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Methodological aspects of determining nitrogen fixation of different forage legumes

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Introduction

Nitrogen fixed by legumes is the main nitrogen source in organic farming systems. The design of crop rotation is strongly depending on the knowledge of how much nitrogen is fixed by legumes. Also for farm scale budgeting of nitrogen it is essential to know the amount of nitrogen fixed by the single leguminous crops. According to the literature, the determination of nitrogen fixation is expensive, time consuming and bears a lot of methodological problems (Larue and Patterson, 1981; Shearer and Kohl, 1986). The purpose of this study was to quantify methodological effects of three common field methods on the estimation of nitrogen fixation of different forage legumes. The legumes were grown in different seed mixtures and a varied management was imposed.

Material and methods

In a field study carried out in Northern Germany nitrogen fixation of different grass/clover swards with (i) varying legume species (red clover, alfalfa, white clover) in (ii) different seed mixtures (pure legume, mixtures with perennial ryegrass) and (iii) a varied management (forage use, green manure) was estimated parallel with 3 different methods (N-difference, natural ¹⁵N abundance and ¹⁵N enrichment). Perennial ryegrass was chosen as reference crop. The objective was to prove if the experimental factors had an effect on the results of the estimation methods. Results obtained with these methods based on harvestable plant material were compared with those taking also into account the non-harvestable plant parts like stubble and roots as well as the soil mineral N content (Nmin).

Results and discussion

The table shows significant effects of the experimental factors seed mixture and management on the amount of nitrogen fixed by legumes. The determination of N fixation based on harvestable plant material underestimates the amount of fixed N by 70 kg ha⁻¹ on an average compared to techniques including non harvestable plant parts and soil mineral N. While N difference method and ¹⁵N enrichment technique gave comparable estimations, results obtained by natural ¹⁵N abundance were significantly lower. The choice of estimation method slightly affects the ranking between the experimental treatments. For each method there are strong correlations between legume yield and nitrogen fixation.

Table: Effect of method on estimation of N fixation of different grass/legume swards [kg N ha⁻¹ yr⁻¹]
(1997, average of three legume species)

Seed mixture (management)	based on harvestable plant material			based on total plant material + Nmin		
	N difference	¹⁵ N enrichment.	natural ¹⁵ N abundance	N-difference	¹⁵ N enrichment	natural ¹⁵ N abundance
Pure legume (forage use)	274.0a	285.0a	168.5a	315.2a	354.9a	248.5a
Grass/legume (forage use)	259.8b	235.8b	159.0a	303.8a	291.9b	215.8b
Pure legume (green manure)	100.4c	92.8c	52.7b	178.4b	196.8c	172.5c
Grass/legume (green manure)	90.8c	80.9d	47.7b	166.4b	168.2d	111.0d

(Means with the same letter are not significantly different, Student-Newman-Keuls test, $\alpha = 0,05$)

Conclusions

Farm scale budgeting of nitrogen fixation based on experimental data has to take into account that estimations are depending on the chosen method. The strong dependency of nitrogen fixation on legume yield can be used for empirical models for calculation of nitrogen fixation on field level.

References

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