Effect of Cover Crops on Nitrogen Uptake, Soil Water Content and Biomass Production in a Short Rotation Poplar Plantation

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Introduction

The agricultural production of biomass for energy-giving uses is attracting increasing interest particularly in relation to the possibility of reducing the use of fossil fuels and thereby limiting the emission of greenhouse gases. However one of the barriers to wider development of biomass energy sources is the lack of information about the environmental impacts on the landscape of increasing production of biomass crops. In the first growth phases as in the subsequent harvesting stages, the risks of erosion can become considerable due to the absence of any sort of protective canopy. In this case resorting to the use of cover crops can represent a useful agronomic measure since it provides and maintains a suitable ground covering, above all in the winter months when leaf fall exposes the soil to rain action.
The aim of the present work was to evaluate some of the agronomic effects of the planting of two different species of cover crops, the legume *Trifolium subterraneum* L. and the grass *Lolium perenne* L. in a closely spaced forestry plantation.

Methods

Field experiment set-up. The poplar grove (*Populus deltoides* cultivar LUX) was planted in March 2012 with a density of 8000 plants/ha (2.5 x 0.5 m). In the first year the natural flora was controlled mechanically by 2 cutting operations carried out in May and September. On the first of October of the same year the experimental plots (25 x 30 m) were laid out and sown with two different cover crops: *Trifolium subterraneum* L. (TS) cultivar Clare (35 kg/ha) and *Lolium perenne* L. (LP) cultivar Argo (30 kg/ha). Some of the plots were used as controls (without cover crop) and left to normal colonization of the natural flora (CO).
Study site. The plantation was located at the "Centro di Ricerche Agro-ambientali" of Pisa University situated in the lower part of the Arno valley in Tuscany, Central Italy (43° 40' lat N, 10° 19' long E, 2 m a.s.l. The soils were classified as xerofluvent according to USDA classification and presenting the following physical-chemical characteristics: clay 19%, silt 52%, sand 29%; pH 7.9, organic matter 1.5% (Walkley-Black method), total nitrogen 0.14% (Kjeldhal methods) and available P_2O_5 20.5% (Olsen method).
Data collection and processing. Samples of poplar branches and leaves from each of the experimental plots were taken every month, dried in stove and sent to the laboratory for chemical analysis. On the same dates soil samples were taken at two different depths (0-30 cm and 30-60 cm) and used to determine the soil water content gravimetrically and nitrates content. In approximate correspondence with the maximum vegetative growth of the cover crops (end of May), destructive samples were taken from each of the experimental plots and analysed for N content. The experimental design consisted of randomized blocks and means were compared using Fisher's least significant difference (LSD) test.

Results

Weed biomass in the control plots was about 0.75 t ha^{-1} dry matter, while cover crop growth was much greater: 1.79 t ha^{-1} for LP and reaching 3.46 t ha^{-1} for TS.As regards nitrogen content in the plants, it can be seen that TS gave the highest values (over 2%) compared to LP and the control, whose concentration in both cases was about 1.3%. At the end of the cultivation cycle, the legume returned more than 70 kg/ha of nitrogen to the soil (mainly biologically fixed), an amount that is decidedly greater than that returned either by LP (23 kg ha^{-1}) or by the natural flora (10 kg ha^{-1}) (Tab.1).

The return of a large amount of organic residuals rich in nitrogen to the soil led, in the plots with TS, to a significant increase in nitrates present in the shallower horizons. The concentrations measured in the three treatments were in fact significantly different on almost all the sampling dates, showing the highest values for the first (3rd June) and the fourth (27th August) sampling when values of about 6 ppm were obtained. On the contrary, LP displayed evident signs of decrease, showing significant reductions in nitrogen content with values often less than 2 ppm. These differences tended however to disappear in the underlying soil layer.

The soil water content was also strongly influenced by the type of plant cover present over the ground. In the 0-30 cm soil layer the control plot always gave the lowest values, often less than 15%, whereas the presence of the two different cover crops resulted in an increase in the soil water content which was however independent of the cover crop species. The situation is inverted however in the underlying soil horizon (30-60 cm).

The different nitrate concentration and water content of the soil gave rise to significant differences in nitrogen uptake and content in the Poplar plants. In particular the nitrogen content in both the branches and the leaves was always greater in the poplars grown on the plots with TS (with the exception of the content in the leaves on the 3rd June); whereas the treatment with LP produced lower values compared to the control even at, and subsequent to, the third sampling on the 18th July.

From the yield point of view, the two different cover crops were able to influence the production of the Poplar plantation. The conditions induced by the presence of TS in the uppermost 30 cm of soil enabled a dry matter yield of 14.65 t ha^{-1} to be achieved which was greater, but statistically equivalent, to that obtained without the help of any cover crop at all (13.38 t ha^{-1}). On the other hand the presence of *Lolium perenne* caused a significant reduction in biomass yield compared to the other two treatments, being only a little more than 10 t ha^{-1}.

	TS	**LP**	**CO**
cover dry weight (t ha^{-1})	3.46 a	1.79 b	0.75 c
cover N content (% N)	2.14 a	1.28 b	1.39 b
N uptake by cover (kg ha^{-1})	74.04 a	22.91 b	10.43 c
Populus yield (t ha^{-1})	14.65 a	10.12 b	13.38 a

Tab.1 - Dry weight, nitrogen content and corresponding accumulated nitrogen by the biomass of cover crops. A control (weeds only) case, with no cover crops, is also reported. Poplar yields in the different cover conditions are reported. Means followed by the same letter do not differ at $P<0.05$ according to Fisher's test. TS: *Trifolium subterraneum*, LP: *Lolium perenne*, CO: control.

Conclusions

The use of cover crops, apart from constituting a useful device for reducing environmental impact in the first period of SRF, may also represent a helpful strategy for driving nitrogen content in the soil and absorption of the element in plant tissues and can influence also the poplar yield.