(25) Management of vegetable crop residues for reducing nitrate leaching losses in intensive vegetable rotations

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Abstract: *Crop residues of field vegetables are often characterized by large amounts of biomass with a high N-content. Even when these are incorporated in autumn, high rates of N mineralization and nitrification still occur causing important N-losses through leaching. Crop residues thus pose a possible threat to maintaining water quality objectives, but at the same time they are a vital link in closing the nutrient and organic matter cycle of soils. Appropriate and sustainable management is needed to fully harness the potential of crop residues. In this research, two fundamentally different management strategies are investigated, namely i) removal of crop residues followed by a useful and profitable application or ii) on-field treatment of crop residues in order to prevent N losses and maintain soil quality. We here present the experimental set-up of the project, results will be presented during the conference.*

Keywords: *Immobilizing materials; incorporation; cover crops; valorisation; economic*

Introduction

Crop residues constitute an important link in soil nutrient and organic matter cycles and aid in maintaining soil quality and fertility (Wilhelm et al., 2004, Blanco-Canqui and Lal, 2009). The combined above- and belowground biomass of crop residues is often greater than the biomass of the harvested crop. Vegetable crop residues take a particular position relative to arable crops due to often large amounts of biomass and high N-content. Economically important vegetable crops such as cauliflowers may leave 50 ton ha^{-1} or more of fresh material as crop residues with a N -content of up to 200 kg N ha^{-1} (Rahn et al.1992). Vegetable crop residues are characterized by low C:N ratios (De Neve and Hofman, 1996) and mineralize rapidly (Fox et al., 1990, Trinsoutrot et al., 2000). During summer generally more than 80% of N present in cauliflower crop residues will be mineralized within 8 weeks (De Neve and Hofman, 1998). An important amount of vegetable crops are harvested during late autumn and despite decreasing soil temperatures during autumn, high rates of N mineralization and nitrification still occur (De Neve and Hofman, 1996). Crop residues may thus lead to considerable N-losses through nitrate leaching during winter (Chaves et al., 2007). Hence crop residues pose a possible threat to maintaining water quality objectives. However, at the same time crop residues are a vital link in closing the nutrient and organic matter cycle of soils. Appropriate and sustainable management is needed to harness the full potential of crop residues (Askegaard et al., 2011).

Materials and methods

On-field management of crop residues

The field experiments in this research are set up in 'long term' experiments (18 months), and 'short term' experiments (2-6 months), all located in the intensive vegetable growing region in Flanders (Belgium). All field experiments were designed in fully randomized blocks with four replicates.

Long term experiments

Two long term experiments are set up to investigate the effect of alternative crop rotations on soil mineral N -content compared to conventional vegetable crop rotations. The potential of including either non-vegetable crops or cover crops in vegetable crop rotations is assessed. In the long term experiments the vegetable crop residues are treated in a conventional manner, i.e. incorporated into soil after harvest. The first alternative crop rotation examines the inclusion of Italian ryegrass (*Lolium multiflorum*) in cauliflower (*Brassica oleracea var. botrytis*) rotations. Per location two treatments, namely (i) cauliflower – Italian ryegrass (sown in August) and (ii) cauliflower – cauliflower – Italian ryegrass (sown in October) are compared to the conventional cauliflower – cauliflower combination. Following spring one or two cuttings of grass is harvested and removed. The remaining organic material is incorporated and a new cauliflower crop is planted. The field experiments are established at three locations with a different soil texture (sand, sandy loam and loam) in order to evaluate the effect of soil texture on nitrate leaching. The second alternative crop rotation examines the use of two cover crops (Italian ryegrass or winter rye (*Secale cereale*) after a cauliflower crop. Similar as for the first alternative rotation two rotations, namely (i) cauliflower – cover crop (sown in August) and (ii) cauliflower – cauliflower – cover crop (sown in October) are compared to a conventional double cauliflower rotation. However in contrast to the first alternative rotation the cover crop will be incorporated during spring instead of harvested. Again three locations with different soil textures (sand, sandy loam and loam) are chosen to take into account the influence of the latter. Field-acquired results will be used in a simulation model (EU_Rotate_N) to fully evaluate the influence of alternative crop rotations on soil N dynamics and crop yields in the long term.

Short term experiments

Several crop residue management strategies are assessed through means of short term field experiments. A first set of field experiments assesses the effect of conventional crop residue incorporation compared to no-incorporation or total removal of crop residues for cauliflower, leek (*Allium porrum*) and headed cabbage (*Brassica oleracea convar. capitata var. Alba*). Two cauliflower crops, one headed cabbage crop and one leek crop were grown on a sandy loam soil. Another three fields with cauliflower are set up on a sandy soil. Following harvest of crop residues a cover crop (winter rye, Italian ryegrass or black oats (*Avena strigosa*)) was sown and compared to leaving the field fallow.

A second set of field experiments examines the effect of three immobilizing materials on N-losses. At two fields on a loam and a sandy loam soil cereal straw (12 t ha^{-1}), corn straw residue (12 t ha^{-1}) or immature green waste compost (50 t ha^{-1}) was mixed with cauliflower residues and subsequently incorporated. The three treatments are compared to incorporation of cauliflowers residues without immobilizing materials.

The potential of cover crops undersown is evaluated at a third set of field experiments. On a sandy loam soil three cover crops (Italian ryegrass, winter rye or phacelia (*Phacelia tanacetifolia*)) were sown 4 week after planting of a cauliflower crop and compared to a treatment without understorey.

A future field experiment will assess the potential of in situ stabilisation of vegetable crop residues. To this end, a mixture of structural materials (straw, wood chips and bark) is brought onto the field and combined with the crop residues of cauliflower. This mixture will subsequently be structured in ridges on the field. The influence of soil quality on soil N mineralisation rate will also be evaluated.

Finally, we will assess the influence of differences in soil quality on the N dynamics after crop residue incorporation on an experimental field where large differences of soil quality were created due to different combinations of organic matter management and soil cultivation over a five year period.

Removal of crop residues

The feasibility of mechanical crop residue removal during late autumn is examined for cauliflower, headed cabbage, celery and leek crops. The potential amount of mechanically removable vegetable crop residues was examined for cauliflower (December), celery (October) and leek (September). Mechanical removal of headed cabbage crop residues took place in August and November. Crop residues of headed cabbage were collected manually (total removal) and mechanically and the mechanical removal efficiency was determined. Organic matter, dry matter, N - and P -content was measured for all crop residues. Mechanical removal of celery crop residues will take place in autumn 2013.

Following crop residue removal the potential of ensilaging, composting or anaerobic co-digestion of vegetable crop residues followed by reapplication on the field is assessed.

Four crop residues (leek, celery, cauliflower and headed cabbage) were mixed with corn straw residues in a 50/50 vol% composition and 42L of this mixture was ensilaged in 15L buckets (Agriton) specially designed for this purpose. Before ensilaging, the bulk density, organic matter, dry matter, N- and P-content was measured for the starting materials. Ensilaging of celery crop residues with a higher crop residue/ straw ratio will be repeated in autumn 2013.

In the composting scenario two compost piles (12 m long × 3 m wide) with crop residues of leek or headed cabbage residues, mixed with additional materials, were set up at the end of November in open air on a concrete floor, with a mixture of 20 vol% crop residues, 30 vol% wood chips, 30 vol% bark and, 20 vol% straw. Temperature and CO_2 levels in the composts were monitored and the compost piles were mixed, turned and covered or rewetted when necessary. Before composting bulk density, organic matter, dry matter, N- and P-content was measured for the starting materials and the feedstock mixture. Next autumn two compost piles with celery residue (one on a concrete floor, one on a grassfield) will be set up with the same composition as previously described.

Evaluation of energetic valorisation of vegetable crop residues by means of anaerobic co-digestion will take place in autumn 2013. The fertilizer value of digestate derived from vegetable crop residues and possible reapplication to the field will be assessed.

Plant and soil sampling

General soil properties were determined at all fields before the start of the experiment. During the experiment soil samples were taken monthly with an auger in three layers: 0-30 cm, 30-60 cm, 60-90 cm. These samples were analysed for ammonium-N and nitrate-N after 1 M KCl extraction in order to determine soil mineral N profiles. Crop and crop residue (leaves and stalks) samples were collected at harvest. Four subsamples were taken per treatment. All plant samples were dried, ground and analysed for N and P content.

Economical evaluation

The economic feasibility of all evaluated crop residue management strategies will be assessed and compared to conventional practice. Farm in- and outputs affected by the concerned crop residue management strategy as well as the influence of farm specific differences and market situation will be taken into account.

Conclusion and perspectives

Appropriate crop residue management may contribute to improved soil and water quality, help meet the Nitrates Directive requirements and possibly imply a new source of valuable organic material for off-field use. Results of the evaluated vegetable crop residue management strategies will be presented at the symposium at the poster sessions.

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