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Nitrogen management by use of an in-season living mulch in organic cauliflower production

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Abstract: *Consumers expect that the production of organic vegetables is less harmful to the environment compared to conventional vegetable cropping. However, vegetables with a high nitrogen demand such as cauliflower may cause intensive leaching of nitrate to natural waters in conventional as well as in organic production. In addition, organic growers face difficulties in providing adequate amounts of organic fertiliser in order to attain high yields due to the scarcity of organic livestock manure. In organic cropping systems, the use of an in-season living mulch may decrease the need for fertiliser and the risk of nitrate leaching. It may also improve nitrogen nutrition for next season's crop. The aim of this study was to investigate the effect of growing an in-season living mulch of grass-clover on cauliflower yields, nitrate leaching over winter, and soil nitrogen availability the following spring. A field experiment was performed on a sandy loam soil using two varieties of cauliflower and with or without grass-clover as living mulch. The mulch consisted of an overwintering grass-clover that was incorporated in strips before the planting of cauliflower, and two levels of fertilisation (dried chicken manure) were applied. Plant samples were taken for evaluation of marketable and non-marketable yields, and for analysis of dry matter and nitrogen content. Evaluation of inorganic N-content in the soil was done at planting, at harvest, in late autumn and in spring by taking soil samples to a depth of 1.5 m. Results show that high yields of cauliflower can be maintained per meter plant row, whereas no effects on nitrate leaching could be observed in a cropping system with an in-season living mulch of grass-clover.*

Keywords: *intercropping; vegetable production; nitrate leaching; crop growth; nitrogen fertiliser*

Introduction

Most consumers expect that the production of organic vegetables is less harmful to the environment compared to conventional cropping. However, leaching losses of nitrate may be high in organic production. In order to reduce nutrient emissions to the environment, new organic cropping systems have been developed where the main crop is intercropped with an in-season living mulch. This is done to better exploit ecosystem services such as attracting beneficial insects, suppressing weeds, increasing biodiversity and decreasing nitrate losses (Kremen and Miles, 2012). In a previous study, overwintering grass-clover has been found to work well as an in-season living mulch when incorporated in rows in late autumn and root pruned (0.2 m depth) and cut aboveground before the main crop is planted in spring. The living mulch formed a "green bridge" between growing seasons over two years, while nitrate leaching was decreased, and high yields and product quality of the main crop were maintained (Thorup-Kristensen et al., 2012). However, the competition between the main crop and the living mulch poses a challenge in providing sufficient amounts of nutrients to the main crop when growing vegetables such as cauliflower, which have a high nitrogen (N) demand and a short growing season. The aim of this study was to investigate the effect of growing an in-season living mulch of overwintering grass-clover on cauliflower marketable yields and potential nitrate leaching over winter.

Materials and Methods

A field experiment was performed on a sandy loam soil at Aarhus University, Research Centre Aarslev in Denmark, as part of the Interveg-project. The experiment was laid out in a randomised block design with three replications and a plot size of 10 m x 3.2 m. Two cultivars of cauliflower (Chambord F1 hybrid, Goodman open pollinated) were grown both with and without rows of living mulch intercropped between the rows of cauliflower. The design was a substitution design where the rows of living mulch replaced every third row of cauliflower. The living mulch was an overwintering grass-clover that was incorporated in strips (the crop + living mulch system: C+L) or fully incorporated (the sole crop system: S) in December 2012 in both systems. The rows of living mulch were cut aboveground and root pruned below ground (0.2 m depth) before planting the cauliflower to control interspecies competition (Båth et al., 2008). The cauliflower was planted 31. May and harvested from 3. until 20. August 2012.

The plots were fertilised with two different levels of dried chicken manure. The amount of fertiliser was adjusted based on the inorganic N found in the soil at planting and in June to a total of soil inorganic N of 240 and 290 kg N ha^{-1}.

After harvest the living mulch was left to grow until spring. Plant samples were taken for evaluation of marketable and non-marketable yield, and for analysis of dry matter and N content. Soil samples (to 1.5 m depth) were taken to evaluate the inorganic N content at planting, harvest (23. August), late autumn (20. November), and spring (April 2014). The field experiment was conducted according to the rules of organic management which exclude the use of inorganic fertilisers or pesticides. Insect nets were used for pest management.

Results and Discussion

The results showed that high marketable yields were obtained of 19 and 12 Mg ha^{-1} in the S and C+L systems, respectively. The lower yield of the C+L system was caused by the fact that every third crop row was replaced by a row of living mulch. When calculated per meter row, there were no differences in marketable yields or total biomass production between the two systems. The fertiliser treatments had no effects on yield or harvest quality, which showed that the lower level was sufficient to obtain optimal yields. The yield results for cultivars were not unequivocal. Soil inorganic N levels were higher in the S system at planting compared to the C+L system with levels of inorganic N in the top soil of 15 and 9 mg N g^{-1}, respectively. The levels decreased gradually in the 0.3-1.5 m soil layer to 1 mg N g^{-1} in both systems. At harvest inorganic N-levels in the soil were similar for both the S and the C+L systems, and for both fertiliser treatments. Inorganic N-levels varied in the range of 2-6 mg N g^{-1}. The highest concentrations of mineral N were found in the top soil layer and decreased with increasing depth. In late autumn there were no differences in N-levels between both cropping systems. Neither were there differences between both levels of fertilisation. The levels of soil inorganic N varied in the range of 4-7 mg N g^{-1} (Figure 1). Thus contrary to the expected, there was no effect of growing an in-season living mulch of grass-clover on soil inorganic N content.

Conclusion

In an organic cropping system, and using an intercropping with an overwintering living mulch of grass-clover, high yields and quality can be obtained in an N demanding and short seasoned crop like cauliflower. However, the use of a substitution design where every third row of cauliflower was replaced by a row of living mulch significantly reduced the yield per hectare, which was not compensated by increased marketable yields per meter row. Fertiliser levels could be reduced to 240 kg N ha^{-1} without jeopardizing yields. Also, there were no clear effects of the living mulch on the potential nitrate leaching during winter. The results of this trial can be used for further development of organic cropping systems including living mulches using ecosystem services for the benefit of organic vegetable production and the environment.

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Effect of fertiliser and cropping system on soil inorganic N in late autumn

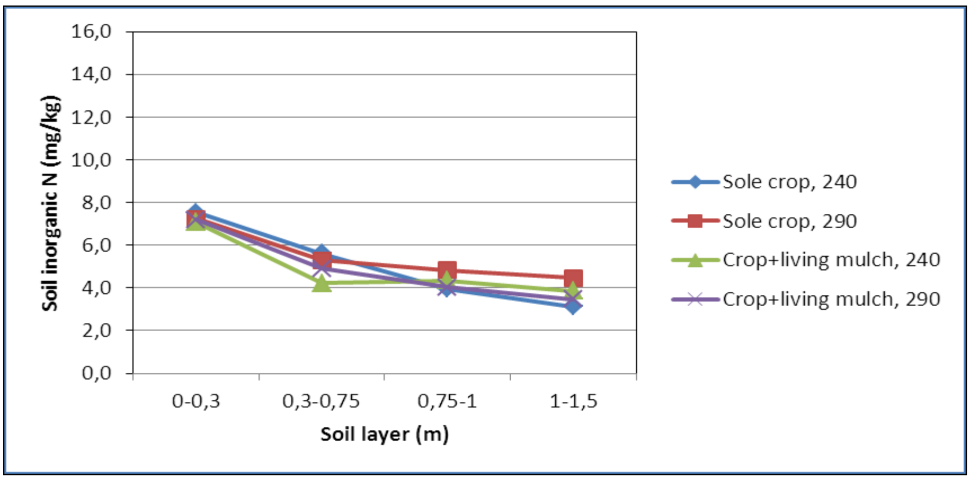

Figure 1 Soil inorganic N in November at the start of the leaching season under a sole crop of cauliflower or cauliflower intercropped with a living mulch of grass-clover at two levels of fertilisers (240 and 290 kg N ha^{-1}).