Opportunities and limitations in use of clovers as N-source in organic farming systems in Norway

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Implications

From an economic as well as ecological point of view, transfer of clover N to the subsequent growing season should be maximised and the risk of environmental pollution minimised. It is very important in organic farming. Detailed studies on white clover lifespan indicated that the foliage is a main source of readily plant-available N as the leaves are short lived. However, the leaf N is largely lost from the plant foliage during the cold season. The risk of loss may probably be reduced by using winter-hardy cultivars that tend to reallocate resources to stolons and roots which are more persistent than leaves.

Background and objectives

Clovers and other legumes are crucial for nitrogen (N) supply in organic farming systems. About 80% of clover N is derived from the atmosphere and is incorporated into clover biomass through symbiosis with *Rhizobium* bacteria. In field in Norway, this N fixation might account for 20 to 175 kg N $ha^{-1}year^{-1}$ (Serikstad et al. 2013) that is essential input of clover-derived N to the soil-plant system. Moreover, the accumulated total N in plant material returns to the soil via the turnover of plant parts or via grazing animals. Amount of clover in the field is also decisive for the protein content and general quality of the forage produced. One of the major problems in maintaining a desired content of clover in grassland is the seasonal and annual variation in performance. Unfavourable management regimes in the previous year might result in poor development of storage organs and low nitrogen and carbohydrate reserves. Clover is sensitive to climate with low temperatures and poor growth can lead to winter damages. Studies have shown that white clover leaves can lose between 57 and 74% of their N between autumn and the following spring independently of harvesting regime during the growing season (Sturite et al. 2006). For the first this may reduce N transfer to the subsequent growing season (Korsæth et al., 2002). For the second, this may have a substantial impact on the risk of nitrate leaching and loss of nitrous oxide because net N mineralisation from dead plant material may be significant even at the winter temperatures prevailing in northern soils (Cookson et al. 2002). Considering that clover is widely used in crop rotations, particularly in organic farming, overwintering of green plant parts may be difficult under northern climatic conditions and can result in pollution hazards.

The objective of the present paper is to evaluate clover as N source during the growing season and clover availability to conserve N throughout the winter under northern climate.

Key results and discussion

The short lifespan of leaves (Table 1) indicated their potential importance as a nitrogen source. Stolons and roots were much less dynamic than leaves during the first growing season. By the end of the second growing season, turnover of stolons and roots increased (Table 1). Thus, dead stolons and roots contributed substantially more to N deposition in the soil in the second than in the first growing season. However, N largely might be lost from the plant biomass during the winter. The winter losses varied greatly (from 14% to 80%) due to different climate conditions during the winter. The amount of inorganic N in soil after snowmelt and mineralization of white clover-derived N during the spring was small. This can lead to negative N balance in the farm, particularly for stockless organic crop rotations with clover-grass fellow and/or postharvest green manure. In the experiment on N recovery, an average of 34 % of the foliage N losses (for four years) was found in seepage water. This indicates a risk of surface water pollution in particular if snowmelt happens on frozen soil. Moreover, losses of N from the plant material might result in nitrous oxide (NO_2) emission and contribute to global greenhouse gas accumulation and to stratospheric ozone depletion. Measurements of N_2O emissions during the winter indicated that pure clover stands containing both white and red clover had significantly higher gaseous losses in form of N_2O than pure grass stands. These losses recovered, however, only 2% of the foliage losses during the winter. This suggests that N might be immobilised by a cold-adapted microflora. Brooks et al. (1998) demonstrated that microbial immobilisation under snow appeared to be a primary mechanism controlling N flows during snowmelt.

Table 1 N content (g/m^2) in white clover plant parts in autumn and turnover of marked white clover leaves, stolon and root segments during the first and second growing season (% of dead plant parts by late autumn in the first and second growing season)

Plant parts	N content in autumn	Turnover during the first growing season	Turnover during the second growing season
Leaves	6	61	59
Stolons	10.8	0	23
Roots	2.1	9	54

How work was carried out?

Experiments were carried out four consecutive years (2000-2004) at Apelsvoll Research Centre in Southeast Norway. Detailed descriptions of the methods are published by Sturite et al. (2006, 2007a, 2007b). Gaseous emissions were measured at Tjøtta Reseach Centre in northern Norway from October 2011 to May 2012 by manually closed chambers.

Refernces

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