

2009 ROYAL SHOW DEBATES
The Energy Gap

BIOENERGY CROPS OPPORTUNITIES AND CHALLENGES

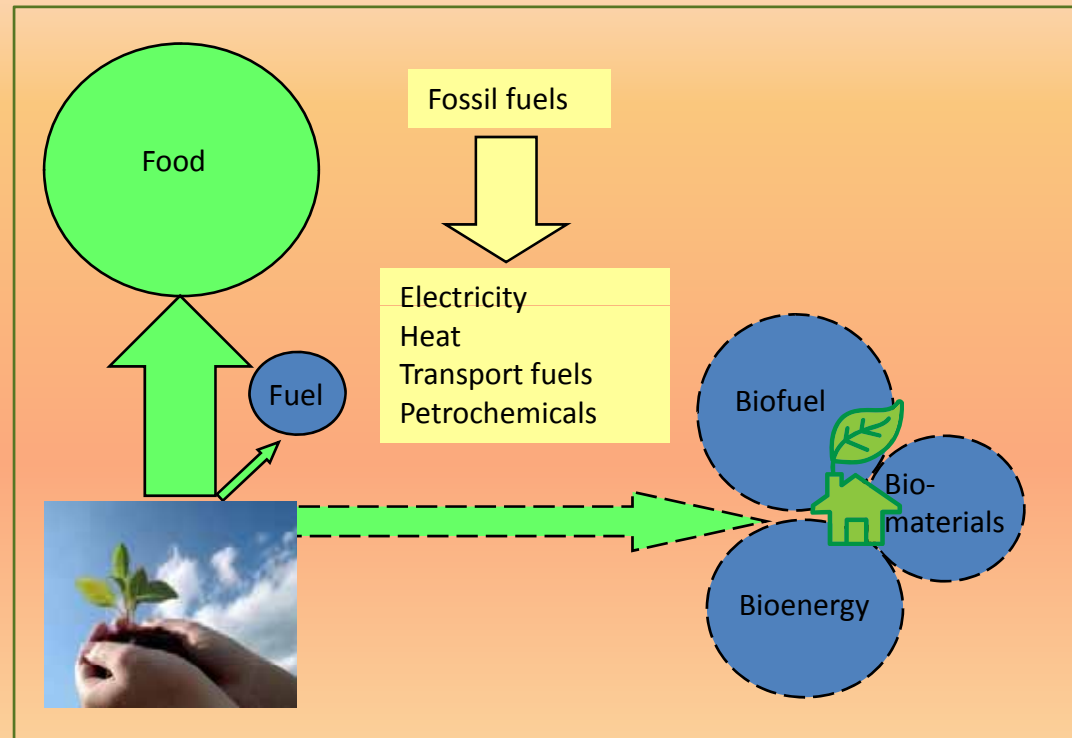
Angela Karp



Backdrop; Miscanthus x giganteus in England

Diverse drivers impact on land use

- Policy Drivers
 - Climate change
 - Energy security
 - Ecosystem Services
 - Rural livelihoods
 - Food Security
- Market Forces
 - Rising food prices
 - Rising energy prices



Opportunities



Challenges

New markets

Bioenergy

Biofuels

Biomaterials

More from your crops

Use of crop wastes

Environmental benefits

More from your land

Using lower grade land

Bioremediation

Flooding

Improving efficiency

Increasing yield

Improving conversion

Agronomy

Market inertia

Regulations

Direct impacts

Indirect impacts

Targets and Obligations

Perceptions

Biomass crops

- High energy savings and GHG reductions
- Non-food crop
- Recycle their nutrients
- No annual cultivation
- All of the plant is used as feedstock
- Longer growing season
- High yields per hectare



Willow



Miscanthus

Improving willow

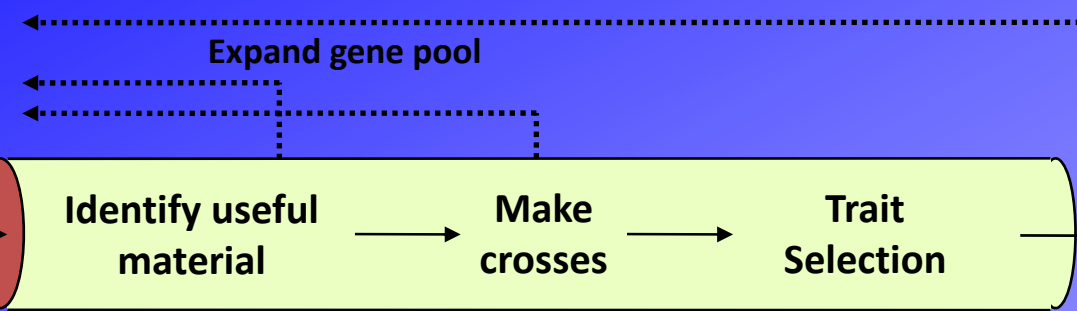


The BEGIN Pipeline

Inputs

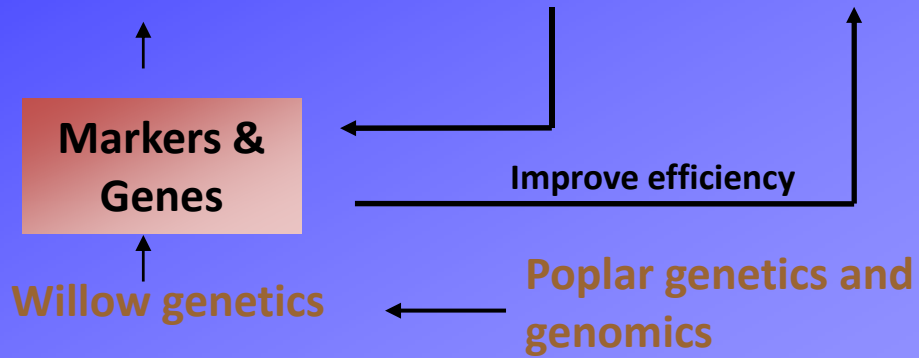
Genetic Resources

- NWC
- Lines
- Varieties



Outputs

Improved SRC willow lines for current and future needs





Unique resources at Rothamsted

Nation Willow Collection

Large families for genetic mapping

Increasing number of trials

Seven newly bred willows are in trials



Spatial arrangement

2 yr yields, t DM ha⁻¹ plotted on the field plan

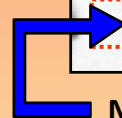
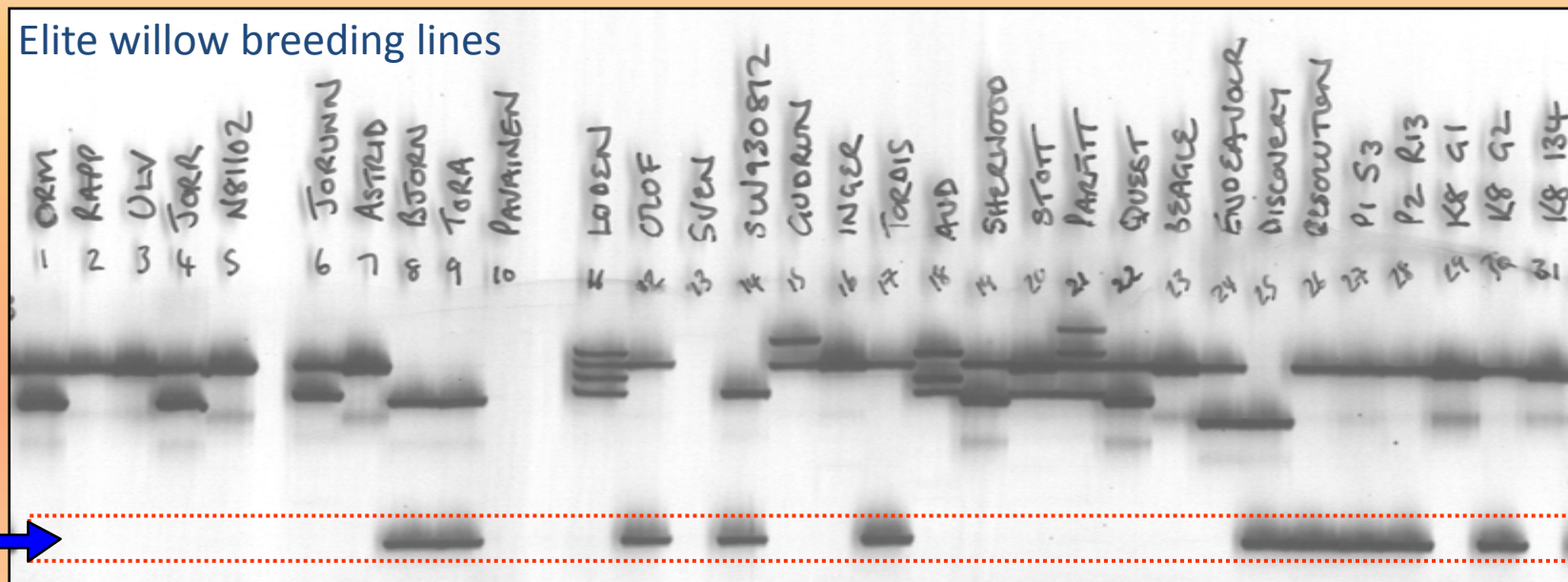
| | | | | | | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 20.85 | 26.93 | 26.83 | 22.53 | 31.83 | 30.74 | 28.68 | 25.10 | 6.35 | 23.94 | 22.71 | 4.09 | 31.97 | 15.56 |
| 29.93 | 7.37 | 17.48 | 21.59 | 11.62 | 17.90 | 23.96 | 26.97 | 29.75 | 18.46 | 16.63 | 15.95 | 18.49 | 20.28 |
| 30.82 | 30.85 | 16.84 | 26.87 | 25.74 | 28.27 | 21.19 | 11.61 | 23.43 | 11.61 | 20.99 | 24.86 | 17.50 | 0.00 |
| 36.04 | 29.81 | 29.85 | 32.52 | 22.82 | 17.19 | 28.20 | 11.35 | 17.64 | 19.38 | 17.34 | 13.37 | 19.82 | 8.54 |

RR04248



At Long Ashton RR04248 produced > 30 ha⁻¹ over two years (=15t DM ha⁻¹ /yr in an area of low growth)

Molecular markers identified for rust resistance and yield



Microsatellite allele linked to *SRR1* major rust resistance locus

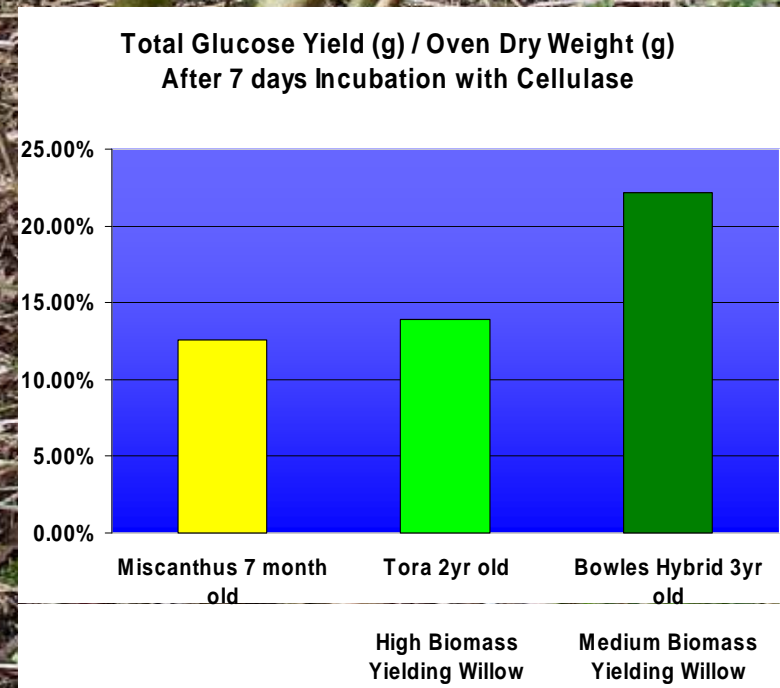
Usefulness of the markers in selecting at the seedling stage is being tested

Emphasis shifting to breeding for lower grade land



New willow plantings at Woburn site –
nutrient and water-limited

Also assessing willows for biofuels





Research on Miscanthus

Agronomy, N-use , quality, modelling (Rres)

Genetic improvement, breeding, conversion ,modelling (IBERS)



BBSRC Sustainable Bioenergy Centre

- £27M investment for BSBECC
 - £20M funding from BBSRC
 - £7M funding from industrial partners
- Biggest ever UK investment in bioenergy
- Virtual centre at 5 main sites:



www.bsbec.bbsrc.ac.uk



BBSRC Sustainable
Bioenergy Centre

Six Research Hubs

1. Perennial Bioenergy Crops
2. Cell Wall Sugars
3. Cell Wall Lignin
4. Lignocellulosic Conversion to Bioethanol
5. Second Generation, Sustainable, Bacterial Biofuels (*Chlostridium*)
6. Marine Wood Borer Enzyme Discovery

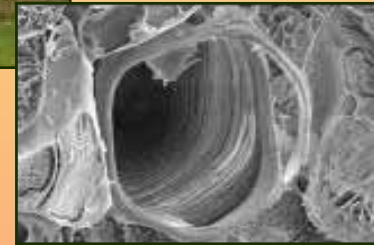
Improving the whole chain



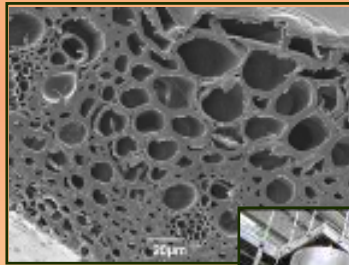
Biomass Growth



Biomass Composition



Biomass Deconstruction



Fermentation



Fuel



Sustainability Analysis





Perennial Bioenergy Crops Hub

Partners

Rothamsted Research

+ IBERS, Imperial College, University of Cambridge

+ Shell, Ceres

Programme Content

Optimising biomass yields of willow and Miscanthus for sustainable bioenergy and biofuels

Genetic improvement of crops

- sunlight capture
- carbon capture and partitioning

Identifying crop variants with improved composition for more efficient conversion



Impacts of large-scale land conversion

Backdrop; Miscanthus x giganteus in England

Biomass crops could occupy up to 2 million ha

Perennial Biomass crops are:

- Non-food crops
- Low-input
- In the ground for circa 25 yrs
- Harvested in winter/spring
- Dense, tall crops



Potential implications for:

- Landscape
- Tourist income
- Water
- Biodiversity
- Soil
- Land availability

RELU-Biomass project

- Both SRC willow and Miscanthus studied
- Two contrasting regions used (SW England and E-Midlands)
- Utilised existing data & generated new data to fill knowledge gaps
 1. GIS-based suitability mapping and landscape visualisations
 2. Public surveys(n=490), stakeholder and focus groups
 3. Biodiversity assessments (24 fields of each crop)
 4. Water use assessments (over the year in both crops)
 5. Economic assessment from farm to wider scale
 6. Developed integrative tools to help decision-makers

<http://www.relu-biomass.org.uk/>



Water-use

SRC willow and Miscanthus roots grow no deeper than deeper rooting annual crops.

SRC willow water use is similar to that of a cereal crop, higher than permanent grass and lower than that of mature woodlands

Miscanthus water-use approaches that of woodlands.



Biodiversity



More butterflies in the field margins

SRC has positive effect on farmland and woodland birds. Miscanthus – still unsure.

More weed biomass and invertebrates in SRC than Miscanthus

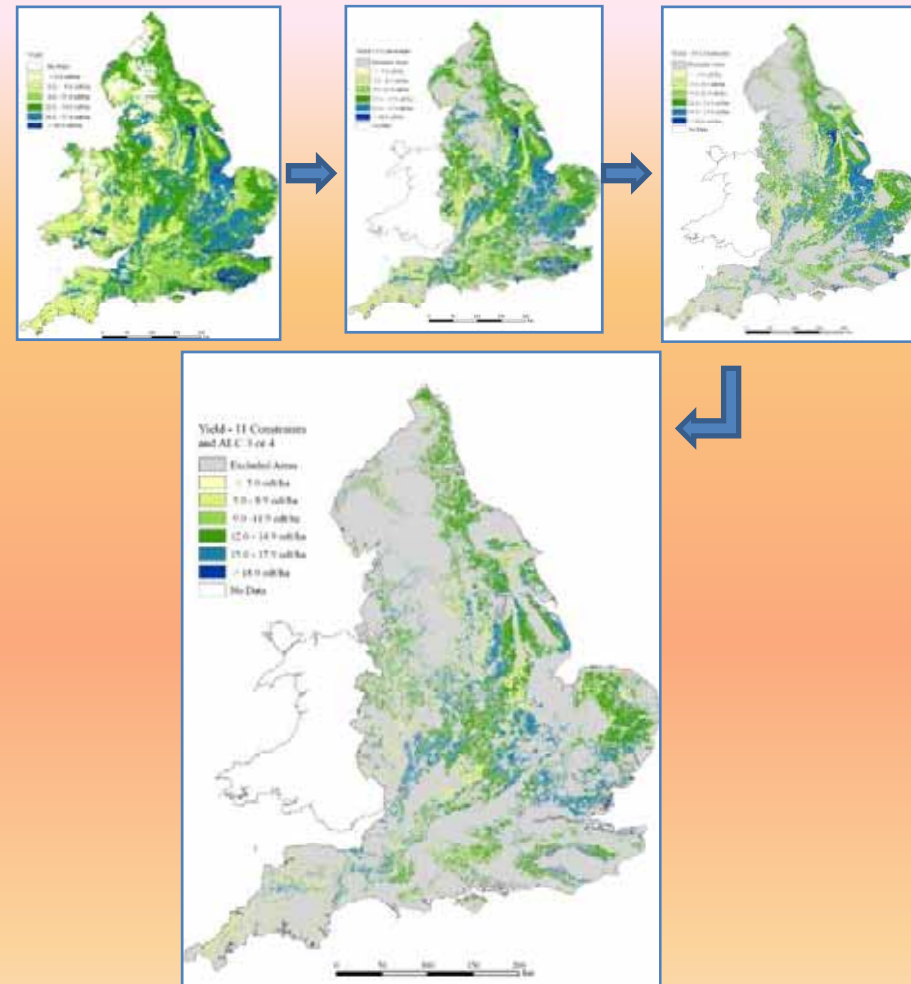
- Certain important species may be negatively affected
- Plantation design and management are important



Impacts on alternative land-use

Miscanthus

- Yield map for all soils except organic (~ 11 M ha)
- Yield map for 9 (primary) constraints (<8 M ha)
- Yield map 11 (secondary) constraints (<5 M ha)
- Yield map for all constraints plus ALC 3 & 4 (~ 3 M ha)



Decision-making frameworks

Advantages of Sustainability Appraisal

- Opportunity for a comprehensive look at biomass alternatives/scenarios
 - - economic objectives
 - - social objectives
 - - environmental objectives
- Opportunity for stakeholders to define the key sustainability issues and objectives for their part of the country
- Mechanism for managing (or reducing) conflict
- Mechanism for generating interest and enthusiasm

Haughton *et al.* 2009. *J. Appl Ecol.* 46, 323-333

Sustainability appraisal process

- Generated sustainability objectives (for SW and EM) Framework with indicators and targets for each Region
- Checked against Regional Spatial Strategies
- Completed Framework was agreed
- Framework is being used to test scenarios



Scenarios



- **SCENARIO 1: TOTAL LAND COVER**
1a) 72,000 Ha 1b) 18,000 Ha 1c) 200,000 ha
of SRC and Miscanthus
- **SCENARIO 2: BIOMASS END USE**
2a) Small-scale CHP 2b) Large-scale co-firing 2c) Dedicated Biomass
- **SCENARIO 3: CROP MANAGEMENT/FIELD DISTRIBUTION PATTERN**
3a) Monocrop
3b) 50/50 (but with no mixing on any individual farm)
 - i) Heavily aggregated
 - ii) Realistic scenario (based on current pattern)
 - iii) Evenly spread across the landscape
- **SCENARIO 4: CROP MANAGEMENT: HEADLAND USE**
a) 4m b) 10m



Summary

- Biomass yields have been improved in willow (UK also has a Miscanthus breeding programme at IBERS)
- Future emphasis is on resource-use efficient biomass crops
- Results so far have shown that many positive (direct) benefits from growing biomass crops could accrue.
- GIS-based yield and suitability mapping can help identify land use implications at national, regional and finer spatial scales
- Sustainability appraisal can be used as a tool to compare impacts of different planting scenarios

Acknowledgements



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Energy Crops at Rothamsted



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