ASSET Series A (2003) 3 (4):45-53

EFFECT OF SOLE AND AMEDED PLANT RESIDUES ON SOIL NUTRIENT CONTENT AND YIELD OF OKRA

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ABSTRACT

The aim of the study is to investigate the soil fertility improvement potential of plant residues (agrowastes.). The relative effect of wood ash, ground cocoa husk, rice bran, spent grain, sawdust and NPK fertilizer on soil nutrient and organic matter contents and yield of okra *(Abelmoschus esculentus)* (L) Moench) was studied in four consecutive field experiments conducted at Akure, southwest Nigeria. The 22 treatments consisted of the control, NPK (15-15-15) fertilizer, and the five residues applied sole or amended with each of goat, pig and poultry manure. Application of sole and amended plant residues at 6t/ha increased soil organic matter, N, P, K, Ca and Mg contents and pod weight of Okra significantly. The mean pod weight recorded for the control, 400kg/ha NPK fertilizer, wood ash, cocoa husk, rice bran, spent grain and sawdust were 17.2, 449.3, 145.2, 180.2, 170.4, 260.7 and 137.3 kg/ha respectively. Amendment of the residues with animal manure led to increase in soil nutrients content and yield.

Keywords: manure, nutrient, okra, plant residue, soil.

INTRODUCTION

Most small-holding resource poor vegetable farmers in Nigeria use the same piece of land continuously. This leads to loss of soil fertility and inadequate supply of nutrients to the crop and loss of yield. However the sole use of chemical fertilizer for soil fertility improvement cannot be sustained because of its high cost and scarcity. Hence there is need to investigate the use of locally available materials such as sawdust, rice husk and bran, spent grain (brewery waste), cocoa husk and wood ash for soil fertility improvement. Some of these materials have also been found to control pathogens (Muhammad et al, 2001) and increase growth of plants (Ogbalu, 1999). Kumar *et al* (1999) in India found that application of groundnut haulm, maize stover and mustard stover supplied considerable amount of nutrients, which improved nutrient uptake by rice, soil organic matter, and N, P, K, and K. However in Nigeria, Olayinka and Adebayo (1983) had found that sawdust manure reduced growth and yield of maize, if not amended with poultry manure. Okra is a popular vegetable in the subtropical and tropical countries grown of its pods. It has been found (Aduayi, 1980) that continuous use of N fertilizer increased soil acidity and reduced micronutrient uptake by okra. The relative effect of plant residues such as spent grain, wood ash, sawdust, rice bran and cocoa husk on soil fertility and yield of okra is not known to have been investigated. Therefore this work compared the effects of these agrowastes, used sole or amended with animal manure, and NPK fertilizer on soil nutrients contents and yield

of okra.

MATERIALS AND METHODS

Field experiments

Field experiments were conducted at Akure, southwest Nigeria on a sandy loam soil (Oxic Tropudalf). The site had been cropped for 10 years with or without fertilizer. The soil had a pH (H20) of 5.1, 0.53% organic matter, 0.02%N, 4.0mg/kg available P, 0.08 Cmo/kg exchangeable K, 0.11 Cmol/kg exchangeable Ca, and 0.011 Cmol/kg exchangeable Mg. The soil was acidic and low in organic matter, N.P,K, Ca and Mg.

Twenty-two manure treatments that included 20 organic materials (sole or amended), 400kg/ha 15-15-15 NPK fertilizer, and the control (no treatment) were investigated. The organic materials applied were wood ash, ground cocoa husk, rice bran, spent grain (sorghum based brewery waste) and sawdust. The materials were applied to soil sole at 6t/ha. Also each was used with goat, pig, poultry manure at equal rates (i.e, 3t/ha plant residue + 3t/ha animal manure). The treatments were replicated 3 times on 4 consecutive crops of okra (NHAe 47-4). The size of each plot was 4m2. The treatments were incorporated 3 weeks before planting.

Three seeds of okra were planted per stand at 60x3Ocm on April 28, 1998, August 6, 1998, April 16, 1999 and August 3, 1999 respectively in case of the first, second, third and fourth crops.

Thinning to one plant per stand was done 10days after planting. The plots were manually weeded thrice starting from the second, fifth and seventh weeks after planting. Out of the 28 plants per plot, 6 plants were selected for observation.

Harvest of mature pods started 50 days after planting, and the harvest continued at 4-days interval till 82 days after planting.

Analysis of soil and plant residue:

At the end of each experiment, composite soil samples were collected to 15cm depth in each plot. The samples were air - dried using 2mm sieve. The pH in 1:1 soil water suspension was determined. Organic matter was determined by the Walkley - Black (1934) method, and N by Kjedahl approach. The available P was extracted using Bray - 1 extractant and evaluated using molybdenum blue colorimetry. The exchangeable K, Ca and Mg were extracted with ammonium acetate; K was determined using the flame photometer, and Ca and Mg using the EDTA titration (IITA, 1982).

The powdered forms of plant residue manures were chemically analysed. Organic C and total N were determined as for soil. Wet ashing of samples was done in nitric-perchloric acid 1:1 mixture (Tel, 1984) and P determined by the molybdenum blue method, K on flame photometer, and Ca and Mg by EDTA titration. For the micro-nutrients, di-benzyl dithocarbamate complex in carbon tetrachloride was added to the aliquot before being read on atomic absorption spectrophotometer for Cu, Zn and Mn, while Fe was determined on spectrophotometer (Tel, 1984). The mean soil analysis and pod weight data for the 22 treatments were compared using the Duncan multiple -tinge test at 5% level.

RESULTS

Table 1 shows the chemical composition of plant residues. They are composed of nutrients such as N,P,K,Ca, Mg, Fe, Mn, Cu, and Zu. The cocoa husk and wood ash had higher concentration of these nutrients compared with spent grain, rice bran and sawdust. The sawdust had the least concentration of N,P,Ca,K and Mg. The rice bran and sawdust had relatively high C:N.

Tables 2,3,4,5,6 and 7 show the values of soil organic matter. total N, available P, exchangeable K, Mg and Ca respectively for the 22 manurial treatments. Application of sole and amended plant residues such as wood ash, cocoa husk, rice bran, spent grain and sawdust to soil increased soil organic matter (Table 2), N (Table 3), P (Table 4), exchangeable K (Table 5) and exchangeable Mg (Table 6) significantly under the first, second, third, ad fourth okra crops. The treatments also increased exchangeable soil Ca significantly (Table 7) under the second, third and fourth crops. Therefore the plant manures increased soil organic matter (OM) and nutrient contents.

Among the plant residue manures, the wood ash mostly improved soil nutrient contents and pH. The mean soil pH recorded for the control, NPK fertilizer, wood ash, cocoa husk; rice bran, spent grain and sawdust manure were 5.2, 5.1, 7.2, 6.9, 5.7, 6.1, and 5.8 respectively. Wood ash gave the highest

Table 1. Chemical composition of plant

Residue	C	1 N	C:N	P (mg/kg	I Ca (%)	1 K	j Mg	Fe (mg/kg)	Mn (mg/kg)	lCu I (mg/kg)	Zn (mg/kg)
Cocoa husk i	16.0	1.44	11.1	110 0	19.34	120. 6	[7.1	150. 4	8.4	10.55	11.7
Wood ash	118.0	1 1.53 ,	11.8	1 8 6	9.40	23.0	1 8.5	65. 5	11.9	'0.66	1.8
Spent grain'	10.0	10.78	12.8	15 6	0.13	7.9	3.1	3.4	0.99	0.10	0.7
Rice bran	14.0	10.60	23.3	76	0.12	7.9	1.8	6.3	1.8	0.18	0.5

residue manure

Table 2. Effect of goat (G), pig (P) and poultry (PO) manure (M) amended plant residue on soil

Treatment	i Crop 1	Crop 2	Crop 3	Crop 4
Control	0.47a	0.20a	i 0.20a	j 0.27a
NPK Fertilizer	0.62b		0.46b	10.41b
Wood ash	0.86h	1.731	2.62h	i 2.90i
Woodash + GM	,	.	. 2.83L	3.5Lm
Woodash + PM	0.99m	1.98n	2.85m	€ 3.70n
I Woodash +	j 1.06n	; 2.130	2.97n	3.78o
Cocoa husk	1 0.79d	1.59de	2.46e	2.83h
Cocoahusk +	1.01r	2.18p	3.13p	
Cocoahusk +	1.110	2.20pq	t 3.05o	3.71 n

Cocoahusk + POM	1.14p	2.28q ;	13.15q	3.82p
Rice bran	10.69cd	1.39cd	2.28c	2.35d
Rice bran + GM	0.82f	1.63g	12.501k	2.718
Ricebran + PM	f 0.85g	1.70h	2.58fg	2.85hi
Ricebran + POM	0.68h	1.72i	2.61 h i	2.95j
Spentgrain	0.76d	I1.52d	2.40d	I2.55e
' Spentgrain + GM	i 0.93i	1.85j	; 2.74j	3.11k
Spentgrain +	0.94j	1.89k	2.78k	13.13ki
Spentgrain + POM	0.97k	11.94L	2.82L	3.22L
Sawdust	0.67c	1.35c	i 2.25fg ;	2.29c
Sawdust + GM	0.80e	1 1.60e	2.49e	2.68f
Sawdust + PM	0,81f	1.63f	2.52f	2.73h
Sawdust + POM	0.85g	# 1.70h	2.60g	2.89hi !

Treatment means followed by the same letters are not significantly different using DMRT ($p>0.05$)

Table 3. Effect of goat (g), pig (P) and poultry (PO) manure (M) amended plant residue on soil N content

Treatment	¡ Crop 1	Crop 2	Crop 3	Crop 4
Control	' 0.017a	0.017a	0.016a	0.017a
NPK fertilizer	0.0101ef	0.181k	0.359L	0.388L
Wood ash	0.075c	0.129e	0.252d	0.264d
Woodash + GM	0.109g	0.139h ;	0.138h	0.334h
Woodash + PM	0.108fg	0.176j	0.345k	0.365j
Woodash + POM	¡'0.1 17h	0.199m	0.397n	0.417m
Cocoa husk	0.072bc	0.116d	0.232d	0.241d
Cocoahusk + GM	0.101ef	0.1671	10.332j	0.3491
Cocoahusk + PM	' 0.103f	0.179jk	0.358L	0.376k
Cocoahusk + POM	0.115g	0.201-m	0.406o	0.4260
Rice bran	10.057b	0.102c	0.024c	0.214c
Rice bran + GM	0.085d	0.145g	0.285fg	0.290fg
Ricebran + PM	0.085d	0.150gh	0.302g	0.314fg
i Ricebran + POM	0.101ef	0.168i	0.336j	0.353j

1 Spentgrain	0.074c	0.142fg	! 0.284fg	0.298fg
Spentgrain + GM	10.098e	0.180jk	0.358L	0.378k
Spentgrain + PM	0.109g	T0.192-L-	0.383m	0.401m
Spentgrain + POM	0.118h	0.217n	$_{1}$0.427p	0.448p
Sawdust	$_{j}$ 0.053b	0.090b	0.179b	0.188b
Sawdust + GM	0.075c	0.129e	0.257e	0.269ef
j Sawdust + PM	0.081 cd	0.139f	i 0.277f	0.291f
Sawdust + POM	0.096e	0.163i	i 0.3261	0.342hi

Treatment means followed by the same letters are not significantly different using DMRT ($p>0.05$)

values of soil OM and K. Cocoa husk nure gave the highest soil P and Ca. The spent grain gave the highest soil N. The sawdust manure gave the least soil OM, N, P, K, and Ca.

Compared with the plant residue manures, NPK fertilizer gave the highest values of soil N (Table 3), P (Table 4) and K (Table 5), but it gave the least values of soil OM (Table 2), Mg (Table 6) and pH.

Amendment of plant residue manures with goat, pig and poultry manure increased soil OM, N, P, K, and Ca status. Also the amendment of wood ash, cocoa husk, spent grain and sawdust increased soil Mg status. Soil OM, N, P, and K and Ca contents increased in the order of amendment with goat manure, pig manure and poultry manure. Therefore amendment of plant residue with poultry and pig manure respectively improved soil fertility better than amendment with goat manure.

Table 4: Effect of goat (g), pig (P) and poultry (PO) manure (M) amended plant residue on available soil P (mg/kg)

Treatment	Crop 1	Crop 2	Crop 3	Crop 4
1 Contr	2.50a			
1 NPK fertilizer	14.5h	36.3m	l94.5a	134.4p i
[Wood ash	7.O	11	25.8e	138.6e
Woodash + GM	?	20.5	30.6h	144.7h
Cocoa husk	7.2cd	j 18.1		
1 Cocoahusk + GM				
Cocoahusk + Sawdust	10.9 5.8b	14.5b	141	61
Spentgrain	! 7.Oc	! 17.6d		
Spentgrain + GM	' 8.7d	21.9g	(Spentgrain + PM	i 10.1e 25.2h
Sawdust + GM	16.2b	15.5bc	23.2c	35.Oc
Sawdust + POM	6.9c	17.4d	25.9e	38.5e
Cocoahusk + POM	' 13.2g	33.1 k		49.7m
Rice bran	j 6.Ob	15.Ob	22.4bc	33.7bc
Rice bran + GM	j 6.6bc	' 16.6c	j 24.9d	37.4de
Ricebran + PM	7.Oc	' 17.6d	j 26.5ef	39.5f
Ricebran + POM				
Sawdust + PM	6.6bc	16.6c	' 24.7d	' 36.9d

Treatment means followed by the same letters are not significantly different using DMRT ($p>0.05$)

The five plant residue manures increased the pod yield of okra. The spent grain gave the highest yield consistently. (Table 8). The wood ash and the sawdust gave the least yield. Mean pod yield of the four croppings recorded for the control, NPK fertilizer, wood ash, cocoa husk, rice bran,

spent grain and sawdust were 17.2, 449.3, 145.2, 180.2, 170.4, 260.7 and 137.3 kg/ha respectively. The NPK fertilizer was significantly more effective in improving yield of okra than any of the residues. The amendment of the plant residues with goat, pig and poultry manure increased the pod yield. Yield increased in the order of amendment with goat, pig and poultry manure. The application of sole and amended plant residues to soil had cumulative effect on soil organic matter (Table 2), N (Table 3). P (Table4), K (Table 5), Mg (Table 6) and pod yield (Table 8). Therefore these parameters increased with the number of application of manure and croppings. Continuous use of the sole and amended manures built up soil fertility and yield of okra.

DISCUSSION

The observation that the plant residue manures increased soil nutrient. (N,P.K,Ca, Mg) contents is consistent with the fact that they are composed of these nutrients. The residues also contained micronutrients, which should have benefited the okra crop. Hence the yield of okra was significantly increased when the residues were applied as manure. The observation that the amendment of the residues with goat, pig and poultry manures increased their effect on soil fertility and yield should be due to the fact that animal manures enhanced the decomposition of the plant residues (Olayinka, 1990). The C.N of the goat, pig and poultry manure used in this study were 7.9, 6.7 and 6.9 as compared with higher values recorded for the plant residues. Carbonaceous plant residues such as sawdust and rice bran with high C.N degrade slowly in soil and the high values

Table 5: Effect of goat (g), pig (P) and poultry (PO) manure (M) amended plant residue on exchangeable soil K (cmol/kg)

Treatment	Crop I	Crop 2	Crop 3	! Crop 4
Control	0.028a ,	0.20a	0.017a	0.012a
NPK fertilizer	0.369Lm	0.738r	0.800r	1.192n
'Wood ash	0.208hi	0.416L	0.417L	0.942j
Woodash + GM	i 0.240i	0.480m	0.480m	0.98jk
Woodash + PM	0.272j	0.5440	0.544no	1.104L
9 Woodash + POM	0.296k	0.592p	0.592p	
Cocoa husk	0.206h	0.412L	0.412L	0.856i
Cocoahusk + GM	0.2481	0.496n	0.496n	0.987k
Cocoahusk + PM	0.300k	0.600p	0.536n	1.072L
Coco husk + POM	0.316L	0.692q	0.632q	1.264o
Rice bran	0.067b	0.I35bc	0.135co	0.270c
Rice bran + GM	0.086f	0.172e	0.172f	0.344d

Ricebran + PM	0.090d	0.180f	0.180g	0.360e
Ricebran + POM	0.101 de	0.203g		
Spentgrain		0.262h		
Spentgrain + GM	0.154f	0.308i	0.308i	0.616g
Spentgrain + PM	0.182g	0.364j	0.364j	0.724h
ı Spentgrain + POM	0.195h	0.309k	0.391k	0.776hi
Sawdust	0.038ab	0.076b	0.090b	0.152b
Sawdust + GM	E 0.063b	0. l2bc	0.127c	0.253c
Sawdust + PM	0.075c	0.148d	0.150d	0.300d
! Sawdust + POM	0.080cd	0.158de	0.160e	10.320d

Treatment means followed by the same letters are not significantly different using DMRT ($p>0.05$)

of C:N could he reduced through amendment with animal manures such as poultry manure (Olayinka and Adebayo, 1985).

The fact that soil fertility and okra yield increased in the order of amendment as goat, pig and poultry manure can be related
to the N content of animal manures which increased in the same order. The N content of the animal manures used in this work were 2.5, 3.7 and 4.3% respectively.

The fact that spent grain and cocoa husk respectively gave the highest okra pod yield can be related to the relatively high soil N

Table 6. Effect of goat (G), pig (P) and poultry (PO) manure (M) amended plant residue on exchangeable soil Mg (cmol/kg)

Treatment	Crop 1	Crop 2	Crop 3 ,	Crop 4
Control	0.003a	0.003a	0.003a	0.002a
NPK fertilizer	0.005b	0.010b	0.061 b	0.069b
Wood ash	0.013e	0.026g	0.236r	0.333c
Woodash +	0.019g	0.039j	0.509i	0.609g
Woodash + PM	0.023L	0.046k	0.565k	
Woodash +	0 032j	0.063n	0.647m	
Cocoa husk	0.014e	0.028g	0.222s	
Cocoa husk +	0.052L	0.035i	0.294d	0.396c
Cocoahusk +	0.25hi	F	0.309de	0.403bd
Cocoahusk +	° 0.031 i	0.062	0.346ef	0.446e
Rice bran	'	0.012cd	0.594L	0.707k
Rice bran +	0.006b	0.011c	0.588L	0.664i
Ricebran + PM	0.007b	0.014d	0.585L	0.144L
Ricebran +	0.007b	0.015e	0.590L	0.683ij
Spentgrain	0.006b	0.012c;	0.518ij	0.597g
Spentgrain +	0.016f	;	0.5991m	0.720ki
Spentgrain +	0.025h	0.0521	0.734o	0.834n
Spentgrain +	0 032k	0.0650	0.676n	0.776m
Sawdust	0.006b	0.011c	0.434g	0.554f
Sawdust + GM	0.007b	0.014d	0.470h	0.569fg
Sawdust + PM	0.007b	0.015e	0 506i	0.602g
Sawdust +	0.008d	0.016f	0.520j	0.619h

Treatment means followed by the same letters are not significantly different using

DMRT ($p>0.05$).

and P, and soil P and Ca given by the two residues respectively. N and P most limited the yield of okra (Fatokun and Chheda, 1983). The correlation coefficients recorded between okra yield and soil N in case of the first, second, third and fourth experiments were 0.87, 0.90, 0.90 and 0.89 ($P > 0.05$)

respectively, the equivalent values for soil P and yield were 0.61, 0.64, 0.64 and 0.62 (P > 0.05) respectively. The values for soil K and yield were 0.54, 0.80, 0.54 and 0.58 (P > 0.05). For Ca and yield they were 0.46, 0.47, 0.48 and 0.58, and for soil organic matter and yield they were 0.55, 0.70, 0.55 and 0.55 (P > 0.05) respectively.

Table 7.Effect of goat (G), pig (P) and poultry (PO) manure (M) amended plant residue on exchangeable soil Ca (cmol/

Treatment	Crop I	Crop 2	Crop 3	Crop 4
Control	0.10a	0.01 a	0 01 a	0 01a
NPK fertilizer	0.172a b	0.024 b	0.022 b	0.012a b
Wood ash	0.14hi	0 211 h	0.42h	0.38h
Woodash + GM	0.18j	0.27j	0.55k	0.10k
Woodash + PM	0.20L	0.31k	0.61m	1.22k
Woodash + POM	0.22m	0.33L	0 66n	1.33L
Cocoa husk	0.20L	0.30k	0.59L	1.20k
Cocoahusk + GM	0.25n	0.37m	0.750	1.50m
Cocoahusk + PM	0.270	0.40n	0.80p	1.61 n
Cocoahusk + POM	0.29p	0.430	0.87p	1,720
Rice bran	0.04b	0.06c	0.12c	0.23bc
Rice bran + GM	0.06d	0.09e	0.17d	0.35c
Ricebran + PM	0.07ef	0.10f	0.21ef	0,42d
Ricebran + POM	0.07f	10.11	0.21 f	0.45ef
Spentgrain	0.07f	j 0,11f	0.20e	0.38cd
Spentgrain + GM	0 12L	0,18i	0.37g	0.73g
Spentgrain + PM	0.15i	~ 0.22k	0,44hi	0.87i
Spentgrain + POM	n 17j	0.27i	~ 0.51j	1,06j
Sawdust	0.04c	0.06d	0.12c	0.25b
Sawdust + GM	0.06de	0.10ef	~ 0.20e i	0.39d
Sawdust + PM	0.07f	0.11 of	~ 0.21 f	; 0.42e
Sawdust + POM	0.08g	0.12g h	0.23f g	0,46f

Treatment means followed by the same letters are not significantly different using DMRT (p>0.05).

Table 8. Effect of goat (G), pig (P) and poultry (P0) manure (M) amended plant residue on pod weight of okra (kg/ha).

Treatment	Crop	Crop	Crop a	D94
No Fertilizer	9.#	2.+	9.+	17.3
	.	@¢E	p&a	642.58
Wood eh	+.k	100.3	m&a	2\mc
wmdeh+GM	**]q.k**	2819		9Ekh
&mdah+P	196.3n	3¢G	586.5	mtm
L 00#6+POM	]m.%	jST#	+ƒ%	miAi
Cocoa husk	~83.5e	X15.#	mi+	mlad
C mh kGM	f1m.a	37.40	q&+	**002 hi**
Cg+Q++PM	mIG	m¢&	mEG	&Zmi
;CgA3k+POM	206.E	m&#	615.E	**q&Ai**
Rice bran	79.a	9&2	2sq	m$mc
Rice bran +GM	]a2	/$q	513.0]	213
ı&G+mn+PM	190.5E	2Ek	572.3	**q¢kh**
~Rc+rna+P M	~]k3m	/6.3	X9$3	**gEai**
~S9%&n	2tm	181.9	(m¢m	95.5!5.
Se%&n+GM	j&i@	m$@	7&@	7¢#
SfUa + PM	255.8u	391 .5u	771 .8u	779.8k
ASS%&n+POM	001&	m&a	7G&	**Lm3k**
SAG/	q.m	**k$b**	**]k.2b**	mIm
Sawdust +GM	m.@	1k.Of	m&5.	m/«
awust+PM	116.&	17.&	347.2	mtk
Swat PO	138.3i	ṁTm	«6.5	47.3

Treatment means followed b %c same letters #enot significantly different using OMRT U> $5/

Therefore 4 is confirmed #l& soil N and # respectively most limited okra yield. Hence the spent 7a treated soil with the highest s6! N had the highest /!c/, Also it is suggested that the increased availability of soil organic matter and nutrient as a result of the application of the plant residue mulch led to increased okra yield. The least pod yield given by sawdust manure

compared with other plant residues is related to the least soil organic matter and nutrients content u its soil. Therefore the performance of okra on the differently manu e soils was dictated by the influence of temaues

The finding that continuous application of sole and amended plant residue tended to improve okra yield can be related to the fact soil fertility was also built up. The cumulative effect of continuous addition of plant residue on soil fertility led to improvement in yield.

CONCLUSION

Plant residues and agrowastes such as wood ash, ground cocoa husk, rice bran, spent grain and sawdust are effective source of nutrients for improving soil fertility and yield of okra. However they are not effective as NPK fertilizer in the supply of N,P, and K. The spent grain and cocoa husk manures were respectively most effective in improving okra yield and soil N and P. The positive effect of the plant residues on soil fertility and okra , ' eld was enhanced by their amendment with poultry, pig and goat manure respectively.

ACKNOWLEDGEMENT

The Authors are grateful to Federal College of Agriculture Akure for granting O.O. Folorunso a study leave and for providing
laboratory and field facilities for this study.

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