Municipal Household Solid Waste Compost: Effects on Carrot *(Daucus carrota)* Yield and Nutrient Content

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Résumé

Osei, B. A., Kwakye, P. K. & Sappor, D. K. *Compost Municipales des Odures Solide : Les Effets sur le rendement de carottes (Daucus carrota) et les éléments nutritifs contenus.* Une essai a été menée pour évaluer l'impact de compost municipal des ordures solide sur N, P et l'absorption de K et le rendement de carotte (*Daucus carrota*), à l'aide d'une savane côtière Acrisol Haplic. Plusieurs échantillons de frais de déchets solides provenant des 45 ménages dans la municipalité de Cape Coast dans la région centrale du Ghana avec la masse totale de 57 % de composants organiques ont été compostées à l'aide de la méthode de la fosse. Les traitements qu'on a appliqués étaient contrôle, unique souper phosphate (SSP) à 1,8 g pot-1 et sulfate d'ammoniaque (SoA) à 2,0 g pot-1, compost à g 7.0 pot-1 et pot de 14.0 g-1, l'application combiné des 2 taux de compost et engrais minéraux et l'application combines des 2 taux g 2.0 pot-1 SoA. Chaque pot contient 7.0 kg de sol. Une conception complètement aléatoire avec quatre réplique a été utilisée. semences de carotte ont été semées et des concentrations d'azote, phosphore et potassium dans les pousses de carotte ont été déterminées dans six semaines après la germination. L'application combinée de compost et l'engrais inorganiques a sensiblement augmenté concentration N, P, K et de cendres dans le tournage de la carotte. Pousses de compost appliqué au 14.0 g/pot en combinaison avec 1,8 g pot-1 SSP et 2,0 g-1 pot SoA fourni 23 % N, 34 % K et 20 % cendres pour le tournage de carotte, considérant que l'application exclusive de compost à 14.0 g/pot a contribué à 4,9 % N, 7,4 % K et 13.65 % cendres respectivement à la carotte. Teneur en phosphore a mesurée dans les turions carotte étaient toutefois< 2.6 % dans tous les traitements. Rendement de carotte une corrélation positive avec shoot N, P et K contenu (P< 0.01).

Mots-clés : Les odures solides, compost, biodégradables, Haplic Acrisol , *Daucus carrota.*

Abstract

An experiment was conducted to evaluate the impact of municipal household solid waste compost on N, P and K uptake and yield of carrot (*Daucus carrota*), using a coastal savanna Haplic Acrisol. Bulked samples of fresh solid waste from 45 households within the Cape Coast Municipality in the Central Region of Ghana with 57 % total mass of organic components were composted using the pit method. Treatments applied were control, single supper phosphate (SSP) at 1.8g pot^{-1} and sulphate of ammonia (SoA) at 2.0g pot^{-1}, compost at

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7.0g pot^{-1} and 14.0g pot^{-1}, combined application of the 2 rates of compost and mineral fertilizer, and combined application of the 2 rates with 2.0g pot^{-1} SoA. Each pot contained 7.0 kg of soil. A completely randomized design with four replicates was used. Carrot seeds were sown and nitrogen, phosphorus and potassium concentrations in carrot shoots were determined at six weeks after germination. Combined application of compost and inorganic fertilizer significantly increased N, P, K and ash concentration in the carrot shoot. Compost applied at 14.0g pot^{-1} in combination with 1.8g pot^{-1} SSP and 2.0g pot^{-1} SoA supplied 23 % N, 34 % K and 20 % ash to the carrot shoot, whereas sole application of compost at 14.0g pot^{-1} contributed 4.9 % N, 7.4 % K and 13.65 % ash respectively to the carrot shoots. Phosphorus content measured in the carrot shoots were however < 2.6 % in all treatments. Carrot yield positively correlated with shoot N, P and K contents ($P < 0.01$).

Keywords: Household solid waste, compost, biodegradable, Haplic Acrisol, *Daucus carrota.*

Introduction

Waste and their disposal cause a great deal of environmental pollution (Alloway and Ayres, 1997). Methods of waste disposal include land filling, incineration and composting. In Ghana, the most commonly used waste disposal method is land filling. The advantages of land filling are that it is relatively inexpensive and the waste can be recycled or treated at a later date (Alloway and Ayres, 1997). The landfills in Ghana are old and work on the principle of waste attenuation, where it is accepted that leachates will leach from the site but intended that, the rates and volumes of leachates will not cause any acute environmental problem. It is now known that this type of waste disposal is responsible for many aquifers being polluted with a wide range of xenobiotic and other chemicals. Owing to the environmental hazards associated with the land filling method of waste disposal in developing countries, including Ghana. Harrison (1994) suggested that a more environmentally friendly alternative for municipal solid waste disposal should be adopted. Composting the biodegradable portion of the waste and applying the final product to the soil as manure does not only slow down the rate at which existing landfills fill up, but also improve soil fertility. Thus resulting in increased crop yield and subsequently, food supply to the growing population (Shiralipour and McConnel, 1993). Municipal household solid waste compost, according to Bierman *et al*. (1999), supply total and available plant N, P and K, and also, some micronutrients to plants. There is, however, a paucity of information pertaining to crop and site-specific impact of municipal solid waste compost on the bioavailability of plant nutrients and yield of vegetable crops such as carrot in Ghana. Besides, information regarding the potential of sole application of compost or combination with inorganic fertilizer, to supply the required quantities of plant nutrients to vegetables is also currently limited. The objective of the study therefore was to investigate the effect of compost applied alone or in combination with SSP and SoA on the yield and N, P and K uptake by carrot.

Materials and methods

A pot experiment was conducted using a coastal savanna soil (Haplic Acrisol) to assess the potential of municipal household solid waste compost (MHSWC) for carrot production. The properties of the soil and compost used in this experiment are in Table 1.

Table 1. Chemical properties of the soil and compost used in this experiment.

	Soil	*Compost*
pH	6.3	10.3
Organic matter g kg^{-1}	-	56.0
Organic C (g kg^{-1})	7.0	32.5
Total N (g kg^{-1})	-	1.5
Available N (mg kg^{-1})	15.1	-
Available P (mg kg^{-1})	6.31	-
Total P (g kg^{-1})	-	3.2
Exchangeable bases		
[Cmol(+)kg^{-1} soil]	3.86	26.8
C/N	-	21.7

The experiment was conducted using a completely randomised design with four replications involving the following treatments applied to 7 kg of soil:

T1 = Control (soil only).
T2 = (SSP, 1.8g + S o A, 2.0g).
T3 = (SSP, 1.8g + S o A, 2.0g + compost, 7.0g).
T4 = (SSP, 1.8g + S o A, 2.0g + compost 14.0g).
T5 = Compost alone (7.0g).
T6 = Compost alone (14.0g).
T7 = (Compost, 7.0g + S o A, 2.0g).
T8 = (Compost, 14.0g + S o A, 2.0g).

Seven kilograms of soil was put in each pot. The pots were perforated to enable drainage of excess water and were partially shaded to avoid excess evaporation. The pots were watered periodically to maintain the soil in moist state (approximately 70 % of field capacity). Carrot (*Daucus carrota* cv Kuroda) seeds were directly sown (not nursed and transplanted). Compost was applied three weeks before seeding. Two weeks after germination, the seedlings were thinned to twelve stands per pot. The appropriate quantities of chemical fertilizers were then added to the soil. Six weeks after germination (6WAG), four seedlings were randomly selected per pot and uprooted. Their shoots were analysed for nitrogen, phosphorus, potassium and ash content. The fresh shoots were washed sequentially in 0.2 % liquid detergent, 0.1 *M* HCl solution and water to remove wax coatings and other contaminants occurring on the surface. The samples were then placed in paper bags, oven dried at 48°C for 7 days and ground to powder. Ground plant sample (0.5g) for each treatment was wet oxidized in a digestion tube using a mixture consisting of 350 ml of 30 % H_2O_2, 10g potassium sulphate, 0.42g selenium powder and 420 ml concentrated H_2SO_4. The digest was then used to determine total nitrogen, phosphorus and potassium.

Measurement of total nitrogen in plant digest followed the Kjeldahl method described by Hesse (1971). Total phosphorus determination was by spectrophotometry (Cottenie, 1980) whilst the flame photometer was used to determine potassium (Cottenie, 1980).

The ash content of carrot shoot was determined by oven drying one gram of each sample in crucible at 105°C overnight. The dried samples were cooled in a desiccator, weighed and placed in muffle furnace at 500°C for 24 hours. The samples were again cooled in a desiccator and weighed (Stewarte *et al*., 1974).

Results and Discussion

Effects of MHSWC and chemical fertilizer application on N, P, K and ash contents of carrot shoots

The levels of N, P and K in carrot shoots as influenced by soil amendments are in Table 2. Significant differences were observed in total N content of carrot shoots among all treatments. Total N concentration in the carrot shoots followed the order T4 > T3 > T2 > T8 > T7 > T6 > T5 > T1. Ozores-Hampton and Bryan (1993) and Akanbi (2002) all observed that combined application of MHSWC and inorganic nitrogen fertilizers compared to separate application of either materials, resulted in higher N content and yield of okra. The results obtained in this study are in conformity with these reports. The results also showed that total N content in T2 plants was significantly ($P < 0.01$) greater than total N content in T5 and T6 plants. The observed differences in total N content between T2 and T5, T6 plants might be attributed to the relatively slow rate at which the sole compost treatments in T5 and T6 released plant nutrients as compared to the sole chemical fertilizer treatment in T2.

Generally, phosphorus concentrations measured in the carrot shoots was below 2.6 % across the treatments, however, significant differences ($P < 0.01$) occurred between P contents measured in the various treatments. The largest P content was recorded for T4 in the shoots whereas T1 showed the least P content (Table 2). Potassium

Table 2. Nutrient content in carrot shoots at 6 weeks after planting.

	Parameters			
Treatments	*Total Nitrogen %*	*Total Phosphorus %*	*Total Potassium %*	*Ash %*
T1	2.25	0.07	3.36	11.53
T2	17.36	0.78	23.34	17.30
T3	19.98	1.07	31.03	18.15
T4	22.86	1.26	34.29	20.20
T5	3.87	0.50	6.19	12.13
T6	4.94	0.50	7.39	13.55
T7	8.17	0.27	15.82	15.09
T8	11.75	0.40	21.67	17.00
CV (%)	0.36	34.92	0.69	1.49
SE	0.042	0.116	0.071	0.093
LSD (0.01)	0.109	0.486	0.298	0.361

concentrations observed in the shoots of carrot were generally high, with T4 showing the largest shoot K content and T1, the least (Table 2).

Shoot N, P and K build-up resulting from the different treatments also reflected in the ash content of the shoots. The ash content of plant shoots is an indication of the mineral concentration in plants. In the study, the ash content generally increased with increased compost rates applied to the soil (Table 2). The largest ash content was recorded for T4 and the least for T1.

Effect of MHSWC and fertilizer application on carrot yield

Yield levels observed in the study following application of fertilizer, compost and combined application of fertilizer and compost are presented in Figure 1. The results indicated that combined application of compost and fertilizer (T3 and T4) significantly ($P < 0.01$) increased yield by 70 % and 68 % over T1 and 41 % and 12 % respectively over T2. Sole treatments of compost (T5 and T6) equally increased yield significantly ($P < 0.01$) by 50 % and 55 % respectively over T1. However, yield level recorded in T2 was 30% and 33 %

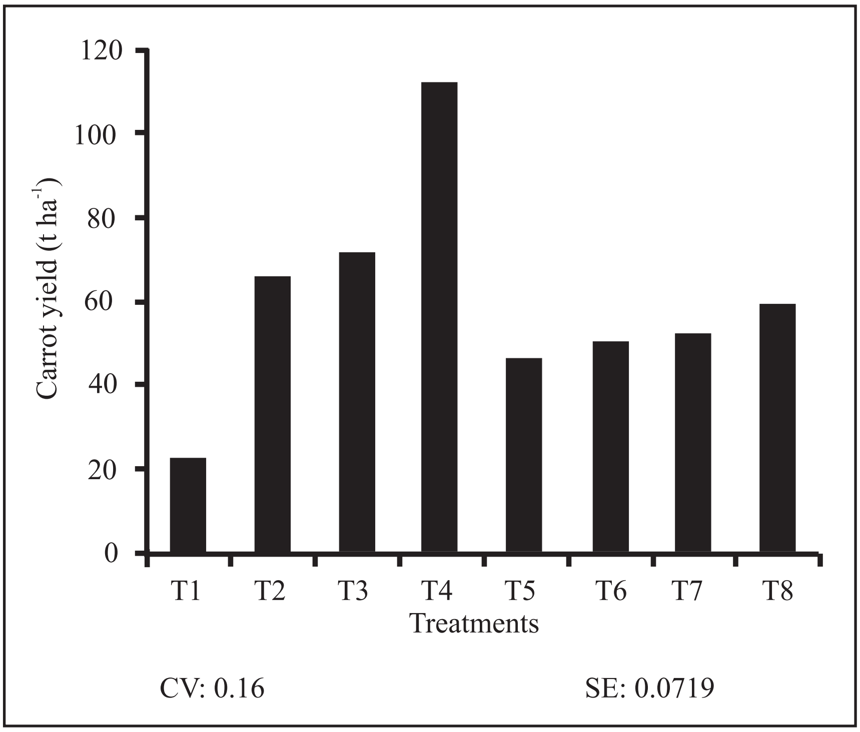

Figure 1. Effect of treatments on root yield of carrot.

greater than yield levels observed in T5 and T6 respectively. The differences in yield levels measured in this study agree with the findings made by Bryan and Schaffer (1992), Obrezer and Reeder (1994) and Manios and Syminis (1998), all of whom found increased yield of various vegetables when MHSWC was combined with inorganic fertilizer in various proportions. Mazur (1996) observed carrot yield increases of about 50 % when MHSWC was combined with urea. Taber and Jauron (1998) obtained carrot yield as high as 1500 – 2000 t ha^{-1}. Carrot yields obtained in this study, however, were relatively smaller than the values reported by these authors. The differences in yields may be attributed to the varietal differences, soil type and possibly climatic conditions. A strong positive correlation was observed between carrot yield and shoot N, P and K contents ($P < 0.01$) as shown in figures 2, 3 and 4.

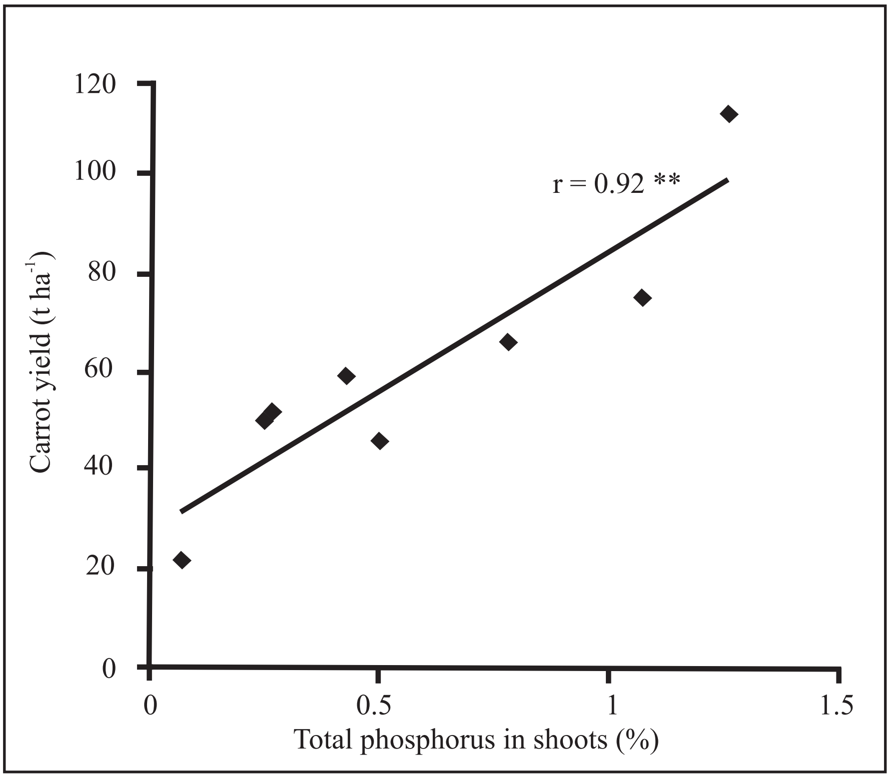

Figure 2. Correlation between total phosphorus in carrot shoots at six weeks and carrot yield.

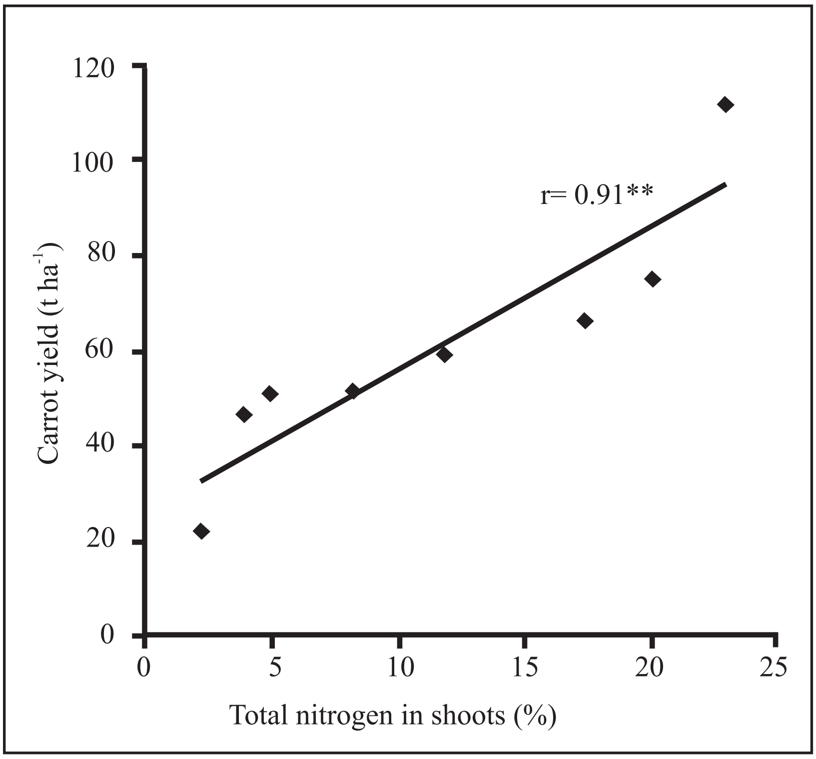

Figure 3. Correlation between total nitrogen in carrot shoots at six weeks and yield of carrot.

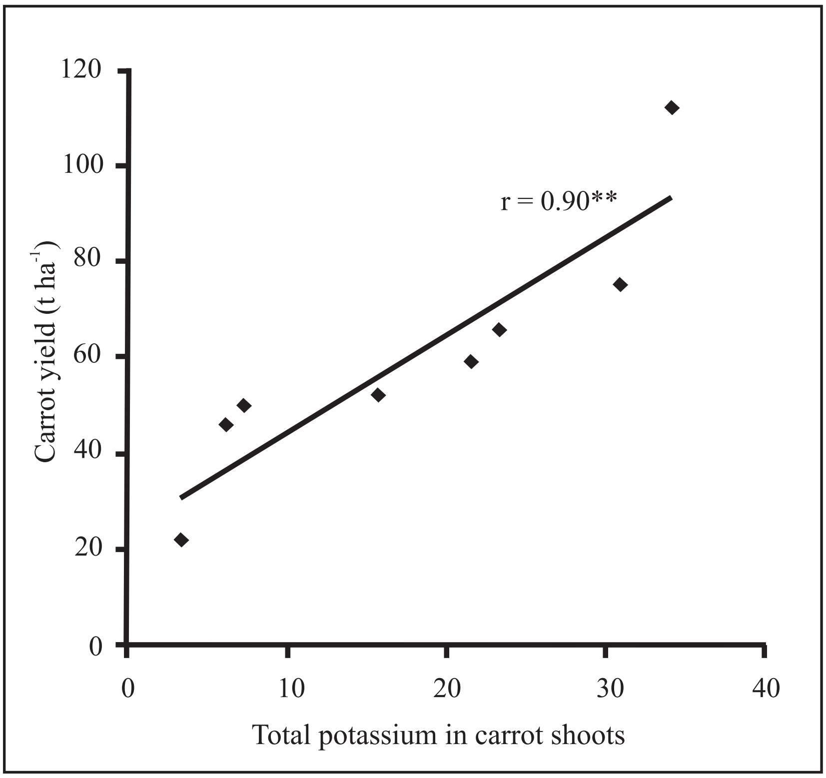

Figure 4. **Correlation between total potassium in carrot shoots at 6 weeks and yield of carrot.**

Conclusion

The effect of combined application of compost and chemical fertilizer generally resulted in a greater supply of N, P and K to carrot compared to sole application of each source. Compost applied at 14.0g pot^{-1} in combination with chemical fertilizers is the best alternative in terms of nutrient supply and carrot yield. This study therefore provides relevant information on integrated nutrient management and important uses our households refuse can be put into.

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