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Nitrogen Use Efficiency Of Long-Term Plantations Of *Arundo donax* and *Miscanthus* x *giganteus*

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Introduction

Perennial, no-food grasses have been proposed as the most efficient species for biomass production due to their natural resource use efficiency, agronomic, environmental and social benefits. Nitrogen requirement is a significant issue in intensive agriculture and greatly affects the energetic balance of crops. Hence, reduced nitrogen fertilizer by means of low input cropping systems could directly mitigate greenhouse gas emissions. In the present study long-term plantations of two perennial grasses (*Arundo donax* and *Miscanthus* x *giganteus*) grown in rainfed conditions under two nitrogen regimes were compared in terms of biomass yield and nitrogen use efficiency.

Materials and Methods

Miscanthus x *giganteus* and *Arundo donax* were grown at the Experimental farm of the University of Catania. *Miscanthus* was transplanted in summer 1993, while *Arundo* in spring 1997. During the first three growing seasons, both plantations received nitrogen fertilization (three-levels) and irrigation water (three-levels) (Cosentino et al., 2007; 2014), otherwise plants were maintained in no-input for the subsequent seasons and harvested only once a year in wintertime.

From 2013, in each plantation, two levels of nitrogen (as ammonium nitrate) were compared: 80 kg N ha^{-1} (N_{80}) and 0 kg N ha^{-1} (N_0).

The present study reports the biomass yield and nitrogen use efficiency of 2014/15, 2015/16 and 2016/17 growing seasons.

Aboveground biomass yield was determined on a sampling area of 20 m^2 per plot in wintertime (February).

Nitrogen use efficiency (NUE) was calculated as agronomic efficiency (kg crop yield increase per kg nutrient applied), according to Mosier et al. (2004). A two-way ANOVA using repeated measurements in time was adopted on biomass yield, while a one-way ANOVA on NUE. Duncan's post-hoc test was used for mean separation at 95% confidence level.

Results

Average yearly mean temperatures were similar among years (from 18.45°C in 2015 to 18.71°C in 2016), as well as average yearly minimum and maximum temperatures (13.5 and 23.6°C across growing seasons, respectively). Precipitations were higher than the long term trend (~550 mm) in both 2016 (765 mm) and 2017 (717 mm) and lower in 2015 (491 mm).

Biomass dry matter yield was significantly affected by the species, nitrogen fertilization and growing seasons ($P \leq 0.05$), while interactions of fixed factors were not significant. *Arundo donax* outperformed *Miscanthus* x *giganteus* in the present environment and cultivation practices applied (Figure 1).

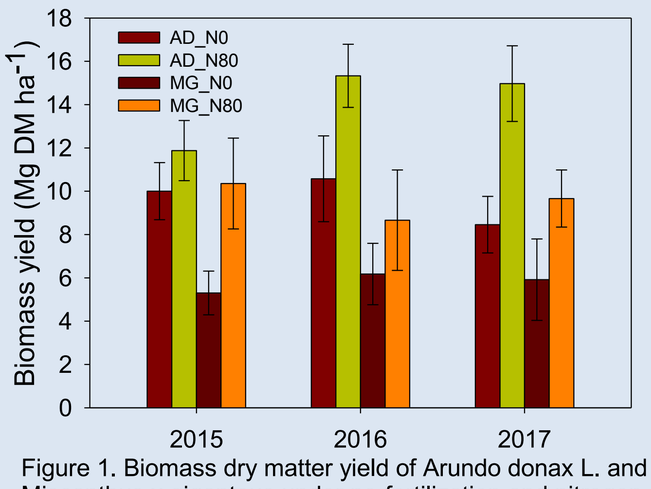

Figure 1. Biomass dry matter yield of Arundo donax L. and Miscanthus x giganteus under no-fertilization and nitrogen fertilization (N0 and N80, respectively).

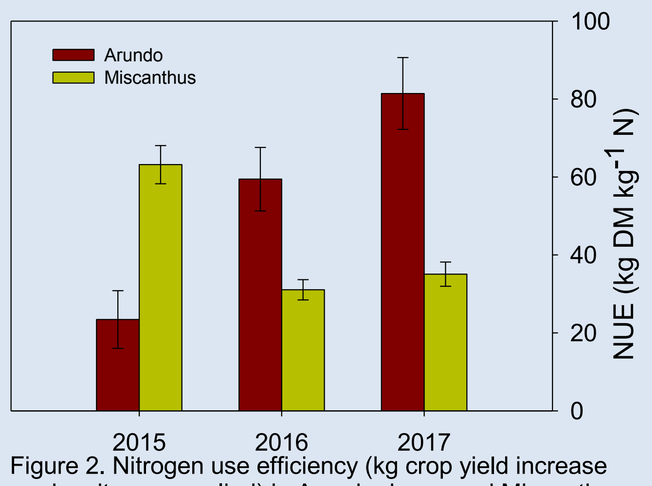

Figure 2. Nitrogen use efficiency (kg crop yield increase per kg nitrogen applied) in Arundo donax and Miscanthus x giganteus in three experimental years

Figure 2 shows the nitrogen use efficiency of both crops. The kg DM yield increase per kg of N applied was significantly affected by species and growing seasons effect, as well as by the interaction *species x growing season* ($P \leq 0.05$). *Arundo* showed the highest NUE across the average of growing seasons (54.7 kg DM kg^{-1} N), while *Miscanthus* attained 43.1 kg DM kg^{-1} N. However, while *Arundo* showed the highest NUE at the wettest growing seasons (2016 and 2017, respectively), *Miscanthus* showed the opposite trend, with maximum NUE at the driest year as compared with *Arundo* (63.1 against 23.4 kg DM kg^{-1} N). Across species, 2015 showed a significantly higher NUE (58.2 kg DM kg^{-1} N) than 2016 and 2017, which were not significantly different (44.2 kg DM kg^{-1} N, on average).

Conclusions

Arundo outyielded *Miscanthus* in both fertilization and no-fertilization treatments. Biomass yield was well related to precipitations in *Arundo*, while it seems unconnected with the yield in *Miscanthus*, likely due to the end of its lifespan. Our findings showed that NUE is maximized when water availability is abundant in *Arundo*, while *Miscanthus* showed the opposite trend, with maximum NUE at the driest. The age of the plantations might have biased NUE trend in *Miscanthus*. Further growing seasons might confirm our assumption. Given the low input requests, as water, nitrogen, pesticide, herbicides and the potential environmental benefits of its cultivation management, giant reed can be considered as a crop with high environmental sustainability in the long-term.

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