CORE organic DOMINO

DELIVERABLE N. 3.3 - 4.3 – 4.6

DYNAMIC SOD MULCHING AND USE OF RECYCLED AMENDMENTS TO INCREASE BIODIVERSITY, RESILIENCE AND SUSTAINABILITY OF INTENSIVE ORGANIC FRUIT ORCHARDS AND VINEYARDS

YEARLY REPORTS OF CROPS' YIELD AND QUALITY DATA AS INFLUENCED BY SOIL MANAGEMENT
YEARLY REPORTS OF SOIL ASSESSMENT DATA
YEARLY REPORTS OF CROPS' NUTRITION DATA

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Work package 4: Report on Soil and Plant Nutrition Data 2019

The partners University of Hohenheim (UHOH, Germany, coordinator of the work package (WP), INHORT (Institute of Horticulture, Poland), LAIM (Research Centre Laimburg, Italy) and FGI (Fruit Growing Institute, Bulgaria) are involved in WP4. In designing the field trials in this WP, each partner (FGI, INHORT, UHOH) focuses on alternative fertilizers and waste materials present in the different regions of the trial location. In addition, each partner uses a control plot with zero fertilization and a plot fertilized with horn grit as a control. The amount of N applied in the trials depends on the productivity / yield level of the apple production system in the different countries / regions. The partner LAIM performs incubation experiments in microcosms and pot trials to gain a better understanding on the N dynamics of the fertilizers used by the partners and open field pot trials with selected fertilizers.

Most important outcomes of the trial year 2019 provided by the consortium partners in WP4

FGI

The trial takes place on private farm at Plovdiv region (42°03' N and 24°32' E and 184 m above the sea level). The experimental apple orchard was established in March 2016, with a spacing 3,50 x 1,25 m, varieties "Golden B" and "Granny Smith"/M 26, spindle training system, drip irrigation, natural grass strip in the interrow. The apple orchard is covered with anti-hail net (mesh size 7x4 mm).
The season during 2019 was very dry – in April, May, August and September the precipitations were less than 5 mm. The relative humidity in August-60% and about 70% for April, May, July. The objective of the trial is to assess the influence of horn grit, the fertilizer "Lumbreco", and of cover crops (white clover interrow; forage pea interrow; forage pea in the tree row) on vegetative and reproductive behavior of apple trees. The horn grit at N 25 kg $ha^{-1}$and zero fertilizer application were used as control. The liquid "Lumbreco" (1liter concentrate + 150 liters H_2O) in 10 liters of solution per tree was applied in two times in BBCH stage 53 and 75 for a total of N 25 kg ha^{-1}.

Soil sampling was done before the beginning of vegetation period at a depth of 0-15 cm and of 15-30 cm for macro and micro nutrients. Leaves were sampled in in July and August after the end of the vegetative growth.

Soil and leaf analyses showed several differences and will be discussed and presented in the next report.

For the variety "Golden B" the optimum picking date was determined for 9th of September, 2019, by penetrometer for a firmness of fruit flesh of 7 kg cm^{-2}. The color was determined by using the color chart of the CTIFL/ INRA, iodine test was used for starch content, and the determination of °Brix was done by refractometer. The optimal picking date for the variety "Granny Smith" was determined for the 8th of October 2019 by penetrometer for a firmness of 7.5-8.0 kg cm^{-2} and by using the other tests mentioned above.

For "Golden B" yield ranged from min 16.7 t ha^{-1} to 19.6 t ha^{-1} and for "G. Smith" between 12.7 t ha^{-1} and 24.8 t ha^{-1}. The yield was generally low because frost occurred on the 29th of March and three times during first decade of April.

The stem diameter of "Golden B" was largest for forage pea in the tree row and lowest for white clover in the inter row. In "G. Smith" the largest stem diameter was for horn grit and the lowest for the white clover in the interrow and the unfertilized control.

INHORT

In 2019, the trial on testing alternative fertilizers established in an organic apple orchard of "Topaz" was continued applying the same treatments (horn grit, dry animal manure, clover-grass pellet, stillage (vinasse) and liquid biodigestate residues). The same level of fertilization was applied (70 kg N/ha), distributing the fertilizers in the tree strip on the first half of May.

Samples to verify the impact on soil biodiversity were collected and analysed to study the dynamic of microbial (bacteria and fungi) and microfauna (nematodes) populations useful to assess the effect on biodiversity (see WP6). Data about yield was collected at harvest, but the results have been affected by the late spring frost, which has damaged the blossoms, and the dry summer, thus not making them representative of the treatments (no differences between treatments).

A second trial testing the inoculation with a P-solubilizer rhizobacterium and mycorrhizal fungi was also established starting from plants initially inoculated in the nursery during 2018. In this trial the

management of the row with micro clover was also associated to the microorganisms' inoculation. Data about plant growth and roots mycorrhization were collected.

One trial was established in a commercial orchard (Task 4.2) testing the use of the micro clover for inter-row management. Some data about the effects on above ground fauna (mainly pests) have been collected that could be useful for the assessment of impact on biodiversity (WP6). Interestingly, the farmer was quite surprised by the results he experienced for the capacity of micro clover in suppressing weeds growth.

LAIM

In May 2019 LAIM started the open field pot trial, where some of the substances selected from the previous laboratory trial were tested. Two digestate, two stillages, the dried peas and the clover pellets were tested on Gala Schniga SchniCo Red (rootstock M9) and compared with two organic approved fertilizers and with an untreated control. The trial was located near the Laimburg Research Center (Vadena – BZ, Italy) and will last for two years. The goal is to simulate an input of 8 grams of nitrogen per tree, equivalent to 30 kg N ha^{-1}, and to observe how fast the organic nitrogen is mineralized and how much mineral nitrogen is released by the different products. The organic fertilizers application was split for three dates: three, five and eight weeks after the tree planting, to avoid possible root damages caused by the excess of nitrogen. The peas were sown three weeks after the tree planting and cut after five and seven weeks. The soil sampling for the N_{min} analyses was done ten, twelve and sixteen weeks after the tree planting. The first sampling showed that all the fertilizers, compared to the untreated control, markedly increase the N_{min} availability. Furthermore, no significant differences were found when the tested organic products were compared to the two commercial fertilizers, whereas peas reached 125 mg of N_{min} kg^{-1} of soil, a significantly higher content than all the other fertilizers. During the second extraction the situation remained similar, no major differences were observed between all the organic fertilizers, but the amount of mineral nitrogen decreased between 36 and 63% compared to the first extraction. Again, the N_{min} peak was reached by peas, markedly higher than all the other substances. The third extraction was more heterogeneous: the two digestates and the stillages were not significantly different from the untreated control, while peas, clover pellets and the two commercial fertilizers significantly differ from it. Moreover, clover pellets were the only

fertilizer that kept the same level of nitrogen as in the previous extraction, but the highest value was reached again by the peas.

The results obtained are positive, as all the tested substances mineralized well and significantly increased the N_{min} level of the soil. Interestingly, peas led to a pronounced increase of the soil N_{min} level, reaching sometimes more than +50% if compared with the other fertilizers.

It is worth to notice how in June 2019 the trench dug in order to protect the trees from possible heatwaves remained flooded for almost one week and caused serious damages to ten trees. We still decided to carry on the trial because a) until June only the first fertilizer application was performed, thus even if possible N losses occurred they were limited to one-third of the total N input, b) the first N_{min} analysis highlights differences between the treatments and acceptable standard deviation/error between the treatments. To further confirm the first year results the trial will be carried out until the end of 2020.

UHOH

In March 2019 interviews with farmers in the region "Altes Land" near Hamburg were done to collect data on the nutrient budgets of the last five years for field balance assessment, together with soil samples for soil basic analysis. Highest surpluses in the field budgets were calculated for Sulphur with up to 100 kg ha^{-1}.

The trial on testing alternative fertilizers in an organic apple orchard was continued at the Competence Centre for Fruit Growing (KOB) in 2019. The trial will continue in the year 2020. Two treatments of winter peas with different times of incorporation in the soil were added to the 9 treatments already established in 2018 (unfertilized control, horn grit and vinasse as commercial fertilizers, clover-grass pellets, clover-grass silage, liquid biogas residues, compost and peas (spring sowing)). The fertilization level was 25 kg N ha^{-1}. Winter peas were sown in the tree row in October and incorporated in the soil either in March or April. Summer peas were sown in March and incorporated in April, together with all the other fertilizers, as in the previous year. Prior to tillage, the germination rate and the biomass of the peas were determined. The trunk circumference of the trees was measured

at the beginning of the trial and in every following winter season. Blooming intensity and fruit set were estimated. Leaf samples were collected in July for analyses of the nutrient status (P, K, Mg, Ca, Na, Zn, Fe, Mn, and B). No nutrient deficits or surpluses could be found based on leaf analyses. Mineral N content of the soil (N_{min}) was determined at 9 dates during the growing season between March and October. Besides N_{min}, S_{min} was determined. Simultaneously, soil moisture was measured by Time-Domain-Reflectometry. N_{min} in the soil increased to highest values in May – the highest in the treatments with peas (78 – 100 kg N_{min} ha^{-1} tree row) and liquid biogas residues (80 kg N_{min} ha^{-1} tree row, compared to 33 kg in the unfertilized control) - then decreased until July and increased again later in the year, showing a smaller peak in August (40 – 60 kg N_{min} ha^{-1} tree row). In contrast, S_{min} levels rised and then stayed high from May on, until decreasing again in August, parallel to the regular application of S-containing plant protection agents, starting mid of April until August. At the time of harvest, yield and fruit quality i.e. size, weight, color, sugar and acid content, starch degradation, fruit firmness and nutrient concentrations (C, N, P, K, Mg, Ca, and Na) were determined in the apples. In comparison to 2018, sugar content (11.4 °Brix), starch degradation and fruit firmness (6.5 kg cm^{-2}) showed more normal values for the variety Santana. There were no significant differences to the control treatments (unfertilized, horn grit and vinasse) in the fruit quality and yield level in the second trial year. However, the trend indicated that the peas and silage treatments showed the lowest yield levels (20 kg per tree), while the peas at the same time had a higher percentage of larger fruits than the control (24 kg per tree). Apples in the summer peas treatment showed the smallest Ca concentration and the highest K:Ca ratio of 24.1, the nitrogen concentration was in a range of 0.31 % (digestates) to 0.36 % (vinasse, winter peas long and clover-grass pellets).

In addition to the scientific field experiments, the together with the partner FÖKO e.V. three on-farm trials with apple growers in 2019 were initiated in 2019. The farmers decided on testing compost, peas or silage in their orchards. N_{min} in the soil was analyzed on 4 to 6 points in time for the trials. It is planned to repeat the on-farm trials in 2020.

In November 2019, a pot trial on the effect of Sulphur on nutrient and heavy metal mobility in the soil was started on the 13th of November 2019 and is planned to run until August 2020. Five different soils from the Lake Constance and “Altes Land” region were chosen and three levels of Sulphur (0,

40, 80 kg S ha^{-1}) will be applied on the soils, followed by leaching events. Element content of N, K, Ca, Mg, S, Cu and Zn are measured in the eluate. After seven months with six leaching events, rye grass will be grown in the same pots to measure nutrient content in the plants as well.

Conclusions for the first and second project year

All trials at the different locations were continued or set up newly in accordance with the project plan and the data were collected for the second year. For the field trials, data collection will continue in project year 3. The alternative fertilizers differ in soil N_{min} contents during the year. However, only few statistically significant differences were second year of trial.