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Tillage and Residual effect of some Organic Amendments on Aggregate associated Soil Carbon of an Ultisol, Growth and Yield of Maize and Cowpea Intercrop

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ABSTRACT

We investigated the tillage and residual effects of some organic amendments on aggregate-associated soil carbon (C_{WSA}) and yield of maize and cowpea intercrop in an Ultisol, Southeastern Nigeria. A land area of 0.1125 ha was planted to sole cowpea, sole maize and maize-cowpea intercrop using minimum tillage (NT) and conventional tillage (CT) with poultry droppings (PD), pig waste (PW), and Cassava peels (CP) as amendments at the rates of 20, 90, 100 t/ha respectively and a control. The experimental design was a split-split plot in a Randomized Complete Block Design (RCBD) with three replications. The same crops, treatments, and replications were maintained for two experimental years (2011 and 2012), after that the residual effect of the amendments on aggregate-associated soil carbon (C_{WSA}) and yield of the test crops was investigated in 2013. Consecutive application of organic amendments for the two years necessitated great improvement on aggregate-associated soil carbon (C_{WSA}) for aggregate sizes > 0.25mm. However, when the amendments were withdrawn, there was a reduction in C_{WSA} values though still significant except for aggregate sizes 1-0.5mm. Pig waste was observed to perform better than all the other amendments followed by Poultry Droppings in aggregating the soil. Tillage had a significant effect on C_{WSA} for aggregate sizes >0.05mm, CT performed better than NT. Organic amendments significantly influenced cowpea and Maize both as sole and intercrop, however, it was observed that the intercrop had a tremendous improvement at the residual compared to the previous years.

1. Introduction

Continuous cultivation or tillage reduces soil organic carbon content and changes the distribution and stability of soil aggregates. In order to preserve the ecosystem, no or minimum tillage is seriously being advocated since increasing cultivation intensity leads to loss of carbon-rich macroaggregates and an increase of Carbon-depleted micro-aggregates in soils (Six *et al.,* 1998). Benbi and Senapati (2010), asserted that the addition of organic amendments (rice straw and FYM) significantly improved the formation of macroaggregates which is linearly related to soil organic carbon content. Maintaining soil aggregate stability is necessary for maintaining soil productivity, decreasing soil degradation and minimizing environmental pollution (Talgre *et al.,* 2012).

Soil fertility depletion in the tropics is a severe issue resulting from leaching and erosion of top soils due to intense rainfall. The decrease in soil productivity is believed to be due to the depletion in soil organic matter (SOM) which is the reservoir of plant nutrients (Eneje and Uzoukwu, 2012); hence, maintenance of SOM is a recognized strategy aimed at reducing soil degradation. The amount of organic matter (OM) in the soil, as well as the rate of OM turnover, are influenced by agricultural management practices, and because OM is composed of a series of fractions, management practices also influence the distribution of organic carbon among SOM pools. No-till and organic amendments are management practices that can increase SOM content and improve soil aggregation. The use of organic amendments, like compost and animal droppings, meet the crop nutrient requirements as well as maintain long-term soil fertility and productivity levels (Nanthi *et al.,* 2011).

As a result of increased cost of chemical fertilizers, depletion of soil micronutrients, environmental and health hazards resulting from the incessant use of chemical fertilizers, use of organic amendments in maintaining soil fertility is gradually gaining attention (Ramesh *et al.,* 2005). Jidere and Akamigbo (2009), recommended that for environmental friendliness, organic amendment (PD) should be preferred to inorganic amendments (NPK). Use of amendments in the tropics has the potential to increase production because the soils are highly weathered; hence it is a core strategy in restoring soil fertility as well as raising crop productivity.

In Nigeria, farmers have realized the need for soil amendments and started using available sources such as crop residues, Farm Yard Manure (FYM) and poultry wastes (Adediran *et al.,* 2003). Complimentary use of organic amendment is a sound fertility management strategy (Rosemary, 2007) which reduces the farmers' over-dependence on the use of inorganic fertilizers

(Schelgel, 2000) that is usually scarce, more expensive, increases soil acidity and cause soil nutrients imbalance.

The quantity and quality of carbon inputs, cropping intensity and soil and crop management practices affect carbon and nitrogen dynamics. Cropping systems like crop rotation, mono and intercropping could conserve organic matter thereby leading to improved Soil organic carbon, improved aggregation and increased crop growth and development. Cropping patterns having cereals and legumes intercrop are common in Nigeria. They could be grown as sole or intercrop. This study was aimed at evaluating the effect of tillage and the residual effect of some organic amendments on aggregate-associated soil carbon in an Ultisol as well as the yield of maize-cowpea intercrop.

2. Materials and Methods

2.1. Experimental Site:

This study was conducted in the Department of Soil Science research field, behind the Meteorological Station of the University of Nigeria, Nsukka in 2013 cropping season after planting with the application of organic amendments for two consecutive years (2011 and 2012). Nsukka is located on Lat. 6^{o} 30′ and 6^{o} 41′ N and Long. 7^{o} 10′ and 7^{o} 14′E with an elevation of about 400 meters above sea level. The soils belong to the well-drained degraded ultisols with sandy loam surface texture and belong to Nkpologu series. The experimental area is characterized by humid tropical wet and dry season with bimodal annual rainfall of 1300 – 2000 mm, with a uniformly high mean annual temperature of 21^{o}C - 30^{o}C and a relative humidity of 71 - 75 %. The vegetation is mainly derived savanna (Igwe and Okebalama, 2006; Igwe and Nwokocha, 2006).

2.2. Field Layout

A plot of an area 0.1125 ha was divided into 3 main plots with each main plot representing the cropping systems: sole maize (*Zea mays*), sole cowpea (V*igna unguiculata*) and intercropped maize-cowpea. Each main plot was divided into two split plots, with each split-plot representing tillage [conventional tillage (CT) and No-tillage (NT)] treatments. Each split plot was divided into 4 split-split plots, representing the amendments with cassava peels; poultry droppings (battery cage source) and pig waste having the fourth as the control. Each of the treatments was replicated three times, giving a total of twenty-four split-split plots replicated thrice to make seventy-two plots. Before the year under study (2013), composted organic amendments were applied 3weeks superficially after planting following the conventional local farmers approach. The amendments were applied at the rate of 20 t ha^{-1} for poultry droppings; 90 t ha^{-1} for pig waste (Adesodun and Mbagwu, 2007 modified) and 100 t ha^{-1} for cassava peels (Agbim, 1985 modified). The same plots, treatments, test crops and replications were maintained for the two planting years, 2011 and 2012. The additive residual effects of the amendments applied in 2011 and 2012 were studied in 2013. The experimental design was a split-split plot in Randomized Complete Block Design (split-split plot in RCBD). The split -split plot size was 3 m x 2.5 m with 1 m between split-split plots and 1.5 m between split plots and 2 m between main plots. This spacing was to avoid overlap of the amendments as much as possible.

2.3. Collection of samples:

Pig waste and poultry droppings were collected from the Faculty of Agriculture Farm, University of Nigeria Nsukka, while cassava peels were collected from local garri processing industry at Opanda in Uzo Uwani Local Government Area, Enugu State. Maize (Oba super II) was collected from the Department of Crop Science, University of Nigeria, Nsukka, while local cowpea (*akidi*) was sourced from a contact farmer within Nsukka.

2.4. Land preparation and Crop establishment:

A land area of 0.1125 ha was cleared, demarcated into plots and tilled according to the treatments' specifications. Sowing at the inter-row and intra row spacing of 0.75 m x 0.25 m to get a plant population of about 20,000 plant/ha for maize and 1m x 0.50cm spacing for cowpea to get a plant population of 53,333 plants/ha was done. Each of the crops was planted two per stand but was thinned down to one plant per stand after emergence Weeding was done manually as the need arose.

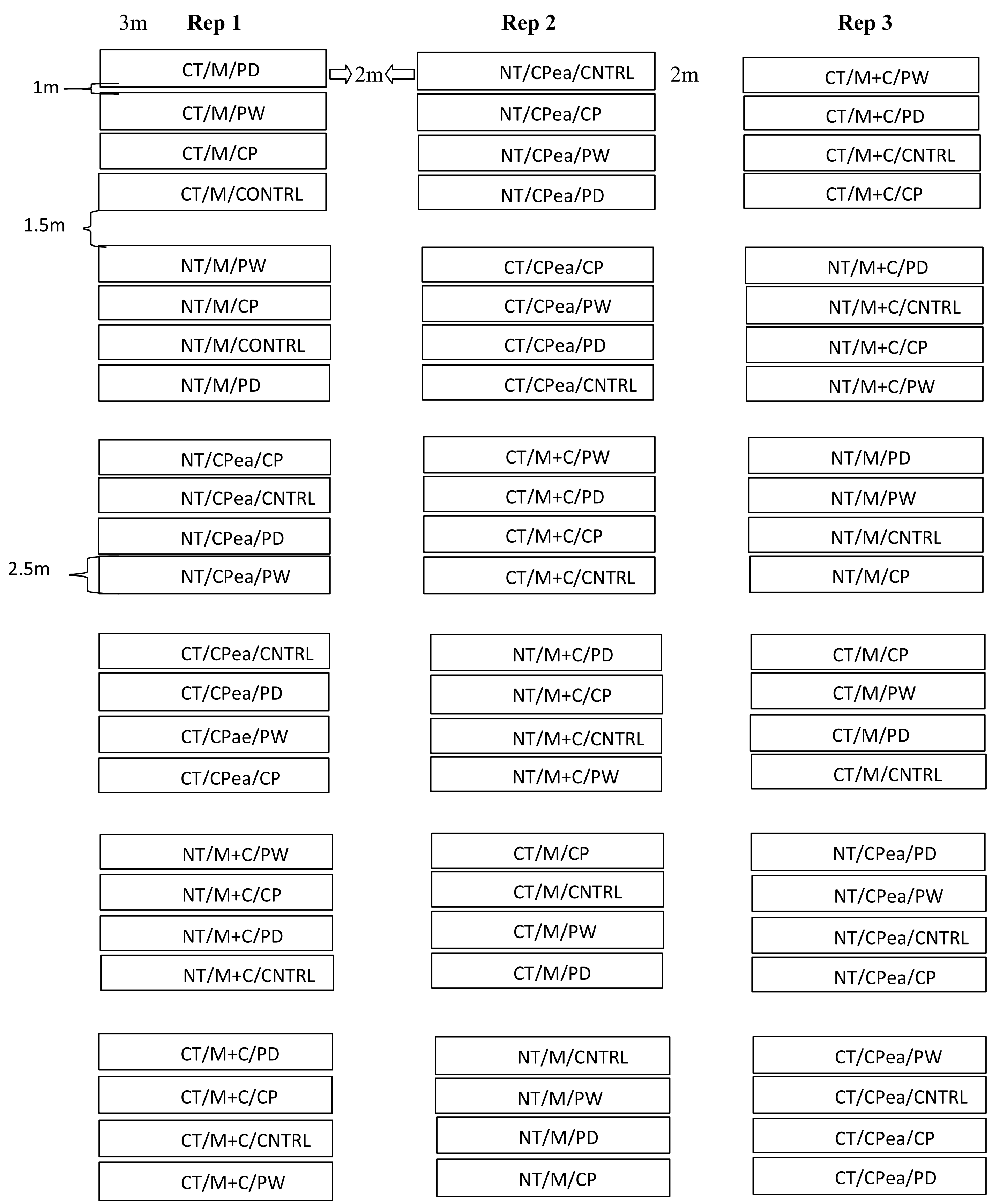
2.5. Determination of Aggregate associated soil organic carbon, crop growth, and yield parameters:

The soil samples collected were separated into aggregate-size classes (>2mm; 2-1mm; 1-0.5mm; 0.5-0.25mm and <0.25mm) by wet sieving and their organic carbon content analyzed in the laboratory using wet oxidation method (standard analytical procedure).

Six plants per plot were selected and tagged to determine the number of branches, Day to first flowering and podding, day to 50 % flowering and podding for cowpea and number of leaves, day to first tasseling and silking, day to 50 % tasseling and silking in maize were observed while vine length for cowpea and plant height, leaf length and width were measured using meter rule. At harvest, fresh and dry weights of maize, as well as the weight of freshly Harvested cowpea pods, were taken immediately using weighing balance.

2.6 Statistical Analysis:

Data collected were subjected to Analysis of Variance (ANOVA) following the routine procedure for a split-split plot in Randomized Complete Block Design using Genstat release 7.22 DE (GENSTAT, 2008). Mean separation was done using Fisher's Least Significant Difference (F-LSD) at 5% level of probability.



CT = conventional tillage; NT = no-till; M + C = maize-cowpea intercrop; C = sole cowpea; M = sole Maize; PD = poultry droppings; PW = pig waste; CP = cassava peels

3. Results and Discussion

Tables 1a, 1b, and 1c showed the effect of cropping system, tillage and organic amendments on aggregate-associated soil carbon (C_{WSA}) for 2011, 2012 and 2013. These results indicated that in 2011, tillage had no significant effect on all the aggregate size fractions, while organic amendments had a significant effect ($P < 0.05$) on 1.0–0.5mm aggregate fractions only. Aggregate-associated soil carbon for all the amendments (PW, PD, and CP) at the aggregate-size classes were statistically similar and same as the aggregate-associated soil carbon in the control plots (Table 1a).

In 2012, tillage had no significant effect on all the aggregate sized fractions. It was, however, observed that the organic amendments significantly ($P < 0.05$) differ from each other in their influence on the soil carbon content in the aggregate fractions > 0.25 mm. The results indicated that pig waste was the most effective of all the amendments in improving aggregate-associated soil carbon (Table 1b).

In 2013, tillage significantly ($P < 0.05$) affected all aggregate associated soil carbon > 0.5 mm sized fractions with CT having higher values than NT (Table 1c). This agreed with Wang *et al.* (2013), who observed that organic fertilizer treatments improved soil aggregate stability and soil microbiological properties. The significant effect of tillage on all the aggregate size fractions > 05 mm could be attributed to no-till which conserves organic binding agents, hence, physical protection of liable carbon within macroaggregates.

Similarly, organic amendments significantly ($P < 0.05$) increased soil carbon in aggregate fractions > 0.25 mm except in aggregate fractions 1 – 0.5 mm. It followed the order: In aggregate size > 2 mm, PW >PD = control = CP; for 2 – 1mm, it was PW > PD = control = CP; and for 0.5 - 0.25, it was PW = Control > CP = PD (Table 1c), indicating micro-aggregate formation within macroaggregates. The significant effect of organic amendments on all the aggregate sized fractions > 0.25mm implies that there was the formation of micro-aggregates in macroaggregates due to the application of organic amendments. The accumulation of carbon in the mineral associated fractions of macroaggregates suggests that inputs of organic debris were rendered into particles or colloids that are associated with mineral matter and so, are physically protected, slowing down decomposition and promoting the development of stable micro-aggregates within macroaggregates. It was observed that PW was most effective in increasing aggregate-associated soil carbon. The finding that CT and organic amendments improved soil aggregate-associated carbon collaborates with Mikha and Rice (2003), findings that tillage and manure further improved soil aggregation and aggregate-associated carbon. Reduction in C_{WSA} values when amendments were withdrawn was an indication that the optimum soil fertility level has not been attained before the amendments were withdrawn; however, there has been an accumulation of enough soil organic matter in the soil that could sustain crop production.

Table 1a: Effect of Tillage and organic amendments on aggregate-associated soil carbon (C_{WSA}) in 2011.

Treatment		> 2mm	2 - 1mm	1.0 - 0.5mm	0.5 0.25mm	< 0.25mm
Crop	Cowpea	1.56	1.56	1.47	1.09	1.19
	Maize	2.00	1.84	1.82	1.01	1.27
	M+C	1.72	1.63	1.53	0.94	1.05
$LSD_{0.05}$		NS	0.14	NS	NS	NS
Tillage	CT	1.79	1.69	1.60	1.01	1.13
	NT	1.73	1.67	1.61	1.02	1.21
$LSD_{0.05}$		NS	NS	NS	NS	NS
Org A	Control	1.60	1.66	1.77	1.03	1.09
	CP	1.80	1.63	1.58	0.97	1.12
	PD	1.86	1.74	1.49	1.02	1.22
	PW	1.78	1.69	1.57	1.05	1.24
$LSD_{0.05}$		NS	NS	0.18	NS	NS

CT = Conventional Tillage; NT = no-till; PD = Poultry Droppings; CP = Cassava Peels; PW = Pig Waste

Table 1b: Effect of Tillage systems and organic amendments on aggregate-associated soil carbon (C_{WSA}) (2012)

Treatment		>2mm	2 - 1mm	1 - 0.5mm	0.5-0.25mm	< 0.25mm
Crop	Cowpea	2.54	2.09	2.10	1.07	1.39
	Maize	2.49	2.18	2.17	1.31	1.86
	M+C	2.08	2.02	1.99	1.02	1.30
$LSD_{0.05}$		NS	NS	NS	NS	NS
Tillage	CT	2.45	2.15	2.11	1.18	1.54
	NT	2.29	2.05	2.06	1.09	1.49
$LSD_{0.05}$		NS	NS	NS	NS	NS
Org. A	Control	1.75	1.82	1.95	1.07	1.46
	CP	2.21	1.82	2.01	1.01	1.50
	PD	2.16	2.09	2.03	1.02	1.38
	PW	3.34	2.66	2.35	1.44	1.72
$LSD_{0.05}$		0.52	0.28	0.25	0.15	NS

CT = Conventional Tillage; NT = no-till; PD = Poultry Droppings; CP = Cassava Peels; PW = Pig Waste

Table 1c: Residual effect of tillage systems and organic amendments on aggregate-associated soil carbon (2013)

Treatment		> 2mm	2 - 1mm	1 - 0.5mm	0.5 - 0.25mm	< 0.25mm
Crop	Cowpea	2.02	1.93	1.68	0.81	1.01
	Maize	1.73	1.86	1.81	0.81	0.96
	M+C	1.81	1.94	1.82	0.829	0.96
$LSD_{0.05}$		NS	NS	NS	NS	NS
Tillage	CT	2.25	2.15	1.97	0.92	1.13
	NT	1.45	1.66	1.58	0.72	0.82
$LSD_{0.05}$		0.72	0.43	0.19	NS	NS
Org A	Control	1.68	1.71	1.67	0.88	0.89
	CP	1.65	1.69	1.82	0.70	0.89
	PD	1.70	1.87	1.79	0.78	1.02
	PW	2.39	2.36	1.80	0.90	1.11
$LSD_{0.05}$		0.46	0.34	NS	0.15	NS

CT = Conventional Tillage; NT = no-till; PD = Poultry Droppings; CP = Cassava Peels; PW = Pig Waste

Comparatively, there was a significant improvement in the aggregate associated soil carbon (C_{WSA}) for all the aggregate sized fractions in 2012 as compared to 2011. This could probably be because the amendments applied in the first year (2011) have decomposed thereby increasing the C_{WSA} at all the aggregate sized fractions. However, when the amendments were withdrawn, a reduction in C_{WSA} values was observed indicating a reduction in the formation of micro-aggregates in macro-aggregates, which could be as a result of a reduction in soil organic matter content (SOM).

Tables 2a, 2b, and 2c showed the effect of tillage and organic amendments on the growth and yield of cowpea for three years (2011, 2012, and 2013). In 2011, tillage had no significant effect ($P = 0.05$) on cowpea yield. However, organic amendments had a significant effect on growth parameters like vine length and onset of flowering as well as on the yield. PW performed better than the other amendments (Table 2a).

In 2012, tillage significantly improved cowpea yield with conventional tillage giving significantly ($P < 0.05$) higher yield (8.04 t/ha). The results revealed that onset of flowering and vine length, as well as yield, were significantly improved by organic amendments ($P < 0.05$). PW was observed to be the best for the onset of flowering because it took the plants under its treatment less number of days (50) to flower and the highest yield was recorded under this treatment. Meanwhile, PD improved vine length better than the other treatments (Table 2b).

In 2013, tillage significantly improved cowpea yield, as the yield value (5.4 t/ha) was higher in conventional tillage (CT) than in no-till (NT). Vine length was the only growth parameter that was significantly ($P = 0.05$) improved by tillage with CT having a longer vine length (205.1cm) than NT (149.8cm). Organic amendments significantly ($P = 0.05$) improved the yield of cowpea in the order PD = PW > CP > control. All growth parameters measured were significantly improved by organic amendments ($P < 0.05$). Number of branches followed the trend: PW = CP = PD > control (Table c).

Table 2a: Effect of Tillage and Organic amendments on Growth and Yield of cowpea (2011)

Treatment		50% Flo	50% Pod	% Emerg	Ist Pod	Branch No	onset Flo (days)	Vine Len (cm)	Yield (t/ha)
Tillage	CT	59.50	64.50	88.20	57.08	5.17	51.42	211.00	5.81
	NT	59.33	66.25	82.10	57.75	5.25	51.67	152.20	4.17
$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS
Org A	Control	59.00	65.33	86.10	57.50	4.83	52.50	129.90	1.89
	CP	60.00	66.00	85.80	57.67	4.67	52.17	160.30	3.55
	PD	59.67	64.67	86.50	57.17	5.33	51.50	223.30	5.00
	PW	59.00	65.50	82.30	57.33	6.00	50.00	213.10	9.53
$LSD_{0.05}$		NS	NS	NS	NS	NS	1.24	53.15	2.04

50% Flo = Days to 50% flowering; 50% pod = Days to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Days to first flowering; Vine Len = Vine length; Yld = Yield

Table 2b: Effect of Tillage and Organic Amendments on Growth and Yield of Cowpea (2012)

Treatment		50% Flo	50% Pod	% Emerg	Ist Pod	Branch No	onset Flo (days)	Vine Len (cm)	Yld(t/ha)
Tillage	CT	56.08	58.67	95.40	49.17	4.25	46.08	257	8.04
	NT	57.58	60.17	91.20	51.67	4.17	48.17	210	5.86
$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	1.66
Org A	Control	60.33	61.50	98.10	52.83	3.00	50.17	131	1.68
	CP	55.67	59.67	92.60	51.17	4.17	47.83	232	6.49
	PD	55.50	59.83	88.90	50.67	4.50	46.50	270	8.27
	PW	55.83	56.67	93.50	47.00	5.17	44.00	302	11.37
$LSD_{0.05}$		2	2.59	NS	2.84	0.61	3.22	76.1	2.86

50% Flo = Days to 50% flowering; 50% pod = Days to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

Generally, cowpea growth parameters were better with PW application, followed by PD application, though both were statistically the same. It could, therefore, be inferred that the residual effect of poultry droppings and pig waste on the growth and yield of cowpea were statistically the same but were different from cassava peel.

Table 2c: Residual Effect of Tillage and Organic Amendments on Growth and Yield of Cowpea (2013)

Treatment		50% Flo	50% Pod	% Emer	Ist Pod	Branch No	onset Flo	Vine Len (cm)	Yield (t/ha)
Tillage	CT	55.17	58.42	87	51.17	4.58	46.08	205.1	5.40
	NT	58.25	62.17	88.9	54.33	4.08	49.5	149.8	2.52
$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	37.98	0.22
Org A	Control	59.67	63.5	79.6	55.83	3.83	51.33	120.7	2.17
	CP	56.83	60.5	88	53.33	4.50	48.17	163.6	3.42
	PD	55.5	59.33	92.6	51.33	4.33	46.83	207.8	5.33
	PW	54.83	57.83	91.7	50.5	4.67	44.83	217.6	4.92
$LSD_{0.05}$		2.58	3.26	NS	2.4	0.55	2.94	34.98	1.48

50% Flo = Day to 50% flowering; 50% pod = Day to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

Maize:

Tables 3a, 3b, and 3c showed the effect of tillage and organic amendments on the growth and yield of maize for the three years. In 2011, tillage significantly (P < 0.05) affected 50% tasseling with the no-till method recording the highest significant 50% tasseling value. It was revealed that organic amendments significantly (P < 0.05) improved leaf area, number of leaves, plant height, day to first tasseling, 50% tasseling, as well as fresh and dry weight. PW was observed to perform better than the other amendments in the improvement of the mentioned parameters.

In 2012, tillage significantly (P < 0.05) affected only 50% tasseling. CT performed better than NT since it took it less number of days to show 50% tasseling. Organic amendments significantly (P < 0.05) improved most parameters measured in maize like leaf area, number of leaves and Plant height, tasseling and silking, Dry and fresh weight as well as yield improved more with PW but tasseling was better with PD.

In 2013, the results showed that tillage practice significantly (P < 0.05) improved leaf area and dry weight as Conventional tillage (CT) increased both parameters (542cm^2 and 530g) more than no-till (297cm^2 and 255g). It was observed that organic amendments significantly (P < 0.05) improved the plant growth parameters measured in the year 2013. It was recorded that the number of leaf and leaf area followed the trend: PW = PD = CP > control, while fresh weight was in the order: PW = PD > CP = control, Dry weight was in the order; PW > PD > CP = control. Plant height followed the trend: PW = PD > CP > control.

Generally, it was observed that PW statistically improved the maize growth parameters than PD and CP within the period of the 2013 year, whereas PD and CP statistically performed same within the period (Table 3c). Increase in crop yield as a result of the application of organic amendments (especially PW and PD) agrees with Lal *et al.* (2003), findings that application of nutritive amendments like commercial fertilizers and organic manure favoured soil carbon, increased yield and the amount of residue returned to the soil. It could be inferred that the residual effect of PW was more than the other amendments, however, for most parameters measured, PW and PD were statistically the same.

Maize – Cowpea intercrop

Tables 4a, 4b, and 4c showed the effect of tillage and organic amendments on the growth and yield of maize and cowpea in a maize-cowpea intercrop for three years. In 2011, only vine length (in cowpea) was significantly increased (P < 0.05) by tillage. CT performed better than NT. It was also observed that organic amendments significantly (P < 0.05) improved number of branches, and yield (in cowpea). PW performed better than the other amendments in improving the number of branches, PD did better in improving the yield. The result on yield indicated that PD and PW were statistically similar, and improved cowpea yield than CP.

Table 3a: Effect of Tillage and Organic amendments on the Growth and Yield of maize (2011)

Treatment		50% Silk	50% Tass	1st Tass	1st Silk	Dry Wt	Fresh Wt	Lf Area	No of Leaf	Plt Ht	Yield (t/ha)
Tillage	CT	74.33	63.08	55.58	66.58	639	770	359	10.08	73.50	0.46
	NT	75.50	67.17	60.42	67.17	554	652	343	10.08	61.30	0.48
$LSD_{0.05}$		NS	3.64	NS	NS	NS	NS	NS	NS	NS	NS
Organic											
A	Control	73.67	68	60.33	65.67	106	178	141	8.33	37.70	0.51
	CP	78.33	65.83	56.5	70.5	177	257	171	9.00	35.90	0.18
	PD	75.17	64.17	58.67	67.67	519	701	444	10.33	77.40	0.42
	PW	72.50	62.50	56.5	63.67	1583	1708	647	12.67	118.5	0.62
$LSD_{0.05}$		NS	3.549	2.99	NS	291.7	313.6	121.7	2.85	23.21	NS

50% Flo = Day to 50% flowering; 50% pod = Day to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

Table 3b: Effect of tillage and organic amendments on the growth and yield of maize (2012)

Treatment		50% Silk	50% Tass	1st Tass	1st Silk	Dry Wt (g)	Fresh Wt (g)	Leaf Area	No of Lf	Plt Ht (cm)	Yield (t/ha)
Tillage	CT	68.58	62.08	56	60.67	705	2238	415	10.00	101.80	0.46
	NT	74.17	68.67	111	66.92	577	1800	343	8.33	75.10	0.39
$LSD_{0.05}$		NS	4.98	NS	NS	NS	NS	NS	NS	NS	NS
Org A	Cntrol	73.50	68.00	161	67.67	32	262	82	6.17	26.00	0.02
	CP	74.67	68.17	63	67.67	136	600	158	8.50	51.20	0.09
	PD	70.50	63.83	56	60.67	452	1563	463	10.17	102.80	0.21
	PW	66.83	61.50	54	59.17	1945	5650	812	11.83	173.90	1.38
$LSD_{0.05}$		3.06	2.68	NS	3.71	205.4	748.8	88.8	1.88	18.94	0.14

50% Flo = Day to 50% flowering; 50% pod = Day to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

Table 3c: Residual effect of Tillage and Organic amendments on the Growth and Yield of Maize (2013)

Treatment		50% Silk	50% Tass	1st Tass	1st Silk	Dry Wt	Fresh Wt	Lf Area	No of Lf	Plt Ht	Yield (t/ha)
Tillage	CT	63.92	56.67	51.08	58.25	530	1146	542	11.58	108.30	0.26
	NT	68.42	61.58	55.33	63.42	255	502	297	9.33	66.40	0.14
$LSD_{0.05}$		NS	NS	NS	NS	188.3	NS	205.2	NS	NS	NS
Organic A	Control	69.50	62.50	56.50	64.50	172	387	230	8.00	46.80	0.07
	CP	66.83	59.67	54.67	61.00	275	625	381	10.67	71.70	0.11
	PD	65.83	58.83	53.17	61.00	452	1050	508	11.33	104.70	0.22
	PW	62.50	55.50	48.50	56.83	672	1233	558	11.83	126.30	0.39
											0.14
$LSD_{0.05}$		1.93	1.49	2.81	1.82		331.2	127.2	1.61	21.60	

50% Flo = Day to 50% flowering; 50% pod = Day to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

Application of pig waste was most effective ($P < 0.05$) in improving both maize and cowpea growth parameters in the intercrop, followed by poultry droppings. Similarly, organic amendments significantly ($P < 0.05$) improved plant height, number of leaves, leaf area, fresh and dry weight in maize. PW performed better in the improvement of all these parameters as compared with the other amendments used (Table 4a). In 2012, tillage significantly ($P < 0.05$) increased number of leaves (in maize) as well as Day to the first podding and 50 percent podding (in cowpea). CT performed better in the parameters measured. Organic amendments significantly ($P < 0.05$) improved most of the parameters measured in both maize and cowpea. Maize and cowpea growth parameters performed best with the application of pig waste, followed by poultry droppings. The yield of cowpea revealed that PD and PW were statistically similar but increased the yield of cowpea more than CP (Table 4b).

In 2013, tillage improved plant height and leaf area (in maize) as well as vine length and the number of branches (in cowpea). The result indicated that CT performed better than NT in all the parameters measured. Organic amendments significantly ($P < 0.05$) improved most of the parameters. Maize and cowpea growth parameters were greatly improved by PW, followed by PD. Influence of Organic amendments on maize indicated that leaf area, number of leaves, plant height and fresh weight of maize cob followed the order: PD = PW > CP > control. Dry weight of maize cob, was in the order: PW = PD = CP > control. For cowpea, vine length followed the order: PD = PW > CP = control, and cowpea yield indicated that the effect of PW and PD were statistically similar and increased yield more than CP. (Table 4c). It could be inferred that the residual effect of PW and PD were statistically similar.

Table 4a: Effect of Tillage and Organic amendments on Growth and Yield of maize and cowpea intercrop (2011)

Treatment		50% pod	1st Pod	Vine Len (cm)	Branch No	Cowpea Yld (t/ha)	No of Lf	Plt Ht	Dry Wt	Fresh Wt	Lf Area	Maize Yld (t/ha)
Tillage	CT	65.42	56.75	228.60	4.67	3.47	9.58	59.80	393	487	268	0.36
	NT	65.75	57.67	168.60	4.83	3.87	8.25	49.10	427	504	244	0.31
$LSD_{0.05}$		NS	NS	56.17	NS	NS	NS	NS	NS	NS	NS	NS
Organic A	Control	66.00	57.17	154.50	4.17	1.52	6.83	26.00	32	59	86	0.18
	CP	64.83	57.50	205.00	4.83	2.67	8.00	28.90	132	193	152	0.05
	PD	65.00	56.83	209.10	4.67	5.38	8.50	55.90	412	512	275	0.32
	PW	66.50	57.33	225.70	5.33	5.10	12.33	106.90	1064	1220	510	0.79
$LSD_{0.05}$		NS	NS	NS	0.73	1.42	1.77	24.62	267.1	284.6	151.5	0.39

50% Flo = Day to 50% flowering; 50% pod = Day to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

Table 4b: Effect of Tillage and Organic amendments on Growth and Yield of maize and cowpea intercrop (2012)

Treatment		50% pod	1st Pod	Vine Len (cm)	Branch No	Cowpea Yld(t/ha)	No of Leaf	Plt Ht	Dry Wt (g)	Fresh Wt(g)	Lf Area	Maize Yld (t/ha)
Tillage	CT	58.42	49.25	218	5.97	4.58	9.42	92.20	530	1768	379	0.38
	NT	62.00	53.42	181	4.66	3.92	8.33	68.30	505	2070	329	0.35
$LSD_{0.05}$		1.56	1.9	NS	NS	NS	0.95	NS	NS	NS	NS	NS
Organic A	Control	62.50	54.00	141	1.31	3.17	6.33	27.80	129	972	90	0.01
	CP	60.33	51.33	185	4.44	4.17	8.33	40.50	85	537	132	0.02
	PD	58.67	49.83	248	7.97	4.50	9.67	86.20	356	1617	390	0.23
	PW	59.33	50.17	223	7.53	5.17	11.17	166.50	1500	4550	804	1.19
$LSD_{0.05}$		NS	NS	66.20	1.92	0.81	1.49	19.67	252.6	1609.9	113.5	0.11

50% Flo = Day to 50% flowering; 50% pod = Day to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

Table 4c: Residual effect of Tillage and Organic amendments on Growth and Yield of maize and cowpea intercropped (2013)

Treatment		50% pod	1st Pod	Vine Len (cm)	Branch No	Cow-pea Yld (t/ha)	No of Leaf	Plt Ht (cm)	Dry Wt(g)	Fresh Wt (g)	Lf Area (cm^2)	Maize Yield (t/ha)
Tillage	CT	58.92	173.40	4.50	1.51	11.5	102.7	51.00	524	1108	521	0.23
	NT	60.08	149.30	3.83	1.81	9.42	51.10	52.25	157	361	258	0.06
$LSD_{0.05}$		NS	20.58	0.359	NS	NS	39.63	NS	NS	NS	263.7	NS
Org A	Control	60.67	122.40	4.17	1.11	7.83	34	53.00	111	272	156	0.02
	CP	61.00	148.20	4.00	1.23	9.83	68.60	52.67	340	716	354	0.13
	PD	58.00	194.00	4.50	2.19	12.00	99.90	50.50	359	842	527	0.20
	PW	58.33	180.90	4.00	2.09	12.17	105	50.33	550	1108	520	0.24
$LSD_{0.05}$		2.03	25.93	NS	0.52	1.83	19.07	NS	245.4	555.5	103	0.13

50% Flo = Day to 50% flowering; 50% pod = Day to 50% podding; %Emer = % emergence; 1st pod = Day to first podding; Branch No = Number of branches; onset flo = Day to first flowering; Vine Len = Vine length; Yld = Yield

4. Conclusion

The result of the study showed that the cropping system did not have any residual effect on the parameters measured. Conventional tillage significantly ($P < 0.05$) affected aggregate associated soil carbon at all the sized fractions > 0.5mm and some plant growth parameters and yield at both sole and intercrop systems. Pig waste (PW) and poultry droppings (PD) were found efficient in increasing carbon in the soil as they were found to have a positive trend in carbon enrichment in the soil, which could be monitored and maintained through regular replenishment of organic materials in the soil. Organic amendments significantly affected all aggregate associated soil carbon at sized fractions > 0.25 mm indicating improvement in the ability of the soil to sequester carbon at all the aggregate size fractions, hence, better structural stability. Pig waste was the most effective of all the amendments in improving aggregate-associated soil carbon, though the residual effect of both PW and PD were statistically similar. There was a visible manifestation of the residual effect of pig waste (PW) and poultry droppings (PD) in the parameters measured under maize-cowpea intercrop. The residual effect of PW and PD on the aggregate-associated carbon and the yield of maize-cowpea intercrop were statistically similar.

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