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Short Communication

Nutrient budgets and new fertilisation strategies in organic apple cultivation

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Abstract

Organic apple production depends on external inputs by fertilisers and pesticides. These contain multiple nutrients that not necessarily match the offtakes of the apple trees and thus lead to nutrient imbalances in the system. In the DOMINO project data was collected on fruit farms in four apple producing regions in Germany with the goal of examining the current status on nutrient budgets. Furthermore, alternative fertilisers (biogas digestates, compost, clover grass products and peas) were tested in a field trial in an organic orchard to develop more sustainable fertilisation strategies by improving nutrient balances while at the same time phasing out contentious inputs (e.g. fertilisers of conventional origin like horn grit and vinasse from sugar beet production).

Current strategies showed moderate nutrient imbalances depending on type of fertilisers used, with K deficits and the highest oversupply of Ca and S, the latter mainly resulting from pesticides. While showing no significant differences in the yield level, the tested alternative fertilisers did not result in a balanced nutrient supply and led to high deficits in K, similar to the current fertilisation strategies. Biogas digestates resulted in a more balanced nutrient supply compared to all other alternative fertilisers. To mitigate one-sided nutrient imbalances, several fertilisers should be alternated in the fertilisation strategies either in one vegetation period or in consecutive years. N mineralisation in the soil was highest in the treatments with peas, horn grit and biogas digestates, the lowest values were found in silage and the unfertilised control. No significant yield differences were found despite different patterns of N release indicating the low N requirements of apple orchards. However, further trials are necessary to improve the match of N release from alternative fertilisers and the trees' nutrient demands.

Keywords: Nutrient input, output, organic apple production, sustainability

Introduction

Organic apple cultivation is an intensive perennial system relying on external inputs via fertilisers and pesticides. All fertilisers permitted in organic farming (base fertilisers like compost or manure and commercial fertilisers like keratin products) contain multiple nutrients with compositions different from that of the crop (Möller & Schultheiß 2014). Additionally, some pesticides also contain nutrients like K, Ca and S that enter the system. This may lead to nutrient imbalances. Furthermore, commonly used external fertilisers like horn grit, feather meal or vinasse are often categorized as "contentious" and thus are discussed to be phased out since their origins are conventional animal husbandry or food processing of conventional inputs (Oelefse et al. 2013).

In the project DOMINO (http://www.domino-coreorganic.eu/) research has been done to answer the question a) how is the current status of fertilisation on fruit farms with regard to nutrient budgets and their effect on soil nutrient status in Northern and Southern Germany

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and b) which fertilisers can substitute contentious inputs and at the same time improve sustainability by a more balanced nutrition of organically managed orchards.

Material and Methods

Semi structured interviews on fruit farms were done in one fruit producing region in Northern (Altes Land region near Hamburg) and three regions in Southwestern Germany (Lake Constance, Freiburg and Neckar region). Data of five consecutive years of up to five orchards per farm on the inputs by fertilisers and nutrient containing pesticides and the output by harvested apples was collected. The nutrient budgets were calculated on field level as (Eq. (1)):

$$Budget\ [kg\ ha^{-1}a^{-1}] = Input\ (by\ fertilisers\ and\ pesticides) - Offtakes\ (by\ harvested\ apples) \quad (1)$$

Soil samples from the upper layer (0-30 cm) were analysed on soil extractable P and K (CAL-extract), Mg ($CaCl_2$-extract) contents as well as pH ($CaCl_2$).

To test the alternative fertilisers for their suitability for apple production, a field trial was carried out at the Competence Centre for Fruit Growing, Lake Constance (2018 – 2020) in an organically managed apple orchard (cv. Santana on rootstock M9, planted in 2014). Recycled fertilisers (biogas digestates, compost) and legume based fertilisers (clover grass silage, clover grass pellets and peas sown into the tree row) were compared to horn grit, vinasse and the unfertilised control. All fertilisers were applied with an N amount of 25 kg ha^{-1} which is the typical fertilisation level in the region. Analysis was done on soil mineral N, nutrient content in leaves, fertilisers and apples, fruit quality, yield and tree growth. Since plant protection via fungicides was carried out equally for all treatments and S (besides Cu) was the only nutrient given via pesticides, the nutrient budgets for the field trial did not contain the pesticides and were calculated as (Eq. (2)):

$$Budget\ [kg\ ha^{-1}a^{-1}] = Input\ (by\ fertilisers) - Offtakes\ (by\ harvested\ apples) \quad (2)$$

Results and Discussion

The management practices differed among the four regions with regard to S input, which was highest in Altes Land and lowest in Freiburg, and in the usage of base fertilisers like compost or manure, with highest amounts in Altes Land.

The field budgets showed imbalanced nutrient flows with highest deficits in K, a slightly positive P balance and higher oversupply of Ca and S (Table 1). The management strategies had an overall acidifying effect mainly caused by the large S inputs via pesticides. The higher the amounts of base fertilisers, the higher the field budgets for Ca, Mg, K and P, while the use of commercial fertilisers (like horn grit and vinasse) lead to a K deficit. The budgets were not reflected in the soil nutrient contents, possibly because of differing initial soil conditions of the different farms at conversion to organic farming.

Table 1: Field nutrient budgets and liming effect (calculated as CaO demand) of apple farms in kg ha^{-1} in the four apple growing regions Lake Constance (n=5), Freiburg (n=6), Neckar (n=4) and Altes Land (n=4) calculated as nutrient input (fertilisers and pesticides) – nutrient offtakes (harvested apples), mean values over five consecutive years.

	N	P	K	Ca	Mg	S	Na	Cl	Liming effect
Lake Constance	35.2	1.6	-10.4	48.2	5.8	61.3	6.1	1.2	-56.8
Freiburg	19.1	1.8	-4.0	22.6	2.0	29.8	0.6	2.7	-41.8
Neckar	19.5	1.1	-6.9	31.6	1.8	53.4	4.7	2.9	-72.8
Altes Land	36.3	8.7	4.4	59.4	8.3	94.5	7.9	6.3	-109.1

In the field trial, the highest N_{min} values were measured in the treatments with peas, horn grit and digestates. The lowest values were found in the unfertilised control and in the silage treatment; silage and compost material showed the highest C:N ratios of 18:1 and 15:1, respectively. Although the mineralisation pattern differed, no significant differences occurred in the yield among all the alternative fertilisers and the control treatments, with only a tendency to lower yields in the peas and silage treatments. The alternative fertilisers could not balance the nutrient inputs and outputs, still resulting in high K deficits. When comparing all fertilisers, digestates revealed the most balanced overall budgets (Table 2).

Table 2: Nutrient budgets of the different treatments in the field trial, calculated as nutrient input (fertilisers) – nutrient offtakes (harvested apples), mean values of 2019 + 2020, n=4.

	N	P	K	Ca	Mg	Na
	kg ha^{-1}					
Unfertilised control	-27.8	-4.6	-59.7	-3.0	-2.4	0.0
Horn grit	-2.9	-4.3	-59.6	-2.1	-2.3	0.3
Vinasse	-3.7	-3.7	-31.3	-1.9	-2.2	10.8
Digestates	-1.9	0.9	-22.6	6.8	0.4	3.2
Spring peas	-0.3	-1.7	-48.7	-2.2	-1.4	0.0
Winter peas	-0.4	-0.9	-47.6	-2.1	-1.4	0.0
Clover grass pellets	-2.6	-2.1	-43.8	6.4	-0.5	0.3
Clover grass silage	-0.6	-1.2	-34.4	10.7	0.5	0.0
Compost	-2.0	0.4	-37.2	93.7	9.4	1.3

As shown in the field budgets of the fruit farms, current fertilisation strategies lead to moderate nutrient imbalances in the orchards and none of the alternative fertilisers tested in the field trial offers perfect strategies. Achieving the goal of a more balanced nutrient management in intensive apple orchards thus remains challenging. In terms of yield performance, all alternative fertilisers can be recommended for apple production. To mitigate one-sided imbalances we would recommend using various fertilisers, especially focussing on a higher K supply in the long term. However, fertiliser availability and applicability in the region are decisive conditions, next to the price of the fertiliser and the competition with usage as feed (e.g. peas, silage).

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Citation of the full publication

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