Nutrient balances of South Tyrolean apple farms - a comparison between the integrated and organic production system

S. Alber[1], T. Mutschlechner[1], A. Forneck[1], A. Matteazzi[2] and M. Kelderer[2]

Abstract

Nutrient balances are used for analysing nutrient inputs and outputs on farm or field level and are vital for establishing balanced nutrient flows, especially when looking at grassland, arable and livestock farms.

For special crops such as fruit, nutrient balances are less common, partly due to the fact that nutrient input and output amounts are relatively small. Here, the authors aim to analyse nutrient flows in integrated versus organically cultivated apple orchards (N, P, K, Ca, Mg). In organic agriculture, in contrast to integrated production (IP), predominantly organic fertilizers are applied. The amounts and ratio among the nutritional elements in organic fertilizers are dynamic and difficult to calculate. Thus, the principal objective of this work was a comparison between the nutrient balances of integrated and organic farms in order to detect possible differences.

The main part of this meta study consisted in summarizing and developing simple soil surface balances of 28 apple farms in South Tyrol (IT) (19 farms working according to IP-criteria and 9 organic farms), focusing on fertilization (nutrient input flow) and nutrient output flows in the form of annually harvested fruits and wood residues from substituting old trees with young trees (approximately every twenty years). Furthermore, different soil and leaf analyses conducted by the Laimburg Research Centre (South Tyrol - IT) were included in order to compare the results of the nutrient balancing with the actual nutrient supply state of the soil and the plants.

Results show that the nutrient balances of the analysed integrated farms are overall similar to the balances of organically managed farms. However, differences appear for N and P. Whereas N-balances of organic farms are more positive compared to the N-balances of integrated farms, P-balances of organically managed farms are more negative than P-balances of farms managed according to IP-criteria. Soil and leaf analyses for both production systems generally indicate a nutrient supply state of the soil and plants that lies within the optimum range and for some nutrients even beyond.

Keywords: Nutrient balances, nutrient input and output flows, soil and leaf analyses, integrated and organic production, apple farming

Introduction

Since in scientific research most of the published papers dealing with nutrient balancing focus on grassland, arable and livestock farming, the aim of this work was to investigate fruit farms in order to gain more data in the sector of special crops. A nutrient balance compares nutrient inputs and outputs on farm or field level and within a defined period of time. If all nutrient flows are taken into consideration, inputs and outputs should possibly be in balance (cf. BACHINGER et al., 2004, 17). This can indicate an efficient and environmentally friendly

[1] University of Natural Resources and Life Sciences, Vienna, Division of Viticulture and Pomology, Konrad Lorenz-Straße 24, 3430 Tulln an der Donau, Austria

[2] Laimburg Research Centre, Vadena, Laimburg 6, 39040 Ora, Italy
E-Mail addresses: simon.alber@students.boku.ac.at (S. Alber), tobias.mutschlechner@students.boku.ac.at (T. Mutschlechner), markus.kelderer@provinz.bz.it (M. Kelderer), astrid.forneck@boku.ac.at (A. Forneck), aldo.matteazzi@provinz.bz.it (A. Matteazzi)

plant nutrition. In organic agriculture, as distinct from the integrated production (IP), predominantly organic fertilizers are applied. The ratio between the different nutritional elements contained in organic fertilizers is often hardly influenceable. The central goal of this research work was therefore a comparison between the nutrient balances of organic farms and farms working according to the rules of IP to show possible differences.

To avoid on the one hand an undersupply of apple trees with nutrients, as could be widely observed in South Tyrol until the end of World War II, and on the other hand an oversupply as in the 1960s and 1970s (cf. Aichner et al., 2004, 11ff), comprehensive analyses are required. In South Tyrol, these analyses are carried out by the Laimburg Research Centre in collaboration with the South Tyrolean Advisory Service for Apple and Wine Growing at certain intervals and for chosen farms. A selection of this data was provided to the authors of this thesis to compare the results of the nutrient balances with the nutrient supply state of the soil and the trees.

Material and Methods

The necessary data was collected for selected farms where the Laimburg Research Centre together with the South Tyrolean Advisory Service for Apple and Wine Growing regularly conducts different analyses. Out of these farms, the authors chose those apple farms with the most extensive data availability. This approach resulted into 28 farms altogether, of which 19 work according to IP-principles and 9 are organically managed. It was not taken into account for how long the orchards had already been cultivated organically.

The first part of the work consisted in drawing up simplified soil surface balances of 28 apple farms and comparing those of IP-farms with the ones of organic farms, focusing on N, P, K, Ca and Mg. This requires on the one hand the nutrient inputs through fertilization and on the other hand nutrient outputs in the form of annually harvested fruits and wood residues from substituting old trees with young trees. Factors that are more difficult or complex to assess such as weathering of soil minerals or nutrient leaching are ignored in simplified soil surface balances (cf. Bachinger et al., 2004, 22ff).

Data concerning inputs through fertilization was collected by contacting the managers of the selected farms and asking for the corresponding records in the orchard registers via e-mail, telephone or in a personal interview. These data have to be provided annually by the farmers. The collected records date back from 3 to 10 years and were turned into an average input value per year for each farm and nutrient.

Harvested fruits can be seen as central nutrient output flow. Together with the estimated yield according to the information provided by the farm managers, this factor was calculated with the help of the mean values of fruit analyses conducted by the Laimburg Research Centre in the corresponding fields over the last years. If no analyses were available, reference values were used.

Also wood residues from substituting old trees with young trees lead to nutrient outputs, namely the nutrients bound in the woody parts of the roots and shoots. In intensive cultivation apple trees are substituted approximately every twenty years (cf. Boschiero et. al., 2015, 237). This factor was included in the calculations by using reference values (cf. Winter, 2002, 67).

Additionally, in the second part of the thesis, soil (including Nmin) and leaf analyses conducted by the Laimburg Research Centre were taken into account in order to compare the results of the nutrient balancing with the actual nutrient supply state of the soil and the plants.

Results

Results show that the nutrient balances of the analysed integrated farms are overall similar to the balances of organically managed farms. Especially Ca- and K-balances indicate strong variances, whereas for N and above all for P and Mg collected data of the different farms vary much less.

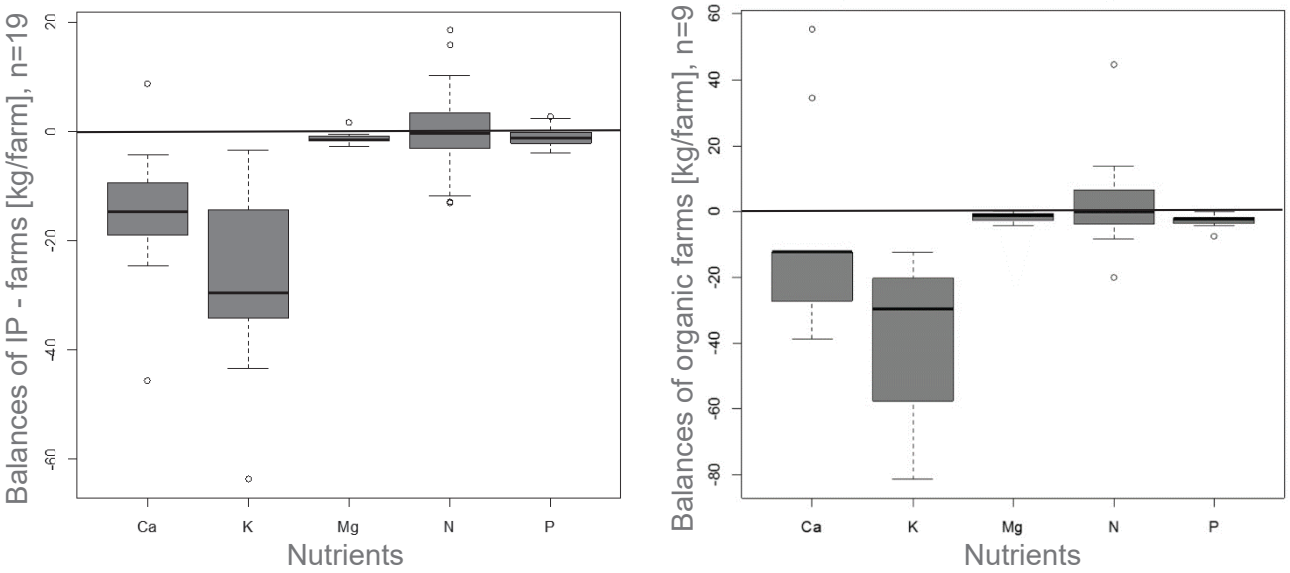

Figure 1: Nutrient balances of integrated and organic farms

It appears that on average for both production systems N-balances are positive, whereas P- and Mg-balances are slightly negative. Ca and K show strongly negative balances. However, differences between the integrated and organic production can be identified for N and P. Whereas N-balances of organic farms are more positive compared to the N-balances of integrated farms, P-balances of organically managed farms are more negative than P-balances of farms managed according to IP-criteria. K-balances are on average more negative for organic farms while Ca-balances are more negative for IP-farms. Mg-balances show no significant differences.

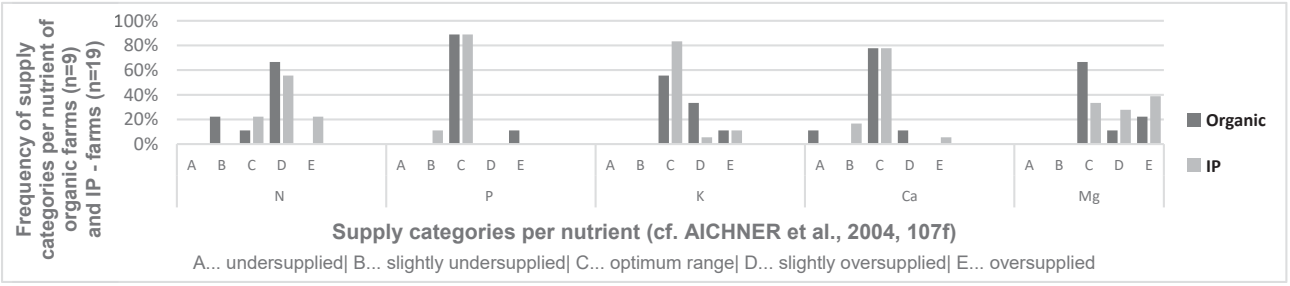

Figure 2: Summary of the leaf analyses of integrated and organic farms

The results of the soil and leaf analyses (that are not further developed in this contribution) for both production systems generally indicate a nutrient supply state of the soil and plants that lies within the optimum range (supply category C prevails) and for certain nutrients even beyond. Particularly analyses for potassium and magnesium show an oversupply of the soil with these nutrients.

Discussion

The negative values of the nutrient balances do not necessarily indicate imbalances in the total input and output flows of the examined nutrients, as several complex factors such as weathering of soil minerals or nutrient leaching are not included. The results do however show (partly major) imbalances between inputs through fertilization and outputs through harvested fruits and wood residues.

The fact that the balances of integrated and organic apple farms are generally similar confirms that an efficient and adequate plant nutrition is of fundamental importance to both production systems.

The key difference between IP and organic production in the field of plant nutrition is certainly the nitrogen supply, as in organic production no mineral fertilization of this element is allowed. Through livestock manure a certain amount of N is applied on the fields. However, in organic apple farming the use of commercial organic fertilizers seems to outweigh the use of livestock manure. These fertilizers are often nitrogen emphasized in order to provide the trees with this important nutrient in due time (e.g. early in spring when mineralisation rates are still low) (cf. Aichner et. al., 2004, 193). This is reflected in the more positive N-balance of organic farms.

The more negative P-balances of organic farms can be explained with the fact that in organic production, compared to integrated production, a much smaller range of mineral phosphorus fertilizers is available. The typical NPK-fertilizers, as well as the fast acting P- leaf fertilizers used in IP are not allowed for organic farming. Higher P-inputs in organic production are mostly a result of applied liquid manure and other types of livestock manure, which are however, compared to commercial fertilizers, not so often used. Consequently, nutrient balances of the organic apple farms analysed in this thesis do not indicate a relative P-accumulation as identified by other authors in the field of special crops (cf. Friedel und Möller, 2016, 473).

Potassium is bound in silicate rocks and clay minerals (vgl. ALBERT, 2003, 51). Depending on location and soil type, K is available in sufficient quantities. Fertilization of potassium is consequently lower than the amount of nutrient outputs through fruits and wood residues and the balances are clearly negative. The same is true of Calcium, which in South Tyrolean soils, depending on the location, can be available in quite high quantities. It has to be stated that in this research work it could not be assessed how many nutrients are released from the soils in order to refill the pool. Even though the deficits of K and Ca may be balanced in the short term with the soil nutrient reservoirs (analyses in fact confirm in general an adequate nutrient supply state of the soils and the plants), such deficits can result in problems after a longer period of organic management.

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