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ABSTRACT

Surface mining for coal removal causes drastic soil disturbance and changes in inherent soil properties. Reclamation restores the area back to its original topography and land use. Restoration of disturbed land is followed by the application of nutrients to the soil to initiate the vegetation development. Reclamation is important both for preserving the environmental quality and increasing agronomic yields. Since reclamation treatments have significant influence on the rate of soil development, this study was designed with the objectives of assessing the potential of different methods of soil reclamation on soil organic C (SOC) sequestration rate, soil development, and changes in soil physical and water transmission properties. The experimental sites, owned and maintained by American Electrical Power, are located along the borders of Guernsey, Noble and Muskingum Counties of Ohio. Among the three sites chosen for this study three were reclaimed in 1987 and one site was reclaimed in 1994. All three sites were reclaimed with topsoil application and were under continuous grass cover. Eighteen experimental plots (4m x 4m) were developed on each site during the month of May 2004. Five treatments applied in triplicate on each experimental site were: manure (M), compost (C), fertilizer (F; N, P, K), manure+ compost (MC), and fertilizer + compost (FC). Equivalent amounts of nitrogen on mass basis were applied on each plot. In addition, a control (no application) treatment in triplicate was also selected on each site. All plots were 4m X 4m and compost, manure and fertilizers were broadcasted on each site. Soil bulk density (ρ_b) increased with depth in all plots and sites. For the 0-15 cm depth, ρ_b was the highest in the control treatment at each site. Total nitrogen (TN) and total carbon (TC) concentrations were higher for 0-15 cm than 15-30 cm depth in all plots and sites. For 30-50 cm depth, TC concentrations were the highest in experimental plots in switch grass and Cumberland site, indicating contamination due to coal dust or particles. No significant

differences in TN and TC concentrations and stocks were obtained for 0-15 cm depth in plots in Tilton Run site. Few differences in TN and TC concentrations were observed in experimental plots in Cumberland site for all three depths. Few differences in TC concentrations and stocks among treatments were mainly due to treatments being applied only last year.

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1.0 **Executive Summary**

This research project is aimed at assessing the soil organic carbon (SOC) sequestration potential of reclaimed minesoils (RMS) and is supported by US Department of Energy- National Energy Technology Laboratory. The proposed research focuses on: (1) assessing the sink capacity of RMS to sequester SOC in selective age chronosequences, (2) determining the rate of SOC sequestration, and it's spatial (vertical as well as horizontal) and temporal variation, (3) developing and validating models for SOC sequestration rate, (4) identifying the mechanisms of SOC sequestration in RMS, (5) evaluating the potential of different methods of soil reclamation on SOC sequestration rate, soil development, and changes in soil mechanical and water transmission properties, and (6) establishing the relation between SOC sequestration rate, and soil quality in relation to soil structure and hydrological properties.

In this project, several experimental sites were identified, which were reclaimed both prior to SMRCA regulation (without topsoil under grass or forest) and after (with topsoil under grass or fores). All these sites are characterized by distinct age chronosequences of reclaimed minesoil, Sites are located along the borders of Guernsey, Noble and Muskingum counties of Ohio. and are maintained and owned by American Electrical Power. Surface mining operations are performed to remove coal from underlying soil horizons in Ohio. These operations require digging and pilling of large amount of soil. Before 1972, surface mining operations were performed by removing the soil and underlying strata and piling them on a side. After mining operations were complete, due to the nonexistence of any specific reclamation guidelines, the excavated area was planted to trees or grass without grading or reclamation. After 1972, Ohio Mineland Reclamation Act (also 1977 SMRCA) made it mandatory to grade the area back to the original topography and topsoil is applied as the final surface. The last step in the reclamation is application of treatments to facilitate vegetation growth (mostly seeding grass). Treatments have significant influence on the rate of soil development, this study was designed with the objective of assessing the potential of different methods of soil reclamation on SOC sequestration rate, soil development, and changes in soil physical and water transmission properties.

Three sites were identified, which were reclaimed with topsoil application, and were under continuous grass cover. One of the sites was reclaimed in 1994 (Tilton Run) and the remaining two (Cumberland and Switch grass) were in 1987. Eighteen experimental plots (4m x 4m) were developed using randomized complete block design during May 2004 on each site during May 2004. Five treatments in triplicate applied on the experimental plots at each site were: manure (M), compost (C), fertilizer (F), manure+ compost (MC); fertilizer + compost (FC). Equivalent amounts of nitrogen on mass basis were applied on each plot. In addition a control (no application) treatment in triplicate was also selected on each site. All plots were 4m X 4m and compost, manure and fertilizers were broadcasted on each site. Soil bulk density (ρ_b) was higher for Tilton Run site reclaimed in 1994 than Cumberland and switch grass sites reclaimed in 1987. Overall, ρ_b increased with increasing depth in all plots and sites. For the 0-15 cm depth, the ρ_b was highest in the control treatment at each site. Total nitrogen (TN) and total carbon (TC) concentrations were higher for 0-15 cm than 15-30 cm depth in all plots and sites. For 30-50 cm depth, TC concentrations were the highest in experimental plots in switch grass and Cumberland site, indicating contamination due to coal dust or particles. No significant differences in TN and TC concentrations and stocks were observed for 0-15 cm depth in plots in Tilton Run site. Few

differences in TN and TC concentrations were observed in experimental plots in Cumberland site for all three depths. Few differences in TC concentrations and stocks among treatments were mainly due to the fact that treatments were applied only last year.

2.0 Experimental
2.1 Experimental Sites:

The experimental sites were reclaimed after the 1972 Ohio Mineland Reclamation Act or the 1977 surface mining reclamation and control act (SMRCA), and were under continuous grass. These sites were reclaimed in conformity to SMCRS law and topsoil was applied as the last surface layer. These sites are located on land maintained by the American Electric Power (AEP) Co., and are located along the borders of Guernsey, Noble, and Muskingum Counties of Ohio. This report includes the analysis of soil data from three experimental sites. These sites are: Tilton Run (TR) reclaimed in 1994, Cumberland (CL) and switch grass (SG) site reclaimed in 1987 with topsoil application. All the experimental plots are under continuous grass cover.

At each site, sixteen plots (4m X 4m) were constructed (or marked) using randomized complete block design during May 2004 (Fig. 1). Five treatments were applied in triplicate to these plots at each site, (e.g., Fertilizer (F): 224-50-92 N-P-K; Manure (M): 27 kg/plot; Compost (C): 24 kg/plot; Compost + Fertilizer (CF): 12 kg/plot + Fertilizer (112-25-46 N-P-K); Compost + Manure (CM): 12 kg/plot + 13 kg/plot). Equivalent amounts of nitrogen on mass basis were applied on each plot. A control treatment (no application) in triplicate was also selected in each experimental site.

All the plots were mowed on June 21, 2004 and treatments were applied on 28 and 29th June 2004. All these plots were mowed again on April 11, 2005. During April to July, soil sampling for three depths was carried out on all the plots to assess physical, chemical properties of soil including soil N and C concentrations.

2.2 Collection of Soil Sample

Core and bulk samples were collected in triplicates from each of the experimental plot from 0-15, 15-30, and 30-50 cm depths during April-May 2005. These bulk soil samples were air-dried in the lab at temperatures <60^0C.

2.3 Analysis of Soil Samples

2.3.1 Soil Bulk Density

All soil cores collected in the field were brought to the lab and trimmed at both ends and bulk density (ρ_b) was obtained according to the method described by Blake and Hartge (1986). The air-dried bulk soil samples were first passed through wooden rollers to break down clods.

2.3.2 Soil Organic Carbon and Nitrogen Concentrations

The air-dried soil was ground to pass through 0.25 mm sieve. About 1 g of the soil was used for the determination of total soil carbon (TC) and total nitrogen (TN) concentrations by the dry combustion method (Elementar, GmbH, Hanau, Germany). The SOC and TN stocks were calculated as the product of SOC or TN concentration, ρ_b and the specific depth of soil layer.

2.4. Statistical Analysis

The analysis of variance (ANOVA) was computed for treatment x sample within each site, treatment x site interactions among sites separately for each depth, and plot x depth interaction for each treatment using Statistical Analysis System (SAS Institute, 1989). Significant mean interactions and the least significant differences (LSD) for mean separation were calculated using Bonferroni multiple comparison method for $P \leq 0.05$.

3.0 Results

3.1 **Soil Bulk density**

Significant differences in ρ_b were obtained for 0-15 cm depth only with ρ_b being lowest in the compost plot (0.99 Mg m^{-3}) and highest in the control plot (1.06 Mg m^{-3}) in Cumberland site, (Table 1). The ρ_b increased with increase in depth and ranged from 0.99 Mg m^{-3} to 1.06 Mg m^{-3} for 0-15 cm, 1.23 Mg m^{-3} to 1.32 Mg m^{-3} for 15-30 cm, and 1.34 Mg m^{-3} to 1.36 Mg m^{-3} for 30-50 cm depths.

In switch grass site, significant differences in ρ_b were observed for 0-15 and 15-30 cm depths, with the lowest in the CM plot (0.98 Mg m^{-3}) and the highest in the F plot (1.12 Mg m^{-3}) for 0-15 cm depth, and the lowest in the CM plot (1.20 Mg m^{-3}) and the highest in the F plot (1.32 Mg m^{-3}) for 15-30 cm depth (Table 2). The ρ_b also increased with increasing depth and ranged from 0.98 Mg m^{-3} to 1.12 Mg m^{-3} for 0-15 cm, 1.20 Mg m^{-3} to 1.32 Mg m^{-3} for 15-30 cm, and 1.40 Mg m^{-3} to 1.44 Mg m^{-3} for 30-50 cm depths.

However, for Tilton Run site, significant differences in ρ_b were observed for 30-50 cm depth only with the lowest in the control plot (1.34 Mg m^{-3}) and the highest in the FC plot (1.41 Mg m^{-3}) (Table 3). The ρ_b also increased with increasing depth and ranged from 1.14 Mg m^{-3} to 1.22 Mg m^{-3} for 0-15 cm, 1.28 Mg m^{-3} to 1.36 Mg m^{-3} for 15-30 cm, and 1.34 Mg m^{-3} to 1.41 Mg m^{-3} for 30-50 cm depths.

Among the sites, no significant differences in ρ_b were observed between Cumberland and switch grass sites for any treatments. However, ρ_b was significantly higher in Tilton Run in teach treatment plot than Cumberland or switch grass site (Table 1-3). Lower ρ_b for Cumberland and switch grass site (reclaimed in 1987) than Tilton Run (reclaimed in 1994) and showed that duration since reclamation is important to soil quality improvement.

3.2 **Soil Carbon Concentrations**

In Cumberland site, no significant differences in TC concentrations were observed among treatments and control in any of the three depths. TC concentrations ranged from 13.18 g kg^{-1} in control to 18.21 g kg^{-1} in C plots. In general, TC concentrations were higher for 15-30 and 30-50 cm depths than 0-15 cm depth, which may be due to the contamination by coal dust or particles.

No significant differences in TC concentrations were obtained among treatments and control for 0-15 cm depth in switch grass site. TC concentrations ranged from 11.12 g kg^{-1} in M to 20.21 g kg^{-1} in CM plots in 0-15 cm depth. TC concentrations were the highest in M (21.15 g kg^{-1}) and the lowest in CM (6.54 g kg^{-1}) for 15-30 cm depth. For 30-50 cm depth, highest TC concentrations were obtained in M plots (25.43 g kg^{-1}). In general, TC concentrations were higher for 30-50 than 15-30 cm depth, and possibility of contamination due to coal particles cannot be ruled out.

In Tilton Run site, TC concentrations were not significantly different among treatments and control for 0-15 and 30-50 cm depths. TC concentrations were the highest in FC (9.60 g kg^{-1})

and the lowest in CM (2.56 g kg^{-1}). Overall TC concentrations were higher for 0-15 than 15-30 or 30-50 cm depths.

Among the sites, TC concentrations were higher in Cumberland and switch grass sites (both reclaimed in 1987) than Tilton Run site (reclaimed in 1994) among treatments and control for 0-15 cm depth. This clearly shows that duration since reclamation is important for soil quality improvement. No significant differences in TC concentrations were observed among sites for 15-30 and 30-50 cm depths.

3.2 **Soil Nitrogen Concentrations**

The highest TN concentrations were obtained for CM plots (1.32 g kg^{-1}) for 0-15 cm depth and lowest in C plots (0.63 g kg^{-1} for 15-30 cm and 0.59 g kg^{-1} for 30-50 cm depth) in Cumberland site (Table 1). The TN concentrations ranged from 0.98 g kg^{-1} in FC to 1.32 g kg^{-1} in CM plots for 0-15 cm depth, 0.42 g kg^{-1} in F to 0.63 g kg^{-1} in C plots for 15-30 cm depth, and 0.42 g kg^{-1} in CM to 0.59 g kg^{-1} in C plots for 30-50 cm depth. In general, TC concentrations in most plots were higher for 0-15 cm depth than 15-30 or 30-50 cm depths.

In switch grass site, the significant differences in TN concentrations were obtained for 0-15 and 15-30 cm depths only. The TN concentrations ranged from 0.89 g kg^{-1} in FC to 1.72 g kg^{-1} in C plots for 0-15 cm depth, 0.50 g kg^{-1} in F to 0.78 g kg^{-1} in FC plots for 15-30 cm depth, and 0.45 g kg^{-1} in F to 0.60 g kg^{-1} in C plots for 30-50 cm depth. In general, TC concentrations were higher for 0-15 cm depth than 15-30 or 30-50 cm depths.

No significant differences in TC concentrations were observed for 0-15 and 15-30 cm depths in Tilton Run site, (Table 3). The TN concentrations were the highest for M plots (0.55 g kg^{-1}) and the lowest for control (0.35 g kg^{-1}) for 30-50 cm depth (Table 3). In general, TC concentrations were higher for 0-15 than 15-30 or 30-50 cm depths.

Among sites, the TN concentrations were higher for Cumberland and switch grass sites reclaimed in 1987 than Tilton Run site reclaimed in 1994 in each plot and depth.

3.3 **Soil Total Carbon Stocks**

In Cumberland site, no significant differences in TC stocks were observed among treatments and control for any of the three depths. TC stocks ranged from 21 Mg ha^{-1} in control to 27 Mg ha^{-1} in C plots for 0-15 cm, 27 Mg ha^{-1} in CM to 52 Mg ha^{-1} in F plots for 15-30 cm, and 33 Mg ha^{-1} in CM to 53 Mg ha^{-1} in M for 30-50 cm depth. In general for most plots, TC stocks were higher for 15-30 and 30-50 cm depths than 0-15 cm depth, which may be due to the contamination by coal dust or particles.

The TC stocks did not vary among treatments and control for 0-15 and 30-50 cm depths in switch grass site. The TC stocks ranged from 17 Mg ha^{-1} in M to 31 Mg ha^{-1} in F plots for 0-15 cm, 12 Mg ha^{-1} in CM to 40 Mg ha^{-1} in M plots for 15-30 cm, and 24 Mg ha^{-1} in C to 55 Mg ha^{-1} in M for 30-50 cm depth. In general for most plots, TC stocks were varied in the order 30-50 cm depth > 0-15 cm depth > 15-30 cm depth. Higher TC stocks for 30-50 cm depth were indicative of the contamination by coal dust or particles.

In Tilton Run site, no significant differences in TC stocks were observed among treatments and control for 0-15 and 30-50 cm depths. TC stocks ranged from 12 Mg ha^{-1} in M to 20 Mg ha^{-1} in control plots for 0-15 cm, 5 Mg ha^{-1} in CM to 22 Mg ha^{-1} in C plots for 15-30 cm, and 5 Mg ha^{-1} in CM to 19 Mg ha^{-1} in FC plots for 30-50 cm depths. In general for most plots, TC stocks were higher for 0-15 than 15-30 and 30-50 cm depths.

Among sites, TC stocks were higher for Cumberland and switch grass sites reclaimed in 1987 than Tilton Run site reclaimed in 1994 in each plot and depth.

3.3 **Soil Nitrogen Stocks**

The TN stocks were significantly different among treatments and control for all three depths in Cumberland site (Table 1). The highest TN stocks were obtained for CM (2.0 Mg ha^{-1}) and the lowest for F (1.5 Mg ha^{-1}) in 0-15 cm depth. The TN stocks were highest for C (1.2 Mg ha^{-1}) and lowest for F (0.8 Mg ha^{-1}) in 15-30 cm depth. Similar variations were also noted in 30-50 cm depth. Overall, the TN stocks decreased with increasing soil depth (0-15 cm > 15-30 cm > 30-50 cm).

In contrast, no significant differences in TN stocks were observed among treatments and control for 0-15 and 30-50 cm depths in switch grass site. The TN stocks were higher for 0-15 cm than 15-30 and 30-50 cm depths and ranged from 1.4 Mg ha^{-1} in FC to 2.7 Mg ha^{-1} in C for 0-15 cm, 1.0 Mg ha^{-1} in M to 1.4 Mg ha^{-1} in FC for 15-30 cm, and 0.9 Mg ha^{-1} in M to 1.4 Mg ha^{-1} in FC for 30-50 cm depth.

In Tilton Run site, significant differences in TN stocks were observed among treatments and control for 30-50 cm depth only (Table 3). The TN stocks were higher for 0-15 cm depth than for 15-30 and 30-50 cm depths and ranged from 1.0 Mg ha^{-1} in CM to 1.3 Mg ha^{-1} in F for 0-15 cm, 0.7 Mg ha^{-1} in CM to 1.0 Mg ha^{-1} in FC plots for 15-30 cm, and 0.7 Mg ha^{-1} in control to 1.2 Mg ha^{-1} in M for 30-50 cm depths.

Among sites, TN stocks were higher for Cumberland and switch grass sites reclaimed in 1987 than Tilton Run site reclaimed in 1994 in each plot and depth.

4.0 **Discussion and Conclusions**

The reclamation operations are mostly carried out by compacting the soil in several layers. Topsoil is usually applied as the last layer and is also compacted with the aim of reducing erosion by rainfall and wind. This was in accord with the increasing soil bulk density with increasing depth for each experimental site. Due to the drastic disturbances, reclaimed soils are usually low in soil C and N. Therefore, in Ohio, start up fertilizer is applied based on the antecedent soil N content and plant N requirement, and the reclaimed area is seeded to grass. The fertilizer application is repeated to establish a good grass cover in the reclaimed site. Once the grass cover is established, roots starts growing and find it difficult to penetrate the soil profile because of the compaction during reclamation process. However, as duration since reclamation increases, roots are able to penetrate the soil profile deeper. This results in lowering of the soil bulk density. Similar trends were also observed in this study as soil bulk density was lower for the sites reclaimed in 1987 than those reclaimed in 1994. The higher C content in the soils reclaimed in 1987 than sites reclaimed in 1994 is also a direct result of higher root growth and more C input over all those years since reclamation. Increases in soil organic C enhances soil aggregation and improves soil quality.

It is generally accepted that application of fertilizer, manure or compost improves the above and belowground biomass productivity. The increased return of biomass to soil increases the organic carbon content in soil, which in turn improves soil structural properties and soil quality. However, changes in soil quality due to the application of treatments are usually evident three to five years after the initial application. No differences in total soil C concentration and stocks among treatments and control for any of the experimental sites is in accord with the previous observations.

5.0 **Tasks to be performed in the next Quarter (July- September 2005)**

We will continue to perform laboratory analysis on determining:

1. Carry out water infiltration tests in experimental plots
2. Determine soil moisture characteristic curves
3. Apply treatments on plots

6.0 **References**

Blake, G.R., and K.H. Hartge. 1986. Bulk density. p. 363-376. *In* A. Klute (ed.) Methods of Soil Analysis, Part I, Second edition. ASA Monograph No. 9. Madison, WI.

SAS Institute. 1989. SAS/STAT user’s guide. Version 6. 4th ed. vol. 1-2. SAS Inst. Cary, NC.

1 F(II)	2 M	3 C	4 F(I) + C	5 C + M	6 No
7 C	8 F(II)	9 C + M	10 No	11 M	12 F(I) + C
13 M	14 No	15 F(I) + C	16 F(II)	17 C	18 C + M

Fig. 1. Schematic of experimental plots in the reclaimed minesoils in Cumberland, switch grass and Tilton Run site. F(II)- fertilization (N:P:K = 358:80:147 kg/plot); M- manure (27 kg/plot); C- compost (24 kg/plot), F(I)- fertlization (N:P:K = 179:40:74 kg/plot)

Table 1. Soil bulk density (BD), total nitrogen (TN) and carbon (TC) concentrations, and total nitrogen (TNS) and carbon stocks (TCS) in experimental plots in Cumberland Ohio under five treatments and one control. The site was reclaimed in 1987.

Treatment	BD Mg m^{-3}	TC g Kg^{-1}	TN g Kg^{-1}	TCS Mg ha^{-1}	TNS Mg ha^{-1}
		0-15 cm depth			
C	0.99	18.21	1.08	27	1.6
CM	1.00	16.44	1.32	25	2.0
F	1.02	15.79	1.00	24	1.5
FC	1.05	16.44	0.98	26	1.5
M	1.04	17.01	1.17	27	1.8
NA	1.06	13.18	1.12	21	1.8
LSD (0.05)	0.07	NS	0.30	NS	0.4
		15-30 cm depth			
C	1.28	16.53	0.63	33	1.2
CM	1.23	14.76	0.46	27	0.8
F	1.32	25.52	0.42	52	0.8
FC	1.23	20.63	0.58	38	1.1
M	1.24	14.73	0.59	28	1.1
NA	1.27	17.50	0.50	34	0.9
LSD (0.05)	NS	NS	0.18	NS	0.4
		30-50 cm depth			
C	1.34	21.74	0.59	44	1.2
CM	1.34	16.17	0.42	33	0.8
F	1.36	21.08	0.44	43	0.9
FC	1.34	20.90	0.50	42	1.0
M	1.34	26.97	0.43	53	0.9
NA	1.34	23.40	0.53	47	1.1
LSD (0.05)	NS	NS	0.17	NS	0.3

where C- compost; CM- compost + manure; F-fertilizer; FC- fertilizer + compost; M- manure; and control- no application

Table 2. Soil bulk density (BD), total nitrogen (TN) and carbon (TC) concentrations, and total nitrogen (TNS) and carbon stocks (TCS) in experimental plots in switch grass under five treatments and one control. The site was reclaimed in 1987

Treatment	BD Mg m^{-3}	TC g Kg^{-1}	TN g Kg^{-1}	TCS Mg ha^{-1}	TNS Mg ha^{-1}
		0-15 cm depth			
C	1.06	18.05	1.72	28	2.7
CM	0.98	20.21	1.61	30	2.4
F	1.12	18.27	1.34	31	2.3
FC	1.05	14.42	0.89	22	1.4
M	1.03	11.12	0.97	17	1.5
NA	1.10	18.36	1.44	31	2.4
LSD (0.05)	0.09	NS	0.80	NS	NS
		15-30 cm depth			
C	1.26	7.71	0.56	15	1.1
CM	1.20	6.54	0.58	12	1.0
F	1.32	16.60	0.50	33	1.0
FC	1.25	9.99	0.78	19	1.4
M	1.25	21.15	0.51	40	1.0
NA	1.28	14.80	0.62	28	1.2
LSD (0.05)	0.10	12.72	0.22	25	0.3
		30-50 cm depth			
C	1.40	11.42	0.60	24	1.3
CM	1.40	16.71	0.53	36	1.1
F	1.40	15.35	0.45	33	0.9
FC	1.40	19.13	0.59	40	1.2
M	1.44	25.43	0.52	55	1.1
NA	1.40	20.43	0.53	43	1.1
LSD (0.05)	NS	11.65	NS	24	NS

Table 3. Soil bulk density (BD), total nitrogen (TN) and carbon (TC) concentrations, and total nitrogen (TNS) and carbon stocks (TCS) in experimental plots in Tilton Run under five treatments and one control. The site was reclaimed in 1994

Treatment	BD Mg m^{-3}	TC g Kg^{-1}	TN g Kg^{-1}	TCS Mg ha^{-1}	TNS Mg ha^{-1}
		0-15 cm depth			
C	1.14	8.38	0.65	14	1.1
CM	1.17	7.20	0.55	12	1.0
F	1.22	10.30	0.73	18	1.3
FC	1.15	9.18	0.71	15	1.2
M	1.22	6.50	0.58	12	1.1
NA	1.21	10.94	0.72	20	1.3
LSD (0.05)	NS	NS	NS	NS	NS
		15-30 cm depth			
C	1.34	7.14	0.41	14	0.8
CM	1.36	2.56	0.34	5	0.7
F	1.33	4.03	0.37	8	0.7
FC	1.28	9.60	0.55	19	1.0
M	1.33	6.28	0.47	13	0.9
NA	1.33	4.22	0.35	8	0.7
LSD (0.05)	NS	5.45	NS	10	NS
		30-50 cm depth			
C	1.39	10.07	0.41	22	0.8
CM	1.39	2.63	0.43	5	0.9
F	1.39	4.19	0.44	9	0.9
FC	1.41	6.07	0.40	13	0.8
M	1.39	7.77	0.55	17	1.1
NA	1.34	7.00	0.35	14	0.7
LSD (0.05)	0.07	NS	0.19	NS	0.4