DETERMINATION OF THE GROWTH PERFORMANCE OF *MORINGA OLEIFERA* UNDER COMPOST APPLICATION

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The research carry out to evaluate the effect of compost made from the household waste on the growth performance of Moringa oleifera as a means to reduce the quantity of organic waste produced from the household, to boost plant production and to provide an alternative means of obtaining fertilizer to small farmer (and even large farmers).The study showed that compost application can increase soil fertility and enhances plant growth performance. The experiment was carried out on three different compost applications that correspond to low-income, middle income, and high-income households. The research inferred that compost made from the low income household showed better nutrients contents than the remaining ones and performed better in the growth of Moringa oleifera. However all composts applied showed better content of nutrients and better performance of plants growth than the soil used without compost application.

KEY WORDS: **Plant growth, Composting, *Moringa oleifera*, Household waste**

INTRODUCTION

The declining of organic matter is one of the most critical threats of soil functions in most agricultural lands worldwide. Among the different farm practices, compost application can be employed to build organic carbon stocks in the soil.

In the composting literature, the composting process and the composition of organic sources play significant roles in the production of high quality stabilized final compost. Municipal solid waste (MSW) is largely made- up of kitchen and yard waste, and its composting has been adopted by many municipalities (Otten, 2001).Composting MSW is seen as a method of diverting organic materials from landfills while creating a product, at relatively low-cost, that is suitable for agricultural purposes. This trend may be attributed to economic and environmental factors (He *et al*., 1992; Otten, 2001; Hansen et al., 2006; Zhang *et al*., 2006).Composting MSW reduces the volume of the waste, kills pathogens that may be present, decreases germination of weeds in agricultural fields, and destroys malodorous compounds (Jakobsen, 1995).

Elevated levels of fermentable organic matter of garbage make them potentially attractive as an organic soil (Mrabet, 2005; Dekkaki, 2008).The compost is a good fertilizer that can increase crop harvests, and improve the physical and chemical properties of the soil. Soil in Municipal city is intensively affected by human activities thus making it to present special features such as mixed horizons, foreign materials and thin topsoil (Short et al., 1986; Civeira and Lavado, 2008). Soils in Municipal cities are mostly poor in organic matter (OM) (e.g., < 1%) and fertility with reductions in their most important physical properties, such as structural stability and water retention. Eventually, these characteristics might have a detrimental effect on plant growth and submit this particular environment to erosion processes (Vetterlein and Hüttl, 1999; Scharenbroch et al., 2005).Consequently, deteriorated soils in populate cities do not tolerate agricultural or recreational uses and turned these environments into places with low probability of community progress. The application of organic wastes from households to degraded soils is a practice globally accepted to recover the desired properties of the said soil, thereby solving a major environmental and economic problem generated in the cities.

Moringa oleifera is indigenous to Northwest India (Ramachandran et al., 1980) but, at present it is widely distributed in the tropics throughout the Pacific region (Aregheore, 2002), West Africa (Freiberger et al., 1998; Lockett et al., 2000), as well as Central America and the Caribbean (Ramachandran et al., 1980; Foidl et al., 1999). It is a typical multipurpose tree of significant economic importance because of its several industrial and medicinal applications and various products to be used as food and feed which can be derived from its leaves and fruits (Ramachandran et al., 1980).Leaves of Moringa represent an important source of nutrients for rural populations (Gupta et al., 1989; Lockett et al., 2000). Most reports indicate that Moringa leaves are rich in protein and present an amino acid composition, which is suitable for human and animal nutrition (Gupta et al., 1989; Makkar and Becker, 1996; Freiberger et al., 1998). Therefore, there is a need to make proper methods to enhance Moringa cultivation. Because of the high rate of micronutrient deficiencies that persist in soil especially in cities like Kano where human activities affect the soil productivity. The objectives of this paper is to,: determine the effect of various compost applications on growth parameters of *Moringa oleifera,* to determine the quantity of the important nutrients which may be present in the different Municipal Solid Waste Compost and to determine the difference which exist in the growth of *Moringa oleifera* planted under different household composts application.

MATERIALS AND METHODS

Composting of the household waste was carried out in the Dorayi compost plant Kano State, Nigeria. Three different composts were made. One was from low-income household, the second one was from the middle-income household and the third one was made from the high income household. These composts were later mixed with soil. Analysis of physical and chemical properties of the soil used and the soil-compost mixture was carried out in the department of soil Science laboratory Ahmadu Bello University, Zaria in Nigeria. These compost mixtures were labelled as treatments A, B, C corresponding to the low, middle and high income household's composts.

Experiment to evaluate the growth performance of the root and shoot length of *Moringa oleifera* was carried out in the technical department, Afforestation Programme Coordinating Unit (APCU) of the National Environmental Standard Regulation Agency (NESREA).The seeds of

Moringa oleifera were planted in the compost mixtures and growth parameters which include the shoot and root length were measured on the weekly basis. Three treatments were used, A, B and C corresponding to low-middle and high income household compost. A control experiment was set and labelled as treatment D. the control experiment does not contain any fertilizer or compost application. The experiment is a completely randomized one with three replicates. Means of the shoot length growth, root length growth, shoot-root ratio were statistically compared using Analysis of Variance (ANOVA). Significance differences of the growth parameters are evaluated at 95% confidence level. P-value=0.05.

RESULTS

Table 1. physical/chemical properties of the soil and soil-compost.

Physical/Chemical parameter	UNIT	TREATMENT A	TREATMENT B	TREATMENT C	TREATMENT D (CONTROL)
pH		7.7	6.9	6.5	6.3
EC	dSm-1	1.2	2.7	2.5	0.08
AVAILABLE P	mg/Kg	255	251	112	36.9
TOTAL P	g/Kg	2.19	1.9	0.9	0.7
TOC	%	29.2	34.5	11.8	11.5
DOC	mg/Kg	39.1	31	17.7	1.9
AVAILABLE N	mg/Kg	99.6	40	38	14
TOTAL N	g/Kg	18	11	9.6	1.9
WHC	g/Kg	391	300	465	250
BULK DENSITY	g/cm3	0.56	0.54	0.49	0.72
WATER CONTENT	gg-1	1.04	0.8	1.46	0.3
Ca	mg/Kg	14.8	29.3	14.6	9.85
K	cmol(+)/Kg	0.79	0.57	0.55	0.25
Mg	cmol(+)/Kg	3	2.2	4	1.19
Na	cmol(+)/Kg	2.9	5.9	6.7	0.08

It can be seen as presented in the table (1) that the four different planting media (Treatments) varies in a range of properties. Treatment A, was fine textured and had the highest concentration of total N (18 g/Kg) and dissolve organic carbon, DOC (39.1mg/kg). This varies greatly when compared with that of treatment D (control) which has a total N concentration of just 1.9g/kg and DOC of 1.9mg/kg. Treatment B and C has a total N concentration of 11g/kg and 9.6 g/kg respectively while their DOC is 31mg/kg and 17.7mg/kg respectively.

Treatment B is coarse textured and has the highest percentage of Total Organic carbon, TOC (34.5%). Treatment A was second to it with the TOC percentage of 29.2% while treatment treatments C and D shows the lowest percentage of TOC with 11.8% and 11.5% respectively.

The water content of the control experiment, treatment D was very low ($0.3gg^{-1}$). Treatment A was found to have a water content of $1.04gg^{-1}$. The water content of treatment C was highest with a value of $1.46gg^{-1}$. Treatment B was found to $0.8gg^{-1}$.

In treatment A, the available N was found to be 99.6mg/kg while that of treatments B, C and D (control) were 40mg/kg 38mg/kg 14mg/kg respectively.

The pH was found to be highest in treatment A with a value of 7.7. Treatment D (control) was seen to have the lowest pH of 6.3 while treatments B and C shows a pH of 6.9 and 6.9 respectively.

In terms of Ca concentration, treatment B contain the highest concentration of Ca with a value of 29.3mg/kg while D has the lowest with a value of 9.85mg/kg. Treatments A and C contained Ca concentration of 14.8mg/kg and 14.6mg/kg respectively.

Na concentration was found to be higher in treatment C with a value of 6.7 cmol(+)/Kg, and lowest in the control with a value of just 0.08 cmol(+)/Kgreatment A and B showed a Na concentration of 2.9 cmol(+)/Kg and 5.9 cmol(+)/Kg respectively.

Mg and K concentrations were found to be higher in treatment A with values of 3 cmol(+)/Kg and 0.79 cmol(+)/Kg respectively. Treatment D (control) showed the value of Mg and K at the lowest with values of 1.19 cmol(+)/Kg and 0.25 cmol(+)/Kg respectively. Treatment B and C showed the value of Mg to be 2.2 cmol(+)/Kg and 2 cmol(+)/Kg and the values of K to be 0.57 cmol(+)/Kg and 0.55 cmol(+)/Kg respectively.

Available P and total P of treatment A were greater with the values 255mg/kg and 2.19g/kg respectively. Relative to treatment A, the value of Available P and Total P were slightly different in treatment B with values of 251mg/kg and 1.9g/kg respectively. The Available and Total P of treatment D (control) were very much lower with values of 36.9mg/kg and 0.7g/kg respectively. Treatment C showed 112mg/kg value for Available P and 0.9g/kg value for the Total P.

The Bulk density is higher in Treatment D (control) with a value of 0.72g/cm^3. Treatment C shows the lowest bulk density of 0.49g/cm`` ^{3} Treatment A and B showed 0.56 g/cm^3 and 0.54 g/cm^3 values of Bulk density.

Treatment A was found to contain a total EC of 1.2 dSm^{-1} while treatment B contain a total EC OF 2.7 dSm^{-1} which is the highest in all the treatments. Next to treatment B in terms of EC is treatment C with a total EC of 2.5 dSm^{-1}. The control treatment (D) contains a total EC of 0.08 dSm^{-1}.

Table 2: Shoot length growth of *Moringa oleifera*

TREATMENTS	2 WEEK	4 WEEK	6 WEEK	8 WEEK	10 WEEK	12 WEEK
A	**12.03b**	**32.367a**	**47.83a**	**68.93a**	**84.76a**	**91.13 a**
B	**11.60b**	**29.33b**	**40.43a**	**58.73a**	**73.100b**	**77.50 b**
C	**11.90b**	**17.23c**	**20.16b**	**24.00b**	**28.56b**	**32.93 bc**
D	**14.56a**	**15.23c**	**16.10c**	**16.66c**	**18.33b**	**20.16 c**
SE	**0.9876**	**1.0198**	**1.043**	**1.962**	**1.855**	**1.500**

The table(2)below shows the result of the shoot length for the four different treatments of compost used to grow the seeds of *Moringa oleifera.* From the table, it can be seen clearly that, on the second week after planting, treatment D which is the control experiment, shows the highest growth of the shoot length with a mean value of 14.56cm. This value varies significantly with the shoot length growth of the remaining treatments. Treatments A, B, and C have the mean values of 12.03cm, 11.60cm, and 11.90cm respectively. There is no significant difference between treatment A, B, and C in terms of the shoot length growth after the first two weeks of planting.

However, after the fourth week, treatment A shows the highest mean value of the shoot length growth that corresponds to 32.367cm. This value varies significantly with the shoot length mean value of treatment B, C and D (control) with values, 29.33cm, 17.23cm, and 15.23cm respectively. There is no significant difference between treatments C, and D, in terms of the shoot length growth after the fourth week at 0.05 level of significance.

On the sixth week, 47.83cm was the highest mean value for shoot length growth and this corresponds to treatment A again. The mean value for the shoot length growth of treatment B was found to be 40.43cm. This shows that at 0.05 level of significance, there is no significance difference between the shoot length growth of treatment A and B after the sixth week. The control experiment (treatment D) shows the lowest growth of the shoot length after the sixth week with a mean value of 6.10cm. Treatment C shows a shoot length of 20.16cm.

On the eight week, the highest growth of the shoot length was seen again in treatment A with a mean value of 68.93cm. However this value does not varies significantly with the shoot length mean value of treatment B which has 58.73cm shoot length. Variation on shoot length growths was significant across the remaining treatments with the lowest growth (6.66cm) seen in the control experiment (treatment D) and 24.00cm in treatment C.

Similarly after the 10^{th} week of planting, highest shoot growth was again observed in treatment A with a mean value of 84.76cm. Next to it is treatment B with a mean value of shoot length growth of 73.1cm. Treatment D was observed to have the lowest growth of shoot with a mean value of 8.33cm. These values varies significantly, with treatment C found to have a shoot length mean value of 28.58cm.

Observations made on the 12^{th} week revealed that treatment A still has the best performance of shoot growth with a mean value of 91.13cm. This value varies significantly with the remaining treatments with 77.50cm for treatment B, 32.93cm for treatment C and 10.16cm for treatment D.

The table 3 below shows the root length growth of *Moringa oleifera* across the four different treatments of household compost. It was observed that, treatment A has the highest mean value of 3.53cm, and following it is treatment D (control) with a mean value of 2.43cm. Treatment B shows the lowest mean value of 2.33cm while treatment C has 2.03cm after the first two weeks of planting.

On the fourth week however, 5.77cm was the highest mean value for the root length growth and this corresponds to treatment A. Treatment C showed a mean value of 2.90cm which is the lowest across the four different treatments. Treatment D was having a mean value of 3.67cm while treatment B had a mean value of 2.93cm. There is no significant difference across treatment B, C, and D on the fourth week after planting.

On the 6^{th} week after planting, treatment A was observed to have a mean value of 10.23cm for the root length growth. This value varied significantly with treatments B, C and D with the mean values of 6.40cm, 6.37cm and 1.33cm respectively. There is no significant difference between treatments B and C after the 6^{th} week.

Highest mean value of root length growth was found to be 16.43cm on treatment A after the 8^{th} week. Lowest mean value of root length growth was found to be 1.40cm on treatment D (control). Treatment B and C are not significantly different on the 8^{th} week with mean value of 9.47cm each.

On the 10^{th} week, treatment D was observed to have the lowest mean value of root length growth (2.00cm) while treatment A was observed to have the highest mean value (27.70cm). Treatment

B and C are not significantly different with mean value of root length growth found to be 12.23cm and 8.67cm respectively.
The last root length observation was made after the 12^{th} week after planting. Observations revealed that treatment A was having a mean value for root length growth at the highest level of 31.13cm. This varied significantly with the treatments B, C and D with mean values of 15.47cm, 14.97cm, and 4.83cm respectively. There is no significant difference between treatment B, and C in terms of the root length growth after the 12^{th} week of planting.
Table 4 below shows the total plant height of*Moringa oleifera*on the four different treatment of household compost. It was observed that, the total plant length at the end of the experiment i.e after twelve weeks of planting, was found to be significantly different across the four different treatments of planting media (compost and the soil). Highest value mean value was found to be 122.27cm and it correspond to treatment A of the low-income household compost. The lowest value of the total plant height was found to be 15.00cm and this correspond to the control experiment (treatment D) that was not treated with compost of any kind. Treatment B and C shows a mean value of 47.90cm and 72.97cm respectively for the total plant height after the 12^{th} week of planting. This means that there is no significant difference between treatment B and C with respect to the growth of the plant height after the 12^{th} week of planting.
Table 5 below presents the shoot-root ratio of the plant growth for the four different treatments that were used to grow the seeds of *Moringa oleifera.* From the table, the ratio of the shoot-root growth for treatment A after the first two weeks was found to be 3.44 which is not significantly different with that of treatment B with a value of 4.98. Treatment C was found to have a shoot-root ratio of 5.87 while treatment D (control) have a value of 5.99. There is no significant difference between treatment C and D in terms of the shoot-root ratio on week two.
On the fourth week, the shoot-root ratio of treatment A rise to 5.63 while that of treatment B rise to 6.33. Treatment C has a ratio of 10.73 while the treatment D falls to the ratio of 4.15 after the fourth week.
On the 8^{th} to 12^{th} week, the value of the shoot-root ratio of treatment D keeps falling. With a value of 1.59, 1.39 and 0.70 corresponding to the eighth, tenth and twelfth week respectively.

Similarly, treatment A, shows a fall in the mean value for the shoot-root ratio from week 6-12. The values corresponds to 4.68, 4.20, 3.08, and .90 for the 6^{th}, 8^{th}, 10^{th}, and the 12^{th} weeks respectively. These shows a little difference with treatment B and a significant differences with D. there is no difference in the mean value of shoot-root ratio of treatment C from the weeks 6, 7, 8, 10 and 12 with values 6.63, 6.33, 3.43, and 3.91 respectively.

Treatment B has mean values of shoot-root ratio of 3.21, 2.55, 2.35, and 2.22 corresponding to 6, 7, 8, 10 and 12 weeks. These value did not varies significantly with treatment A and in some cases of treatment C but varies significantly with treatment D.

Table 3: root length growth of *Moringa oleifera*

TREATMENT	2 Week	4 Week	6 Week	8 Week	10 Week	12 Week
A	3.5333 a	5.7667 a	10.233 a	16.433 a	27.700 a	31.133 a
B	2.3333 b	2.9333 b	6.400 b	9.467 b	12.233 b	15.467 b
C	2.0333 b	2.9000 b	6.367 b	9.467 b	9.667 bc	14.967 b
D	2.4333 b	3.333 b	3.6667 c	4.000 c	4.400 c	4.833 c
SE	0.5254	0.9040	0.6531	1.2391	1.3685	1.7538

Table 4: Total plant height of *Moringa oleifera*

TREAT	2 Week	4 Week	6 Week	8 Week	10 Week	12 Week
A	15.56 ab	38.133 a	58.067 a	85.367 a	112.47 a	122.27 a
B	13.933 b	20.167 c	26.567b	33.500 c	40.80 b	47.90 bc
C	13.933 b	32.233 b	46.800 a	69.100 b	51.80 b	72.97 b
D	17.000 a	18.900 c	7.433 c	8.067 c	10.33 b	15.00 c
SE	2.0752	2.4925	5.0123	6.1471	1.27	1.850

Table5: shoot-root ratio of Moringa oleifera

TREAT	2 Week	4 Week	6 Week	8 Week	10 Week	12 Week
A	3.440 b	5.630 b	4.680 ab	4.200 ab	3.0767 a	2.940 ab
B	4.976 ab	6.330 b	3.2067ab	2.546 b	2.3500 a	2.216 ab
C	5.8667 a	10.727 a	6.6633 a	6.3300 a	3.4267 a	3.9133 a
D	5.9900 a	4.153 b	1.5267 b	1.5867 b	1.3900 a	0.7000 b
SE	0.6747	1.1363	1.6521	1.2840	1.5278	1.0159

1. DISCUSSION

The study showed that all the composts that were made from the low, middle and high income households increases the availability of soil nutrients and also influences some soil physical and chemical properties. This is in line with many previous studies like that of De Bertoldi*et al*. (1983) and Bernal *et al.* (2009). According to their studies, compost have several advantages compared to plant residues when applied to soils, such as reduced volumes, slower mineralization rates and recycling of municipal bio-solid waste. Sanchez-Mondero*et al*., (2004) and Tejada *et al*., (2009) opined that compost has two main effects on soils, particularly nutrient poor soils-replenish soil organic matter and supply plant nutrients. However, these properties differed across the compost made from the low income household, middle income and the high income household. The differences is attributed to the differences in the type of solid waste materials found and used for this research. Cayuela*et al*., 2009 De Araujo *et al*., 2009) opined that compost can be derived from a number of feed stocks materials including woody (trees, shrubs) and herbaceous (turf grass and small flowering plants) green waste, crop residue, bio-solids (sewage sludge) wood by-products, animal manures, biodegradable packaging and building materials and food scraps. These feed stocks differ substantially in chemical composition, particle size and thus decomposition rates according to their studies.

Application of the composts resulted in increased N and P availability but was found to be more concentrated in the low-income household. Similarly, total P, DOC total N and K were found to have values greater than that of the middle and high-income households. These differences could be due to the different life style and income of the household, for instance, more organic waste was found in the low-income household when compared to the two other households and more plastic materials were found in the high and middle income household. Which means that, the low income households have more potential for composting than their high and middle counterparts. The studies of Butler *et al*., (2008); and Soumare*et al., (*2003) revealed that the application of compost from MSW and dairy manure to soils can result in a significant increase in concentration of N & P and other nutrients in soil even several years after application.

The pH of the compost made from the low-income household was found to be very higher, this could be as a result of formation and breakdown of organic acids from the excess organic waste released from the decaying starting materials as well as ammonification and nitrification. The increase could be as a result of adsorption of H^+, development of reducing conditions due to increased microbial activity since this compost contain more different organic feed stocks than the high and middle income composts.

The TOC was found to be increased when applied to soil for all the composts made from the low-middle-high income households. This opposed and varied to the study of Emmerling*et al*., (2009) and Wright *et al*., (2007) were their studies revealed that TOC content was not affected by compost application more than 2 years after compost application.

The electrical conductivity of the compost made from the middle income household was found to have more concentration than that of the low and high income household compost, this could be so because EC as a measure of soluble salt content may be high when the organic solids in it are not sufficient enough to reduce its concentration.

The increased WHC and water availability of the compost treatment conform to the studies of (CIWMB, 2004; Curtis and Claasen 2005; Farrel and Jones 2009) that says other beneficial effect of compost includes increase in water holding capacity (WHC) and plant water availability.

In a nutshell, this research find out that, Compost properties are dependent on compost feed stocks, composting condition and duration. As a result, compost differ in physical and chemical properties and will thus differ in effect on soil properties. This is in conformity with the researches of Eneji*et al*., (2001) and Kawasaki *et al*., (2008).

During the growing period, it was possible to recognize distinct differences in terms of the growth performance of *Moringaoleifera* between the different treatments of the planting media (composts and soil).
The Total plant growth of the control experiment (treatment D) shows a rapid growth of both the shoot and the root on the first two weeks after planting. However as the weeks goes by, these begins to decline and subsequently resulted in the death of some of the plant replicates. The decline in the growth of root and shoot of the control experiment (treatment D) could be as a result of exhaustion of most of the available nutrients needed for proper plant growth. This is true because looking at the soil physical and chemical properties of the control experiment (treatment D) from table 4.2 above, it can be seen clearly that the available nutrients for plant growth are in a little concentration, which means little will be supplied for the growth of the plant. The increase of this treatment at the initial first two weeks could be as a result the nutrients being more readily available for plant uptake than the treatments treated with the composts. This result also agreed with the works of Odolare and pell, (2009); and Vance *et al*. (1987) were they observed that plant N and P uptake from compost may be lower because the organic N in the compost has to be mineralised before it can be taken up by plants or because of microbial immobilization of N. The bulk density of the soil was found to be higher and this can therefore inhibit the growth of the plants grown under it at some stages since increase in EC can increase soil salinity to levels that are toxic to especially salt sensitive plants.
The treatment that shows the best performance of the growth of *Moringa oleifera* is the compost made from the low-income household (treatment A). For instance, the shoot length and the root length of *Moringa oleifera* that is grown under this compost treatment was found to be very high on the first two weeks and the values of the shoot and root growth keep rising even after the twelfth week. This is solely attributed to the fact that most of the soil-compost properties of this treatment (A) were significantly close to optimum values than those obtained from the remaining treatments (B, C and D).
Analysis of variance revealed that difference exists in the growth performance of plant (*Moringa oleifera*) across the compost made from the low-income household and the High income household. This is so because significant differences were observed on the 4^{th}, 6^{th}, 8^{th}, 10^{th}, and 12^{th} weeks in the shoot and root length of the plant, with a better performance on the plants grown under the compost treatment of low-income household.
Treatment B, which is compost made from middle income household shows a moderate growth of plant in terms of the shoot and root length. These growths performed better than the control experiment and not far different from the growth of plants in the low-income household. This could be attributed to the fact that, the compost physical and chemical properties are found to be at a better concentration and close to optimum than the control experiment.
All the plants grown under composts application irrespective of the socio-economic status of household to which the compose is made, perform better and significantly different in mean values of the growth parameters used to determine the performance on *Moringa oleifera*than the control experiment grown in soil without compost application. This is in conformity to many researches like that of Epstein, (1997); Heymann*et al*., (2005); Kawasaki *et al*., (2008);

poll *et al*., (2008) where they observed increase in plant nutrients availability after compost application.

CONCLUSIONS AND RECOMMENDATIONS

In respect of the experiment carried out to determine the growth performance of *Moringa oleifera*under compost application, it was found that application of compost enhances the shoot and root length growth of the plant. However this varies across different type of composts. The compost made from low income status household perform better than the compost made from the middle-income household and the compost from the middle income household shows a better performance of root and shoot length growth than that compost made from the household waste of high-income houses. The quality of compost therefore determines the growth and development of plant. The composts were all seen to improve both physical and chemical properties of the soil. This inferred and confirmed the fact that compost can be used for soil amendment. It is recommended at this point that more researches should be carried out to understand the effect of compost application on many economic plants to bridge the gap. Further researches should be carried out on the long-term effects of compost application on soil properties and plant growth performance.

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