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Short Communication

N supply by row and inter row management with legume intercrops in an apple orchard

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Abstract

Intensive organic apple production faces a number of challenges with regard to a sustainable fertilisation management, like the replacement of fertilisers of conventional origins (e.g. horn grit) and the integration of biological N_2 fixation into a perennial system. A trial was done at the Competence Center for Fruit Growing Lake Constance for two years (2020 – 2021) to test the integration of legumes into the orchards, that either fix N in the orchard (clover) or deliver already fixed N into the orchard (via pea seeds), and to assess their effect on N mineralisation and nutrient supply. Two clover varieties (micro and white clover) were sown in the inter row. Before mulching the inter row, the amount of biomass was measured and the nutrient content was analysed. The first cut of the season (in May) was transferred to the tree row. Peas were sown into the tree row in October and mulched in March. N_{min} in the soil was analysed at five to six dates per year.

Due to dry weather conditions after seeding, the clover had difficulties to establish in the orchard and had to be seeded twice. After establishment, the area covered by clover decreased again in the second trial year. With the first biomass cut approx. 20 kg N, 4 kg P, 30 kg K, 7 kg Ca and 2 kg Mg per ha were transferred to the tree row, with micro clover delivering less biomass than white clover. While N_2 fixation by clover adds N to the system, it has to be considered that nutrients like P and K are transferred from inter row to tree row and thus create spatial differences in soil nutrient concentrations between the tree row (nutrient enrichment) and the inter row (nutrient depletion). N_{min} values in the soil did not reflect the N transfer via the biomass, since they were rather low in the two clover mulch treatments, compared to high N_{min} values in the pea treatments and the horn grit. The supply of trees with readily available N by peas was higher due to their lower C:N ratio of 12 compared to 21 in the inter row biomass. N (25 kg) and P (3 kg) inputs by peas were similar to the biomass cuts, at the same time the peas provided smaller amounts of K (8 kg), Ca and Mg (<1 kg). The combination of peas and inter row mulch serves the goal of providing quickly available N as well as other nutrients like K, however, with the risk of depleting the inter row.

Keywords: Organic apple production, fertilisation, clover, mulching, internal nutrient supply.

Introduction

Organic apple production systems are intensive perennial systems. Therefore, it is difficult to implement strategies for nutrient management frequently used in organic farming like crop rotation with legumes for nitrogen fixation. Another challenge is the substitution of commonly used fertilisers of conventional origin (e.g. horn grit), as they are categorized as “contentious” and consequently are discussed to be phased out (Oelefse et al. 2013). To test the integration of legumes (clover and peas) into the perennial system of intensive apple cultivation and assessing their effect on N mineralisation and nutrient supply, a trial was set up at the Competence Centre for Fruit Growing, Lake Constance (KOB).

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Material and Methods

The trial was conducted in the years 2020 – 2021 in an organic apple orchard with the variety Santana on rootstock M9. White clover (*Trifolium repens* var. Liflex) and micro clover (*Trifolium repens* var. Euromic) were chosen as legumes to fix N in the orchard. They were seeded on a width of 80 cm at the center of the inter row (2 g m^{-2}), while leaving the tracks close to the tree row for the existing vegetation (mainly grasses and herbs) in order to ensure trafficability. Winter peas (variety E.F.B. 33) were selected as grain legumes to bring previously fixed N into the orchard. They were sown into the tree row in October (740 kg ha^{-1}, which was 25 kg N ha^{-1}) and mulched in March of every trial year. The treatments "micro clover mulch", "white clover mulch", "white clover mulch and peas" were compared to "only peas in the tree row", horn grit (25 kg N ha^{-1}, applied in April) and an unfertilised control. The treatments were repeated three times, with 10 trees per plot. Before each cut of the inter row biomass, the ratio of ground cover by herbs, grasses and legumes was estimated in the inter row and biomass and nutrient content were measured in all inter row cuttings of each season. The first biomass cut took place at the end of May and was placed into the tree row. The remaining two to three cuts during the year were not transferred to the row and were left in the inter row. Soil samples (0 – 30 cm) were taken in the tree row five to six times each year for N_{min} analysis.

Results and Discussion

The establishment of the clover in the middle of the inter row was not as successful as expected. The first seeding took place in September 2018, but due to dry conditions during germination and plant establishment, seeding had to be repeated in May 2019. After a more stable growth 40 – 50 % of the area of the central 80 cm of the inter row was covered by clover in May 2020, but decreased to 10 – 20 % in the following year. In both treatments, clover was mostly replaced by grasses. Micro clover provided slightly less biomass than white clover. By the first cut in 2020 potentially 16 to 20 kg N per ha were transferred from inter row to tree row via micro and white clover, in addition to 25 to 30 kg K, 3 kg P, 6 kg Ca and 2 kg Mg per ha. In 2021, the first cut contained 21 to 25 kg N per ha, next to 34 kg K, 4 kg P, 7 kg Ca and 2 kg Mg. Mean values of the two years are shown in Table 1, as well as the nutrient input via peas.

Table 1: C:N ratio and amounts of nutrients in the first biomass cut (end of May) of the inter rows with micro and white clover, transferred to the tree row, and in the peas, seeded in the tree row in October of the previous year (mean of 2020 and 2021).

	C:N	N	P	K	Ca	Mg
		kg ha^{-1}				
Micro clover	22.3	18.5	3.44	29.4	6.15	1.65
White clover	20.8	22.0	3.73	31.7	7.04	1.79
Peas	11.9	25.0	3.36	7.5	0.49	0.88

N_{min} contents were highest in the treatment "white clover and peas", "peas" and horn grit. Clover mulch only resulted in low values of N_{min} during the time of the trial, possibly due to higher C:N ratios and thus a delayed fertilisation effect.

Establishing a pure clover crop in the inter row is unviable at the location of KOB. Nevertheless, even with the current vegetation (grasses, herbs and small numbers of legumes) in the inter row, high amounts of N and other nutrients could be translocated by transferring the inter row biomass to the tree row. While the N_2 fixation by clover adds N to

the orchard system, it has to be considered that the nutrient transfer (of P, K, Ca and Mg) creates spatial differences in soil nutrient concentrations between the tree row (nutrient enrichment) and the inter row (nutrient depletion). Application of peas adds other nutrients in addition to N to the system. Therefore, the field budget e.g. for K would be higher than in the clover treatments, while at the same time peas provide less K for the trees than the clover cuts. By the peas similar amounts of N were given to the trees, yet these were more efficient in supplying quickly available N than the biomass cuts. In conclusion, a combination of peas and inter row mulch serves the goal of quickly available N for the trees as well as providing other nutrients like K, however with the risk of depleting the inter row.

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