Phyto-recurrent Selection: A Method for Selecting *Populus* and *Salix* Genotypes for Environmental Applications

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Short rotation woody crops (SRWCs) research began in 1968 at the U.S. Forest Service, Northern Research Station, Institute for Applied Ecosystem Studies (IAES) in Rhinelander, Wisconsin, USA. Genetics, physiology, and silviculture were at the forefront of research priorities, and the IAES became a national and global leader in SRWCs research and development. Given the vast amount of information learned during these decades coupled with the growing need for merging traditional intensive forestry with waste management, phytotechnologies research at the IAES began in the mid-1990s. The primary emphasis at the time was to evaluate the use of *Populus* and *Salix* as biological filters atop or adjacent to closed landfills. The practical implications for resources managers included being able to recycle and reuse municipal solid waste landfill leachate on-site to reduce the economic and ecological costs associated with treating the waste waters, along with maintaining regional environmental integrity of groundwater aquifers and nearby water bodies.

Early phytotechnologies research at the IAES involved testing the performance and phytoremediation capabilities of SRWCs in greenhouses and growth chambers, then progressed to field tests in tanks with engineered soil layers and ultimately field-scale plantations. Current research involves a combination of greenhouse and field tests. Adopting crop and tree improvement strategies used in forestry, horticulture, and agronomy, *phyto-recurrent selection* was developed to choose superior-performing genotypes for specific environmental applications. The method involves using multiple testing cycles to evaluate, identify, and select favorable clones based on the response of genotypes to variable wastewater chemistries and site conditions. Early cycles are relatively short and data collected are easy to acquire (typically done in the greenhouse or growth chamber), while later cycles require more time and resources to increase knowledge of genotypes advancing

(typically done in the field). Less clones are tested as the complexity of the data increases, and multiple-trait selection strategies are used to evaluate the combination of complex phenotypic expressions regulated by quantitative traits. The ultimate goal is to deploy a combination of genotypes with improved phytoremediation potential over the original set of clones, as well as adequate genetic variation to guard against insect/disease outbreaks, changes in soil conditions (especially those induced by the wastewaters), and unfavourable genotype × environment interactions.

We will summarize these efforts by integrating results from eleven studies conducted during the last decade and a half in order to highlight the importance of phyto-recurrent selection for research studies and practical applications.

An Own Consumption Wood Energy Micro-Chain

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The micro-chain has been realized inside the firm of the research unit for agricultural engineering of Monterotondo (Rome). The action, financed by Italian Agriculture and Forestry Ministry has started in 2005. The purpose is to produce biomass to use for the Institute heating (total volume of 5.880 m^3) in substitution of the actual diesel system. The sanitary water is produced also. The installed thermal boiler, has a nominal power of 232 kW. The poplar short rotation coppice (SRC), established with the clones AF2, AF6 and Monviso (single and twin rows), feed the micro-chain. The total surface is 4 hectare. The rotation of plantation is two years, beginning from the third year. The average plantation production (t dm ha^{-1} $year^{-1}$) has been of 10.2, with a maximum value of 13.53 for the twin rows AF2 and minimum value of 8.00 for the single row Monviso. The annual economic advantage in comparison to the diesel has been of around 18,700 €. The energetic budget of plantation, compiled using the Gross Energy Requirements method, it has furnished output/input index (in comparison to different clones and planting typology) varying from a minimum of 9.6 to a maximum of 16.5. The lowest output/input index for the whole micro-chain it has been of 4.

Using willow riparian buffers for biomass production and riparian protection

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There is increasing interest in the development of willow biomass as a renewable source of energy and woody lignocellulosic feedstock for bioproducts. Riparian buffers have been identified as an effective barrier to soil and nutrient movement from agricultural fields into watercourse. Willows are ideal riparian species in that they are well adapted to growing conditions in riparian zones and they vigorously re-grow following coppicing which allows them to be harvested for biomass in 3-4 year cycles. Characteristically riparian edges are highly productive due to water availability, therefore it is anticipated that willow biomass yield per unit area in riparian zones would be attractive. Research is being conducted to determine if using riparian buffer strips for willow biomass production provides energy alternatives and economic opportunities for land owners, but also leads to environmental benefits such as reduced erosion and nutrient leaching and preservation of water quality.