Utilization of nitrogen in legume-based mobile green manures stored as compost or silage

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Implications

The utilization of nitrogen (N) in green manure leys can be improved by harvesting, storage and spreading of the plant material as manure in other crops. By green manure storage as silage, storage losses of N are lower than by composting. Also, a relatively high fertilizer value of silage N is achievable depending on the C/N ratio of the material. Nitrogen availability in green manure leys is higher after storage as silage compared to composting. Use of mobile green manures is mainly relevant in arable cropping systems without livestock where utilization of the roughage for animal feed or biogas production is impossible, as costs for ley/roughage harvest and transport can be relatively high. Our study showed that surface application of green manure silage to growing crops can damage plants and is therefore not recommended, whereas incorporation of silage before sowing has significant positive effects on crop yields.

Background and objectives

Nitrogen supply is often limiting for crop yields in organic arable cropping systems, especially if animal manures are not available. Under current farming practices, green manure leys are often cut and mulched during the growing season with the associated risk of N losses to the atmosphere, and to leaching during the season, and possibly reduced N fixation in the ley. By harvesting and storage of the green manure until spring it can be used for targeted fertilization of spring-sown crops. The objectives of this field study were: a) to quantify the fertilizing effects of grass-clover and lucerne stored as either silage or compost (mixed with straw) and to relate the N availability to the chemical composition of the manures; b) to compare N utilization after incorporation of silage by ploughing or harrowing, or by surface application in a growing crop; and c) to quantify the losses of N during storage or composting of green manures.

Key results and discussion

During composting of the green manures, N losses of 18-30% were estimated from N/P ratios before and after storage, while N losses from silage storage were estimated to be 6-8%. The N fertilizer value, measured in a spring barley crop, was 32-48% for silage and only 13-22% for the corresponding composts compared to application of mineral N (Table 1). The fertilizer value of injected cattle slurry and digested manure was measured in the same experiment as a reference and found to be 56% and 63%, respectively. There was a significant negative linear relation between C/N ratio of the green manures and the fertilizing value which is in accordance with other studies of N release from green manures/plant residues (Sorensen and Thorup-Kristensen, 2011). There was no difference in fertilizer value whether the grass-clover silage was incorporated by ploughing or harrowing just before sowing the barley crop. The C/N ratio of the green manure has significant influence on the N availability, and leys should be harvested at a young stage to obtain a high N availability. However, the harvest cost also increases with increasing harvest frequency.

In Experiment 2, increasing application rates of red-clover silage applied to oats and winter rye were tested. Yields of oats increased linearly with silage application rate (max 120 kg N ha^{-1}), and the fertilizer value of the silage N based on grain yields was 40% and similar to that of silage measured in Exp. 1. Silage application to winter rye caused plant scorching and had negative effects on yields. This is probably due to temporary poisonous effects of organic fatty acids in the silage combined with acidic conditions.

Table 1. Availability of N in ensiled or composted green manures of grass-clover and lucerne, and in injected slurries, relative to mineral N applied to spring barley, as calculated from N uptake in grain. All treatments received 120 kg N ha^{-1}, and values in parentheses indicate standard errors (n=4).

Manure	C/N	N effect (% of total N)
Grass-clover silage, ploughing	14.9	33 (6.5)
Grass-clover silage, harrowing	14.9	32 (5.2)
Grass-clover-straw compost, ploughing	16.2	13 (3.2)
Lucerne silage, ploughing	12.4	48 (7.2)
Lucerne-straw compost, ploughing	14.9	22 (1.8)
Anaerobically digested mixed manure, injected	5.8	63 (3.0)
Cattle slurry, injected	7.6	56 (2.8)

How work was carried out

Experiment 1: Grass-clover and lucerne crops were harvested in late August about 6 weeks after the previous cut. The crops were either baled and wrapped in plastic as silage, or they were mixed with cut barley straw (4:1, w:w) and composted in porous big bags (0.9m x 0.9m x 1.4m height) insulated on the sides with a 50-mm layer of plastic-coated rockwoll. The insulated bags were thus ventilated via bottom and top. The composting temperature remained above 55°C for several weeks. The composts were covered with loose plastic to avoid leaching losses of nutrients. Losses of N during green manure storage were calculated from N/P ratios before and after storage assuming no P losses. In late April, the manures were applied to field plots on a loamy sand soil at a rate of 120 kg total N ha^{-1}. The manures were incorporated by ploughing, and in a separate treatment grass silage was applied after ploughing and incorporated by harrowing to compare effects of incorporation method. Spring barley was sown in all plots, and N uptake in grain was measured and related to grain N uptake in separate plots receiving increasing amounts of mineral N (Sørensen and Eriksen, 2009). Mineral N was used as a well-defined reference, even though the use of mineral N fertilizers is not allowed in organic farming. Experiment 1 was placed in a conventionally cultivated field; previous studies have shown that land use history has no significant influence on the utilization of N in manures (Bosshard et al, 2009).

Experiment 2: In a second experiment on a coarse sandy soil, ensiled red-clover was applied at increasing rates (40, 80, 120 kg N ha^{-1}) either by incorporation by ploughing before sowing of oats, or by application at the soil surface in an established winter rye crop in spring. Dry matter and N yields were related to yields in separate plots receiving increasing mineral N. The field experiments were organized in a randomized block design with four replicates.

References

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