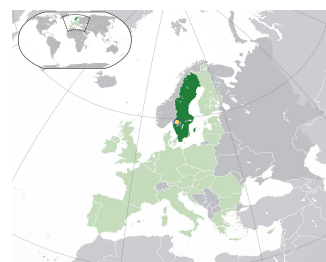


# Carbon sequestration in long-term, on-farm studies in organic and biodynamic agriculture, Sweden



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Sweden with study site location in yellow.

## Introduction

This field experiment was established within an integrated biodynamic crop and animal farm. Treatments were based on resources available on the farm; using only manure produced on-farm. The aim was to evaluate long-term consequences on quality and yield in crops as well as quality parameters in soil, by comparing the use of composted and not composted manure, with or without use of the full set of biodynamic preparations.

Long-term trials on organic farms, compared to conventional farms, have shown increased soil organic carbon (SOC) (Marriott & Wander 2006). However, uncertainty remains about SOC sequestration in organic and biodynamic agriculture (Leifeld & Fuhrer 2010).

## Materials and methods

The soil at the field trial site is mainly a clay loam, with an organic carbon content of between 1.9% and 2.9%. Soil under the topsoil is stratified, with glacial layered clay at the bottom. Topsoil has undergone secondary sorting of soil fractions (post-glacial clay, loam and silt) since the last ice age. The soil is generally high in potassium (K), low in phosphorus (P) and has a pH between 5.7 and 6.2.

Soil samples were taken after Ley III in the five-year crop rotation before manuring and sowing winter wheat. Samples from the upper soil layer (0–20 cm) of each of the 48 plots of the field trial were sent to Agrilab (Uppsala, Sweden), and analysed according to established standards. Total C (carbon) and N (nitrogen) content were measured with a LECO CHN 600 element analyser (SS-ISO 11464). Available P (phosphorus), K (potassium), Ca (calcium), Mg (magnesium) and Na (sodium) were analysed after extraction in ammonium lactate (AL) solution (SS 028310). Total P, K, Mg, Ca and Cu (copper) were determined according to SS 028311 after extraction in hydrochloric acid (HCl) and pH was determined according to SS-ISO 10390.

Carbon balance for each year based on total carbon yield, incorporation of crop residues in soil, harvested carbon and recirculation via manure, increase of carbon through SOM (soil organic matter), formation and decrease of organic carbon in SOM through mineralisation during the five-year crop rotation was calculated according the model developed and tested by Granstedt & L-Bäckström (2000). Values calculated in the model were compared to values obtained in trials in 1995, 2000 and 2005.

Computer program Excel 2010 (Microsoft Corp., Redmond, WA, USA) was used for calculations and statistical evaluations.



Field trial sites at Skilleby farm in Sweden



Design, field trial 1991			
Treatment	Plot	Block	Plot Treatment
NCM25-	25	C	1 CM50+
NCM25+	26		2 CM50+
CM12.5+	27		3 NCM12.5+
CM12.5-	28		4 NCM12.5-
CM25+	29		5 CM12.5+
CM25-	30		6 CM12.5-
NCM12.5-	31		7 NCM50+
NCM12.5+	32		8 NCM50-
CM50-	33		9 NCM25-
CM50+	34		10 NCM25+
NCM50+	35		11 CM25-
NCM50-	36		12 CM25+
CM50-	37	D	13 NCM12.5-
CM50+	38		14 NCM12.5+
NCM50+	39		15 NCM25+
NCM50-	40		16 NCM25-
CM12.5+	41		17 CM25-
CM12.5-	42		18 CM25+
NCM25+	43		19 CM12.5+
NCM25-	44		20 CM12.5-
NCM12.5-	45		21 NCM50+
NCM12.5+	46		22 NCM50-
CM25-	47		23 CM50-
CM25+	48		24 CM50+



Manure treatments			
Abbreviations	Type	Ton/ha	Kg N/ha
NCM12.5-	Non-composted manure 1991	12.5	31.3
NCM12.5+			
NCM25-	Non-composted manure 1991, 1995, 2000	25	62.5
NCM25+			
NCM50-	Non-composted manure 1991, 1995, 2000	50	125
NCM50+			
CM12.5-	Composted manure 1991	12.5	31.3
CM12.5+			
CM25-	Composted manure 1991, 1995, 2000	25	62.5
CM25+			
CM50-	Composted manure 1991, 1995, 2000	50	125
CM50+			
Biodynamic preparations			
-	no		
+	yes		

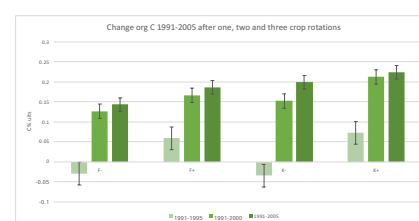
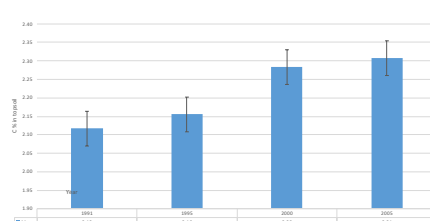
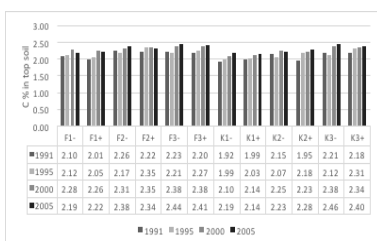


Clover plant and nitrogen fixing nodules

## Results

During the 15-year period 1991 to 2000 pH, P-AI, K-AI, Mg and Ca increased in all manure treatments despite of negative values for P and K in the farm gate balances. Soluble P content in the soil is very low (P class 1 to P class 2) but soluble K is at a sufficient level (K class 3).

Average total organic carbon content in topsoil increased in all treatments during the 14-year period from 1991 to 2005.



## Discussion

Increase in soil carbon averaged 400 kg carbon per ha and year in the topsoil (0–20 cm and an average bulk density of 1.25 g/cm<sup>3</sup>) from 1991–2005. During the first 4 years, we observed a significant increase ( $p < 0.05$ ) for composted and not composted manure with use of biodynamic treatments compared use of manure without biodynamic treatments. Additionally, we observed an average increase of 0.14 % in organic carbon in the B horizon (60–90 cm).

During the first 14 years of the field trial there was a positive correlation between the calculated total increase in soil carbon content and the measured value. There was a higher carbon sequestration in treatments with biodynamic composted manure compared to composted manure without biodynamic treatments in accordance earlier long-term studies (Mäder et al. 2002) and Bachinger (1996). With background of this results long term studies and evaluation of already obtained results are going on under Nordic conditions.

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## Further information

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