

Original Research Article

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Soil Amendment for Vegetable Production: An Example with Cow Dung Manure and Eggplant (*Solanum melongena*)

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ABSTRACT

Soil degradation as a result of improper land use and management practices has limited the ability of the soil to produce optimally. Therefore, this study was aimed at assessing the effects of cow dung manure amendment on some properties of a degraded soil located within the Teaching and Research Farm, Ladok Akintola University of Technology, Ogbomoso, Nigeria and the influence on the growth of egg plant (*Solanum melongena*). Soil samples were collected from 0-30 cm layer of the soil and were packed in pots. The soil samples in the pots were treated with 0, 10, 15 and 20 ton/ha of cow dung designated as control, T1, T2 and T3, respectively in 3 replications. At harvest, soil samples were collected at 0-10 and 10-20 cm depth in the pots for the analysis of physico-chemical properties. Plant growth parameters were monitored from five weeks after transplanting till harvest. The results revealed that at both depths (0-10 and 10-20 cm), there was significant ($p < 0.05$) decrease in soil bulk density (BD), and corresponding increase in total porosity (Pt) and mean weight diameter (MWD). Soil pH, OC, TN and P significantly ($p < 0.05$) increased while the C:N ratio was decreased with application of cow dung. Plant height and number of leaves were significantly ($p < 0.05$) higher in soils amended with cow dung, with treatment T3 (20 ton/ha) giving the best results. The results showed that cow dung has great potentials for amelioration of degraded soils however further studies are required to establish optimum rate for sustainable crop production. Also the increase in P loading with increasing application rates also call for further investigation in terms of negative impact on the environment.

Keywords

Soil amelioration, farmyard manure, soil properties, crop performance

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Introduction

Degraded soil results not only due to natural phenomena but also from improper land use and management practices over years causing decline in soil functions. For instance, the increasing pressure on soil

resource to increase crop production to meet food demand of increasing world population has made the traditional shifting cultivation to be obsolete and the bush fallow system for maintaining the productivity, shorter.

Thus soils are no longer naturally able to supply the needed nutrients required by plants with a consequent decline in yield (Amhakhian *et al.*, 2010). Therefore, efforts are being made in almost every country of the world to reclaim degraded soils for agricultural purposes. Nevertheless Ahmad *et al.*, (2014) stated that the success of fertility rehabilitation projects require recovery of soil organic matter and mineral nutrient cycling in the soil. In this context, the use of organic materials or organic agriculture as soil amendments has been accorded considerable attention for reclamation of degraded soils for nutrient recovery and recycling and increase crop productivity, using available resources and management such as green manure (Alves and Souza, 2008; Bonini and Alves, 2010), crop rotation (Ahmad *et al.*, 2014), compost and bio solids (McGeehan, 2012; Abubakari *et al.*, 2015), livestock waste (Ewulo, 2005; Ikeh *et al.*, 2012; Oyewole *et al.*, 2014), vermicompost (Moraditochae *et al.*, 2011), however results are site-specific depending on soil type, climatic condition and cultural practices. Despite the success of the various schemes, not much is known on the applicability and efficacy of cow dung for soil amendment.

Managing cow dung is a common problem as other animal wastes in developing countries such as Nigeria. Putting these wastes into effective agrarian use is also often a problem because they are bulky, low-grade in terms of nutrient contents. Cow dung has high water content, making it cumbersome to transport far from the source to the point of use. In addition, the irritating malodorous gases emanating further complicate its use. Despite these shortcomings, cow dung has potentials to alleviate soil nutrient depletion problems in crop production (Ahmad *et al.*, 2014). Fening *et al.*, (2008) identified cow dung as

soil amendment that possesses the potential for use in the interior savannah zone of Ghana. In Nigeria, few studies have explored the potentials of cow dung for soil amelioration and crop performance (e.g. Ewulo, 2005; Ewulo *et al.*, 2007).

Eggplant (*Solanum molengena*) is one of the most important grown vegetable in West Africa, it originated from tropical Africa, and is well adapted to tropical climate (Tindall, 1992). The crop is known by many names such as eggplant and aubergine in the United States and Europe, brinjal in the South East Asia and garden egg in West Africa including Nigeria (Obeng-Ofori *et al.*, 2007). Depending on the variety, the crop is grown for the fresh fruits (eaten raw or cooked) or the leaves. The fruits are known for being low in calories and rich source of potassium, magnesium, calcium and iron (Zenia and Halina, 2008). Because of the nutritional value beneficial for human health, the production of eggplant has recently increased, resulting into continuous use of same land every year and encroachment of marginal lands. According to Stoorvogel *et al.* (1993), continuous cropping with low or no soil amendment, nutrient losses through harvest, soil erosion and leaching cause decline in soil fertility. Just as other vegetables, eggplant also requires balanced soil nutrients for optimum yield. In this context, several studies have evaluated the effect of different soil amendments on growth and yield of eggplant (e.g. Dauda *et al.*, 2005a, b; Moraditochae *et al.*, 2011; Suge *et al.*, 2011; Oyewole *et al.*, 2014), but none of these studies have reported the soil condition due to the various amendments. However, such information is vital for management decision towards sustainable environment.

Majority of the land used for eggplant (and other vegetable crops) production in

Ogbomoso has been degraded due to continuous cropping and washing away of top soil due to the scouring velocity of irrigation water, with consequent sharp drop in yield and low income. Thus, there is the need for comprehensive approach towards rehabilitation of such farms. Therefore, the aim of this study was to assess the effects of soil amendment using cow dung manure on some physical and chemical properties of a degraded soil and the influence on the performance of egg plant (*Solanum melongena*).

Materials and Methods

Description of the Study Area

The study was conducted in the experimental field of Department of Agricultural Engineering, Ladoko Akintola University of Technology (LAUTECH), Ogbomoso (Latitude 8° 10' N and longitude 4° 10' E). Ogbomoso is marked with a distinctive rainy season, averaged at eight months (April- October) with mean annual rainfall of over 1000 mm (Olaniyi *et al.*, 2010). The rainfall distribution is bimodal with peaks in July and September, with a period of low precipitation in August (August break). The mean minimum and maximum temperature is 28 and 33°C, respectively. Relative humidity is quite high- about 70% (Ganiyu *et al.*, 2013).

A degraded soil under eggplant cultivation was located within the campus of LAUTECH. Samples were collected at the depth of 0-10 and 10-20 cm of the soil profile, the sample was tested for organic carbon (OC) and total nitrogen (TN). These were done to estimate the fertility level of the soil. The results of the test indicated that the soil is degraded. Afterwards, disturbed soil samples were collected at the depths 0-10 and 10-20 cm of the soil layer. The samples were taken to the laboratory for

analyses. Other routine parameters analysed using standard laboratory procedures included Organic Carbon (OC) Total Nitrogen(TN), Total Phosphorus (P), pH, Electrical Conductivity (EC), Aggregate Stability (WSA), Bulk Density (BD), C:N ratio and Total Porosity (Pt).

Experimental design

The experiment was laid out in randomized complete block design (RCBD) in three replications. The treatment consisted of four levels of cow dung namely: T1: 10ton/ha; T2: 15 ton/ha and T3: 20 ton/ha and control: 0 ton/ha.

Preparation of mini-lysimeters

The materials used for this work include plastic pots (made from 20 L buckets, 58 cm diameter and 33 cm high. The pots (twelve in numbers) were perforated at the bottom to allow for free drainage of water that could have contributed to deep percolation. A metallic measuring tape was used to measure (from the surface) the depth of soil and samples collected and done in the range of 0-10, 10-20 and 20-30 cm. The inside of the pots were divided into three sections. About 5 cm depth from the tip of each pot was left to allow water to be collected from rain and to avoid runoff from the surface of the pot. Soil samples collected from each layer were used to fill each section, with soil from 20-30 cm at the bottom in that order. The pots were arranged on the field following the experimental design. Before transplanting, the pots were then left on the field for one week for possible rearrangement of the soil particles.

Soil treatment and planting

The soil in the pots previously arranged according to the experimental design were treated with three levels of cow dung (10, 15, 20 t/ha). Cow dung, dried to 17%

moisture content and ground into fine, soil-like texture (Traunfeld and Nibali, 2013), was incorporated into the superficial layer of the pots and were left in the open field for two weeks before transplanting. Three week old seedlings of garden egg (*Solanum melongena*) which have earlier been raised in a nursery within the experimental field were transplanted at two plants per each pot. The pots were watered adequately to ensure crop establishment. There was no inorganic fertilizer application and weeding was done manually throughout the growing period of the vegetable.

Soil sampling and analysis at harvest

After harvest, both disturbed and undisturbed soil samples were carefully collected from the 0-10 and 10-20 cm layers of each pot for the determination of physical and chemical properties. Soil Organic Carbon (OC), Total Nitrogen (TN), Total Phosphorus (P), pH, Electrical Conductivity (EC), Water Stable Aggregate (WSA), Mean Weight Diameter (MWD), Bulk Density (BD), C:N ratio and Total Porosity (Pt) were determined for the soil samples collected at the two layers.

Plant growth parameters

Plant growth parameters of plant height (PH), number of leaves (NOL) and stem girth (SG) were monitored on weekly basis, starting from the fifth week after transplanting (5 WAT). pH was determined from the soil surface to the tip of last leaf using a steel tape; NOL was determined by visual counting of green leaves while SG was determined using a verniercaliper.

Statistical Analysis

Descriptive statistic and analysis of variance (ANOVA) were carried out on the soil properties and means were separated using

Tukey test at 5% level of probability. Means between the two soil layers were compared using student's t-test. Pearson correlation test was also performed on soil properties. All statistical analyses were done using SPSS (IBM version 20.0) and SAS (version 8).

Results and Discussion

Preliminary soil analysis

The results of the preliminary investigation of the perceived degraded soil are shown in Table 1. The soil is slightly acidic (pH = 6.43) and the textural classification indicated that the soil is sandy loam textured. The soil is characterized by high bulk density which is reflected in the relatively low total pore space, with Pt about $0.31 \text{ cm}^3/\text{cm}^3$. The electrical conductivity (EC) was low for the soil to be considered saline. The organic carbon (OC) was 0.63 and 0.53% for the 0-10 cm and 10-20 cm layers, respectively while total nitrogen (TN) was not more than 0.48 g/kg (Table 1). Although the soil OC falls within 0.29-2.32% established for soils of southwest Nigeria (Adepetu and Corey, 1976), however a comparison with critical levels of 1.74% OC; 1.5 g/kg TN and 10.0 mg/kg P set for crop production in this region (Akinrinade and Obigbesan, 2000) showed that these major soil nutrients are below critical. In terms of physical quality, the BD falls within the range ($1.75 - 1.85 \text{ g/cm}^3$) considered restrictive to root growth and crop development (Reinert *et al.*, 2008); impedance to water dynamics and gaseous exchange (Reichert *et al.*, 2009) and which is reflected in low Pt observed. Therefore, for sustainable crop production and protection of the environment, amelioration is needed and organic manure, such as cow dung, could be of great help. The levels of mineral nutrients of the cow dung used for the study (Table 1) were

within the range reported in literature (e.g. Adediran *et al.*, 1999; Ewulo *et al.*, 2007). Ewulo *et al.* (2007) stated that the faecal composition of cow dung cannot be the same as a result of age, type of feed and feeding system.

Soil physical properties of the amended soil at harvest

The addition of cow dung significantly ($p < 0.05$) influenced the average soil bulk density (Table 2). The average values BD at depth 0-10 cm ranged between 1.65-1.78 g/cm^3 , with the control (without cow dung) having the significantly highest BD value while cow dung application at 15 ton/ha (T2) had the lowest BD. Similar trend was observed at the depth 10-20 cm where the application of cow dung also showed significant difference ($p < 0.05$) compared with control although T1 had the lowest BD. A comparison of the two depths showed 10-20 cm layer had higher BD but this was not significantly difference from that of the 0-10 cm surface layer (Table 2). In addition, the average BD of the 0-10 cm surface layer was lower than the pre-amended value while that of 10-20 cm was still at par.

The application of cow dung significantly ($p < 0.05$) affected the soil total porosity (Pt) at both depths (Table 2). For the 0-10 cm surface layer, the average values of Pt ranged between 0.33 and 0.39 cm^3/cm^3 , with the control having the lowest value. A comparison between the three levels of cow dung showed that the application rate of 10 ton/ha (T1) gave the highest Pt. For the 10-20 cm layer, the average values of Pt ranged between 0.31 and 0.38 cm^3/cm^3 , with the lowest and highest values from control and T1 treatment, respectively. A comparison between the two layers showed that the average Pt was at par (0.35 cm^3/cm^3). At harvest of eggplant, the Pt of the soil increased compared with the pre-amended

value. The mean water stable aggregate (WSA) at the depth 0-10 cm ranged from 0.64 to 0.69, with the lowest value from control which did not significantly ($p < 0.05$) differ from other treatments (Table 2). For the 10-20 cm sub surface layer, average WSA was lower and ranged between 0.53 and 0.57, with control having the lowest value. Treatments T2 (15 ton/ha) and T3 (20 ton/ha) had higher WSA than treatment T1 (10 ton/ha). The statistical comparison between treatments means showed that WSA did not significantly differ, however combining the treatments, the surface layer had significantly higher WSA compared with that of subsurface layer. Similarly, there was improvement in the WSA compared to pre-amended soil condition.

We went further to analyse the mean weight diameter (MWD) and similar trend was obtained as WSA (Table 2).

The improved soil structure characterized by decrease in BD and increase in Pt is attributed to improved aggregation and increased pore space caused by increased organic matter level of the soil due to cow dung. The non-significant difference in WSA may be attributed to the short duration of the experiment which could not allow enough time for the amendment (cow dung) to homogenize with the soil to form stable aggregates. Furthermore, the sandy nature of the soil could not favour inter-particle bonding to enable the amendment (cow dung) bind the soil particles to form stable aggregates (Khalid, 2010).

Soil chemical properties of the amended soil at harvest

The average values of pH, electrical conductivity (EC), phosphorus (P), organic carbon (OC), total nitrogen (TN) and carbon-nitrogen ratio (C:N) of the two soil layers under different levels of cow dung

amendment and control are presented in Table 3. At both depths, there was significant difference ($p < 0.05$) in the pH between the control and treatments. For the surface layer, the control soil was more acidic (pH = 6.05) compared with other treatments. In the subsurface layer, it was treatment T1 (10 ton/ha) that had the significant lowest value of pH. Irrespective of treatments, the 0-10 cm surface layer had significantly higher pH than that of the 10-20 cm subsurface layer (Table 3). Compared with pre-amended soil pH values, the surface layer had the pH increased while the subsurface layer had its pH reduced. Our results agree with that of Ewulo *et al.*, (2007) who found increased soil pH due to soil amendment by cow dung, the increase was attributed to addition of cations to the soil. Organic manure has also been reported to increase soil pH (Ullah *et al.*, 2008), which helped to check the liming potential in an acidic soil.

There were significant differences ($p < 0.05$) in the average values of EC between the control and treatments in both soil layers (Table 3). The EC significantly increased from 6 $\mu\text{s/cm}$ in treatment T1 (10 ton/ha) to 12.67 $\mu\text{s/cm}$ in treatment T3 (20 ton/ha) in the 0-10 cm layer. The opposite trend was observed in the 10-20 cm layer as the EC significantly decreased from about 14 $\mu\text{s/cm}$ in treatment T1 (10 ton/ha) to about 29 $\mu\text{s/cm}$ in treatment T3 (20 ton/ha). Comparing the soil layers, the 10-20 cm layer had EC almost twice as much as that of the surface layer and these values were higher than the pre-soil amendment condition. Angelova *et al.* (2013) also reported that the addition of compost and vermicompost to the soils led to slightly increase in EC values compared with control soil. In addition, the increase in EC with increased doses of cow dung observed in the surface layer may be due to high salt

concentration of the cow dung while the reduction in the subsurface layer is attributed to complex processes at play. Atiyeh *et al.* (2001) also observed increased EC with increasing application rates of pig manure.

The average values of total phosphorus (P) significantly ($p < 0.05$) differed in both soil layers due to the addition of cow dung (Table 3). In both layers, there was increase in soil P with increasing rate of cow dung, with soil receiving 20 ton/ha (T3) giving P more than double that of soil that received 10 ton/ha (T1) and the control having the significantly lowest values. The values P from the control were comparable with those of pre-amended soil while those of the treated soils were higher than the initial values. Increase in soil P due to organic amendment has been reported by several researchers (e.g. Bayu *et al.*, 2006; Ewulo *et al.*, 2007; Padmavathiamma *et al.*, 2008; Angelova *et al.*, 2013). The greater than 200% increase in P when the application rate was double (from 10 to 20 ton/ha) and more than triple compared with control concurs with the findings of Devliegher and Verstraete (1997) who found a significant increase in the P contents after the vermicompost amendment, reaching double the initial value for some treatments, or even triple in others, which was attributed to increase in the enzymatic activity of phosphatases from earthworms.

The soil organic carbon (OC) and total nitrogen (TN) differed significantly in both soil layers as a result of soil amendment. In the 0-10 cm surface layer, the average values of OC and TN were higher from treated soils compared with the control while the different rates of cow dung did not differ from one another, although treatment T2 appeared having the highest (Table 3). In the subsurface layer, it was treatment T2 (15

ton/ha) that had the highest values of OC and TN while treatment T1 had the lowest values. Nevertheless, the 0-10 cm surface layer had the significantly higher values of these parameters than the 10-20 cm subsurface layer. Compared with pre-amended soil condition, there was increase in both OC and TN at harvest. Several studies have also reported increase in soil TN and OC due to addition of farm yard manure (Bayu *et al.*, 2006); cow dung (Ewulo *et al.*, 2007) and compost (Angelova *et al.*, 2013). The increased soil TN with increasing rate of cow dung showed that remarkable amount of N would be available for plant because of increased organic matter and favourable pH (Zupanc and Zupanc, 2010).

There was no significant difference in the carbon-to-nitrogen ratio (C:N) due to soil amendment in the two layers, however there was reduction in the C:N ratio from about 14 from pre-amended soil to about 9 from amended soil (Table 3). In this study, the average values of C:N of soil was low (around 9.6), below 20:1 considered minimum for N to be easily mineralised in all treatments, thus we can say there was good turnover of cow dung decomposition which is reflected in the increased TN. Our results agree with that of Angelova *et al.* (2013).

Correlation between soil properties

The result of the correlation analysis of the physico-chemical properties of the amended soils after the harvest of the vegetable was presented in Table 4. The OC and TN correlated significantly with pH, EC, WSA and MWD, while the correlation was

positive with pH, WSA and MWD, it was negative with EC. In addition, the MWD had significant positive correlation with the pH. As expected, the BD had significant negative correlation with both WSA and MWD. P did not show correlation with any of the soil parameters, OC had perfect and positive correlation with TN while BD was almost perfectly correlated, though negative, with Pt. The varying degrees of significant correlations indicated that OC, TN, pH, EC, WSA, MWD and BD could be used to monitor the quality of soil when subjected to organic manure. It is however necessary to carry out further analysis, such as factor analysis, to determine which parameters that actually affect the soil and to focus on in other to avoid redundancy.

Effect of cow dung manure on some growth parameters

Figure 1a shows the effect of three rates of cow dung manure on the number of leaves (NOL) from 5 to 10 weeks after transplanting. Except at 8 WAT, application of cow dung significantly ($p < 0.05$) influenced the NOL. NOL increased with increasing rate of cow dung only at 5 and 6 WAT and over time (10 WAT), T1 (10 ton/ha) produced the most number of leaves.

The average plant height (PH) of eggplant under the different rates of cow dung manure is shown in Figure 1b. The application of cow dung had significant effect ($p < 0.05$) on PH throughout the monitoring period. There was also an increase in PH with increasing rate of cow dung applied throughout the growing cycle, with T3 (20 ton/ha) having the significantly highest plant, giving the order: T3>T2>T1.

Table.1 Preliminary investigation of selected soil physico-chemical properties

Chemical properties	Soil layer, cm		Cow dung
	0-10	10-20	-
pH _{H2O}	6.43	6.83	7.3
EC ($\mu\text{s}/\text{cm}$)	7.67	5.33	-
P (mg/kg)	7.36	4.48	7.8
OC (%)	0.67	0.53	8.1
TN (g/kg)	0.48	0.37	3.0
K (%)	-	-	1.3
Ca (%)	-	-	0.9
Mg (%)	-	-	0.3
Physical properties			
BD (g/cm^3)	1.78	1.79	-
Pt (cm^3/cm^3)	0.312	0.305	-
WSA	0.654	0.532	-
Particle size distribution, %			
Sand	76.60	74.60	-
Silt	12.92	12.86	-
Clay	10.48	12.54	-
Texture	SL	SL	-

EC= electrical conductivity; P= total phosphorus, OC: organic carbon content, TN= total nitrogen; BD: bulk density; Pt: total porosity; WSA: water stable aggregate; SL: sandy loam

Table.2 Some physical properties of the cow dung-amended soil after harvest of eggplant.

Treatments	BD	Pt	WSA	MWD
	0-10 cm			
T1	1.68±0.08b	0.39±0.01a	0.66±0.02a	0.96±0.03b
T2	1.65±0.10b	0.36±0.03b	0.69±0.00a	1.05±0.01a
T3	1.70±0.06b	0.37±0.04b	0.67±0.02a	1.03±0.04a
Control	1.78±0.04a	0.33±0.01c	0.64±0.04a	0.94±0.02b
Mean	1.70A	0.35A	0.66A	1.00A
LSD _T (p<0.05)	0.16	0.06	0.06	0.06
Treatments	10-20 cm			
	BD	Pt	WSA	MWD
T1	1.73±0.12b	0.38±0.03a	0.54±0.02a	0.82±0.04ab
T2	1.78±0.15b	0.38±0.01a	0.57±0.03a	0.88±0.04a
T3	1.73±0.07b	0.33±0.00b	0.57±0.03a	0.87±0.05a
Control	1.83±0.02a	0.31±0.00b	0.53±0.01a	0.76±0.02b
Mean	1.77A	0.35A	0.55B	0.83B
LSD _T (p<0.05)	0.21	0.04	0.04	0.07

T₁= treatment with 10 ton/ha of cow dung; T₂= treatment with 15 ton/ha of cow dung; T₃= treatment with 20 ton/ha cow dung; BD: bulk density; Pt: total porosity; WSA: water-stable aggregate; MWD: mean weight diameter;

LSD_T: least significant difference between treatments at 5% level of probability by Tukey test.

Means followed by the same lower case letters did not differ significantly between treatments while means followed by the same upper case letters did not differ significantly between soil depths by t-test.

Table.3 Some chemical properties of the cow dung-amended soil after harvest of eggplant.

	pH _{H2O}	EC(μ S/cm)	P (mg/g)	OC (%)	TN (g/kg)	C:N
Trmts	0-10 cm					
T1	6.78±0.12a	6.00±1.00b	9.24±1.98b	0.69±0.08a	0.72±0.01a	9.63±0.06a
T2	6.74±0.25a	7.67±0.58b	10.40±0.69b	0.71±0.12a	0.74±0.01a	9.64±0.05a
T3	6.75±0.10a	12.67±7.51a	24.47±5.85a	0.70±0.13a	0.73±0.01a	9.63±0.05a
Control	6.05±0.22b	7.67±7.37b	7.36±8.29b	0.61±0.07b	0.64±0.01b	9.62±0.02a
Mean	6.58A	8.50B	11.87A	0.68A	0.71A	9.63A
LSD _T	0.40	9.28	10.95	0.21	0.21	0.08
	10-20 cm					
T1	6.25±0.26c	29.33±17.04a	7.36±1.52ab	0.40±0.19c	0.41±0.02c	9.67±0.04a
T2	6.57±0.11ab	15.33±11.37b	9.68±3.25ab	0.61±0.19a	0.63±0.02a	9.63±0.02ab
T3	6.67±0.12a	14.33±9.29b	16.98±7.07a	0.47±0.04b	0.49±0.00b	9.59±0.03b
Control	6.32±0.23bc	5.33±1.15c	4.48±6.49b	0.48±0.06b	0.50±0.01b	9.58±0.02b
Mean	6.40B	16.08A	9.63A	0.49B	0.51B	9.62A
LSD _T	0.32	25.37	10.77	0.30	0.31	0.07

T₁= treatment with 10 ton/ha of cow dung; T₂= treatment with 15 ton/ha of cow dung; T₃= treatment with 20 ton/ha cow dung; Trmts: treatments; EC= electrical conductivity; P= total phosphorus, OC: organic carbon content, TN= total nitrogen and C:N= carbon-nitrogen ratio.

LSD_T: Least significant difference between treatments at 5% level of probability by Tukey test.

Means followed by the same lower case letters did not differ significantly between treatments while means followed by the same upper case letters did not differ significantly between soil depths by t-test.

Table.4 Correlation between soil properties

	pH	EC	P	OC	TN	C:N	WSA	MWD	BD	Pt
pH	1	-0.353	0.400	0.412*	0.415*	-0.089	0.395	0.474*	-0.271	-0.009
EC		1	0.171	-0.417*	-0.422*	0.272	-0.180	-0.101	-0.099	0.349
P			1	0.278	0.278	0.045	0.211	0.320	-0.078	0.333
OC				1	1.000**	0.200	0.524**	0.542**	-0.252	0.238
TN					1	0.186	0.522**	0.540**	-0.251	0.234
C:N						1	0.209	0.295	-0.110	0.300
WSA							1	0.976**	-0.500*	-0.100
MWD								1	-0.515*	-0.026
BD									1	-0.998**
Pt										1

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

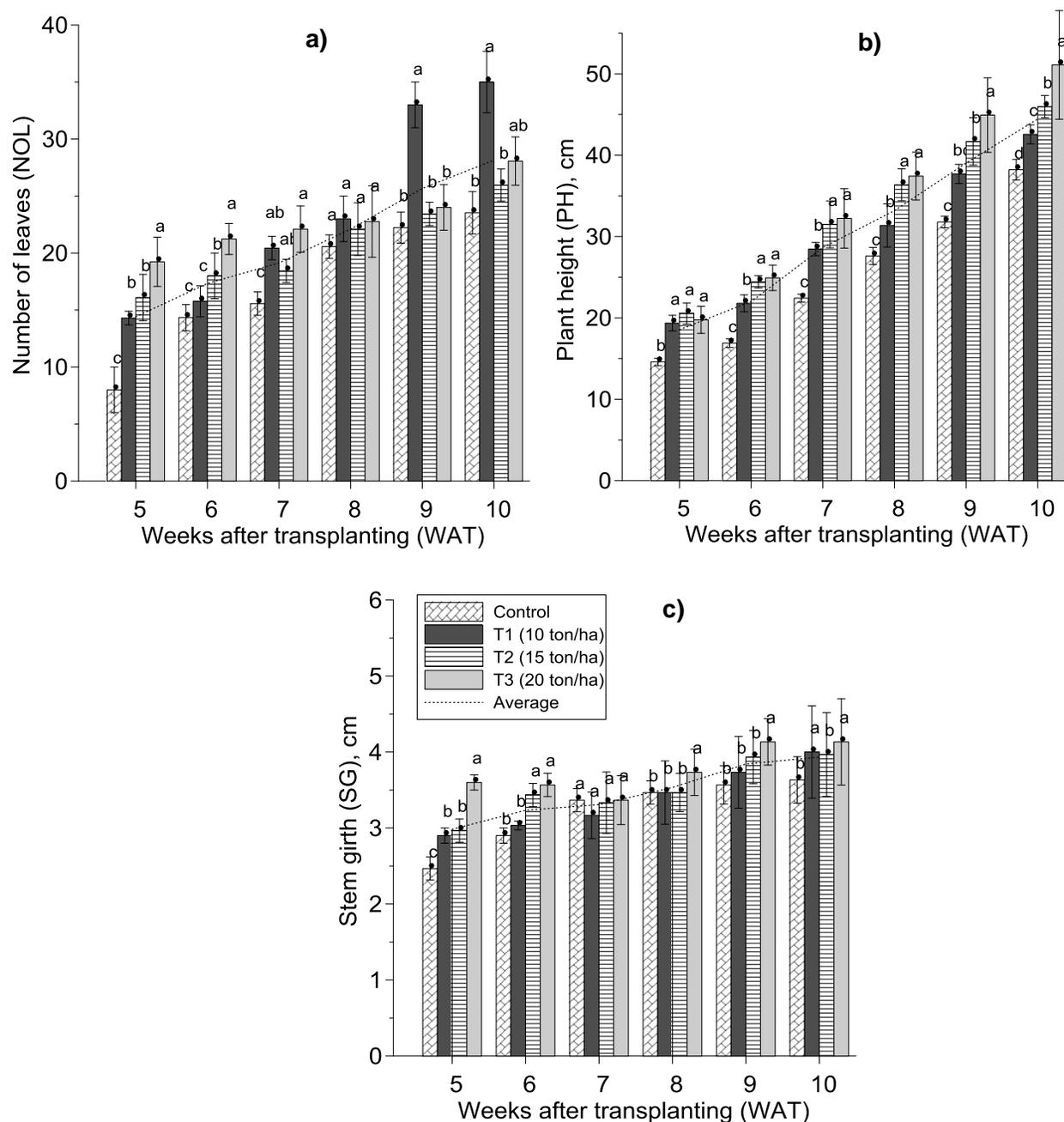
Table.5 Correlation between plant growth parameters and soil properties

	NOL	SG	PH
pH	0.607*	0.367	0.624*
EC	-0.196	0.137	0.185
P	0.050	0.227	0.487
TC	0.231	0.657*	-0.017
TN	0.233	0.671*	-0.023
WSA	-0.303	-0.015	0.562
MWD	-0.187	-0.006	0.686*
BD	-0.238	-0.371	-0.243
Pt	0.647*	0.425	-0.015

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Fig.1 Effect of different rates of cow dung manure on a) number of leaves (NOL); b) plant height (PH) and c) stem girth (SG) during the crop cycle of the eggplant.



Means with different alphabets differed significantly at 5% level of probability by Tukey test. Vertical bars represent the standard error.

The effect of cow dung application on eggplant stem girth (SG) is presented in Figure 1c. Except at 7 WAT, the SG was also significantly ($p < 0.05$) influenced due to

the application cow dung manure, with T3 (20 ton/ha) having the highest SG. Over time (8-10 WAT), the average values of SG increased with increase in the rate of

application of cow dung manure. A comparison between the control and amended soils showed that the growth parameters of NOL, PH and SG were significantly lowest from the control soil (Figures 1a-c).

The correlation between plant growth parameters and soil properties evaluated is shown in Table 5. The NOL and PH showed significant positive correlation with pH while the SG showed significant positive correlation with both OC and TN. The PH also showed moderate correlation with P, though not significant. Both WSA and MWD correlated positively with PH, with that of WSA not significant. All the plant growth parameters showed negative correlation with BD. On the other hand, the correlation between Pt and the growth parameters was positive except that of NOL was significant. Only the EC did not show appreciable correlation with the growth parameters.

The addition of different doses of cow dung manure had significant effect on vegetative growth of eggplant expressed by higher number of leaves, plant height and stem girth compared to the control. The turnover resulting from the decomposition of organic manure improves the nutrient cycling and availability to the plants especially, TN and P which improved root development and subsequently vegetative growth (Suge *et al.*, 2011). The better performance from treatment T3 (20 ton/ha) is attributed to improved soil structural formation (decreased BD and higher Pt) by the decomposing manure, the roots were able to explore more soil volume, ensuring strong stems and taller plants. In addition, the increased soil pH by organic manure allowed the release of most nutrients. Ewulo *et al.* (2007) also reported improved plant growth and yield of pepper under different

doses of cow dung. Suge *et al.* (2013) found higher growth parameters and yield of eggplant under organic manure compared to inorganic fertilizer.

In conclusion, the use of cow dung for soil amendment increased the organic matter content and improved the physical properties of the degraded soil. Essential nutrients, TN and P, were significantly increased and made available due to increased pH. The application of cow dung had positive impact on the growth of eggplant (*Solanum melongena*), with the application rate of 20 tons/ha giving the best results. The results showed that cow dung has great potentials for amelioration of degraded soils however further studies are required to establish optimum rate for sustainable crop production. The increase in P loading with increasing application rates also call for further investigation in terms of negative impact on the environment.

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