Water drainage and nitrate leaching under contrasted biomass crops

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The development of biomass crops for energy production is expected to provide significant fossil energy substitution and greenhouse gas mitigation (Sims *et al.*, 2006). However environmental impacts of biomass crops are poorly known, including the effects on water resource and quality. In this study, we have investigated the effect of contrasted biomass crops on water drainage and nitrate leaching over 4 years.

Materials and Methods

Six cropping systems with two rates of N fertilization (N- and N+, depending on species) are compared in a mid-term experiment: *Miscanthus x giganteus*, switchgrass, fescue and alfalfa in rotation, triticale and fiber sorghum in rotation. The experiment was established in 2006 in Northern France in a deep loamy soil (Ortic Luvisol). From 2007 to 2011, the mean annual rainfall was 630 mm and potential evapotranspiration was 731 mm. Soil water content (SWC) and mineral nitrogen (SMN) were measured twice a year (mid-March and early November) in 5 layers (30 cm thick) by coring down to 150 cm, each year from November 2007 to March 2011.

STICS model (Brisson *et al.*, 2008) was used to simulate SWC and SMN and calculate water drainage and nitrate leaching below 150 cm. Simulations were performed during each winter starting at the first measurement date (November used as initial data) until mid-April. We assumed that the crop had no effect on water and nitrogen dynamics during this period since plants were in dormancy. The soil nitrogen mineralization rate was calibrated in order to match the SMN profile measured in March.

Results and discussion

SWC in March was unaffected by the treatments and fairly constant between years, indicating that soil moisture was close to field capacity. SWC was lower in November and dependent on the previous crop. SMN in November was affected by the crop and N rate and their interaction. The highest SMN (mean of the 4 years) was found after miscanthus N+ (55 kg ha^{-1}) and the lowest after switchgrass N- (23 kg ha^{-1}).

Simulated water drainage was dependent firstly on crop and secondly on N rate, with a small increase for the N- treatments (Figure 1). The mean water drainage was lower for miscanthus, fescue and alfalfa than for the other crops, in accordance with McIsaac *et al.* (2010) who observed greater water consumption for miscanthus than for switchgrass and annual crops. Simulated nitrate leaching was dependent on crop and nitrogen treatments but was generally very low (2.4 kg ha^{-1} yr^{-1} on average). Nitrate losses with miscanthus were particularly high during the first winter (2007-2008) and markedly decreased during the following years, as reported by Christian and Riche (1998). This is probably due to the low development of the crop during the first year which implies low N uptake. The average nitrate concentration was also dependent on crop and nitrogen treatments (Figure 2). It ranged from 3 mg l^{-1} for switchgrass N- to 36 mg l^{-1} for miscanthus N+.

Conclusion

All perennial and multi-annual crops except switchgrass reduced water drainage as compared to annual crops. Nitrate leaching was low for all crops and treatments, except for miscanthus during the first year of measurement. Differences in water consumption must be further investigated, as well as the entire nitrogen cycle, including greenhouse gas emissions.

References

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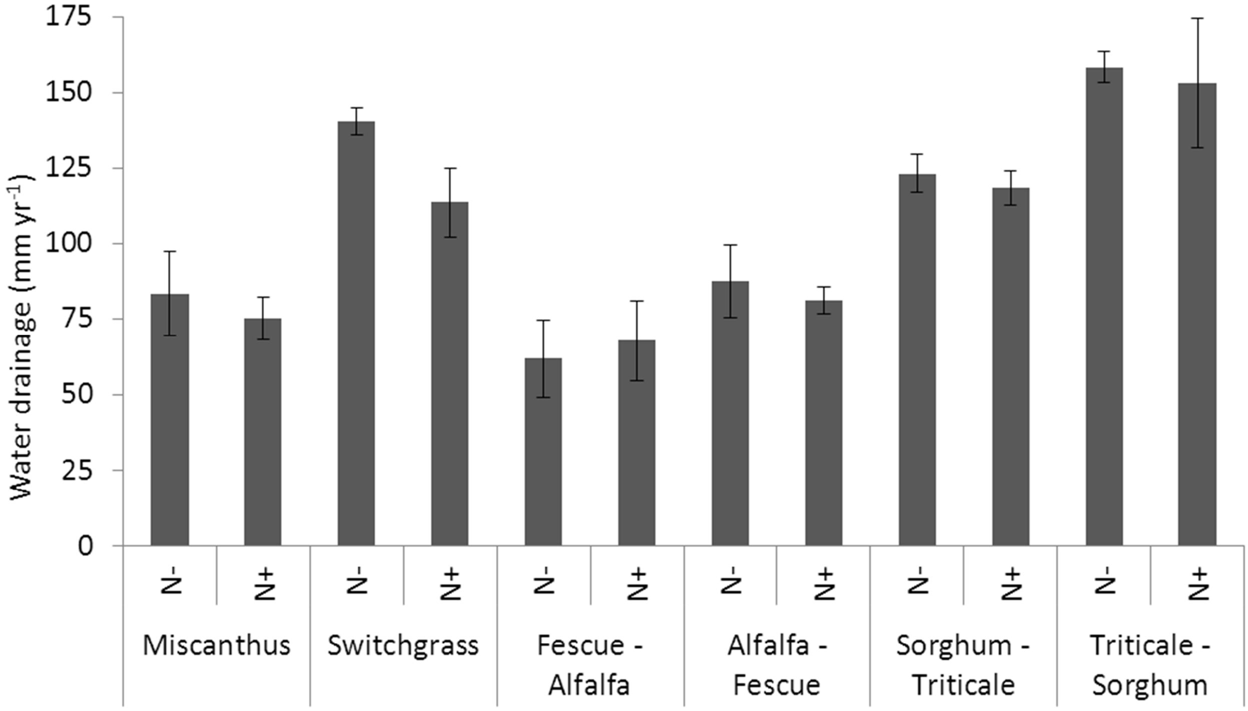

Figure 1: Simulated water drainage (mean value of the period 2007-2011) in the various cropping systems. Bars represent standard error.

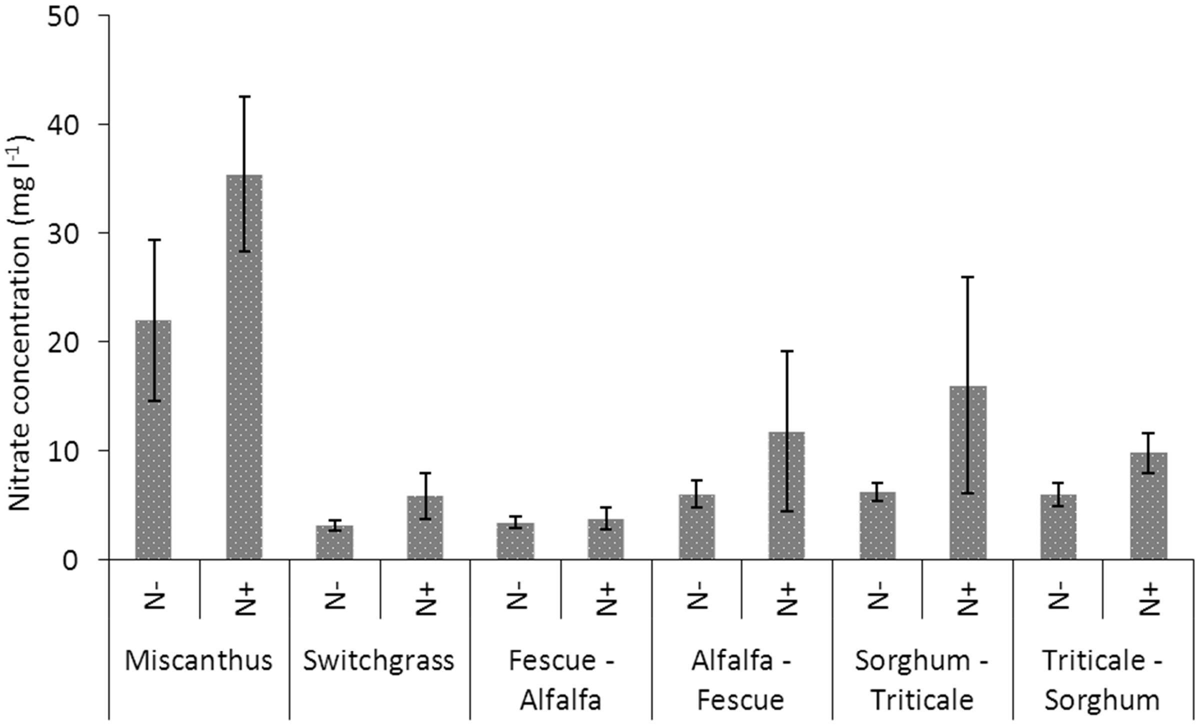

Figure 2: Simulated nitrate concentration in the drained water (mean value of the period 2007-2011) in the various cropping systems. Bars represent standard error.