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Effect of pre-crops, cover crops and manure application on organic potato production in a field experiment in eastern Austria

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The effect of different preceding crops, cover crops and manure application on the agronomic performance of potato was studied in two consequantial years in an organic farming system. The effect of lucerne, field pea and spring barley as pre-crops, non legume and mixture used as cover crops were tested as well as the influence of farmyard manure application on potato yield and quality. The cover crop treatments were studied in comparison to control bare fallow. The overall yields of main crop potato remained significantly ($P < 0.01$) less in 2010 than in 2011. The subsequent crop response to preceding crops was negligible since there was no indication of a greater tuber yields (fresh tuber, marketable and dry matter) after legume pre-crops compared to barley. Cover crops and manure both slightly increased tuber dry matter (DM) yield from 4.9 t ha^{-1} to 5.2 t ha^{-1} in 2010 only, on the contrary DM yield was not affected by cover crop and manure in 2011. The percentage of small sized tubers (< 35 mm in diameter) was distinctly increased in 2011 (25.6 %) compared with 2010 (4.7 %). Moreover, cover crops regarded as green manures significantly ($P < 0.01$) increased the percentage of large sized tubers (> 65 mm in diameter) on average of two years. However, the tuber quality was generaly higher in 2010 than in 2011. Regarding tubers with potato virus Y, common scab, malformation, growth cracks and greening, the percentage was lower in 2010.

Keywords: organic farming, nitrogen availability, potato yield, preceding crop, cover crop, manure application

1 Introduction

The potato (*Solanum tuburasum L.*) is one of the staple food of modern western civilization and is getting more important in developing countries. In terms of production, the potato is the fourth most important food crop in the world ranking at 365.8 million tons per year (Faostat, 2014). This crop can be highly productive, but since it has a relatively shallow root system it often requires substantial nutrient input to maintain tuber productivity and quality. Therefore, nutrient management of potato crops is considered very important (Alva et al., 2011). Legumes such as lucerne (*Medicago sativa* L.) and field pea (*Pisium Sativum L*) have received considerable attention as an important component of organic cropping systems especially in semi-humid and semi-arid conditions because they can supply biologically fixed N to subsequent cultivated crops. Total nitrogen contents of legume crops grown in rotaion with potatos can be as high as 240 kg N ha^{-1} y^{-1} (Griffin and Hestermann, 1991), most of which is released during the first year after incorporation. Tuber yield response mainly dependents on the rate at which nitrogen is released from preceding crops (Van Delden, 2001) or organic amendments such as animal manures or green manure crops (Neuhoff and Köpke, 2002). The aim of this experiment was to study the growth of three different preceding crops followed by legume and non-legume catch crops and their residual effects with and without manure application on a succeeding potato crop.

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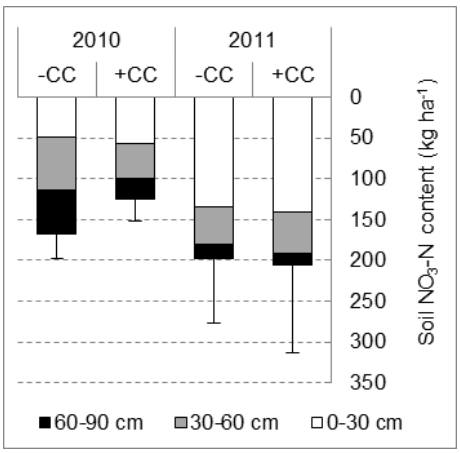
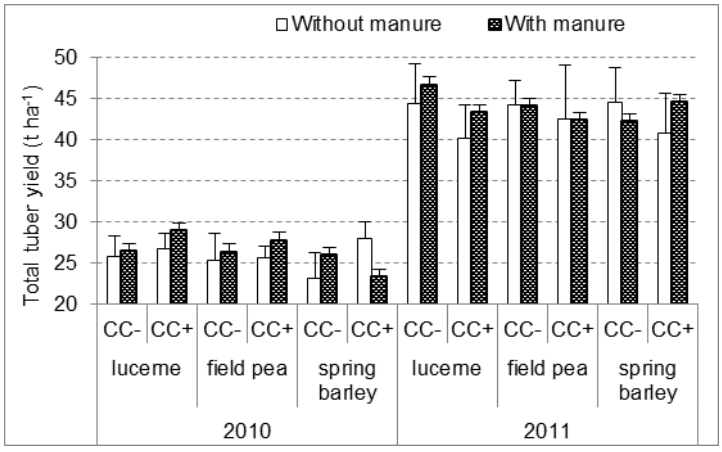
2 Material and Methods

The effects of legume (lucerne and field pea) and cereal (spring barley) pre-crops, legume (oil radish + common vetch + field pea) and non-legume (oil radish + common vetch) catch crops and manure application on yield and quality of a subsequent potato crop (cultivar 'Ditta') were studied in two subsequent field trials in eastern Austria, in the growing seasons 2009/2010 and 2010/2011. Soils at the study site are classified as Calcaric Phaeozems from Loess (silty loam, 2.2 % TOC, pH 7.6) (Rinnofner et al., 2008). The mean annual precipitation is 550 mm, the mean annual temperature 9.8 °C. The twelve treatments comprised a factorial arrangement of three different pre-crops (lucerne, pea or barley), green manure-cover crop management (catch crop or bare fallow control) and farmyard manure application (30 t ha^{-1} vs. no manure control) using 48 plots each 5.6 m × 6 m (plot size: 33.6 m^2). A three-factorial experiment was laid out as a randomized complete block design with four replications (blocks) in a split-split plot arrangement. All pre-crop treatments were ploughed at the same time in Mid-July after harvest. Cover crops were ploughed down in early November and the manure was applied in the same time to the fields. Potato fresh matter yields were taken from the center of each plot. The harvested tubers were graded and sized. The culls of tuber yield were removed and weighted separately. Marketable yield was defined as tubers with diameters greater than 35 mm and without visible blemishes. A two kg of tuber sub-sample from each plot within each block was cut into quarters and rated for internal quality. Tuber dry matter yield was calculated as fresh tuber yield multiplied by the DM content. Finally the analyses of variance were derived from univariate-general linear effect model.

3 Results

During the growing season 2010 the precipitation was approx. 60 % above the annual average value. However, the average temperature was nearly 1 °C lower than the long-term mean. Whereas in the growing season of 2011, weather conditions were more favourable for potato crop since the precepitaion was approx. 20 % above the annual average value and the air temperature was 2 °C warmer than the long-term mean. Potato yield, size distribution, and grade were not significantly affected by pre-crop treatments tested over the two experimental years. Total tuber yield ranged from 23.0 to 28.8 t ha^{-1} and from 40.0 to 43.6 t ha^{-1} in 2010 and 2011, respectively. The tubers contained very few internal defects in both years. Soil mineral N availability (Fig. 1a), potato total yield (Fig. 1b) and marketable tuber yield differed significanty between 2010 and 2011 ($P < 0.01$).





Legend: -CC: without cover crop; +CC: with cover crop. Error bars indicate standard deviations

Fig. 1a Cover crop and year interaction for NO_3^--N content in March

Fig. 1b Potato tuber fresh matter yield affected by preceding crop, cover crop, manure and year

A significant ($P < 0.01$) interaction between cover crops and year was found for total tuber yield and tuber dry matter yield. In addition, a four-way interaction effect was observed for total tuber yield (Fig. 2). Thereby, manure and cover crop combination had a positive effect on tuber yield after lucerne and field pea in 2010, and no influence in 2011. After spring barley, cover crops influenced tuber yield also only in 2010 (Fig 2). There were no clear benefits of cover crops and manure. The only positive significant ($P < 0.01$) cover crop effect was found on potato tuber size distribution.

However, cover crops even negatively affected potato tuber yield and quality. A manure application in autumn resulted in similar yield values compared to the plots without this amendment. Again, the conditions of the growing years significantly ($P < 0.01$) affected tuber starch content and tuber N uptake. The tuber starch content (14.7 and 18.8 %), and accumulated nitrate N during the growing period represented 188 and 91 mg kg^{-1}, in 2010 and 2011, respectively. The significantly ($P < 0.01$) highest nitrate nitrogen uptake by tubers was found after legume lucerne (147 mg N kg^{-1}), followed by field pea (138 mg N kg^{-1}), and the lowest value was observed after spring barley (125 mg N kg^{-1}).

4 Conclusions

Higher soil mineral nitrogen availability resulted in higher marketable potato tuber yield (31.1 t ha^{-1}) and DM yield (7.7 t ha^{-1}), compared to plots poorly supplied with soil N. In general, cover crops and farmyard manure did not consistently enhance potato tuber yield and quality in a high fertility soil. However, by introducting cover crops as green manure, the percentage of large tubers could be increased. However, the results of 2011 indicate that a high soil N availability due to application of organic amendments such as cover crop biomass and manure may lead to delayed potato tuber maturity and lower yield quality presumably due to the warm and wet weather conditions.

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