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Effects of Different Long-Term Soil Management Systems on Some Physical and Chemical Properties and Crop Production in Soils in Berlin-Dahlem and Dedelow- ZALF Müncheberg (Germany)

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ABSTRACT

Soil management systems influence the agricultural system as they have in short- and long term period different effects on soil physical and chemical properties, therefore influencing the efficiency of production as well. A well directed choice of tillage equipments leads to a better soil protection and enables a higher fertility which is an important requirement for sustainable agriculture. The aim of this study is to investigate the effects of different soil management systems on some physical and chemical properties and the crop production of these sandy soils. This study demonstrates the first results obtained from the year 2006, performed on the long-term land use experiment with the effects of three different factors (deep and shallow tillage; 17 and 28 cm, lime application; +Ca and –Ca and Farmyard manure; +FYM and –FYM) in Berlin-Dahlem (Germany), Humboldt University of Berlin and the ZALF experimental station at Dedelow (Germany) in 5 different tillage systems (no-tillage, mulch; 10 cm, cultivator; 15 cm, plough; 15 cm and plough; 25 cm).

The soil heterogeneity were determined and evaluated with the computer program "Surfer" depending on the different depths of the sand and loam layers. The penetration resistances of both experimental fields showed that the deep tillage systems caused a higher compacted zone in deeper soil layers. It was found that there are significant differences in the soil aggregate stability and pH values between the shallow and deep tillage systems in Berlin-Dahlem. The pH values were significantly higher in the deep tillage systems. The soil organic matter contents were found higher in the deep tillage systems but there were no significant differences. There were also no significant differences in grain yield between these two tillage systems in Berlin-Dahlem.

Key words: Penetration resistance, soil compaction, pH, aggregate stability, soil organic matter, crop production

INTRODUCTION

Long-term tillage experiments are needed to understand soil chemical and biochemical processes and provide consistent experimental results. Long-term experiments require considerable resources, time and labour input, but they offer the best practical means of understanding many of the problems of farmers, ecologists and policy makers have to deal with (Poulton, 1996).

Tillage management and manure application are among the important factors affecting soil physical properties and crop yield. Still today, farmers continue to use intensive conventional tillage for plant production in some European areas. However, the European Community agricultural policy has strongly encouraged conservation tillage practices in order to decrease soil loss (European Union, 2000).

Benefits of long-term no-tillage over conventional tillage include: reduced soil erosion, increased organic carbon, higher infiltration, more soil biological activity, reduced evaporation, reduced labour requirements and greater profits (Lal et al., 2003; Souza Andrade et al., 2003). Many farmers are taking advantage of the economic and environmental benefits of no-tillage, by the increased adoption in many parts of the world (Towery, 2002).

According to the soil physical characteristics, farm yard manure application is very important because it changes the structure which has a positive effect on soil and crop yield. Manures have traditionally been accepted as a source of plant nutrients; however, the beneficial soil physical effects have received little attention. The maintenance of optimum soil physical fertility is an important component of soil management, which has only recently been accepted (Haynes and Naidu, 1998). Manure application significantly increased soil organic matter content on row and inter-row positions.

In addition to tillage and farm yard manure application benefits, calcium improves the soil physical properties and is one of the most important nutrition elements for plant growth.

The objective of this study was to determine the effects of different long-term soil management systems on some physical and chemical properties and crop production in soils in Berlin-Dahlem and Dedelow- ZALF Müncheberg (Germany).

MATERIALS and METHODS:

The field experiment were conducted by the Experimental Station in Berlin Dahlem (52° 28'' N, 13° 18'' E) which is located between oceanic and continental climate conditions. This experiment was created by Kurt Opitz in 1923. Thus it is the oldest long-term field experiment on sandy soils in Germany.

The soil of the area is an Albic Luvisol (FAO). The soil properties are: Approximate water holding capacity 21 mm per 100 mm; approximate soil organic matter content: 1.2 %; approximate carbon content: 0.7 %; approximate carbon: nitrogen ratio:10:1; approximate soil bulk density: 1.7 g cm^{-3}; clay (i.e. particles smaller than 2 µm): 4 %; silt (i.e. particles between 2 µm and 63 µm): 23 %; sand (i.e. particles between 63 µm and 2000 µm): 73 %; approximate soil pH: 5.5.

This experimental design consists of three different factors which has different tillage depths (17 cm and 28 cm), farm yard manure application (with or without) and lime application (with or without) with 6 replications. Each main plot has acreage of 20 m² and harvest acreage of 10.08 m². According to these factors, the disturbed and undisturbed soil samples where taken from totally 48 plots from 10-15 cm and 20-25 cm soil depths. The penetration resistance values were taken from all these 48 plots in spring 2006.

Geographically the research area Leibniz Centre for Agricultural Landscape Research (ZALF) Müncheberg is situated in Northeast Germany which was established in 1985. The approximately soil properties are: Soil organic matter content 0.9 %, carbon content 0.98 %, carbon: nitrogen ratio 7-10:1, soil bulk density: 1.7 g cm^{-3}, clay (i.e. particles smaller than 2 µm): 10 %; silt (i.e. particles between 2 µm and 63 µm): 30 %; sand (i.e. particles between 63 µm and 2000 µm): 60 %, pH: 7.5-8.2.

The experimental design consists of 5 different tillage depths (No-tillage, mulch: 10cm, cultivator: 15 cm, plough: 15 cm and plough: 25 cm) from where the soil samples were taken from 10-15 cm and 20-25 cm depths.

RESULTS and DISCUSSION:

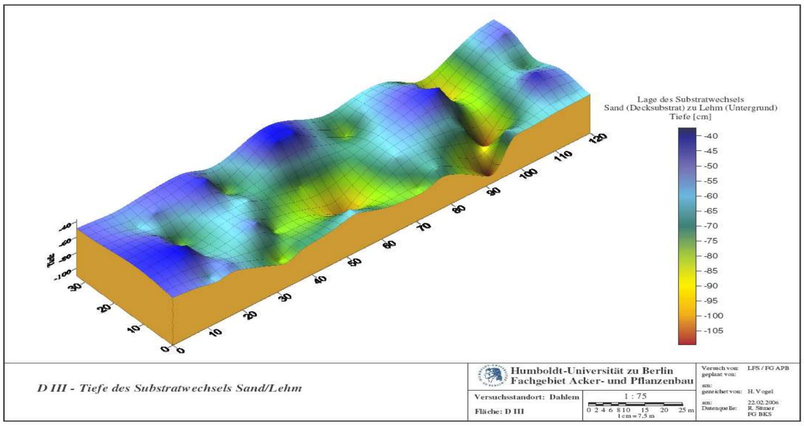

Figure 1: Display of Substrat- Change in the Long-Term Field Experiment DIII at Berlin Dahlem via Software „Surfer“.

The spatial variability of soils plays in important role in plant growth. Therefore it’s important to know the heterogeneity which affects the root elongation for a healthy plant growth. This field experiment showed that the sand layer varies between the depths of 35 cm and 110 cm. The spatial variability showed a wide heterogeneity.

Table 1: Results from some physical and chemical properties and crop production in soils in Berlin-Dahlem

Factors		pH 10-15 cm	pH 20-25 cm	Humus (%) 10-15 cm	Humus (%) 20-25 cm	Aggregat St. (%) 10-15 cm	Aggregat St. (%) 20-25 cm	C/N 10-15 cm	C/N 20-25 cm	Grainyield (dt/ha)
deep (28 cm)	(+) FYM, (+) lime	5,8 de	5,9 c	1,27 cd	1,25 cd	13,30 ab	13,05 ab	13,94 a	13,64 bcd	27,79 b
	(+) FYM, (-) lime	4,4 c	4,3 b	1,16 bc	1,06 abc	13,06 ab	13,14 ab	14,33 a	13,30 abc	29,24 b
	(-) FYM, (+) lime	6,0 e	6,0 c	1,09 ab	1,01 ab	13,32 ab	13,24 ab	14,38 a	14,07 cd	25,89 b
	(-) FYM, (-) lime	4,0 bc	4,0 b	0,98 a	0,94 a	11,62 a	12,71 a	14,32 a	14,34 d	23,70 b
shallow (17 cm)	(+) FYM, (+) lime	5,5 de	5,6 c	1,78 e	1,28 d	18,76 d	15,61 abc	14,49 a	12,45 a	24,96 b
	(+) FYM, (-) lime	3,9 ab	3,9 ab	1,68 e	1,11 abcd	18,03 cd	16,15 c	14,57 ab	13,09 ab	28,74 b
	(-) FYM, (+) lime	5,4 d	5,6 c	1,40 d	1,14 bcd	15,51 bc	15,61 bc	14,73 ab	13,28 abc	23,75 b
	(-) FYM, (-) lime	3,5 a	3,5 a	1,38 d	1,11 abcd	15,41 bc	17,60 c	15,63 b	13,94 bcd	15,32 a
	LSD_{A*B*C} (a= 5 %)	0,45	0,42	0,16	0,18	3,05	2,89	1,13	0,95	6,40
	* significant in multipler T- Test									*

According to this one year experiment in Berlin Dahlem 2006, results show that there was a positive effect between three treatments (lime, FYM and tillage depth) on Humus- Aggregate Stability relation. Each tillage system shows higher Humus and Aggregate Stability results in contrast to none FYM applications in itself. The humus content is closely related to soil aggregate stability Furthermore, the Humus and Aggregate Stability results are higher in shallow tillage in contrast to deep tillage system. A relatively higher Humus content in the shallow tillage system shows that deep tillage went to a reduction in soil organic carbon in the deep tillage system.

The soil C/N ratio (10-15 cm and 20-25 cm) were between 12.45 and 15.63 for both soil depths in all tillage systems. The pH values were between 3.5 and 6.0 and show higher results in deep tillage system. There was found no significant differences between the grain yield in both tillage systems except of the (-) FYM and (-) lime application in shallow tillage.

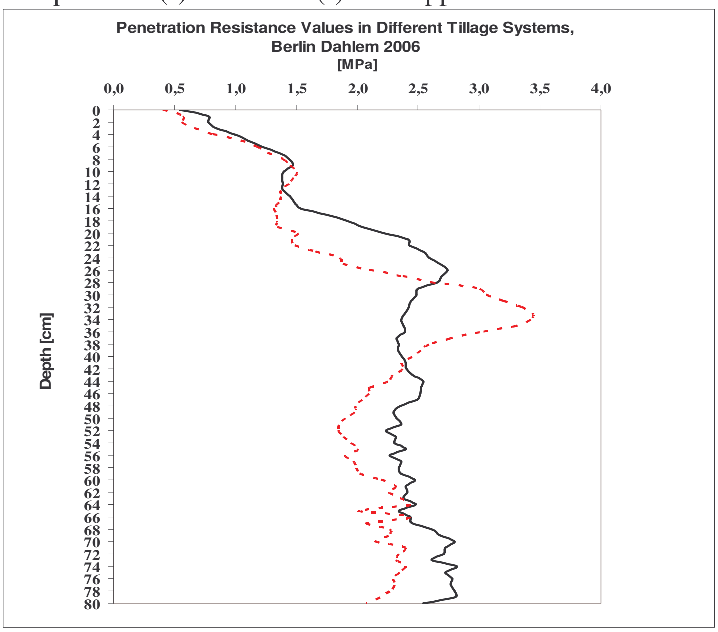

Figure 2: Penetration Resistance Values in Different Tillage Systems,Berlin Dahlem 2006

The penetration resistance begins with nearly the same value at the surface of both deep tillage systems. Until reaching the 10 cm soil depth, both systems show nearly the same resistance effects. Between 10- 26 cm soil layer there is a more compacted soil layer in shallow tillage. The deep tillage system shows a maximum compacted soil layer with a value of 3.5 MPa in 32 cm depth whereas in shallow tillage this value is only 2.7 MP in 26 cm soil depth. The penetration resistances of both experimental fields showed that the deep tillage systems caused a higher compacted zone in deeper soil layers.

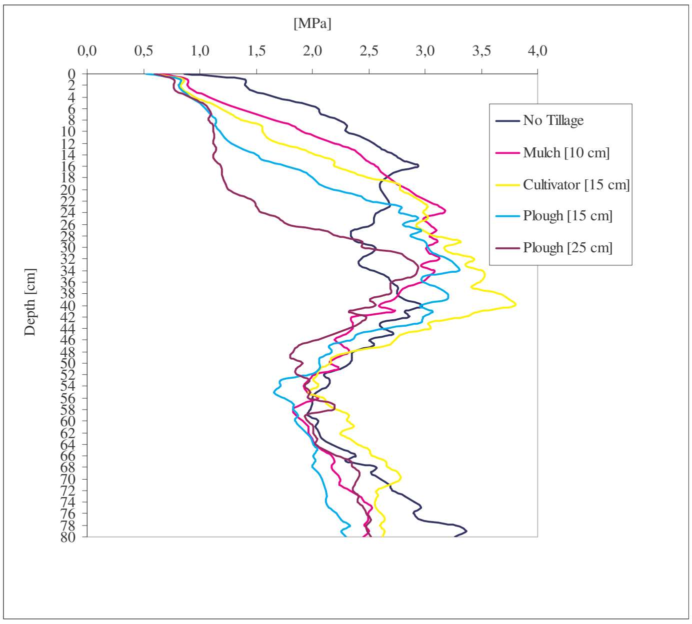

Figure 3: Penetration Resistance Values in Different Tillage

Systems, ZALF 2007

The penetration resistance values in ZALF show the most compacted zone between 0-16 cm soil depths belonging to No- Tillage system. The lowest compacted soil zone between 0-25 cm can be seen at plough (25 cm).

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