NITROGEN EFFICIENCY IN ORGANIC FARMING USING A GPS PRECISION FARMING TECHNIQUE

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Abstract

A GPS-controlled precision farming technique using the same tracks in the field year after year offers the opportunity to improve soil structure. Organic dairy manure sludge was applied at 40 and 14 ton/ha corresponding to farmers' practice and phosphate equilibrium respectively. Effects on soil structure, nutrient use efficiency and spinach yield were evaluated. Manure inputs could be reduced by 65% with comparable yields in traditional tillage and GPS-controlled precision tillage on permanent tracks.

Introduction

In the coming years, agriculture in the Netherlands will be forced to produce more high quality produce with smaller inputs of fertilisers. Organic agriculture should play a leading role and set an example for sustainable soil management. This implies greater nutrient use efficiency and fewer inputs. GPS-controlled precision tillage using the same tracks in the field year after year offers the opportunity to improve soil structure. The tracks become compacted, improving trafficability (Vermeulen & Klooster, 1992). Our hypothesis is that the soil structure of the remaining beds will improve, providing better aeration and rooting for the crop and access to necessary nutrients. This would mean that nutrient use efficiency would improve in GPS-controlled precision tillage systems. The aim of this study was to assess the effects of a GPS-controlled precision tillage system using permanent tracks on soil structure, nutrient use efficiency and spinach yield. The study was carried out at an organically-managed arable farm in the Netherlands.

Methodology

In a four-year study (2003-2007) the impact of lowering manure input levels in organic farming was studied in combination with GPS-controlled precision tillage. In 2004 spinach was used as a study crop in an on-farm experiment on an 80 ha organic vegetable farm in Langeweg (N. Br), the Netherlands. The soil in the study was characterized as loam (2.6% organic matter, 23% clay, pH-KCL 7.4). The experimental plots (6.3x25 m) were arranged in the open field according to a randomised block design with 4 replications, resulting in 16 experimental plots. Half of the plots were treated using GPS-controlled tillage, half of the plots with traditional organic tillage using no specific tracks in the field. Fertilisation was applied at two levels: 40 and 14 ton/ha dairy manure sludge (NPK= 4:1,5:5,5) corresponding respectively to farmers' practice (100%) and to phosphate equilibrium (35%) in the spinach based on total rotation. The experimental treatments are shown in table 1.

During the growing season, nitrate-N (NO_3-N) levels in the soil, soil structure and resistance were determined. NO_3-N in the soil was measured for each plot 1 month after fertilisation to a depth of 30 cm, as described by Koopmans & Brands (1993).

Soil structure was determined visually with a qualitative soil scan. Soil structure was rated as a percentage of crumbly, round and angular structures, using a modified method according to Shepherd (2000) as described in Koopmans & Brands (1993).

Table 1. Tillage and fertilisation treatments

Treatment	Tillage system	Fertiliser application	Nutrient application (kg/ha)		
			N	P2O5	K2O
1	Traditional	100% (=40 ton/ha)	160	60	220
2	Traditional	35% (=14 ton/ha)	56	21	77
3	GPS precision	100%	160	60	220
4	GPS precision	35%	56	21	77

Soil resistance was measured to a depth of 50 cm, using a penetrometer. At harvest time, crop yield and crop quality indicators (N, P) were determined. Nutrient use efficiency was calculated as the N-application rate with fertilisation divided by the total N amount taken up by the plant. Data were analysed with GENSTAT 7.2, ANOVA.

Results and brief discussion

Nitrate-N levels in the soil, one month after fertilisation were significantly higher ($P<0.05$) with the 100% fertilisation treatment (81 kg NO_3-N/ha) compared to the 35% fertilisation treatment (54 kg NO_3-N/ha).

Using GPS-controlled precision tillage resulted in more crumbling and less angular properties of the topsoil compared with the traditional organic system (figure 1 *left* and *right*).

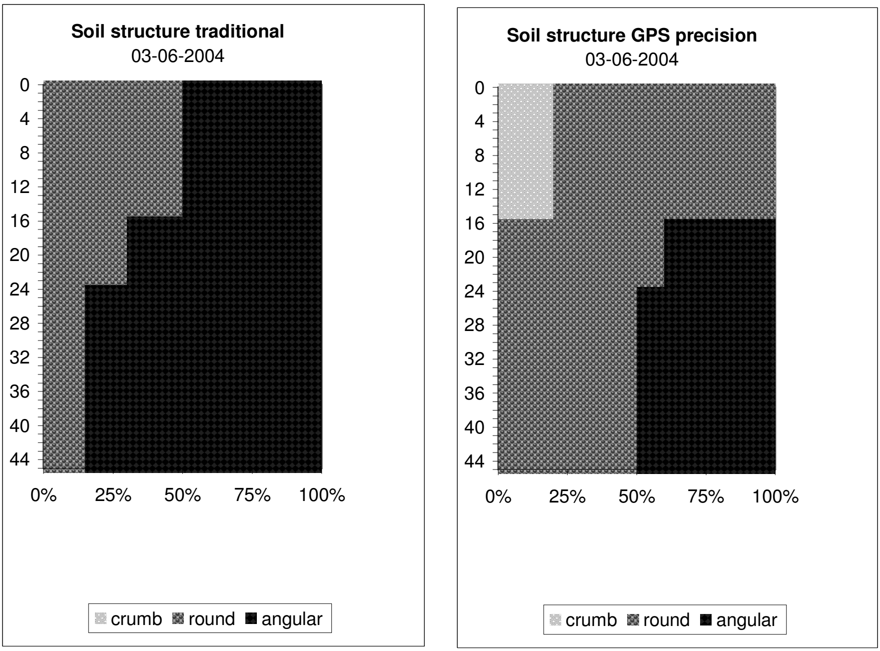

Figure 1. ***Left*: soil structure with traditional tillage system. *Right:* soil structure with GPS-controlled tillage system.**

Soil resistance was lower when using the GPS-controlled precision tillage technique (figure 2).

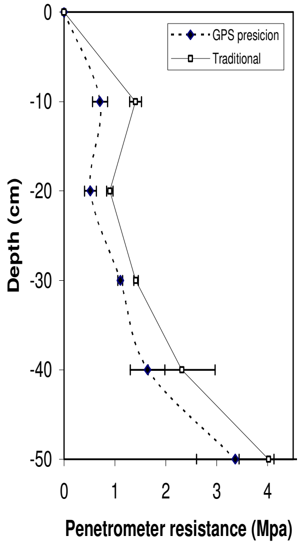

Figure 2. Penetrometer resistance of the soil with GPS-controlled tillage and traditional tillage.

There was a significant difference in the effect of fertilisation on yield between the 100% and 35% fertilisation treatments. The highest yields were obtained from plots with a fertilisation level of 100%. GPS-controlled precision tillage resulted in a significantly higher yield than traditional tillage. Interestingly there was no significant difference between yields in plots with GPS-controlled precision tillage with 35% fertilisation and traditional tillage with 100% fertilisation (figure 3). Nutrient use efficiency was significantly higher with the 35% fertilisation treatment (87%) as compared to the 100% fertilisation treatment (44%). GPS-controlled tillage a showed higher mean nutrient efficiency (71%) compared to traditional tillage (59%).

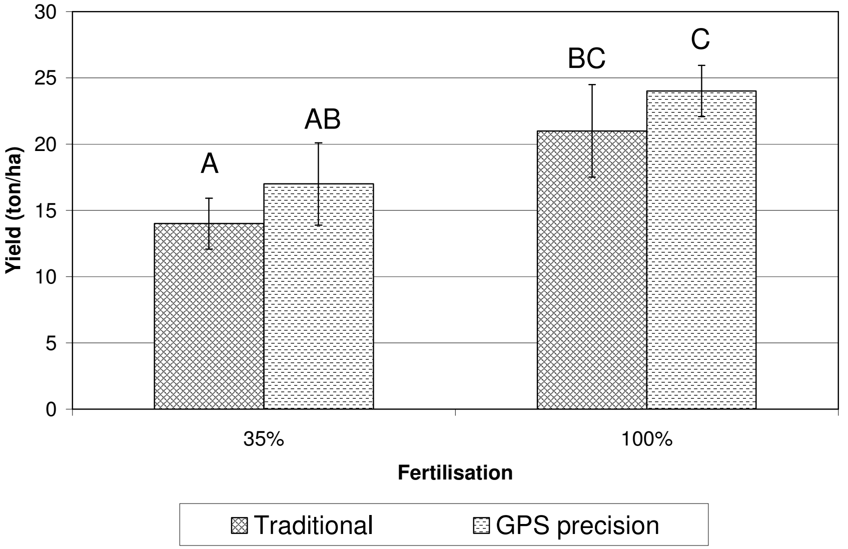

Figure 3. Mean spinach yield in 4 treatments: 35% fertilisation + traditional soil treatment; 35% fertilisation + GPS precision treatment; 100% fertilisation + traditional soil treatment, and 100% fertilisation + GPS precision treatment. Different characters indicate significant differences between the four treatments (Genstat Anova, P<0.05).

Conclusions

The results indicate that, possibly due to improved soil structure, nutrient use efficiencies can be improved using a GPS-controlled precision tillage system. A study of one crop in the rotation showed that lowering the amount of fertiliser has no significant effect on yield reduction when GPS-controlled precision tillage is used. The higher nutrient use efficiency at lower fertilisation levels stretches the possibilities for reducing inputs in organic agriculture. If fertilizer inputs are reduced in the next few years towards phosphate equilibrium at the crop rotation level, the GPS-controlled precision tillage system might become an important tool for organic farmers to maintain high-level yields. For farmers in the field the GPS systems might be a solution to improve their soil structure and increase the sustainability of their practices without substantially lowering yields. The evaluation of the relationship between N availability, soil structure and crop yield is ongoing.

References

Koopmans, Chr. & Brands, L. (1993) *Testkit bodemkwaliteit*. Louis Bolk Instituut; Driebergen, The Netherlands.

Shepherd, T.G. (2000). *Visual soil assessment. Volume 1. Field guide for cropping and pastoral grazing on flat to rolling country*. Horizons.mw & Landcare Research; Palmerston North, New Zealand.

Vermeulen, G.D. & Klooster, J.J. (1992) The potential of a low ground pressure traffic system to reduce soil compaction on a clayey loam soil. *Soil & Tillage Research* 24: 337-358.