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Contribution of N from frequently chopped green manure to a succeeding crop of barley

Frøseth, R.B.[1], Hansen, S.[2] & Bakken, A.K.[3]

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Abstract

The aim of the present work was to study to what extent N in mulched green manure herbage contributes to spring barley grain yield the subsequent year. The green manure herbage was either chopped and left on stubble (GML) or removed (GMR). On silty clay loam with spring incorporated green manure the subsequent barley grain yield was 10% higher with GML than with GMR. The additional grain N yield of 4 kg ha^{-1} with GML corresponded to only 3 % of N in above-ground green manure biomass. On loamy soil with late autumn incorporated green manure the treatments did not affect the grain yield the subsequent year. How large part of the N that was lost through leaching or gaseous emissions and how large part that was built into soil organic matter was not measured. However, this investigation confirms that potential N losses from mowed green manure might be large. Alternative ways of using the herbage should be found.

Introduction

Nitrogen (N) supply in stockless organic cereal production is based on leguminous green manure plants within the crop rotation. In northern temperate regions both undersowing of clover in cereals and whole season green manure crops are used. Whole season green manure is managed by repeated mowing; this to control perennial weeds and encourage regrowth and N-fixation. Due to the large content of easily degradable N accumulated in the green manure crops, the potential N losses from the green manure herbage are large (Breland 1996 a, b; Askegaard *et al*. 2005). The practice of leaving the herbage as mulch after repeated mowing increases this risk of N losses (Larsson *et al.*, 1998) both through gaseous emissions (NH_3, N_2O and NO), and surface runoff or leaching of NO_3^- and soluble organic N. Such N losses are a hazard for the environment and a reduction of the N input to the system, which is not compatible with a sustainable development of organic farming. Hence, it is important to focus on strategies improving N utilization of whole season green manure in organic spring cereal production.

The aim of the present work was to study to what extent N in mulched green manure herbage contributes to spring barley grain yield the subsequent year.

[1] Norwegian Institute for Agricultural and Environmental Research, Organic Food and Farming Division. Bioforsk, NO-6630 Tingvoll, Norway, E-mail randi.froseth@bioforsk.no, Internet www.bioforsk.no

[2] As Above, E-mail sissel.hansen@bioforsk.no

[3] Norwegian Institute for Agricultural and Environmental Research, Grassland and Landscape Division. Bioforsk, NO-7500 Stjørdal, Norway, E-mail anne.kjersti.bakken@bioforsk.no

Materials and methods

Two field trials were carried out from 2005 to 2006. They were located on organically farmed soil at the Norwegian Institute for Agricultural and Environmental Research at Kvithamar (Field 1) in central Norway (63°29´N, 10°52´E) and Apelsvoll (Field 2) in central south-east Norway (60°42´N,10°51´E). The soil on field 1 is a silty clay loam and on field 2 is a loam. The precipitation during the growing season 2005, the subsequent winter and the growing season 2006 was 473, 546 and 222 mm, respectively, for field 1 and 270, 339 and 222 mm for field 2.

The experiment was designed in blocks with four replicates. The green manure crop consisting of a mixture of common vetch (*Vicia sativa* L., 80 kg ha^{-1}), phacelia (*Phacelia tanacetifolia* Benth., 5 kg ha^{-1}), ryegrass (*Lolium multiflorum var. Italicum* Lam., 10 kg ha^{-1}) and red clover (*Trifolium pratense* L., 5 kg ha^{-1}) was grown in 2005. The green manure was cut with a plot harvester and then either chopped with a stubble cutter and left on stubble (GML) or removed from the plot (GMR). The green manure on field 1 was incorporated into the soil by ploughing (depth of 23 cm on both fields) in the spring the day before barley was sown. Field 2 was ploughed in late autumn 2005. In May 2006, immediately before sowing of spring barley (*Hordeum vulgare* L.), the soil was dragged and harrowed on both sites. No fertilizer was applied.

Grain yield and biomass of green manure was recorded on all plots by harvesting subplots of 9.75 m^2 (Field 1) and 20 m^2 (Field 2). The stubble height of green manure was 5-6 cm. Grain quality parameters; thousand grain weight, hectolitre weight, content of protein and starch were analysed in samples from all plots; the last three parameters by Infratec 1241 Grain Analyzer. Above-ground biomass of barley at early stem elongation (Zadoks 30) was recorded on all plots by harvesting two subplots of 0.25 m^2. Soil mineral N (0-25 cm) was measured in late autumn (Field 1: 7th November, field 2: 19th October); one month after the last green manure cut, and in the spring the day before ploughing. Analyses were done by 1M KCl extraction.

Statistical analyses were carried out by analysis of variance (proc glm; SAS, 2002).

Results

The barley yield in field 1 was 10 % higher for plots with GML compared with GMR (Table 1). The straw yield on the same plots was 15 % higher. No differences between the treatments of green manure herbage were found in amount of N in plants at early stem elongation or in hectolitre weight, thousand grain weight, and amount of protein or starch in grain.

On field 2 no differences in barley yield, straw yield, N content or the quality parameters were found between the treatments.

Tab. 1: Barley grain and straw yields (g dry matter m^{-2}) after whole season green manure with herbage left (GML) or removed (GMR) from the plots. SE in brackets (n = 4)

	Grain			Straw		
	GML	GMR		GML	GMR	
Field 1	240 (14)	217 (11)	*	161 (8)	137 (3)	*
Field 2	237 (16)	225 (22)	n.s.	168 (3)	160 (6)	n.s.

* significant for $p<0.05$

On field 1 dry matter yield and N yield of the 3rd green manure harvest on plots with GMR were 36% lower than GML ($p<0.05$). There was a tendency to higher amounts of legumes at the 3rd harvest with GMR. On field 2 the dry matter yield of the 3rd harvest was not significant, but there was a tendency to be higher with GMR. On plots with GMR the total N was higher, due to a higher amount of legumes.

The amount of mineral N in soil in autumn on both fields tended to be higher on plots with GML than with GMR. In the spring no difference in mineral N content in soil was found between the treatments. The amount of nitrate in soil in autumn was highest on plots with GML on both fields. Highest amount of nitrate was found in depth 12.5-25 cm on field 1 and in depth 0-12.5 cm on field 2. The difference between treatments in ammonium content was not significant.

On field 1 the amount of N in grain yield with GML was 9% higher than with GMR. This additional N yield of 4 kg ha^{-1} corresponded to 3 % of the N in the above-ground biomass of green manure herbage the year before (Figure 1).

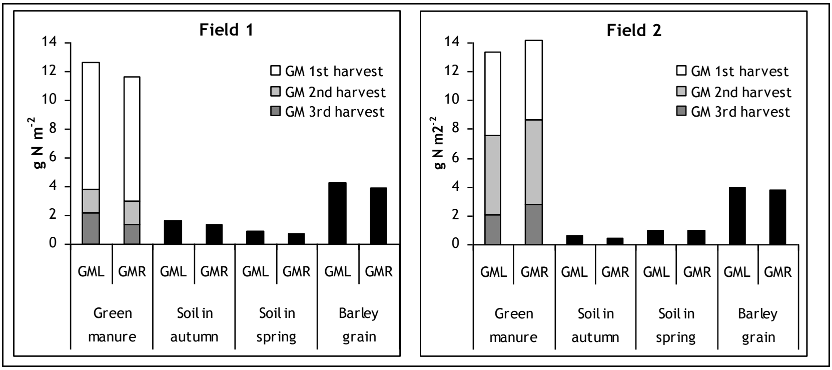

Figure 1: Amount of total N in three harvests of green manure, mineral N in soil (0-25 cm) and total N in barley grain after green manure herbage left (GML) or removed (GMR) from the stubble.

Discussion

Small differences in cereal grain yield succeeding green manure with the herbage left or removed in the field were also observed by Whitbread *et al*. (2000) and Solberg (1995). As no or only a little part of the N from green manure herbage seemed to be recovered by barley the subsequent year, the main N source for the barley was probably soil organic matter (C/N ratio of 11) and the under-ground biomass of the green manure. Autumn incorporation of the green manure on loamy soil (field 2) seemed to remove any difference between the treatments.

How large part of the N that was lost through leaching or gaseous emissions and how large part that was built into soil organic matter was not measured. However, the results indicate that N losses from mowed and mulched green manure may be substantial, as also found by e.g. Janzen & McGinn (1991) and Larsson *et al*. (1998).

Løes *et al.* (2007) found that whole season green manure in one out of four years in cereal crop rotation does not accumulate enough N to compensate for the N removed in cereals. They concluded that additional N sources are needed. Strategies to improve N utilization of whole season green manure in organic spring cereal production should be sought. An alternative strategy could be the conservation of the green manure herbage during the winter as hay, silage, compost, or biogas slurry from anaerobically digestion of green manure herbage, for early incorporation in the spring before sowing the cereal crop. This topic requires further study.

Conclusions

The results from the field experiments showed a 10% lower or no difference in subsequent spring barley grain yield when green manure herbage was removed from the field after each cut compared with green manure herbage left on the stubble after the cuttings. The additional grain N yield of 4 kg ha^{-1} with mulched herbage corresponded to only 3 % of the N in above-ground green manure biomass. This fact, together with the knowledge of high risks of N losses from remaining herbage, implies that alternative ways of handling and storage of green manure herbage should be sought.

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