Municipal Household Solid Waste Organic Compost: Effects on Soil Plant Nutrients

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Abstract

Apart from its role in soil physical condition improvement, compost substantially contributes to the productivity of land as a source of plant nutrients. The objective of the study was to evaluate the effects of municipal household solid waste compost (MHSWC), applied alone or in combination with inorganic fertilizers at different rates on the chemical properties: pH, organic carbon, available nitrogen, available phosphorus and exchangeable potassium levels of a coastal savanna Haplic Acrisol. The research was carried out as a pot experiment involving eight treatments and four replications. Each experimental port contained 7kg of soil. The treatments included T1 (Control), T2 [SSP (45kg/ha) and S o A (120kg/ha)], T3 [SSP (45kg/ha) + S o A (120kg/ha) + compost (2t/ha)], T4 [SSP (45kg/ha) + S o A (120kg/ha) + compost (4t/ha)], T5 Compost alone (2t/ha), T6 [Compost alone (4t/ha)], T7 [Compost (2t/ha) + S o A (120kg/ha)] and T8 [Compost (4t/ha) + S o A (120kg/ha)]. Three weeks after application of the treatments to the soil, Dacus carrota (cv Kuroda) was sown. After harvest of the crop (3 months after sowing), soil samples were collected from each treatment, prepared and analysed in the laboratory. Organic amendments increased soil organic carbon by margins of 0.14 0.24 % in compost amendments. Available phosphorus increased by a margin of 6.9 and 9.4 $mgkg^{-1}$ for T3 and T4. Available nitrogen improved from 6.17 to 11.2 60.16 $mgkg^{-1}$ and available potassium also increased from 0.34 in the control to 0.36 0.81 $cmol(+)kg^{-1}$. Combined application of MHSWC and inorganic fertilizers generally improved soil organic carbon, available nitrogen, available phosphorus and exchangeable potassium more than sole amendments. The results obtained in the study amply demonstrated that fertilizer supplements are paramount in the use of MHSWC for soil fertility management.

Keywords: Haplic Acrisol, solid waste compost, soil chemical properties, crop production.

Compost Organique De Déchets Solides Ménager Municipaux: Effets Sur Les Nutriments Des Plantes De Sol

Résumé

En dehors de son rôle dans l'amélioration de la condition physique du sol, le compost contribue de manière substantielle à la productivité des terres comme source d'éléments nutritifs des *plantes. L'objectif de cette étude était d'évaluer les effets du compost des déchets solides ménagers municipaux (CDSMM), appliqué seul ou en combinaison avec des engrais inorganiques à des taux différents sur les propriétés chimiques: pH, carbone organique, azote disponible, phosphore disponible et niveaux de potassium échangeables d'une savane côtière Haplic Acrisol. La recherche a été menée comme une expérience en pot comprenant huit traitements et quatre répétitions. Chaque pot expérimental contenait 7 kg de sol. Les traitements comprenaient T1 (Control), T2 [SSP (45kg/ha) et S o A (120kg/ha)], T3 [SSP (45kg /ha) + S o A (120kg /ha) + compost (2t/ha)], T4 [SSP (45kg/ha) + S o A (120kg/ha) + compost (4t/ha)], T5 Compost seul (2t/ha), T6 [Compost seul (4t/ha)], T7 [Compost (2t/ha) + S o A (120kg/ha)] et T8 [Compost (4t/ha) + S o A (120kg/ha)]. Trois semaines après l'application des traitements sur le sol, Dacus carrota (cv Kuroda) a été semée. Après la récolte de la culture (3 mois après le semis), des échantillons de sol ont été prélevés sur chaque traitement, préparés et analysés dans le laboratoire. Les modifications organiques ont augmenté le carbone organique du sol par des marges de 0,14 - 0,24% dans les amendements du compost. Le phosphore disponible a augmenté d'une marge de 6,9 et de 9,4 mgkg-1 pour T3 et T4. L'azote disponible a amélioré de 6,17 à 11,2 - 60,16 mgkg-1 et le potassium disponible a également augmenté de 0,34 dans le témoin à 0,36 - 0,81 cmol(+) kg-1. L'application combinée de MHSWC et des engrais inorganiques a généralement amélioré le carbone organique du sol, l'azote disponible, le phosphore disponible et le potassium échangeable plus que les modifications exclusives. Les résultats obtenus dans l'étude ont largement démontré que les suppléments d'engrais sont primordiaux dans l'utilisation de MHSWC pour la gestion de la fertilité du sol.*

Mots-clés: Haplic Acrisol, compost de déchets solides, propriétés chimiques du sol, production de culture.

Introduction

Adequate nutrient supply is a prerequisite to sustainable crop production and maintenance of soil fertility (Hochmuth and Albregth, 1994). The use of chemical fertilizers for soil fertility improvement has been observed to have some disadvantages that include short periods of residual effect and its inability to improve soil structure (Campbell, 1990; Gershuny and Smillie 1995). The replenishment of soil nutrients has also been hampered by the application of low levels of chemical fertilizers and the addition of insufficient quantities of organic matter to the soil. The application of organic matter in the form of compost could be a way of addressing the declining productivity of soils in Ghana. The application of organic matter can significantly improve soil structure but may not provide all plant nutrients in adequate quantities nor in the right proportion because nutrient release by organic matter is small (Facelli and Pickett, 1991; Attiwell and Adams, 1993). An integrated approach to soil fertility management involving the application of organic and inorganic sources of nutrients in the appropriate combination should therefore be adopted (MCconnel *et al.*, 1993). Municipal household solid waste is a potential source of plant nutrients and composting the biodegradable portion of it is likely to improve soil fertility and also, provide avenue for waste recycling.

Municipal household solid waste compost (MHSWC) plays a significant role in the development and maintenance of soil organic matter (Sikora and Enkiri 2001; Ozores *et al.*, 2001). However, many others (Gallard-Lora and Nogales, 1987; Hernando, *et al.,* 1989;

and McConnell, *et al.*, 1993) have reported that compost enhances soil physical fertility rather than its chemical fertility. Steffens *et al.*, (1992) and Maynard (1995), however, attributed increased vegetable crop yield in response to MHSWC applications, to the ability of the compost to supply the required plant nutrients in adequate quantities to crops through mineralization. The objective of this work, therefore, was to evaluate the effects of municipal household solid waste compost on some soil chemical properties.

Material and Method

A completely randomized design was used to establish a pot experiment using a Haplic Acrisol of low fertility status. The general characteristics of the soil and compost used are presented in Tables 1 and 2. The experiment comprised eight treatments, each of which was replicated four times. Each experimental pot contained 7 kg soil.

Treatments were:

- T1 = Control (Soil only)
- T2 = SSP (45 kg/ha) and S o A (120 kg/ha)
- T3 = SSP (45 kg/ha) + S o A (120 kg/ha) + compost (2 t/ha)
- T4 = SSP (45 kg/ha) + S o A (120 kg/ha) + compost (4t/ha)
- T5 = Compost alone (2 t/ha)
- T6 = Compost alone (4t/ha)
- T7 = Compost (2 t/ha) + S o A (120 kg/ha)
- T8 = Compost (4 t/ha) + S o A (120 kg/ha)

Carrot (Dacus Carrota cv Kuroda) seeds were sown in the soil, 3 weeks after treatments were applied. The carrots were harvested, three months after sowing. Thereafter, composite soil samples were taken from each pot. The samples were air dried ground and sieved through a 2 mm sieve, and then analyzed. The parameters determined included soil pH, organic carbon, available phosphorus, exchangeable potassium, nitrate nitrogen and ammonium nitrogen. The pH of soil was determined using Pyeunicon pH meter in soil to water ratio of 1:2.5. Organic carbon was

Table 1: Some chemical properties of the soil

Soil Property	*Value*
Soil pH (H2O to soil ratio of 1:2.5)	6.3
Organic carbon (%)	0.6
Total nitrogen (%)	0.02
Available nitrogen ($mgkg^{-1}$)	15.1
C: N ratio	30:1
Available phosphorus ($mgkg^{-1}$)	6.3
Exchangeable potassium ($cmol_ckg^{-1}$)	0.5
Calcium ($cmol_ckg^{-1}$)	2.4
Magnesium ($cmol_ckg^{-1}$)	0.6
Sodium ($cmol_ckg^{-1}$)	0.3
Total exchangeable bases ($cmol_ckg^{-1}$)	3.9

Table 2: Some chemical properties of the Municipal Household Organic Solid Waste Compost

Compost Property	*Value*
Compost pH	10.3
Organic carbon (%)	5.3
Nitrogen (%)	0.3
C:N Ratio	18:1
Phosphorus (%)	0.3
Potassium (%)	8.6
Calcium (%)	11.4
Magnesium (%)	4.9
Sodium (%)	1.4

determined using the Walkley and Black (1934) method. Measurement of the nitrate and ammonium nitrogen followed the Kjeldahl method described by Hesse (1971). Available phosphorus determination was by Bray number 1 method, described by Bray and Kurtz (1945) and exchangeable potassium content of soil was measured using the procedure described by Jackson (1962). The data were subjected to analysis of variance for the separation of means using the MSTAT-C statistical software (Russell, 1990).

Results and Discussion

Effect of MHSWC on soil pH

The effect of municipal compost amendments on soil pH is presented in Table 3. Significant ($P < 0.01$) changes in pH occurred in soil when compared to the initial soil pH (Table 3). T2, T3, and T7, showed significant ($P < 0.01$) reduction in soil pH. T6, however, increased soil pH by margin of 1.72 pH units above the initial soil pH measured. The increased acidity in soils treated with sulphate of ammonia, corresponds with the findings of Tisdale *et al.*, (1993) who observed that when ammonium fertilizer is applied to soil, the process of nitrification releases hydrogen ions that acidify soil. The combined effects of SSP and MHSWC at 4 t/ha however, led to neutralization of the soil acidity caused by sulphate of ammonia and further raised the initial soil pH by 24 % as in T4. But combined the application of MHSWC of 2 t/ha with the 3same rates of inorganic fertilizers was not able to completely neutralize the acidifying effect of the sulphate of ammonia (T3). Probably, the amount of basic cations released by the 2 t/ha compost was not enough to neutralize the quantity of H^+ ions released by the sulphate of ammonia

MHSWC and soil organic carbon content

Significant differences ($P < 0.01$) existed among organic carbon levels, with a general increase towards increased amount of compost application (Table 3). The 4 t/ha treatments (T4, T6 and T8) had the highest level of organic carbon, showing an average increase of 0.24 % over the control. At 2 t/ha (T3, T5 and T7), however, MHSWC increased soil organic carbon by an average of 0.14 % over the control. After the experiment, the soil of the control treatment registered a significant decline of 20 % in organic carbon content. On the organic carbon levels described by Walkley and Black (1934), none of the amendments (Table 3) was able to bring soil organic carbon level to sufficiency, because, values obtained in all treatments were below 1.5 %.

The influence of MHSWC on soil available nitrogen`

Available nitrogen levels as affected by soil amendments are presented in table 3. Even though the application of sulphate of ammonia significantly increased available nitrogen of soil by 70 %, combined treatments of fertilizer-N with MHSWC (T3, T4, T7 and T8) generally provided better residual effects. T4 significantly ($P < 0.01$) yielded available nitrogen that was 85 and 54 % over those of the control (T1) and sole chemical fertilizer treatment (T2), respectively. T3 was however, able to increase available nitrogen levels by only 31 % over that of T2. Probably, nitrogen supplied by the added sulphate of ammonia to MHSWC enabled soil microbes to mineralize organic nitrogen in the compost, leading to increased soil residual nitrogen for the combined compost-inorganic amendments (T3, T4, T7, and T8) compared to the sole amendment of both materials (T1, T2, T5 and T6), respectively. Fertilizer-N supplements therefore would be paramount in MHSWC amendments where nitrogen levels in the compost are low (Muzur, 1996).

Table 3: The effects of municipal compost on soil pH and Organic Carbon

Treatments/ Parameters	*Soil pH*	*OC (%)*	*Available N(mgkg^{-1})*	*Available P(mgkg^{-1})*	*K+(cmol$_c$kg^{-1})*
T1	6.30	0.56	6.2	3.2	0.3
T2	5.16	0.55	27.8	8.0	0.4
T3	5.90	0.7	40.1	10.1	0.6
T4	7.80	0.8	60.2	12.6	0.8
T5	7.02	0.7	11.2	6.4	0.6
T6	8.02	0.8	19.5	6.6	0.8
T7	5.90	0.7	34.4	6.7	0.6
T8	6.40	0.8	45.1	7.4	0.8
CV:	0.71	1.78	1.855	2.89	4.31
SE:	0.027	0.006	0.159	0.127	0.015
LSD ($P < 0.01$)	0.109	0.0243	0.671	0.533	0.769

MHSWC and soil available phosphorus

The combination of single super phosphate (SSP) at 45 kg/ha with MHSWC at 4 t/ha (T4) significantly ($P < 0.01$) increased the residual available phosphorus over all other treatments (Figure 2). The amendment increased the levels of soil residual phosphorus by 75 and 36 % over T1 and T2 respectively. The combination of the same chemical fertilizer rates with MHSWC at 2 t/ha (T3) also performed better than T2. T3 significantly ($P < 0.01$) increased soil phosphorus level by 67 and 20 % over T1 and T2, respectively. T5 and T6, however, did not show any appreciable increase in soil phosphorus. Based on Bray 1 method of nutrient classification, none of the treatments has been able to bring soil phosphorus level to sufficiency. These results also confirm the assertion of Roe (1997) that, MHSWC generally contains limited quantities of phosphorus. Consequently, fertilizerP supplements may be required to improve phosphorus supply to soils amended with MHSWC.

Effect of MHSWC on soil potassium levels

Compost soil amendments have also significantly influenced exchangeable potassium levels (Table 3). In T1 and T2, exchangeable K levels dropped by 30 and 27 %, respectively below the initial K value of soil. This is probably because of plant mining of the nutrient for growth. T5 and T6, however, significantly ($P < 0.01$) increased exchangeable potassium levels of soil by 17 and 39 % over the initial soil exchangeable K. High potassium content found in MHSWC (8.5 %) that accumulated from wood ash whose composition in the household waste was significant (Mayea and Querol, 1995). Considering the ammonium acetate extraction method used, however, the 2 and 4 t/ha treatments brought the soil K+ levels to sufficiency.

Conclusion

The study showed that, municipal solid waste compost had considerable effects on the soil chemical properties. Though sole amendments of MHSWC significantly increased levels of soil pH, organic carbon, ammonium nitrogen, and nitrate nitrogen, the results obtained from the combined application of mineral fertilizer with MHSWC indicated that combined amendment of both nutrient sources would be a better option.

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