CONTROLLED TRAFFIC FARMING INCREASES ROOT GROWTH, CROP AND SOIL NITROGEN IN VEGETABLE CROPPING SYSTEMS

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INTRODUCTION

Problems of machinery induced soil compaction are evident in crop production, resulting in changes of nitrogen (N) availability, restricted root growth and reduced yields (Batey & McKenzie, 2006). Controlled traffic farming (CTF) uses GPS signals to keep machine traffic in permanent lanes, which restricts soil compaction to wheel tracks. In our study we compared effects of CTF to random traffic farming (RTF) on root growth, soil N mineralization, N uptake and crop yield, in organic vegetable cropping systems across two soil types in Denmark after a period of two years since establishment. Our hypotheses were that CTF will in contrast to RTF (1) improve root growth, (2) not affect N mineralization and (3) increase crop yield and N uptake.

MATERIAL AND METHODS

Field experiments were conducted at two commercial organic farms in Denmark from 2013 to 2016. The farm of Skiftekær Økologi (54°58'N, 10°32'E) was situated on a fine sandy loam and the farm of Vostrup Øko (55°89'N, 8°45'E) on a coarse sandy soil. CTF was compared to RTF as the control (n=3). CTF was carried out with auto-guidance and highly accurate RTK-GPS (Real Time Kinematic). Machinery traffic in the CTF plots was restricted to permanent tracks contrary to machinery traffic in the RTF plots. Crop samples were analysed for marketable yields, total biomass and N content to calculate N accumulation; and soil mineral N. Potential soil N mineralization was studied by incubating top soil samples at 25°C for 35 days. Root growth was registered by filming by use of minirhizotrons reaching 1.5 or 2.5 m depth (Xie & Kristensen, 2017). The number of roots was calculated as root intensity and tested by fitting to a Poisson distribution including a random component and adding an offset to improve the statistical analysis. This resulted in an arbitrary (no) unit.

The 5-year crop rotation at Skiftekær Økologi was red clover – white cabbage – potato followed by vetch as a winter cover crop – beetroot – winter squash. The experimental design included the full crop rotation in adjacent fields each year. Three out fields per treatment were sampled each year, being at the same GPS position within the bed throughout the experiment. At Vostrup Øko the 4-year crop rotation was grass-clover – carrot – potato – beetroot with a similar design as at Skiftekær, but only growing one crop each year.

RESULTS AND DISCUSSION

Crops had more roots at harvest especially in the deep part of the root zone in four out of the six crop seasons at Skiftekær Økologi, that is, in white cabbage and potato in 2015 and in beetroot and winter squash in 2016 (Figure 1). At Vostrup Øko more roots were found under beetroot in 2015 (data not shown). N accumulation was higher in CTF treatments in white cabbage and potato in 2015, but not in beetroot in 2015 or in 2016 at Skiftekær Økologi. The difference was not significant at Vostrup Øko (Table 1). Yields at the two farms followed the same pattern as the N accumulation (data not shown). Soil mineral N was higher below CTF for some crops, whereas potential mineralization of N did not differ between CTF and RTF treatments (data not shown). These results indicate a positive effect of CTF on crop yields, root growth and N accumulation already 2 and 3 years after conversion from RTF at Skiftekær Økologi on a fine sandy loam. However, the effect was not evident every year or clearly linked to crop species. At Vostrup Øko on coarse sandy soil, the effect of CTF was significant only on root growth.

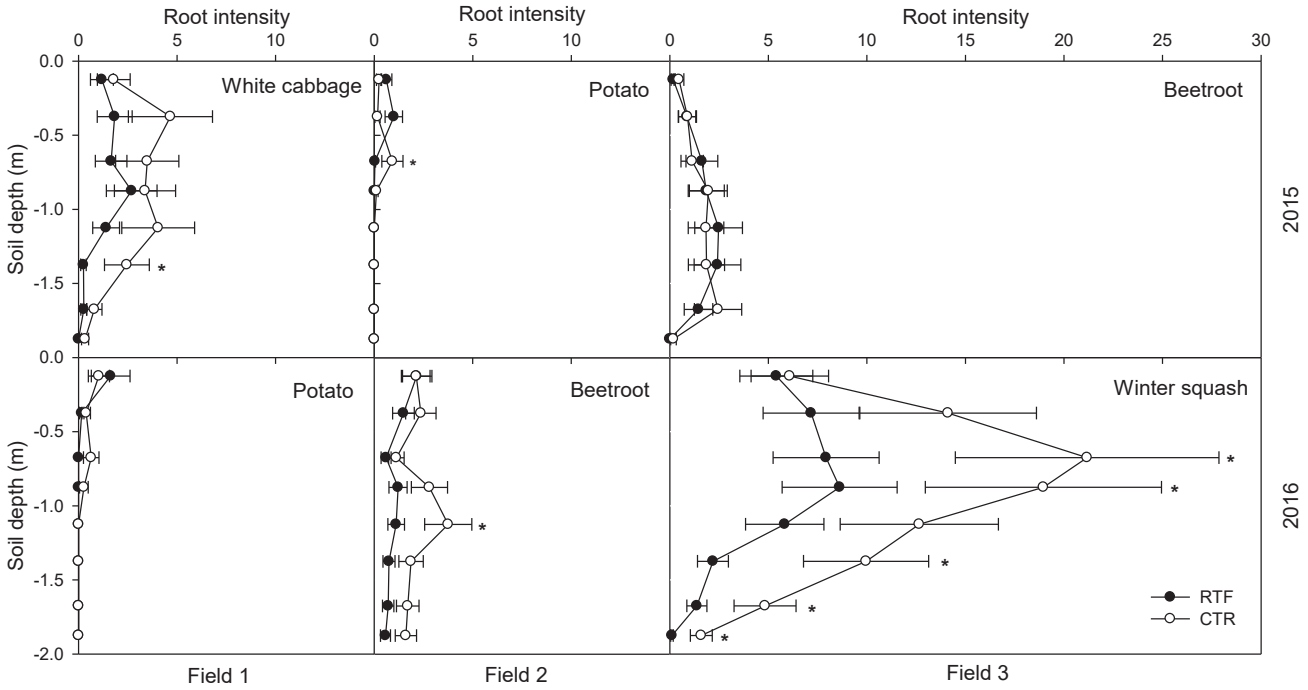

Figure 1. Root intensity at Skiftekær Økologi in 0 to 2 m depth at crop harvest in the sampled fields in 2015 and 2016. Bars show 95% confidence intervals. indicate significant difference between treatments at p<0.05.*

Table 1. Nitrogen accumulation (kg ha^{-1}) in the aboveground plant parts at Skiftekær Økologi (Fields 1-3) and Vostrup Øko. Confidence intervals at 95% are shown. Different letters indicate difference between treatments at p<0.05.

Treatment	Field 1	Field 2	Field 3	Vostrup
2015	White cabbage	Potato	Beetroot	Beetroot
CTF	142 (131-153) [a]	153 (134-172) [a]	87 (74-101) [a]	113 (87-139) [a]
RTF	116 (105-127) [b]	92 (73-111) [b]	71 (57-84) [a]	87 (61-113) [a]
2016	Potato	Beetroot	Winter squash	
CTF	51 (33-69) [a]	72 (54-91) [a]	68 (50-87) [a]	-
RTF	52 (34-70) [a]	68 (49-86) [a]	48 (30-66) [a]	-

CONCLUSION

CTF increased root growth, yields and N accumulation in several vegetable crops in an organic crop rotation on sandy loam and increased root growth on sandy soil. The results underline the potential of CTF to improve yields and N use efficiency in organic vegetable production.

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