PHYTODEPURATION PROCESSES IN TWO SHORT ROTATION FORESTRY SYSTEMS WITHIN THE VENICE LAGOON WATERSHED

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Introduction

Bioenergy crops are promising option for integrating fossil fuels and achieving European environmental targets. Wooded systems like Short Rotation Forestry (SRF) in the plain areas, counting agroforestry as well, start to be considered an opportunity for sustainable agricultural development, because of the environmental benefits related to their use on agricultural lands. One of this is to enhance water resources quality. Moreover, the EU has encouraged the use of biogas to produce energy, and consequently there is a need of recycling digestate as fertilizer with high content of inorganic nitrogen (Moller and Stinner, 2009). The nutrients intake by spreading digestate can be an ecological and economical alternative to inorganic fertilizers, allowing at the same time to improve soil fertility, increase the productivity and dispose of livestock waste. However, the geographical concentration of livestock in areas with little or no agricultural lands has led to manure management worries for fresh water and groundwater (Oenema et al., 2007).
This research has highlighted the virtuous pairing of the bioenergy promotion (biogas and wood energy sectors) and a correct management of digestate, with particular reference to the opportunity they offer, if used correctly, to fertilize crops, SRF or agroforestry by enabling improvement of agricultural soil processes. The experimentation was carried out in two SRF plantations: one planted with *Platanus hispanica* characterized by highly permeable soils, localized in the upper part of the drainage basin of the Venice Lagoon (called **Tezze**); and a second one planted with *Populus ibrida* (clone BALDO) placed in the low plain and characterized by low permeability (called **Monastier**).
The aims of this study are: 1) to measure nitrogen leaching in two quite diverse SRF plantations fertilized with two different amount of digestate; 2) to assess the benefit of digested slurry spread on SRF in terms of biomass growth.

Experimental sites

The two experimental sites are located in the North East of Italy: Tezze lays in the upper plain within the main recharge area of the Venice Lagoon drainage basin and the second, called Monastier, is located in the low plain.
Tezze is characterized by a loamy-skeletal, mixed, mesic soil. In the upper 90 cm the soil is a mixture of coarse and fine sediment. The groundwater level fluctuates approximately between 15 and 19 m below ground level. The experimental site consists of monoculture plot (60x50 m) of *Platanus Hispanica* (Mill ex Muench, a hybrid of *Platanus orientalis* x *Platanus occidentalis*), planted with a distance between rows of 2.5 m and a distance within rows of 2.0 m (1532 trees/ha).
Monastier has a clay soil down to a depth of 120 cm, so the water flows are very slow except during the dry season when soil fissures caused preferential flows. The planting system (*Populus* X canadensis Mönch "Baldo clone") had a density of 1125 trees per hectar.
In each of the two experimental sites, two theses with different amount of digested slurry from biogas plant were tested (Three workshops (WS) were organized between June and September 2014, in Sardinia, Umbria and Veneto with 13, 13 and 22 participants, respectively. In each WS, SHs included representatives of: a) farmers who have already experienced AF systems or farmers willing to start a new AF project; b) professional associations, farm advisors, local policy makers; and c) AGFORWARD researchers.
In the first phase of each WS, participants were invited to talk about their experience and knowledge and to reflect upon the challenges and issues of current AF systems and practices in order to bring information about their opinions and priorities (qualitative data). Then, SHs were

invited to fill a questionnaire in which several issues concerning benefits and constraints of AF systems were reported. The list of issues was grouped in the following categories: production (animal health and welfare, qualitative and quantitative productions of crops, animal and trees, etc.), management (mechanization, complexity of work, management cost, etc.), environment (biodiversity conservation, climate mitigation, landscape value, etc.) and socio-economy (income diversity, market opportunity, subside and grant eligibility, etc.). WS participants were

asked to rank each issue with positive or negative score from 1 to 10 according to their perceptions of how AF performs on each issue (quantitative data).

Data analysis
The key issues and challenges identified by SHs were analyzed as qualitative data to highlight the research topics to be addressed, and quantitative data was added by analyzing the responses to the questionnaire. As regards to the latter, the level of importance of an issue was expressed as Very Important (VI) when the score ranged between 1 and 4, Important (I) (5-7), Less Important (LI) (8-10), and Not Important (NO) when no answer was given. Different weights were assigned to each score: VI = 4; I = 3; LI = 2: NO = 1
The frequency of answers per each score class was calculated as well as the total score obtained from the sum of the frequency multiplied by the value of the relative score class. This analysis was performed in order to assess: i) the differences among the positive and negative total scores by categories of AF issues calculated in relation to the total number of participants (Kruskall-Wallis test, $P \leq 0.1$); ii) the differences among the positive and negative total scores by categories of issues calculated for each SH group, 24 farmers, 17 policy-makers, 7 researchers (Kruskall-Wallis test, $P \leq 0.05$); iii) the difference among the positive and negative scores related to each issue within the group ($\chi 2$ test, $P \leq 0.1$).).

Table 1: Experimental theses: the theoretical nitrogen amount to be spreaded in each thesis and site, soil texture within the first 90 cm.

cod thesis	N spread Kg ha^{-1}	sand %	silt %	clay %	skeleton %
TEZZE SUL BRENTA - *Platanus hispanica*					
TA0	0				
TA1	170	50	34	16	abundant
TA2	250				
MONASTIER- *Populus X canadensis Mönch (clone Baldo)*					
MA0	0				
MA1	170	0	8	92	absent
MA2	340				

Methods

Measurements on nitrogen losses have been done over the four theses and two control plots for three years, from November 2012 to October 2015. Water samples were collected at 30, 60 and 90 cm using tension lysimeters. Only in Monastier, the soil water samples were collected inside the furrow (MA1in and MA2 in) and just outside of it (MA1ex and MA2ex) (see **Figure 1**).

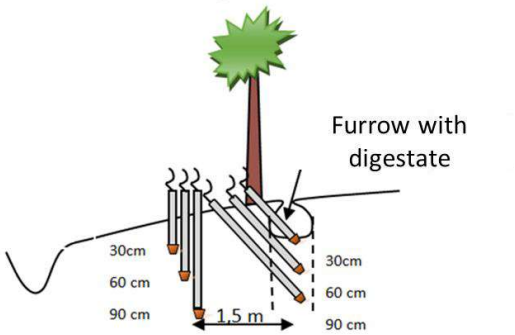

Figure 1: sampling scheme to collect soil water samples in Monastier site.

The soil water content, expressed as % of volumetric water, was registered every 30 minutes through FDR Probes (Frequency Domain Reflectometry, spectrum SM 100 waterscout soil moisture sensor) connected to a data logger (data-logging WatchDog 1000 Series Spectrum Technologies) and placed at different soil depths (15, 30, 60 and 90 cm below the soil surface).
In the Tezze site, due to the consistent presence of cobble and the high soil permeability, instead to bury the digestate in the soil it was sprinkled on the top, where the tiny superficial soil skin was slightly moved. In this way the permanence on the surface is short but at the same time the first layer, rich in fine sediment, is fully exploited. In Monastier the digestate was buried within furrows, at about 20-25 cm depth.
Only in the Tezze site the daily balance of nitrogen leached have been calculated by multiplying the daily volume of water deep seepage (at 90 cm) by the concentration measured during the sampling date considered representative for that period.
To calculate the woody biomass and the nitrogen wood content the following formula was used:
$\mathbf{Y = B_0 + B_1\,XH + B_2H}$
Y = total weight in kg of a single sucker
X = diameter at 1,30 cm
H = sucker height
B_0, B_1, B_2 = numeric coefficients of the regression.

Results

Hydrology. As a consequence of the two site locations (high and low plain) and of the quite different soil textures, the hydrology results strongly different in the two experimental sites. In all the area of Tezze, there is a quite fast vertical infiltration rate (Ks) towards groundwater, but the presence of significant content of fine sediment in the first 45 cm layer leads to a delay in the percolation time. On the other hand the clay-loamy soil in Monastier acts like a sponge, during the wet season it absorbes water increasing its volume while in the dry season due to evapotranspiration processes, the soil water content is reduced so that several cracks may form.

Nitrogen leaching. The hydrology has a strong influence on phyto-depuration processes. Such differences in hydrology dynamics affect strongly the nitrogen processes and the resulting nitrogen leaching. In the Tezze site, although a suitable method of digestate distribution was applied, the nitrogen leaching was calculated to be about 36% and 37% in TA1 and TA2 rispectively. Differently in Monastier the digestate remained confined within the furrow where it is used and transformed by plant uptake and microbial processes (Denitrification). This aspect was confirmed by the very low nitrogen concentration measured at short distance (about 1m) from the furrow where the digestate was burried (**Figure 1**).

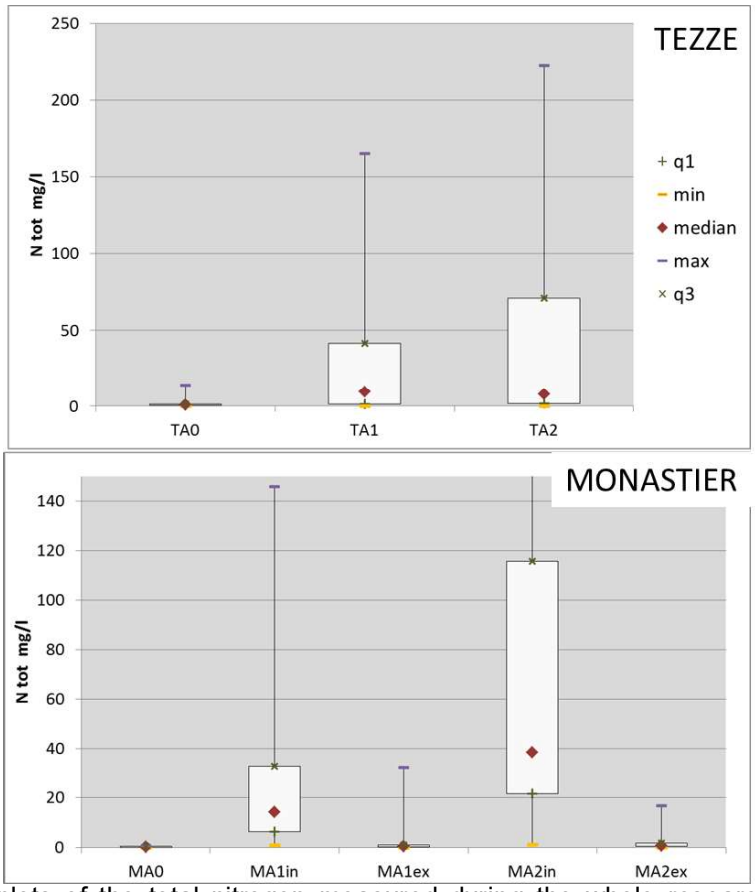

Figure 2: Box plots of the total nitrogen measured during the whole research period. Tezze theses are shown above. See below: in the Monastier site soil water collected inside the furrow (MA1 in and MA2 in) and just outside of it (MA1ex and MA2ex). See the theses cod in table 1.

Woody biomass. In the Tezze site the total fresh woody biomass estimated after 7 years was about 104 t/ha. Although the mean values showed some difference between the theses, control plot included, was not possible to argue that digestate had a significan effect on the woody biomass production, because the comparison between the theses, performed via T student test, was not significant. Monastier at the end of the research was still at his early stage, 3rd year, as a consequence it was not possible to compare the theses to see the digestate effect, anyway the fresh woody biomass estimated at the end of the study period ranged between 35 t/ha to 40 t/ha.

Conclusions

The results achieved have identified significant differences within the Venice Lagoon watershed in both the functioning and effectiveness of these productive forested systems. Policy has to interface with diversity and complexity of the territory in order to increase the effectiveness of environmental measures. These differences have a strategic importance in landscape planning and in the identification of suitable areas. It is important to focus efforts and financial incentives on areas most at risk instead of spreading them all over the territory (see PSR, Greening etc.).

References:

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