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DOMINO – Synthesis of Soil Management Strategies Integrating Plant and Waste Based Alternative Fertilizers

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Abstract

The project DOMINO (http://www.domino-coreorganic.eu/) focused on the evaluation of alternative fertilisers based on locally available wastes, legume-based materials and vermicompost extracts as alternatives to animal-based fertilizers from conventional agriculture in apple orchards. The project included incubation experiments, pot and field experiments in different European countries. In addition, a survey on nutrient budgets and soil nutrient status in organic fruit orchards was conducted in Germany. The evaluation of the fertilizers encompassed also their impact on soil nematodes and microbial activity and biodiversity. Considering all pros and cons, there is no single ideal solution for fertilization. An integrated approach using fertilizers based on legumes in combination with stillages that provide N early in the season can enhance farm internal N cycles leading to an overall higher N efficiency.

Keywords: contentious inputs, clover-based fertilizers, nutrient budgets, organic apple production

Introduction

The project DOMINO - Dynamic sod mulching and use of recycled amendments to increase biodiversity, resilience and sustainability of intensive organic fruit orchards and vineyards (http://www.domino-coreorganic.eu/) - focused on the evaluation of alternative fertilisers based on locally available waste materials (composts, biogas digestates, stillages), legume based materials (clover-grass pellets, silage from clover grass, green manure from peas sown at different dates) and vermicompost extracts as alternatives to commonly used animal based fertilizers from conventional agriculture like horn grit, dried manure and stillage. Even though the latter fertilizers are permitted for use in organic farming according to the current EU Regulation on Organic Food and Farming (European Commission, 2008) they are considered to be contentious inputs that should be phased out (BioAustria, 2014, Demeter e.V. 2021, Oelefse et al. 2013). Intensive organic fruit production systems often depend strongly on external fertilizers as practices such as rotations with legumes that are common in organic arable farming are not possible. In addition, intensive fruit farms are often specialized farms without animal husbandry and thus have no access to internal fertilizers like animal manures. Moreover, first screenings of nutrient budgets of organic apple orchards (Alber et al. 2020, Möller & Zikeli 2020) showed that current nutrient management in intensive organic fruit orchards may lead to nutrient imbalances adding an additional need to revise current fertilization strategies. The project DOMINO took up these research questions and worked on apple as the target crop. This short communication gives an

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overview on the most important outcomes of the project and synthesizes the potential of the different alternatives for phasing out unwanted commercial fertilizers in organic fruit growing.

Materials and Methods

The assessment of the different regionally available alternative fertilizers was carried out in the different partner countries (Bulgaria, Germany, Italy, Poland and Switzerland). Different methods were used to assess the fertilisation effects: comparing mineralization rates with incubation experiments, testing the fertilizers effect on plant growth, nutrient level and yield (only in field experiments) with pot experiments in Italy and Switzerland as well as in field experiments in Bulgaria, Germany and Poland. In addition, a survey on nutrient budgets in organic fruit orchards was conducted in Germany, which included soil analysis for the main nutrients. The evaluation of the fertilizers encompassed also their impact on soil microbial activity and biodiversity as well as nematodes trophic groups community's composition.

Results and Discussion

In the incubation trials, biogas digestates and yeast stillage released N at a fast rate, thus making them suitable to match early season nutrient demand by trees. Other fertilizers like composts and clover pellets, but also the commonly used horn grit, showed a slow N release. In case of clover grass silage and mushroom wastes an immobilization of mineralised N occurred (data not shown). In the pot trials, biogas digestates and stillage confirmed having the fastest and highest N mineralization rate. However, in Italy, at Laimburg, two different biogas digestates with different C/N ratios lead to different patterns in N release (data not shown). The N mineralization of peas as green manure was low and delayed. Application of both clover-grass pellets and fresh white clover first resulted in a nitrogen immobilization followed by a slight nitrogen release.

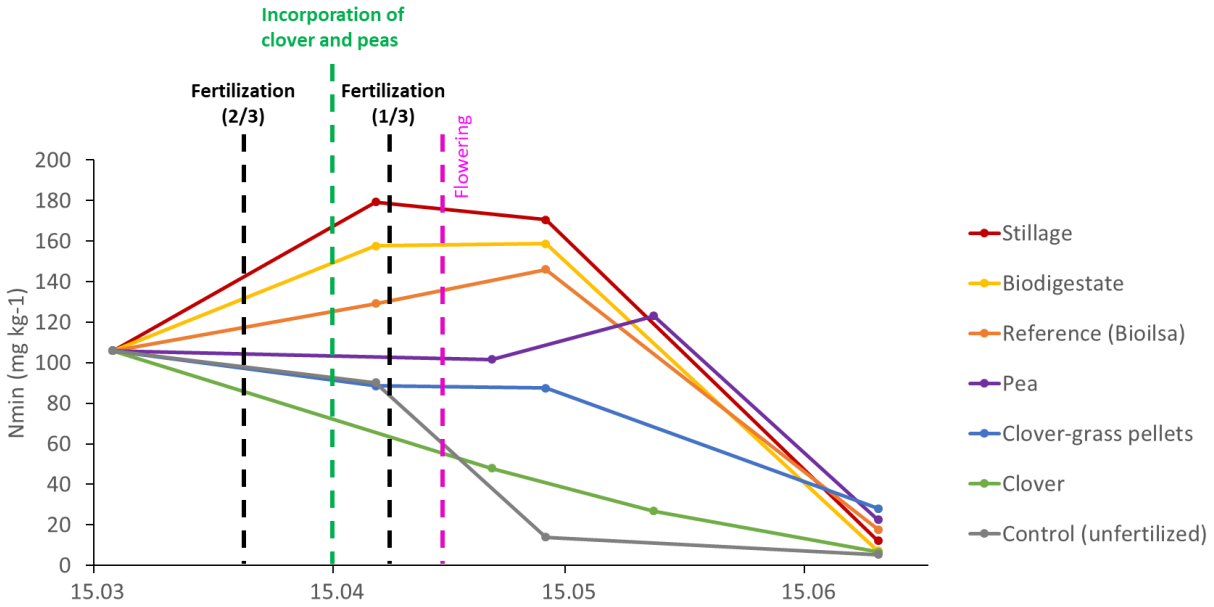

Fig. 1. Soil N_{min} contents measured in the pot trials for the alternative fertilizers tested at FiBL, Switzerland (split application of fertilizers (three weeks and four days prior to full bloom); Pea: directly sown into the pots on the 18.03.21, White clover: was sown on the 20.02.21, peas and white clover were incorporated in the soil when BBCH 39 was reached for each

In field trials, the pedo-climatic conditions of the different trial sites in Bulgaria, Germany and Poland affected nitrogen release. However, in general a pattern overlapping with that of microcosm and pot trials was observed: N release from silage and clover pellets was slower compared to the release from biogas digestates, vermicompost solution and control

materials such as horn grit and stillage. These results underlined the challenges in developing fertilization strategies to match the trees' N demand at flowering. Even though no differences were found in yield in all trials, the survey of the orchards in Germany showed that the highest surplus occurred for Ca and S. If inputs of base fertilizers (manure, compost) were high, surpluses of Ca and K turned out, while for the farms relying on commercial fertilizers, K deficits occurred. The yeast stillage and biogas digestate resulted to increase both microbial activity and biodiversity as well as the nematodes populations. However, a modification of the composition of trophic groups was generally transient during the seasons.

Considering all pros and cons, we concluded that there is no single ideal solution for a correct fertilization of organic apple orchards. However, an integrated approach using fertilizers based on legumes (clover grass silage, clover biomass from the inter row or peas mulching on the row) in combination with stillages or biodigestates, that provide nitrogen early in the season, can enhance farm internal N cycles leading to an overall higher N efficiency in organic fruit growing systems.

In addition, the effect of the fertilization on nutrient balances has to be taken into account. This can only be achieved if different fertilizers are used within a single growing season and/or during several years. The use of recycling products from external (urban) sources like biogas digestates or composts requires additional caution in order to reduce the risk of soil contamination. To solve this problem, quality control systems are in place in many European countries that minimize such risks.

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