Are tree morphological determinants indicators of Nitrogen Use Efficiency (NUE) in hybrid *Populus* clones for bioenergy plantations?

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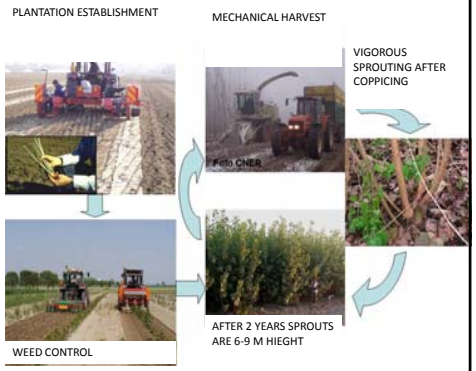
Poplar Bioenergy plantations in Italy

- 7000 ha of poplar SRF commercial plantations
- Swedish model (high density, 2-3 years of rotation cycle)
- Public grants to farmers for plantation establishment
- Bioenergy (and phytoremediation)



Wood chips for:

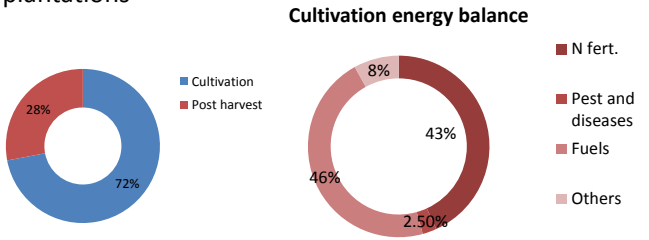
- Combustion in bioenergy industrial plants for electricity and thermal energy (500 MW_{el} -110 plants)
- Ligno-cellulosic ethanol (any commercial application)

Energy and CO_2 Ratios for bioenergy

Bioenergy Source	Energy Ratio (Input/output)	CO_2 emission balance
• Bioethanol from corn (USA)[1]	• 1/1,3	• -22%
• Bioethanol from sugarcane (Brasil) [1]	• 1/8	• -56%
• Biodiesel from rape (Germany) [1]	• 1/2,5	• -68%
• **Chips from Short Rotation Forestry (Italy)[2]**	• **1/9**	• **-91%**
• Cellulosic ethanol[1]	• 1/2-36	• -91%

[1] US DOE, World Watch Institute, in Bourne and Clark, 2007; [2] Balsari e Airoldi, 2002

Breakdown of the energy consume in bioenergy plantations



Nitrogen fertilization is the second most important factor affecting energetic balance in poplar bioenergy plantations

Wood N% variability in hybrid poplar clones

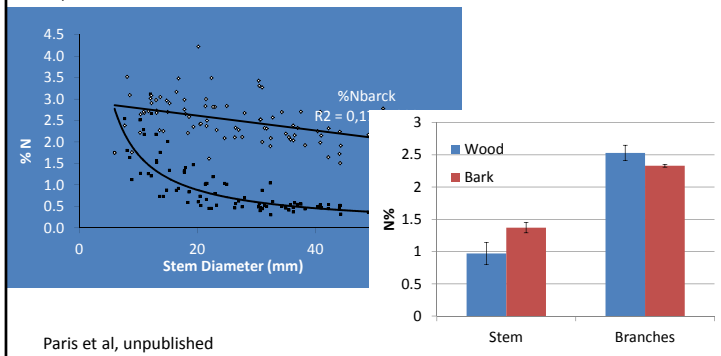
- From 0.6 to 1.2 %
- On an ave. yield of 10 Mg DM year^{-1}: from 60 to 120 kg of N uptake ha^{-1}year^{-1}

Element	Energetic Cost per 100 Kg of Fert. Unit	
	M Joule	Oil Barrel
N	7.330	1.2
P	1.340	0.2
k	920	0.15

Opportunity to improve Nitrogen Use Efficiency (NUE) across hybrid poplar clone ……

……According to clone morphological parameters affecting biomass allocation

Wood, bark and branches

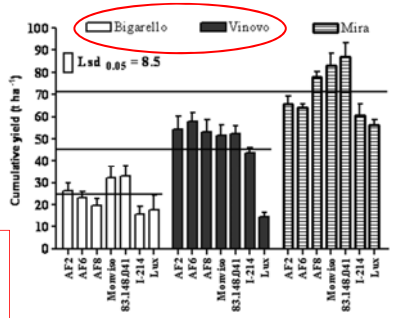


Paris et al, unpublished

The Hypothesis

Connecting clones wood N% (NUE)
To
Morphological determinants affecting growth and aerial biomass allocation
(branches, sprouts per stool, height, diameter)

The Experiment
Network of exp. plots comparing hybrid poplar clones – 2 biennial rotations



Studied clones for N uptake:
Monviso
83.148.041 (83)
AF2
AF6
I214 (control)

Paris et al., 2011. Biomass and Bioenergy, 3 5

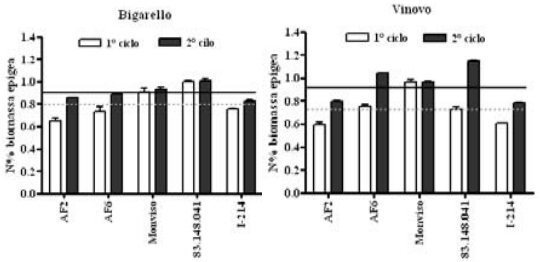
Very accurate sampling methodology for N analysis

For each site, rotation cycle and clone collection of selected stems/sprouts evenly distributed across diametric classes (7-13 sample plants per treat.)

For each stem/sprout: 3 sampling positions:
0.20 m H; H/2 and $H_{stem\ diam}$=2 cm

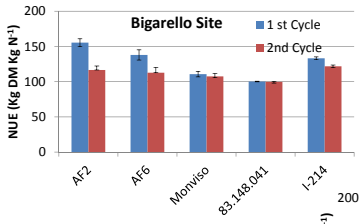
Separated collection and sampling for branches

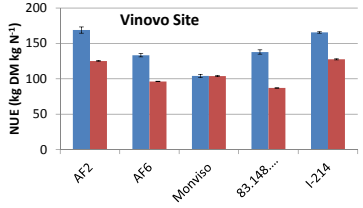
N% in woody biomass (wood and bark)



- AF2 was constantly the clone with lowest N%
- Monviso and 83.. were the clones with highest N%

Nitrogen Use Efficiency (NUE)





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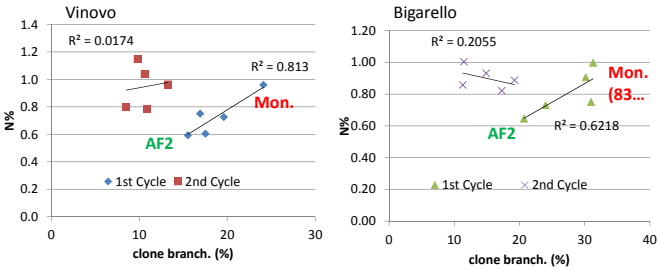
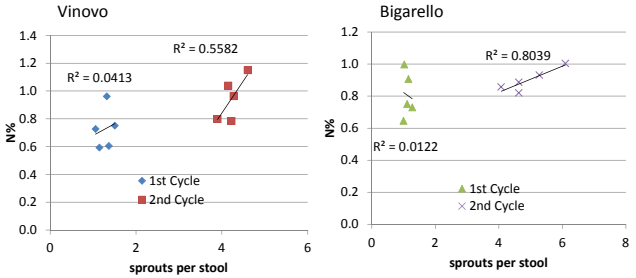
N% and clone branchiness

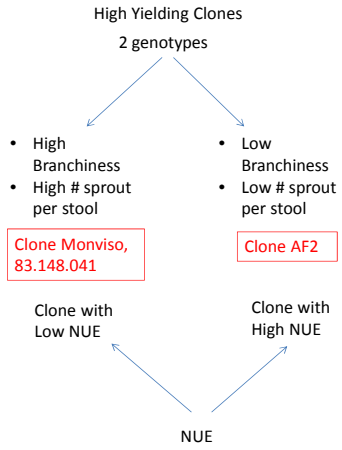


During the first cycle, with higher branchiness, the lower it is the clone branchiness the lower it is N%

N% and # sprouts per stool



During the second cycle, with higher sprout density, the lower it is the #sprouts per stool of the clone, the lower it is its N%



- Results are consistent with *P.J. Tharakan, et al., 2005 , Can. J. For. Res. 35*:
- Morphological traits of 30 willow clones and their relationship to biomass production,…..
- **two distinct high yielding "functional types" of willow clones with:**

I. large number of small diameter stems…….
II. low number of large diameter stems……..

Thank you for the attention

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