Miscanthus giganteus

AgBoard Purpose

- reactive
  - Eg, californian thistle
  - beetle established at 90% of release sites
- proactive
  - Eg, Catlin's Hemp Group
  - identified problems with weed and bird pests

AgBoard – being proactive

- Sheep & Beef farming - what's happening to us?
- reducing margins
  - –meat
  - –wool
  - –crops
- competing land usage
  - –conversion to dairying
  - –dairy support
  - –amalgamation of remaining Sheep & Beef farms
- what is my core business definition?
  - –Am I a Sheep farmer?
  - –Am I a pastoral farmer?

Core Business definition – why it matters

- NZ Post
  - –information delivery is their core business
  - –they've focused upon physical delivery of information
- a proper core business definition confers flexibility
  - –NZ Post should've switched focus to electronic information delivery
- what is my core business definition?
  - –am I in the business of farming sheep?
    - no
  - –am I in the business of farming pasture?
    - no
- I grow plants

My core business is plant growing

- Sheep & Beef farmers have 3 main revenue streams:
  - meat
  - wool
  - **crops**
- what would be an ideal new type of crop?
  - high yielding
  - easy to grow
  - profitable margin
  - little additional specialised machinery required
  - not part of the sheep & beef commodity market
  - can supply existing and emerging markets

Miscanthus giganteus

Miscanthus – the plant

- a native of the sub-tropical and tropical regions of South-East Asia
- been used for forage and thatching in Japan for 1000's of years
- a close relative of sugarcane, but with much lower sugar content
- been used to breed disease resistance and cold tolerance into sugarcane
- the *Miscanthus* genus contains 17 different species
- 2 of these species have been crossed to produce *Miscanthus giganteus*

M. sinensis

- fast growing rhizomes
- highly productive in warm & wet conditions

X

M. sacchariflorus

- tolerant of cold & wet conditions

=

M. giganteus

- a giant sterile hybrid

Miscanthus rhizome

Miscanthus
- the mule of the plant world

- a perennial that regrows from its rhizome each spring
- grows 3 to 4m tall each season with a minimum rainfall requirement of 600mm pa
- a very productive temperate crop:
  - –European yields: 12.5 - 28.5 t/Ha
  - –American yields: 25.0 – 37.5 t/Ha
- suitable to many soil types
- tolerant of wide climatic range:
  - –Europe: southern Italy – Denmark
  - –North America: Gulf of Mexico – central Canada

Miscanthus
- the mule of the plant world

- very efficient user of nutrients
  - –bulk of nutrients returned to rhizome at end of season
- forms thick mulch that suppresses weed growth
- high energy value
  - –(17 - 20 MJ/Kg DM)
  - –between lignite and sub-bituminous coal
- introduced to Europe in 1930's
  - –various yield and agronomic trials since 1980's
  - –England largest grower with 400 farmers growing 9,000 Ha of Miscanthus
  - –now being trialled in America as a biofuel crop
  - –Lincoln has started research work

Miscanthus
- the mule of the plant world

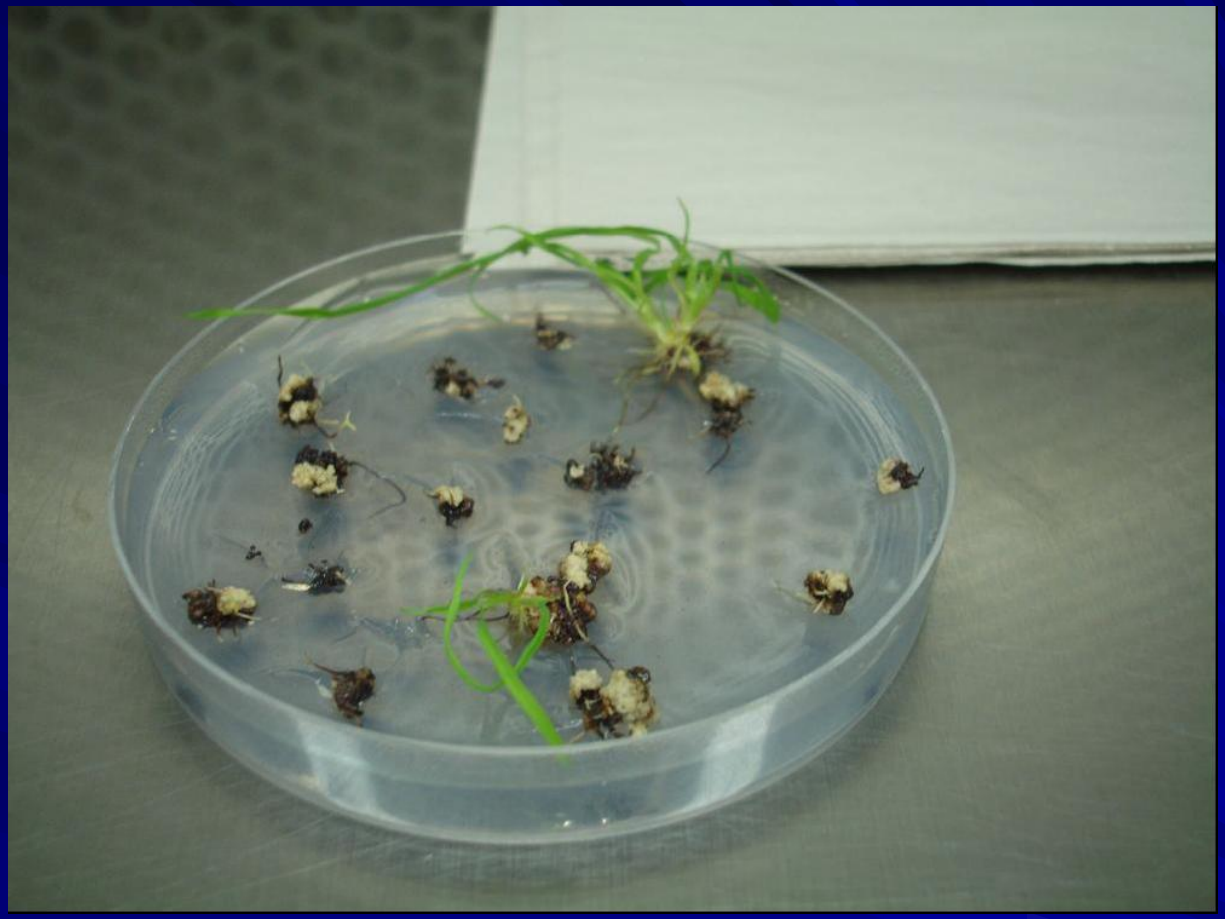
- biggest disadvantage is cost of establishment
  - –sterile hybrid
  - –must produce plantlets from rhizome splitting or tissue culture
  - –however, ongoing costs are low

Splitting Miscanthus rhizomes by hand

(University of Illinois)

Trials of Miscanthus rhizome harvesting using specialised rhizome lifting and splitting machinery

(University of Illinois)



Miscanthus plantlets being produced via embryogenic tissue culture

Miscanthus plantlet produced via tissue culture

- ready to be transplanted into plug

(University of Illinois)

30,000 Miscanthus in NZ greenhouse (2009)

- grown from tissue culture

Miscanthus New Zealand Limited
miscanthus@pfsc.co.nz

Miscanthus plugs in the greenhouse ready for planting

Miscanthus New Zealand Limited
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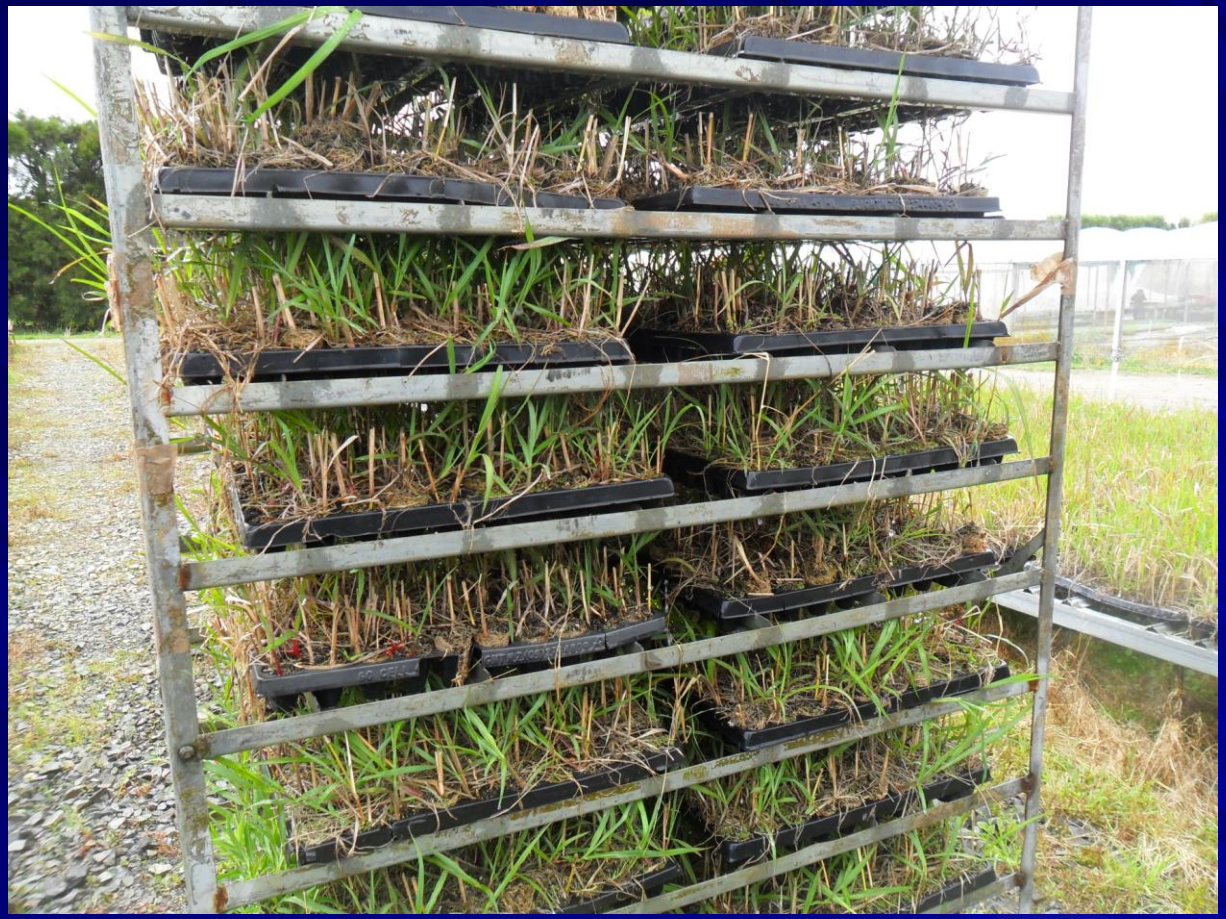
Miscanthus arrives in Clutha



2000 Miscanthus plants per stillage

Miscanthus plants showing plugs

trays of Miscanthus being transferred to paddocks

Miscanthus plants meet good Akatore soil

Miscanthus - the business case

- 3 pronged approach:
- **1.** short-term (1 to 3 years)
  - –bedding and supplementary feed options
- **2.** medium-term (1-5 years)
  - –thermal fuel options
- **3.** long-term (1-10 years)
  - –liquid fuel options

Miscanthus
1. bedding options

- bedding option
  - –large part of Miscanthus usage in Europe is for bedding
  - –for ideal bedding, Miscanthus harvested latter in season, which decreases yield by 30-50%

Chipped Miscanthus

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April 30

August 24

November 5

Growth cycle of Miscanthus in the American mid-west
(University of Illinois)

February 14

Trials of Miscanthus harvesting using a modified forage harvester mounted on a combine

(University of Illinois)

Miscanthus
1. supplementary feed options

- supplementary feed
  - –silage, balege, straw
- growth data for Otago
  - –data across Europe and America from 12.5 – 37.5 t/Ha
- nutrient profile and digestibility over growing season
  - –can nutrient profile be altered?
  - –how will multiple harvests affect growth and nutrient status?

Miscanthus
1. supplementary feed options

- what are fertiliser requirements?
  - –overseas trials show an inconsistent, but very low response to fertiliser
  - –Miscanthus very efficient at recycling nutrients back to rhizome at end of season
  - –but if harvesting for silage or balege will require a higher than normal nutrient status within the plant

Commercial on-farm Miscanthus crop

(France)

Commercial on-farm baling of Miscanthus
(France)

Commercial on-farm crop

- new season’s growth (Ontario)

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Previous year’s harvest

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miscanthus@pfsc.co.nz

Possible silage or balege?

- beginning of December (NZ)

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Miscanthus
2. thermal fuel options

- Miscanthus has required attributes for a thermal fuel:
  - –low water content at harvest
  - –low ash content
  - –high calorific value
  - –high biomass production
  - –ability to grow on low class soils; won’t displace food crops

Miscanthus
2. thermal fuel options

- England is world leader in Miscanthus use for thermal power generation
  - –400,000 tonnes used in power stations (2010)
  - –Drax power station is tripling purchase of Miscanthus to 300,000 tonnes
  - –Drax expects much of this to be supplied by farmers in the local Yorkshire area

Miscanthus
2. thermal fuel options

- Example of energy yield:
  - –low end assumption: calorific value of 17 MJ/kg DM and biomass production of 15 t DM/Ha
  - –energy yield of 260 GJ energy per Ha of Miscanthus
  - –this equivalent to 6 tonnes of coal or 75,000 kWh
  - –thermal fuel can be in a pellet or chipped form

Miscanthus
2. thermal fuel options

- Example of pellet use in NZ:
  - –Radford Yarn Technologies
  - –installation of a 150kW pellet-fired boiler
  - –previously running solely on electricity: 1,000,000 kWh consumption pa
- after installation:
  - –electricity consumption decreased to 450,000 kWh pa
  - –pellet-fired boiler producing 500,000 kWh pa
  - –production run times 33% more efficient
  - –direct savings of $72,500 pa

Miscanthus wood pellets

- the first Miscanthus pellets made in NZ

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Small-scale boiler house & pellet storage

(Radford Yarn Technologies)

NaturesFlame; info@naturesflame.co.nz

Small-scale (150kW) commercial pellet furnace
(Radford Yarn Technologies)

NaturesFlame; info@naturesflame.co.nz

Small-scale (200kW) commercial pellet furnace
(Katikati Primary School)

CO_2 & SO_2 emissions decreased by 100%, ash content decreased by 90%, boiler operating costs significantly reduced

NaturesFlame; info@naturesflame.co.nz

Miscanthus trial crop

- next to thermal power station (England)

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Miscanthus
3. liquid fuel options

- Miscanthus has required attributes for a liquid fuel:
  - –low water content at harvest
  - –low ash content
  - –high calorific value
  - –high biomass production
  - –ability to grow on low class soils; won't displace food crops
  - –chemical composition – low K, Cl, N, and S
  - –high polysaccharide (complex sugar) concentration
  - –correct lignin content and composition

Miscanthus
3. liquid fuel options

- Miscanthus may be suitable as a possible dedicated energy crop
  - –University of Illinois trials show Miscanthus yields are 2 to 4 times that of the next best dedicated energy crops (ie, Corn & Switchgrass)
  - –"*Our highest productivity is actually occurring in the south, on the poorest soils in the state …. So that also shows us that this type of crop may be very good for marginal land or land that is not even being used for crop production*." (Stephen Long, Prof. Crop Sciences, Institute for Genomic Biology, University of Illinois)

Miscanthus
3. liquid fuel options

- Energy Independence and Security Act (2007)

  –White House inititative requiring enough ethanol production to offset 20% of all domestic petrol consumption

  –current yields of ethanol from corn indicate this would require 25% of all US cropland

  –initial Miscanthus trials indicate only 9.3% of all cropland would be required

  –or, bring non-cropland into Miscanthus production

Miscanthus
3. liquid fuel options

- diesel from Miscanthus is high quality

	# 2 diesel	Low temp FT diesel
Energy MJ/kg	~45	~46
Cetane number	45	>74
S content ppm	300	<1
Aromatics %	~30	0.1-2.0

- practical benefits:
  - –cetane number >55 reduces engine noise and NOx emissions (13%: NREL, 2003)
  - –lower concentrations of aromatics, sulphur, and high chain hydrocarbons reduces exhaust particle emissions (26%: NREL, 2003)

Miscanthus
3. liquid fuel options

- diesel yield from Miscanthus
  - –current conversion ratio of Miscanthus to diesel is 3:1
  - –it takes 3kg DM of Miscanthus to yield 1 litre of diesel
- Example of diesel yield:
  - –low end assumption: 15t/Ha(oven dried) Miscanthus will yield 5,000 litres of diesel per Ha
  - –projections by NZ company indicate total cost of production at $1.13 per litre
  - –this includes on-farm and refinery costs, and excludes excise tax

ORION - Biomass to Diesel Demonstration Plant
(Italy)

REEP Development LLC

CPD-Swiss Ag Biomass to Diesel Demonstration Plant
(Switzerland)

Trial plots of Miscanthus and Switchgrass

- University of Illinois at Urbana-Champaign

Trial plots of 3 year old Miscanthus

(England)

Trial plots of 4 year old Miscanthus

(University of Illinois)

Commercial on-farm crop of Miscanthus

Caveny farm, Monticello, Illinois

Commercial on-farm Miscanthus crop in Waikato, near end of first year (1m tall)

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Commercial on-farm Miscanthus crop in Hawke's Bay, near end of second year (3m tall)

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Commercial on-farm Miscanthus crop in Hawke's Bay, near end of third year (3-4m tall)

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Mechanical planting of Miscanthus in Canterbury - shelterbelt trial

Lincoln University

Cows grazing around Miscanthus in Canterbury - shelterbelt trial

Lincoln University

My core business is plant growing

- Sheep & Beef farmers have 3 main revenue streams:
  - meat
  - wool
  - **crops**
- what would be an ideal new type of crop?
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Miscanthus giganteus

The End

Table ES-2 - Different Technologies to Convert Biomass to Fuels

Process	Product	End-use
Natural oils →		
Esterification	Biodiesel (by-product glycerol)	Transport fuels
Hydrotreatment	Biobased diesel	Transport fuels
No processing	Oils	Food, energy
Biomass → syngas →		
Fischer-Tropsch	FT-fuels, ethanol, various other products, chemicals	Transport fuels and chemical industries
Methanol-to-liquids	Gasoline type fuels ("MTG" process)	Transport fuels and chemical industries
Syngas to alcohols, ethers	Methanol, ethanol etc.	Transport fuels and chemical industries
Water-shift	H_2	Fuel cells
No processing	Syngas	Power and heat
Biomass → pyrolysis oil →		
Hydroprocessing	Biobased fuels, other products	Feed to petroleum refinery, transport fuels and chemical industries
No processing	Pyrolysis oil	Power and heat, feed to syngas production
Biomass → sugars →		
Biochemical	Ethanol	Transport fuels and chemical industries
Anaerobic digestion	Methane (biogas)	Transport

From Biomass to Biofuels

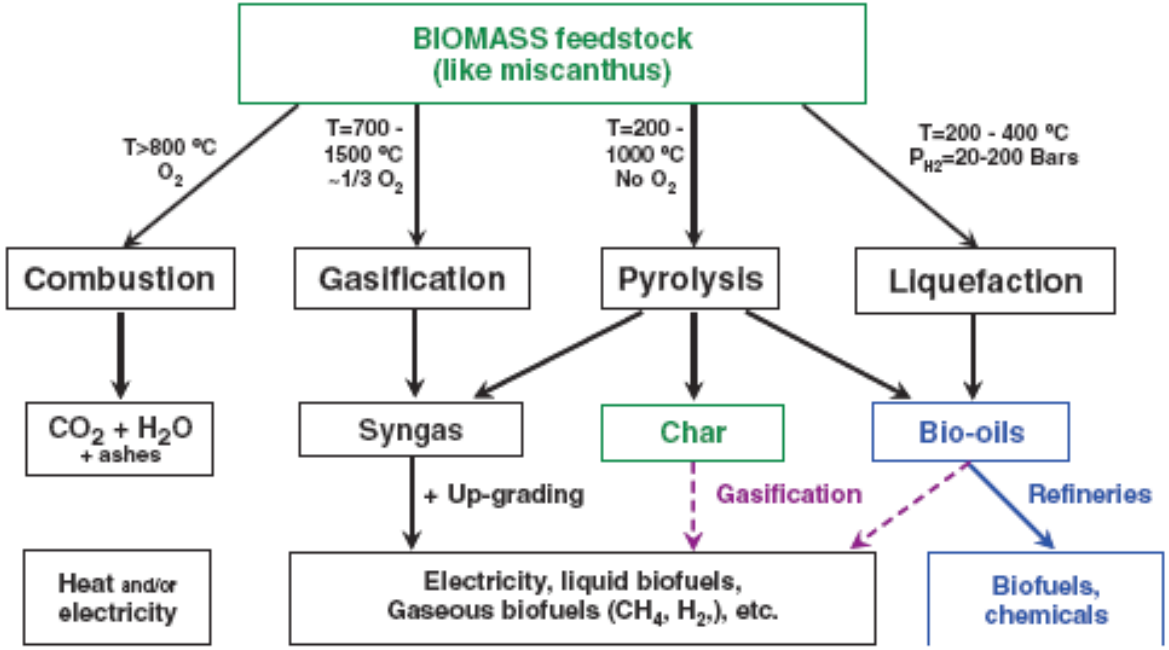

Figure 2. Main thermo-chemical routes for miscanthus valorization.[a]

[a] T refers to the temperature of the reactor but not of the solid biomass decomposition in the reactors.