Entwicklung eines integrierten Stickstoffmanagementsystems im Gemüsebau

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Introduction

Nitrogen efficiency is low in regions with intensive field vegetable production. Under these conditions, several weak points may be involved in low N use efficiency, namely (i) poor root growth caused by both soil structure problems and cultivation of shallow rooting vegetable species, (ii) large amounts of N left in the field in crop residues, which are subjected to leaching over winter, and (iii) excessive N fertilization, due to quality standard demands of the market, such as size and color of the product. To improve N-efficiency in agriculture, numerous measures have been tested and recommended in the past decades, including improved choice of fertilizer, soil and crop management strategies. We conducted field experiments to identify the most effective measures to improve N efficiency in field vegetable production. These measures were used to develop integrated N management strategies in field vegetable production. Based on the weak point analysis given above, various crop rotations, different methods of crop residue management and different systems of predicting N fertilizer demand were compared.

Materials and Methods

The field experiments were conducted between 2004 and 2010 at two study sites in a vegetable production region in southern Germany. Climatic conditions for both sites are comparable with mean annual air temperature of 10 °C and mean annual precipitation of 600 mm. The soil at the first site is a gleyic cambisol (loamy sand) and a haplic luvisol (loam) at the second site. Four crop rotations ((i) vegetable monocropping, (ii) vegetable followed by a summer cover crop, (iii) vegetable followed by a winter cover crop, (iv) vegetable followed by cereal), three methods of crop residue management ((i) incorporation immediately after harvest, (ii) delayed incorporation after harvest, (iii) export from the field) and three methods of predicting N fertilizer demand ((i) application of fixed N rates), (ii) N-Expert: taking into account the soil mineral N supply, (iii) SPAD: clorophyllmeter measurements) were compared. Marketable yield, N uptake and nitrate concentration in seepage water (suction tubes in 105 cm soil depth) were measured and N balances (N import with fertilizers minus N export with the marketable produce) and nitrate leaching were calculated.

Results and Conclusions

N rates applied taking into account the soil mineral N ranged between 61% and 74% of those applied according to farmers practice. A further reduction of the amount of N application could be achieved by the use of the SPAD chlorophyllmeter. Marketable fresh matter yield of vegetables was hardly affected by the method of N fertilizer recommendation. Compared with vegetable mono-cropping, growing of summer or winter cover crops increased marketable yield. Long-term export of crop residues without any compensatory supply of organic material causeed yield losses, due to negative effects on the soil humus content. N fertilization according farmers practice resulted in high average leaching losses of 330 kg ha^{-1} yr^{-1} N for the sandy site and 242 kg ha^{-1} yr^{-1} N for the loamy site, respectively. Losses could be reduced by more than 50% when N fertilizer application was based on soil tests or by the use of the SPAD chlorophyllmeter. A further significant reduction in nitrate-N leaching could be achieved when the N-Expert method was combined with an environmentally friendly crop rotation, such as the vegetable /summer cover crop rotation. Export of N-rich crop residues resulted in an additional reduction of leaching.

Accurate prediction of N fertilizer demand is a prerequisite to grow vegetables environmentally friendly. Nevertheless, yearly N leaching losses are still too high from the environmental point of view. Accurate fertilization has to be combined with the inclusion of cover crops in the rotation to further reduce N leaching. Export of crop residues should be adopted with caution, particularly due to the fact that export of crop residues also affects soil humus content negatively. These results indicate effective measures to improve nitrogen efficiency in agriculture and may be used as a basis to develop integrated N management strategies in vegetable production.