Università degli Studi di Torino

Facoltà di Agraria

UNIVERSITÀ DEGLI STUDI DI TORINO

FACOLTÀ di AGRARIA

I CAMPI DELLA SCIENZA

www.naturalmenteagraria.to.it

Dept. of Agriculture, forestry and food sciences – University of Turin, Italy

- 140 professors
- 4000 students
- 400 staff (e.g. technician, clerical)
- 320 Fellowships
- Annual turnover of 19.5 M€
- Team working on logistic and sustainability issues

Short Rotation Forestry and dedicated biomass

Chipping

Transport within the farm

Loading

Delivery to the power plant

Biomass production and logistics

GOARUNDO -Logistic of Arundo donax for M&G – Chemtex plant in Crescentino, Italy

Digestate logistics

BIOLOGIS – Logistic of biogas plant supply chain

Biomass Sustainability: Present and Future challenges

Remigio Berruto, Patrizia Busato

DISAFA– University of Turin

Sustainability of energy production from biomass

- Biomass store (solar) energy
- Biomass, to grow use other resources: land, water, energy (from sun, fossil fuels)
- Biomass needs to be transported, stored → energy, losses
- **KPI example**:
  - Output/input ratio: efficient conversion of the input energy into output energy
  - Net energy produced/ha: efficient use of soil/water resource
- The destination of energy/material produced and **USED** from biomass changes both the above indexes

Logistic definition

- Is that part of the supply chain that plans, implements and controls the efficient and effective flow and storage of good, services and related information from the point of origin to point of consumption in order to meet customer's requirements. (Ricks et al., 2002)

- 7 r's – Part of the supply chain that ensure the availability of the right product, in the right quantity, in the right time, in the right conditions, right place, right customer, right cost.

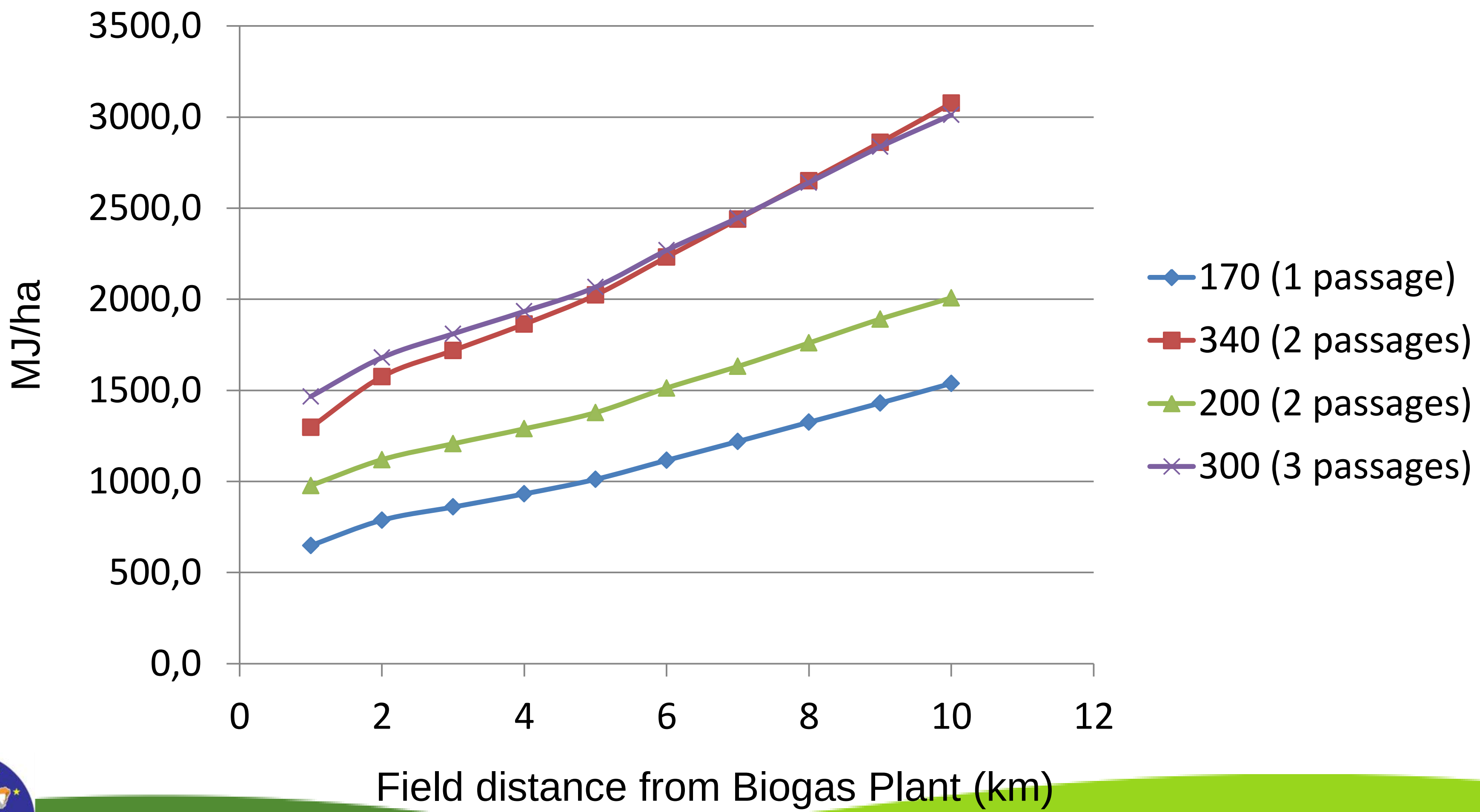
- If it is not feasible by logistics, it will not be done

SAHYOG

Improve sustainability in biomass production

- **Logistics** (harvest & transport):
  - Corn silo (**18 tDM/ha, 200-240 GJ/ha**) 13 €/tDM @ 5 km BCR, 24 €/tDM @ 20 km BCR [biomass collection radius]
  - Corn silo (**18 tDM/ha, 200-240 GJ/ha**), 5.7 GJ/ha @ 5 km BCR, 12.5 GJ/ha @ 20 km BCR
  - Rice straw (**3 tDM/ha, 48 GJ/ha**): 33 €/tDM @ 5 km BCR, 77 €/tDM @ 20 km BCR (low yield →more expensive than corn silo)
  - Corn stover Canada (**4.5 tDM/ha, 63 MJ/ha**): 22 €/tDM (within 5 km BCR)
- **Low yield** or **high distances** imply **higher logistic costs**

Energy consumption for slurry distribution



Improve sustainability in biomass production

- **Irrigation**:
  - Sprinkler irrigation: add 8 GJ/ha
  - It is possible to save 450 m^3/ha→ 152 Mm^3/year in Piemonte Region, with associated energy (400000 GJ/year at low consumption rate)
- **Drying**:
  - For corn is equal to fuel used for operations (add 8 GJ/ha) – can be greater for lignocellulosic feedstocks!!
  - Should be avoided to make higher net energy retrieval
- **Reduce inputs**: e.g. mineral fertilizers (14.3 GJ/ha)
- **Reduce losses**: e.g. just in time delivery, no storage

Energy balance – use of mineral fertilizers

Parameters	Rape seed		Wheat		Sunflower		Corn Grain	
	Input	Output	Input	Output	Input	Output	Input	Output
	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)
Fuel	-6.209		-6.883		-4.466		-5.490	
Fertilizers	-8.331		-10.297		-6.374		-14.336	
Energy Input (totals)	-19.097		-24.665		-16.563		-37.072	
Energy Outputs (total)		124.578		204.949		125.425		208.689
Net energy		105.486		180.291		108.868		171.621
Net energy (toe/ha)		2,52		4,31		2,60		4,10
Ratio Output / Input		6,53		8,31		7,58		5,63

Energy balance of crops – use of digestate

Parameters	Wheat		Sorghum silo		Corn grain		Corn Silo	
	Input	Output	Input	Output	Input	Output	Input	Output
	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)	(MJ/ha)
Fuel	-4.973		-5.767		-5.655		-5.871	
Energy Input (totals)	-12.506		-12.674		-21.083		-15.415	
Energy Outputs (total)		139.886		233.752		163.561		219.649
Net energy		127.377		221.076		140.891		204.237
Net energy (toe/ha)		2,98		5,18		3,30		4,79
Ratio Output / Input		11,18		18,44		7,21		14,25

www.bioresource4energy.eu

INTELLIGENT ENERGY EUROPE

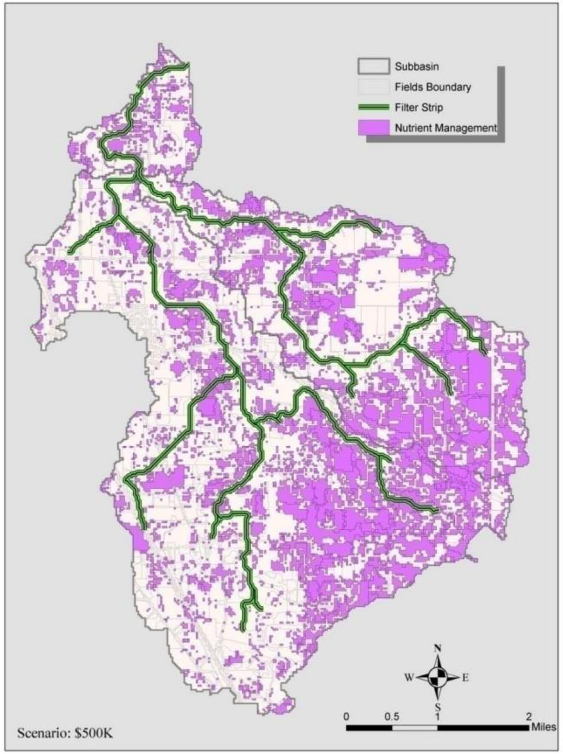
SAHYOG

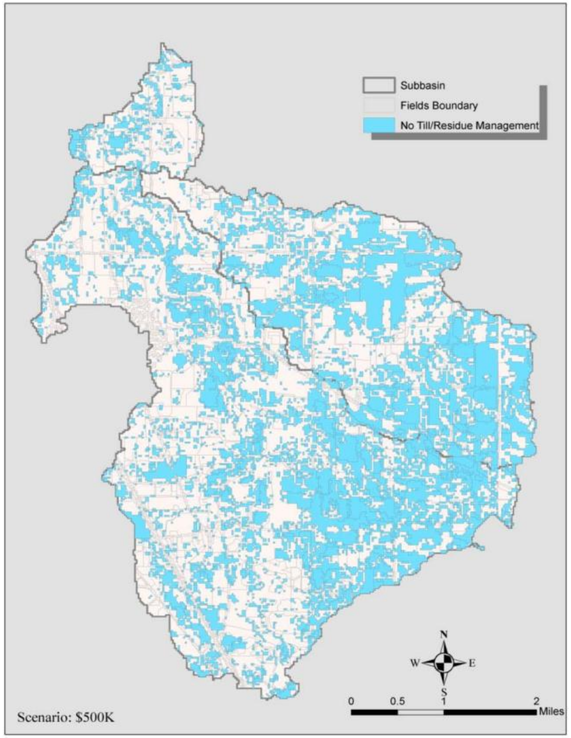
Improve energy use/land use

- Corn grain For drying: 30-60 kg/t of corn grain→ 3-5% of area (3-5 ha every 100 ha) → very SHORT supply chain
- Corn grain For heating: 1MW thermal →140 kL diesel→300 t of corn→ 24-30 ha (all energy used, 80-85% yield) 190 GJ/ha/year
- Electric energy (with biogas), 1MWe: 320-400 ha (a lot of thermal energy wasted ~ 60%)→ 31720 GJe/year→ 79.3 GJ/ha/year
- Biomethane Injection (with biogas): 66800 GJ/year → Good fuel also for transport (167 GJ/ha/year)
- Biofuels/biomaterial made with efficient process
- Use of marginal land (keep in mind it is marginal)

Improve water quality and quantity

- Biomass, if located and managed right, could increase water quality: pesticide reduction 30%, nutrient reduction 50%; sediment loading reduction 50% (work with Purdue University, USA)





Biomass **chain** success factors

Advantages

- CO_2 neutral
- No taxes → low production cost
- Local economy delopment
- Positive cash flow
- Waste-residues value (e.g. corn with mycotoxins, straw)
- High yield→ less area
- Incentives?
- Other use?

Problems

- Non uniform (e.g. moisture, composition, quality)
- Availability
- Storability
- Market (risk)
- Logistics issues
- Equipment investment (risk)
- Training on production (risk)
- Sustainable for the soil?

The more items you able to drop on the right of this list, the more successful will be the biomass chain

Challenges in biomass production

- Improve logistics and reduce distances (both economic and environment affected)
- Technologies and crops to improve yield (ASABE 2010: top farmers +25% yield)→ reduced land use
  - Increase water efficiency, water quality, fertilizer efficiency
- Residues → reduced land use, remember
- Just in time delivery – reduced operation time, no drying
- Reduce field losses (50% for corn stover, dried in the field)
- Increase ratio of material/energy produced vs. resource used (energy used, water used, land used)

Challenges in biomass utilization

- Better, complete use of feedstock, yield while making biofuels/biochemicals
- Provide frameworks that allows this assessment for free, case by case, of the BAT (best available techniques), logistics and sustainability
- Regulations
- Emissions
- Incentives (subsidy are paid by ALL)

Incentives → Land use problem (Piedmont, Italy)

Before incentives (2008): 5 biogas plants, no land used

By the end of 2012:

- **~ 80 biogas plants working**
- **~ 100 MWe installed power**
- **~ 350 ha for 1 MWe (biomass production)**

↓

~ 35.000 ha dedicated crops for biomass (about 11% of irrigated land – 320.000 ha)

Conclusions

- Strategic Research Agenda, when estimate the biomass exploitation potential, should consider:
  - Sustainability (also the economic one)
  - Logistics (distance, density)
- Great improvements are possible:
  - Increase the yield
  - Increase the use of energy/chemical content
  - Reduce waste and losses
- We are ready to join SAYHOG efforts in this domain

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"Be sustainable also means to "buy the time", to extend the time we (our childrens) could afford our lifestyle",

Hunter Lovins, author of "natural capitalism"

patrizia.busato@unito.it
remigio.berruto@unito.it

http://www.bioenergyfarm.eu

Biogas- national projects

- BIOLOGIS – BIOGAS – Biomass and digestate logistics
- PROBIO - BIOGAS – monitoring of biogas plants
- FERTIBIO – Use of digestate in vineyards, orchards

EU project EU-Agrobiogas (FP 6)

- Emission reduction (e.g. from storage, etc.)
- Yield of methane production for different biomasses
- Optimization of digestate management

Bioenergy Farm Project

- Sustainability assessment of biomass production
- www.bioenergyfarm.eu
- 400 farms involved
- Economic and energy balance of biomass crops (and residues – e.g. straw)
- 7 languages so far (EN, IT, NL, DE, PL, BE, EE) and country specific data
- Include also forestry biomass assessment

POLIBRE – industrial research projects

- AGROLOGISTIC – Biomass supply chain logistic study for SRF and wood residues

- GOARUNDO – Optimized management of Arundo Donax biomass delivery to a Bioenthanol II generation plant (Just in time delivery following MRP, no storage, no drying, max quality and yield in bioethanol production)

- BIOPLATFORM – Environmental certification of biomass supply chain following the RED EU directive (production of solid/liquid biomass, gas, production of biofuels and energy)