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Improving N efficiency in barley through green manure management and biogas slurry

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1. Background & Objectives

In cereal production on stockless organic farms green manure (GM) is commonly used to improve soil fertility. The clover-grass swards are mown frequently as a means to control perennial weeds in GM-cereal rotations and to keep the ley in a vegetative state, thus avoiding decrease in biomass production and in N_2-fixating activity. The mown GM herbage is commonly mulched (Dahlin et al., 2011). The purpose of this study was to increase knowledge of the N-dynamics in such rotations, in order to suggest methods for improving N efficiency and thus organic cereal yields. The hypothesis was that spring application of biogas residue from anaerobic digestion of GM herbage increases the N uptake and yield of a subsequent barley crop, compared to repeatedly in situ mulching of the same GM herbage in the preceding season.

2. Material & Methods

The effect of various GM treatments on spring barley yields and nitrogen dynamics was investigated, at four sites differing in soil and climatic conditions. The locations were Central Norway (Site 1: silty clay loam and Site 2: sandy loam), Eastern Norway (Site 3: loam) and South-Eastern Norway (Site 4: clay loam). In 2008 a grass clover mixture was undersown in barley. In 2009 the clover-grass herbage was either harvested or mulched. In spring 2010 the GM sward was ploughed down, and barley was sown. Six treatments were compared (Table 1), with four replications. Biogas residue from anaerobically digested GM herbage was applied in spring 2010. It contained 11 g total N and 6 g NH_4-N m^{-2} (56 % of the total N in the GM herbage). Two control treatments were included, in which cereals were grown in all three years (without any fertilizer in 2008 and 2009, and with biogas residue or mineral fertilizer in 2010).

Table 1. Overview of treatments.

Treatment	2008	2009	2010
GM+	GMU[a]	GM all harvests mulched	Barley
GM-	GMU[a]	GM all harvests removed	Barley
GM-(B)	GMU[a]	GM all harvests used for biogas	Barley + biogas residue (6 g NH_4-N m^{-2})
GM2/3	GMU[a]	GM first 2 removed, last mulched	Barley
C(B)	Barley	Oats	Barley + biogas residue (6 g NH_4-N m^{-2})
C(M)	Barley	Oats	Barley + mineral fertilizer (8 g N m^{-2})

[a]GMU = Spring barley undersown with green manure.

Soil mineral-N was analysed at 0-0.8 m depth on several occasions from 2008 until spring 2011.

3. Results & Discussion

On average, the mulched or harvested GM herbage contained 19 g N m^{-2}. In spring 2010, before ploughing down the GM, there was a higher level ($P > 0.001$) of mineral N in soil with GM mulched (GM+) compared with the other treatments at all sites. But two weeks after germination of the barley crop there were no difference in the levels of mineral-N in soil between GM mulched (GM+) and removed (GM-).

Barley dry matter yields in 2010 were approximately 300 g m^{-2}, except in trial 1, where it was only half as high. The use of biogas residue (GM-(B)), raised the nitrogen yield of the barley crop to the same level as of the mulched treatment (GM+). When biogas residue was applied on control plots that had been exhausted by two consecutive cereal crops without any form of fertilization (C (B)) the nitrogen yield of the barley crop reached the same level as the treatment of GM with two of three harvests removed (GM2/3). At sites 1, 2 and 3 barley N yields in 2010 (Figure 1) were 29-38 % lower ($P > 0.001$) when GM herbage was removed (GM- and GM2/3) than when it was mulched (GM+). In these trials, N deficiency symptoms in barley were seen already at the 3rd leaf stage on plots where the GM herbage had been removed. At site 4, there was a similar trend, but the effect was not statistically significant.

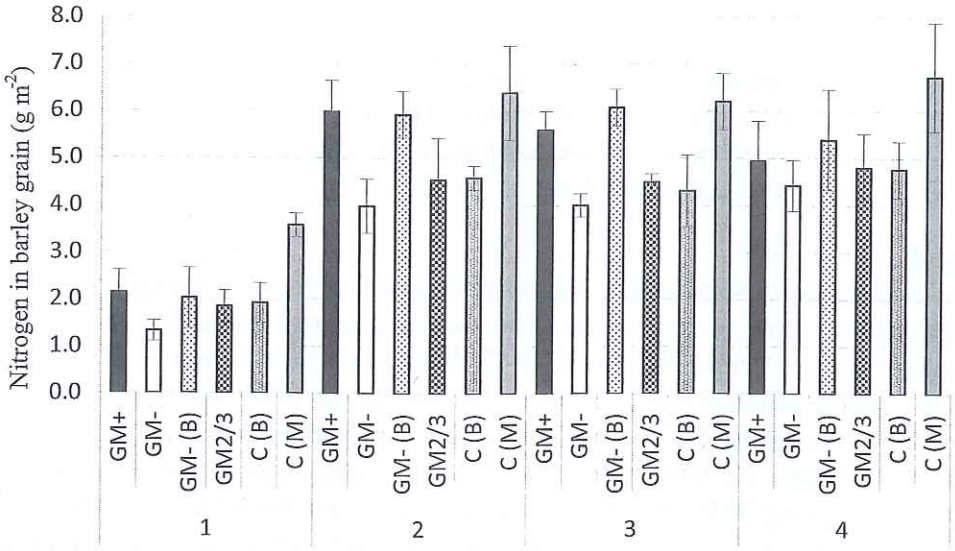

Figure 1. Nitrogen yields of barley grain in 2010 (g m^{-2} ± standard deviation) following contrasting green manure treatments in 2009 in four trials. Abbreviations for green manure treatments are explained in Table 1.

In spring 2011 there was a higher level ($P > 0.001$) of NO_3-N in soil with GM in 2009 than without, but no effect of the different GM treatments was seen in NH_4 -N content.

4. Conclusions

The results suggest that, under the Norwegian climate, mulching of GM herbage can increase cereal yields compared to its removal, depending on soil type and rotation history. However, the use of GM herbage for biogas production appears to be much more N-efficient on farm level. We applied about half of the N available in GM herbage, and the surplus residue makes it possible to manure other fields.

References

Dahlin A.S., Stenberg M. and Marstorp H. 2011. Mulch recycling in green manure leys under Scandinavian conditions, Nutrient Cycling in Agroecosystems 91:119-129.