THÜNEN

Building Organic Bridges

Volume 3
Indonesia – Sri Lanka, page 675–998

Proceedings of the 4th ISOFAR Scientific Conference
at the Organic World Congress 2014

13–15 October 2014 in Istanbul, Turkey

Gerold Rahmann and Uygun Aksoy (Editors)

Thünen Report 20

Organically grown grassclover in nature areas to remove soil phosphate for development of specious rich grasslands

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Key words: biodiversity, nutrient cycles, soils, species richness, *Trifolium repens*

Abstract

Worldwide the current reserves of phosphate rock are being exhausted. In The Netherlands many former agricultural soils have been enriched by large quantities of phosphorus as a result of fertilization. It is thought that this phosphorus prevents development of target-nature types. Nature organizations currently seek ways to remove it. We tested grassclover, organically managed by local farmers, as a tool to extract excessive soil phosphate from nature areas and reimport it into the mineral cycle agricultural farms. In a small scale experiment we have shown that grassclover with potassium fertilization can remove more than twice the amount of soil phosphate compared to mowing alone. We tested the methodology on 60 ha of grasslands in nature areas and measured large decreases in soil phosphate. We conclude that organically managed grassclover could form an elegant way to solve problems with excessive soil phosphate in nature areas and recycle phosphate.

Introduction

Large areas of Dutch agricultural soils have been enriched by phosphorus (P) (Schoumans, 2004). Causes are high levels of fertilization. This results in high losses of P to surface and soil water (Schoumans & Groenendijk, 2000). Dutch nature policy has led to the conversion of large areas of agricultural land to nature areas. In such areas, the high P levels associate with low species diversity (Janssens et al., 1998; Critchley et al., 2002). The current way to remove P is either removal of the top soil or cutting of perennial grass swards. Removing the top soil is expensive and irreversible. The cutting management is very slow in lowering P due to a restricted availability of other nutrients. Specific management can help to remove P from such nature areas. Our objective was to test the an organically grown grassclover sward with potassium fertilization under cutting management as a tool to remove P from nature areas on sandy soils, and to quantify the amount of P thus removed.

Material and methods

Grassclover swards were sown in 2007 on 60 ha of former agricultural lands with sandy soils in in the south of The Netherlands. The grass/clover was planted with a seed mixture of grasses (Lolium perenne, Phleum pratense, Festuca pratensis and Poa pratensis) and clovers (Trifolium repens). The grassclover was organically managed and mown by 12 local farmers in 2007, 2008 and 2009. The management included intensive mowing (4 to 5 cuts annually) and fertilization with potassium fertilizer (Patentkali, 240 kg K2O per ha annually, 100 kg for the first cut, 80 kg for the second cut and 60 kg for the third cut). On one of the fields, located in "Nieuwkerk", two treatments were realized by marking 9x9 m plots with metal plates. Two marked plots were left unfertilized by potassium, and two marked plots were fertilized with potassium as mentioned above. In the plots, shortly before each cutting, a strip was mown and clover percentage, dry matter yield, potassium content and fodder value (including crude protein content) were determined. In the overall area of 60 ha, a total of 20 plots of 5x5 m were marked with iron plates, with a maximum of 1 plot per field. In each of these plots, soil measurements were done at the start of the experiment (early 2007) and at the end of the experiment (autumn 2009), in the layers 0-10 cm and 0-30 cm depth. Soil P contents were measured as P-total (soil destruction) and P-Al (plant available P) by a commercial soil analysis laboratory (AgroXpertus, Wageningen, The Netherlands).

Results

In "Nieuwkerk" in the first year after sowing, clover percentages in both treatments were high (maximal 70-80%, Figure 1A). The clover, that acted as the source of nitrogen, resulted in high yields (12 to 14 tons of dry

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matter per ha) in both treatments (Figure 1B) and over 80 kg of P_2O_5 ha^{-1} was removed in the mown crop the first year (1C).

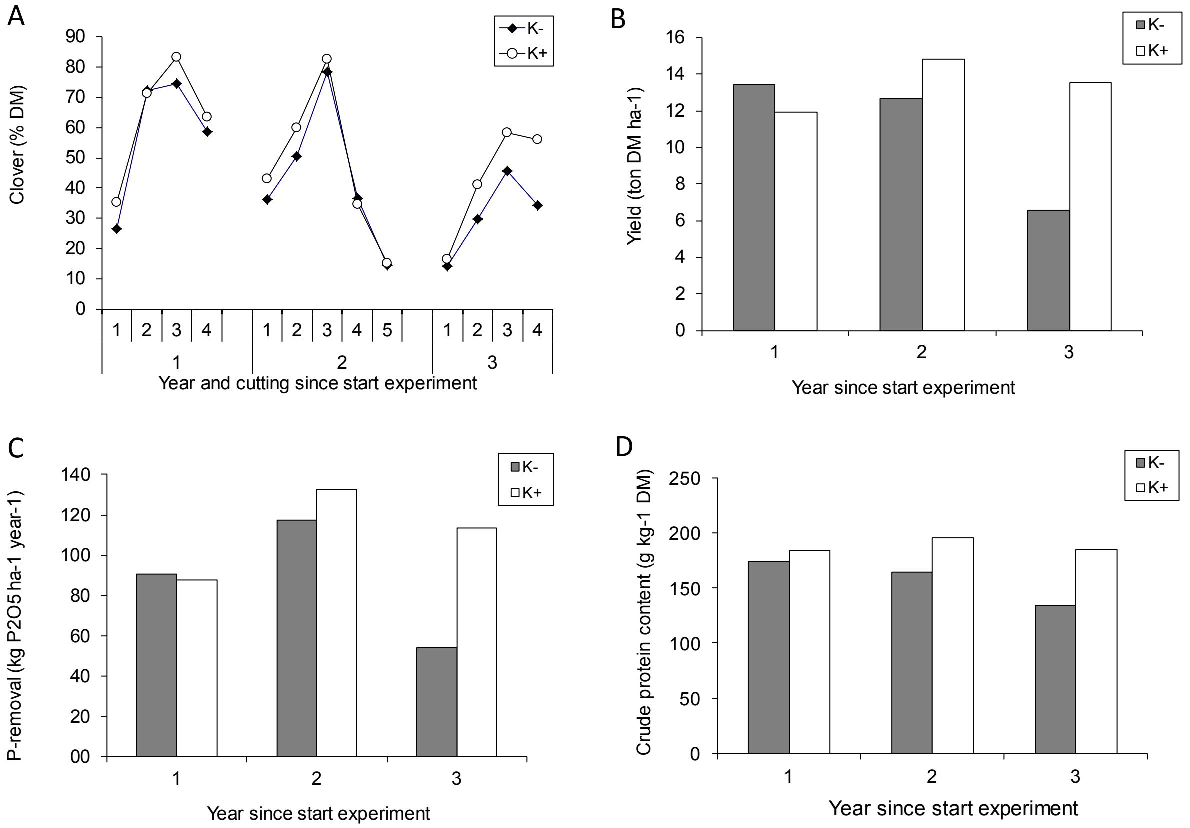

Figure 1. Results of the experiment in "Nieuwkerk" for grasclover with (K+) and without (K-) potassium fertilization: A. Clover percentage in the dry matter. B. Yields of mown grassclover (4-5 cuttings a year) . C. P-removal by the mown crop. D. Crude protein content of the grassclover.

During the course of the experiment, especially in the third year, the clover percentage of the plots without potassium fertilization decreased. As a result, the dry matter yield and phosphorus removal dropped even more, being less than halve the yield and phosphorus removal of the plots with potassium fertilization. Finally also the crude protein contents were measured: they were quite high (about 180 g kg^{-1} DM) for both treatments in year 1, and stayed about 180 g kg^{-1} for the treatment with potassium fertilization, but dropped to 134 g kg^{-1} DM in the treatment without potassium fertilization.

Soil measurements for phosphate in the 20 plots on the fields with grassclover and potassium fertilization ranged from low (P-total of 38 mg P_2O_5 per 100 g^{-1} dry soil) up to high (244 mg P_2O_5 100 g^{-1} dry soil) soils at the start of the treatment, with an average of 129 mg P_2O_5 per 100 g^{-1} dry soil in the top layer (0-10 cm) of the soil. After three years of P removal with the grassclover and potassium fertilization, an annual average decrease of 113 kg P_2O_5 ha^{-1} $year^{-1}$ dry soil was measured in the layer of 0-10 cm, and an annual decrease of 130 kg P_2O_5 ha^{-1} $year^{-1}$ in the layer of 0-30 cm (Table 1A). The annual decrease in plant available phosphorus for both layers was 2.9 and 2.6 mg P_2O_5 per 100 g^{-1} dry soil respectively (Table 1B).

Table 1. A: decrease of total soil P concentration (mg P_2O_5 100g^{-1} soil) and annual reduction per ha (kg P_2O_5 ha^{-1} y^{-1}), averages of 20 fields in nature areas managed with grassclover and potassium fertilization during 3 successive years. B: decrease in plant available P in the soils (mg P_2O_5 100g^{-1} soil) and average annual reduction (mg P_2O_5 100 g^{-1} soil).

A.

layer:	year 1	year 3	average reduction	SE	(p-value)	average reduction per ha
0-10 cm	129	115	14.2	5.5	0.019	113
0-30 cm	139	123	16.3	6.0	0.014	130

B.

layer:	year 1	year 3	average reduction	SE	(p-value)	average annual reduction
0-10 cm	53	45	8.6	2.3	0.001	2.9
0-30 cm	58	51	7.9	4.0	0.063	2.6

Discussion

Our field test showed that organically managed grassclover with potassium fertilization offers an alternative way to lower soil P levels. Quite a high production was maintained during the three years of measurements, resulting in high decreases of soil P levels. An extra was the high protein content of the mown material, caused by the presence of the clover in the sward: this made the mowing worthwhile for local farmers, and ensured a successful collaboration between farmers and nature organizations. Although these first results are positive, the methodology presented here is currently being tested in long term experiments to test whether high production and P removal levels are maintained also on a longer time scale, and at lower soil P levels to start with. In the long term, it could be an elegant way to reimport soil P that is bound in soils in nature areas back into the mineral cycle of an agricultural farm, and redirect/replace at least part of the imported P fertilizer that comes from mines abroad.

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