SHORT COMMUNICATION

COMPARING THE EFFECT OF FERTILISER WITH NO FERTILISER ON SOIL PROPERTIES TO 600 MM DEPTH AFTER 79 YEARS OF SUGARCANE CULTIVATION

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Introduction

The oldest sugarcane trial in the world (BT1, established on 25 October 1939) is located on the premises of the South African Sugarcane Research Institute. The initial treatments consisted of burning versus mulching and fertiliser versus no fertiliser (Pearson, 1952). In 1979 the burnt treatments were split to acknowledge two practices following burning: removal of all residue and spreading of unburnt residue. Over the last 79 years the topsoil was disturbed only seven times, each time at replant. A recent EMI survey of the BT1 trial site revealed that soil properties were sufficiently altered by the treatments to affect the apparent electrical conductivity properties to a depth of 600 mm. The purpose of this paper was to establish the depth to which treatments have affected soil properties.

Materials and Methods

The soil of the long term sugarcane burning and mulching trial contains 40-45% clay. The soil of the upper part of the trial site is classified as a Mayo (Cambisol) and the lower portion as a Bonheim (Nitisol). The main treatments are: (i) green cane harvested with retention of the mulch blanket (100% soil cover; M), (ii) burning prior to harvest with unburnt residue left scattered on plots (67% soil cover; Bt) and (iii) burning prior to harvest with all unburnt residue removed (0% soil cover; Bto). The subplot treatments are either (*a*) unfertilised (Fo) or (*b*) fertilised (F) annually with 140 kg N/ha, 20 kg P/ha and 140 kg K/ha. The green cane harvested treatments are replicated eight times, and treatments burnt at harvest are replicated four times in a randomised split-plot design. Soil samples were collected at depth intervals of 0-200, 200-400 and 400-600 mm and analysed using the routine package of the Fertiliser Advisory Service. Soil samples were collected after harvest in September from a depth of 0 to 200 mm, taking one sample on the row and seven from the interrow. For depths greater than 200 mm one sample was taken on the row and two from the interrow. Laboratory analyses included pH (1:2.5 soil:water ratio), organic carbon by Walkley-Black, K, Ca and Mg extracted with 1.0 *N* NH_4OAc and quantified on an inductive coupled plasma (ICP) instrument (model Leco TruMac® CNS). Aluminum and exchangeable acidity were extracted with 1 M KCl (Hunter, 1974) and measured by titrating KCl with sodium hydroxide while the extracted aluminium was measured with ICP. To analyse the data statistically two depth interval strategies were included. The first was to compare depth intervals of 0-200, 0-400 and 0-600 mm because quantification of soil properties by the EMI instrument uses similar depth intervals (Geonics, 2009). The second was to compare successive depths of 0-200, 200-400 and 400-600 mm. Data were statistically analysed for differences between depths using a two tail equal variance t-test with alpha equal to 0.05.

Results and Discussion

A comparison of data between the depth intervals of 0-200 and 0-400 mm revealed that significant differences occurred for most parameters except Ca and total cations from the MF

treatment (Table 1). For the burnt treatments (BtoF and BtF) significant differences between these depth intervals were obtained for only pH. A comparison of data between depth intervals 0-200 and 0-600 mm revealed significant differences for all parameters except total cations from the MF treatment. Significant differences between these depth intervals for the burnt treatments were obtained for pH and K and additionally also for Mg from the BtF treatment. The remainder of parameters in the BtF treatment were almost significant at P=0.05. The latter suggest that differences with the surface layer increased with an increase in depth. Significant differences disappeared almost completely when the 0-400 and 0-600 mm depth intervals were compared, indicating that the depth at which changes took place was closer to the surface. All but one of the depth comparisons for the unfertilised treatments were insignificant across all three depth comparisons. The most responsive constituent to show significant differences between depth intervals was pH, and the least responsive was total cations.

Table 1. Differences between mean values from the upper interval minus the deeper interval for all treatments at BT1. Negative values indicate larger values from the deeper interval compared to the upper interval. Values in bold indicate significant differences between depth intervals (P=0.05).

Depths compared 0-200 vs 0-400 mm	**BtoFo**	**BtFo**	**MFo**	**BtoF**	**BtF**	**MF**
pH (CaCl2)	0.09	0.13	0.08	**-0.34**	**-0.28**	**-0.35**
K (mg/L)	-3.10	2.30	-5.47	49.50	59.90	**57.35**
Ca (mg/L)	136.72	90.48	135.03	-474.77	-175.57	-433.32
Mg (mg/L)	-7.35	8.83	1.40	-149.74	-140.34	**-127.04**
Exch Acidity (cmol/L)	-0.01	-0.01	-0.06	1.01	0.77	**1.74**
Total Cations (cmol/L)	0.59	0.53	0.60	-2.45	-1.17	-1.35
Acid Saturation (%)	-0.06	-0.15	-0.39	7.42	4.71	**12.09**
Depths compared 0-400 vs 0-600 mm	**BtoFo**	**BtFo**	**MFo**	**BtoF**	**BtF**	**MF**
pH (CaCl2)	-0.09	-0.05	**-0.15**	**-0.20**	-0.21	**-0.19**
K (mg/L)	7.84	12.99	5.77	29.25	31.56	30.20
Ca (mg/L)	362.31	262.61	-34.70	-142.93	-222.12	-330.23
Mg (mg/L)	-47.86	-38.51	15.90	-24.53	4.44	-25.86
Exch Acidity (cmol/L)	0.02	0.03	0.06	0.51	0.35	**0.91**
Total Cations (cmol/L)	1.44	1.03	0.05	-0.29	-0.56	-0.80
Acid Saturation (%)	0.06	0.16	0.33	3.72	2.20	**6.28**
Depths compared 0-200 vs 0-600 mm	**BtoFo**	**BtFo**	**MFo**	**BtoF**	**BtF**	**MF**
pH (CaCl2)	0.00	0.08	-0.06	**-0.54**	**-0.49**	**-0.54**
K (mg/L)	4.74	15.29	0.30	**78.76**	**91.46**	**87.56**
Ca (mg/L)	499.03	353.09	100.33	-617.70	-397.69	**-763.55**
Mg (mg/L)	-55.21	-29.68	17.30	-174.26	**-135.90**	**-152.90**
Exch Acidity (cmol/L)	0.01	0.02	0.00	1.52	1.12	**2.65**
Total Cations (cmol/L)	2.04	1.55	0.66	-2.75	-1.73	-2.14
Acid Saturation (%)	0.00	0.02	-0.06	11.14	6.91	**18.38**

A comparison of data between successive depths 0-200 and 200-400 mm revealed significant differences between depths for most parameters except acid saturation from the BtoF treatment, Ca from the BtF treatment and total cations from the BtF and MF treatments (Table 2). Significant differences between depths 200-400 and 400-600 mm were obtained only for pH from the BtoFo and TFo treatments which was also the only significant differences from the unfertilised (Fo) treatments. Comparison of data between depths 0-200 and 400-600 mm revealed that significant differences occurred for all parameters from the MF treatment. Significant differences between depths for the BtF treatment was obtained for K, Ca and total cations and for pH, K and exchangeable acidity from the BtoF treatment. The above indicated that the depth to which the soil was affected by the treatments was properly at about 200 mm.

Table 2. Differences between mean values from the upper depth minus the deeper interval for all treatments at BT1. Negative values indicate larger values from the deeper interval compared to the upper interval. Values in bold indicate significant differences between successive depths (P=0.05).

Depths compared 0-200 vs 200-400 mm	**BtoFo**	**BtFo**	**MFo**	**BtoF**	**BtF**	**MF**
pH (CaCl2)	0.18	0.26	**0.17**	**-0.68**	**-0.55**	**-0.70**
K (mg/L)	-6.20	4.61	-10.95	**99.01**	**119.81**	**114.71**
Ca (mg/L)	273.44	180.97	270.07	**-949.54**	-351.14	**-866.65**
Mg (mg/L)	-14.70	17.65	2.80	**-299.48**	**-280.68**	**-254.08**
Exch Acidity (cmol/L)	-0.02	-0.03	-0.12	**2.02**	**1.54**	**3.48**
Total Cations (cmol/L)	1.18	1.06	1.21	**-4.91**	-2.34	-2.69
Acid Saturation (%)	-0.12	-0.29	-0.77	14.85	**9.42**	**24.19**
Depths compared 200-400 vs 400-600 mm	**BtoFo**	**BtFo**	**MFo**	**BtoF**	**BtF**	**MF**
pH (CaCl2)	**-0.27**	-0.24	**-0.38**	-0.07	-0.15	-0.03
K (mg/L)	18.78	23.67	17.01	9.00	3.21	3.06
Ca (mg/L)	587.89	434.73	-204.43	188.91	-268.68	-227.13
Mg (mg/L)	-88.38	-85.84	30.40	100.68	149.22	75.32
Exch Acidity (cmol/L)	0.05	0.07	0.18	0.01	-0.06	0.07
Total Cations (cmol/L)	2.30	1.52	-0.50	1.87	0.05	-0.25
Acid Saturation (%)	0.18	0.47	1.04	0.01	-0.30	0.48
Depths compared 0-200 vs 400-600 mm	**BtoFo**	**BtFo**	**MFo**	**BtoF**	**BtF**	**MF**
pH (CaCl2)	-0.09	0.02	-0.21	**-0.75**	-0.70	**-0.74**
K (mg/L)	12.58	28.27	6.06	**108.01**	**123.01**	**117.76**
Ca (mg/L)	861.33	615.69	65.63	-760.62	**-619.81**	**-1093.78**
Mg (mg/L)	-103.08	-68.18	33.20	-198.79	-131.45	**-178.76**
Exch Acidity (cmol/L)	**0.03**	**0.05**	**0.06**	**2.03**	1.48	**3.56**
Total Cations (cmol/L)	3.48	2.58	0.71	-3.04	**-2.28**	**-2.94**
Acid Saturation (%)	**0.06**	**0.18**	**0.27**	14.86	9.11	**24.66**

Conclusions

Soil properties reflecting on cation and acidification statuses were affected to a depth of about 200 mm by applying mulching and fertiliser treatments continuously for the last 79 years. This effect faded as less parameters showed significant differences between depths with a decrease in the amount of residue retention in the fertilised treatments (BtF followed by the BtoF). It is known that soil acidification of the MF treatment is significantly higher compared to any other treatment at the BT1 trial (Mthimkhulu, 2016). Judged by the number of parameters showing significant differences between depths the work reported here suggests that the rate of acidification is fastest where fertiliser was applied and the full complement of residue retained (MF). In this study the unfertilised treatments showed mostly no differences between the soil depths and are the least affected by acidification. It is therefore concluded that soil acidification caused by field management options (fertilisation and level of residue retention) are the mechanisms driving differences between depths and the rate at which soil properties are affected to depth.

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