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THÜNEN

Innovative Research for Organic 3.0
Volume 1

Proceedings of the Scientific Track
at the Organic World Congress 2017

November 9-11 in Delhi, India

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Carbon sequestration in long term on farm studies in Organic and Biodynamic Agriculture, Sweden

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Key words: carbon sequestration, biodynamic agriculture, compost, crop rotation, manure

Abstract

Beginning in 1958, three sets of long-term field trials have been conducted at the Swedish Biodynamic Research Institute in Järna, Sweden. Design of the field trial described in this paper differs from the earlier long-term experiments - it was established on an integrated biodynamic crop and livestock farm. Treatments were based on resources available on the farm; using only manure produced on-farm. The aim was to evaluate long-term effects on quality and yield in crops and quality parameters in soil, by comparing use of composted and not composted manure, with or without the full set of biodynamic preparations. Increase of carbon was calculated to a carbon sequestration averaging 400 kg carbon per ha and year in the topsoil, with the highest value (500 kg) with use of biodynamic treatments and composted manure, compared to 300 kg with use of not composted manure without biodynamic treatments.

Introduction

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).

Three sets of long-term field trials have been conducted at the Swedish Biodynamic Research Institute in Järna, Sweden, since 1958. The basic aim was to develop biodynamic farming during Nordic conditions. The experiments started as an initiative within the Scandinavian Research circle for biodynamic agriculture, founded already in 1949 with members from the all Nordic Countries.

The results from the initial K-experiment (Kjellenberg, Granstedt, & Pettersson, 2005) formed the basis for one 6- and one 9-year trial, jointly called the UJ-experiments. Results from the two trials corresponded well with each other, as well with the results from the K- experiment (Dlouhy, 1981; Kjellenberg & Granstedt, 2015; Pettersson, 1982)

The design of the field experiment reported from in this paper differs from the earlier long term experiments. It was established within an integrated biodynamic crop and animal farm. The field trial was established within an integrated biodynamic crop and livestock farm in Järna, Sweden, 59° N. 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.

Material and methods

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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.

Design, field trial 1991

Treatment	Plot	Block	Block	Plot	Treatment
NCM25-	25	C	A	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	B	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+

4 m

15 m

Manure treatments

Abbreviations	Type	Tons/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		

Figure 1. Field trial design, Skilleby Research Farm

Soil samples was 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.

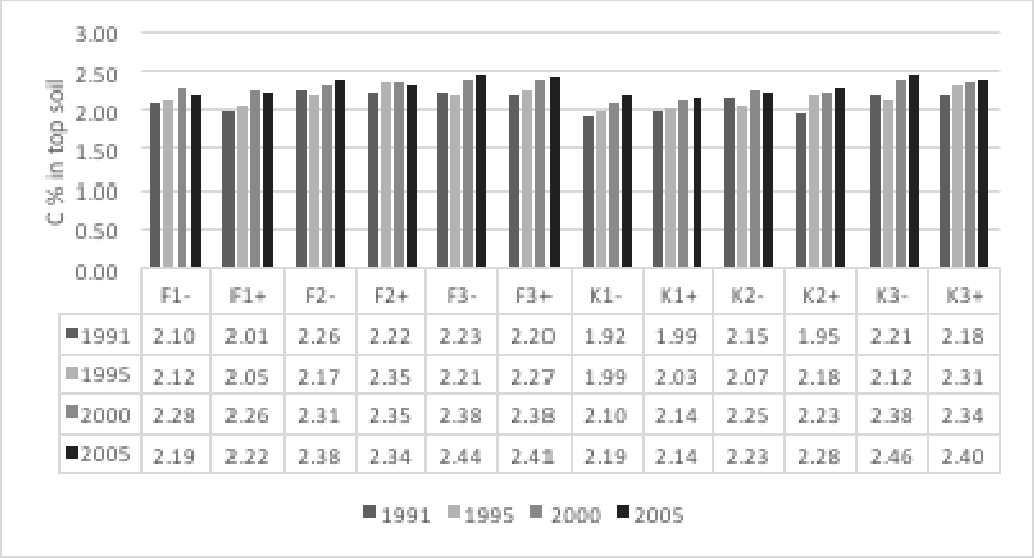
Carbon balance for each year based on total carbon yield, incorporation of crop residues in soil, harvested carbon and recirculation via manure, increase of carbon through SOM (soil organic matter), formation and decrease of organic carbon in SOM through mineralisation during the five-year crop rotation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

Results

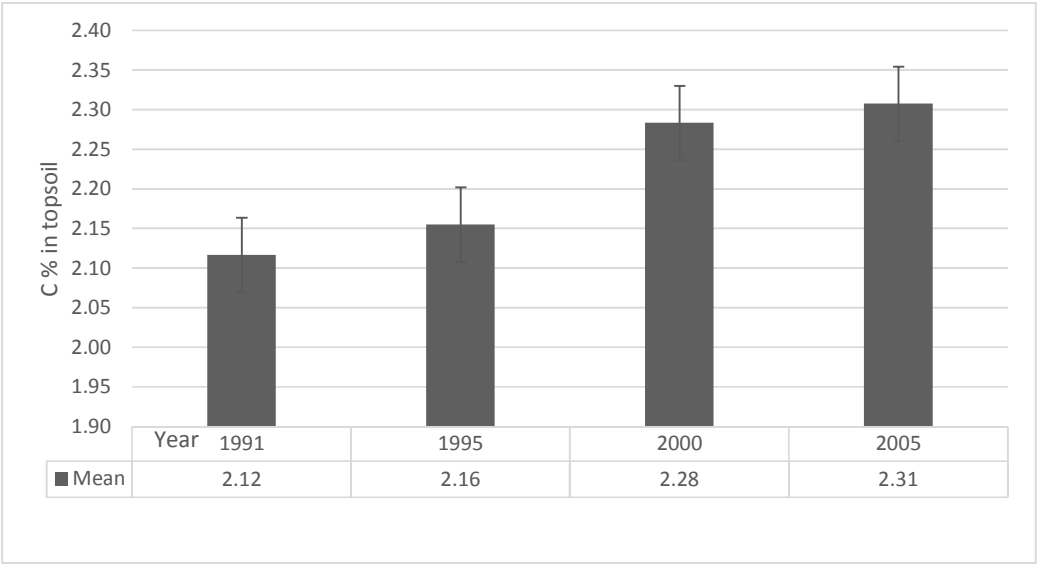
During the 15-year period 1991 to 2000 pH, P-Al, K-Al, Mg and Ca increased in all manure treatments despite of negative values for P and K in the farm gate balances. Soluble P content in the soil is very low (P class 1 to P class 2) but soluble K is at a sufficient level (K class 3).

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



	F1-	F1+	F2-	F2+	F3-	F3+	K1-	K1+	K2-	K2+	K3-	K3+
1991	2.10	2.01	2.26	2.22	2.23	2.20	1.92	1.99	2.15	1.95	2.21	2.18
1995	2.12	2.05	2.17	2.35	2.21	2.27	1.99	2.03	2.07	2.18	2.12	2.31
2000	2.28	2.26	2.31	2.35	2.38	2.38	2.10	2.14	2.25	2.23	2.38	2.34
2005	2.19	2.22	2.38	2.34	2.44	2.41	2.19	2.14	2.23	2.28	2.46	2.40

Figure 2. Total carbon content in topsoil in the 12 different treatments 1991, 1995, 2000 and 2005.



Year	1991	1995	2000	2005
Mean	2.12	2.16	2.28	2.31

Figure 3. Average total carbon in topsoil, all treatments, in 1991, 1995, 2000 and 2005. General trend concerning total carbon content in the top soil in the 12 different treatments. Error bars indicate standard error (SE).

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^3) 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.

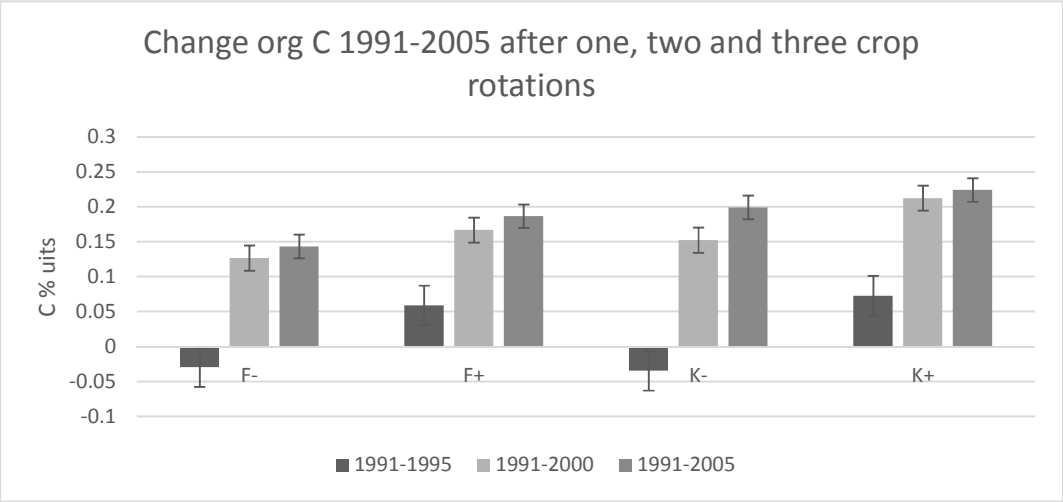


Figure 4. Average increase of total organic carbon content in topsoil in treatments with not composted manure without (NCM-) and with biodynamic (NCM+), and composted manure without (CM-) and with biodynamic (CM+) from 1991 - 1995, 1991-2000 and 1991-2000.

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