by Translation



Genome sequencing
Genome mining and exploitation
Marker development
GBS
Accelerate variety development
Variety–environment matching

Remote sensing
Drone systems
Crop yields (potato barley)
Water and nutrient modelling
Predictive agriculture
Precision agri

Algorithm development for
Crop development
Trait enhancement
Precision agri-systems
App based decision systems

SIFSS

Smart phenotyping
Remote – GIS
In situ – App-based analyses
Lab – Metabolomics; 10^3 components
Lab – Transcriptomics; 50K genes

What are the KETs required moving forward?

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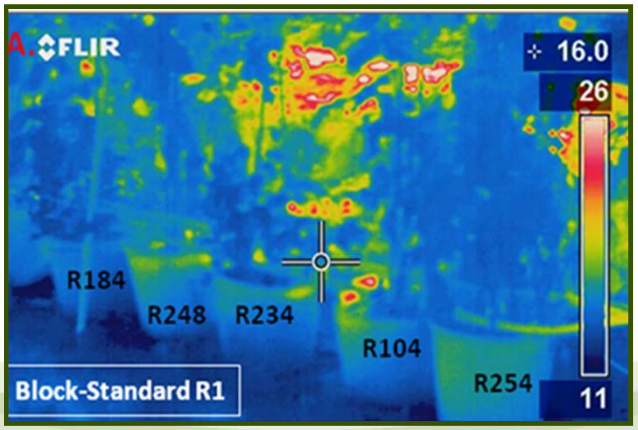
True systems biolog

Better metabolic and environment

Bioinformatics and visualisation



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