Nigerian Journal of Soil Science 23 (2013) 103 – 113

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

RESPONSE OF SOYBEAN (*GLYCINE MAX L.*) TO COW DUNG AND WOOD ASH APPLICATION IN TROPICAL ACID SOILS OF SOUTH-WESTERN NIGERIA

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ABSTRACT

The study examined the effect of cow dung (beef cattle manure) and wood ash on the growth and yield of soybean in two acid soils (Typic dystrudepts) of south-western Nigeria. The experiment was conducted under field conditions at two different locations, namely, Epe and Ibiade (Ijebu-waterside) of Lagos and Ogun States, Nigeria, respectively. It was a 3 x 3 factorial experiment arranged in randomized complete block design (RCBD) with three replications. The treatments were three rates of cow dung (0,5 and 10 t ha^{-1}) and three rates of wood ash (0, 2.5 and 5.0 t ha^{-1}). Agronomic parameters which included plant height, shoot dry matter and root yields, shoot/root ratio and the grain yield were determined per soybean plant.

Cow dung applied singly at 10 t ha^{-1} significantly ($P<0.05$) increased dry matter accumulation of soybean during the growth season. Wood ash (W) applied singly at the rate of 2.5 t ha^{-1} also significantly ($P<0.05$) increased the growth and grain yield of soybean at both locations. The grain yield increase over the control was 46% at Epe and 28% at Ijebu-waterside. Cow dung applied at 5 t ha^{-1} in combination with 2.5 t ha^{-1} of wood ash significantly ($P<0.05$) increased grain yield at Epe. The grain yield increase over the control was 110% at Epe and 58% at Ijebu-waterside. These results demonstrate that tropical acid soils can be managed through the use of organic wastes for optimum productivity.

Keywords: acid soils; agronomic parameters; cow dung; soybean; wood ash

INTRODUCTION

Application of wastes generated from domestic, agricultural and industrial activities on agricultural land has been known as a popular means of their disposal. Since organic wastes could enhance the levels of both major and minor elements in the soil, these could be explored as an alternative to the costly commercial fertilizers to boost crop production. Moreover, commercial N fertilizer is not recommended for leguminous crops. It is always advocated that organic manure should be applied along with rhizobium culture.

Olayinka (1990) observed that liming a poultry manure amended acidic ultisol enhanced microbial decomposition of the organic manure, and the release of NO_3^-N and available P. Hence, liming along with organic manure would be beneficial to plants grown in an acidic ultisol. Board and Caldwell (1991) hypothesized that a major effect of soil acidity on soybean yield was a reduction in the ability of the plants to fix N_2, either by interfering with nodulation or reducing the availability of molybdenum (Mo).

Acid soil reaction causes ineffective nodulation because of its low content of Ca, Mg, P and Mo. The rhizobial cell has a specific requirement for Ca for its cell wall development. Calcium ions also help in counteracting soil acidity. Phosphorus is important for its role in protein synthesis and Mo for its role in the nutrition of rhizobium and the N_2 fixing process. Soil acidity, therefore, adversely affects symbiotic N_2 fixation by legumes. Liming of acid soils is a common agricultural practice in several areas of the tropics. It results in the reduction of aluminum and manganese toxicities, improves N and P availabilities, Effective Cation Exchange Capacity (ECEC) and soil structure, and promotes nitrogen fixation. Further, liming of acid soil makes it possible for a greater number of crops to be grown. The most commonly used liming materials are the oxides, carbonates and silicates of calcium and magnesium. Only scanty information is available on miscellaneous materials such as shells, industrial slag, flue-dust from cement, iron smelting slag, chicken litter ash and wood ash. The liming value and phosphate fertilizer effectiveness of these materials are poorly defined. They are byproducts which are commonly dumped in landfills; therefore, any use of byproducts to ameliorate land will contribute to the preservation of alternative resources and produce an effective solution for the disposal of such byproducts (Francis and Youssef, 2004). It seems necessary to evaluate the effects of these locally available waste materials on the performance of soybean in acid soils of the tropics. This study was undertaken to determine the effects of the application of cow dung and wood ash on the dry matter accumulation and grain yield of soybean in acid soils.

MATERIALS AND METHODS

Study location

The field experiments were conducted in 2007 at two locations, namely, Epe and Ijebu-waterside areas of Lagos and Ogun States, Nigeria, respectively. Epe is situated in the rain forest and lies between Lat 6° 59′ N and Long 3°59′E while Ijebu-waterside, also in the rain forest lies between Lat. 6°55′ and Long. 4°35′N. Both soils are classified as Typic Dystrudepts.

Representative soil samples were collected randomly at 0-15 cm depth from the two locations, air-dried and passed trough a 2 mm sieve. The soils obtained at Epe and Ijebu-waterside are loamy sand with pH of 5.3, respectively.

Sources of materials used and preparation

The rhizobium inoculant used was sourced from the Department of Microbiology, Obafemi Awolowo University, Ile-Ife, Osun State. The cow dung (C) used was collected from the Livestock Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State. Wood ash (W) was sourced from a commercial bakery in Abeokuta. The soybean seed used (TGX 1448-2E) was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State. Cow dung and wood ash were air dried and passed through a 2 mm sieve before application.

The soil, cow dung and wood ash samples were analyzed routinely for pH, organic matter, exchangeable Ca, Mg, K and Na, total N, available P, and particle size distribution as outlined by Page *et al*. (1982).

Experiment layout

The experimental design was a 3 x 3 factorial in a randomized complete block design with 3 replications. The treatments were three rates each of cow dung (0, 5, and 10 t ha^{-1}) and wood ash (0, 2.5 and 5 t ha^{-1}). The plot size was 2 m x 2 m with an alley of 0.5 m between plots and 1 m between replicates. The treatments were applied and allowed to equilibrate for two weeks before planting. The soybean seeds were inoculated with rhizobium innoculant (*Bradyrhizobium japonicum*) and planted by seed drilling with inter-row spacing of 0.5 m. The seedlings were thinned to an intra-row spacing of 0.05 m at two weeks after planting.

Data collection

Observations were taken at 4 and 8 weeks after planting (WAP) on the plant height, shoot and root dry weight, shoot/root ratio (dry weight) and the grain yield was determined at harvest.

Statistical analysis

Statistical analyses were done using SAS (Statistical Analysis System Institute Inc., 1990). The experimental data collected were subjected to analysis of variance (ANOVA) to determine the statistical differences between treatments at 5% probability. The treatment means were compared using Duncan's Multiple Range Test (DMRT).

RESULTS

Characteristics of the soils of Epe and Ijebu-waterside

The characteristics of the surface soils (0-15 cm) obtained from Epe and Ijebu-waterside and the amendments are presented in Table 1. The soil from Epe was loamy sand, strongly acid in reaction (pH 5.3), low in organic carbon content (5.4 g kg^{-1}), available P (13.2 mg kg^{-1}) and total N (0.9 g kg^{-1}). The soil was low to medium in exchangeable cations with values of 2.78, 1.21, 0.42 and 0.93 cmol kg^{-1} for Ca, Mg, K and Na, respectively. Hence, the soil was low in fertility.

The soil from Ijebu-waterside was loamy sand with contents of sand, silt and clay being 900,40 and 60 g kg^{-1}, respectively. It was strongly acid in reaction (pH 5.5.) and medium in organic carbon (20.8 g kg^{-1}). The soil was moderate in total N (1.8 g kg^{-1}), low in available P (24 mg kg^{-1}) and low in exchangeable K^+, Ca^{2+} and Na^+ with values of 0.20, 0.62, 0.31 and 3.66 cmol kg^{-1}, respectively. Both soils are classified as Typic Dystrudepts according to Soil Survey Staff (1999).

Effect of single applications of cow dung and wood ash on soil pH under field conditions at Epe and Ijebu-waterside

Table 2 shows the effects of cow dung and wood ash on the soil pH under field conditions at Epe and Ijebu-waterside. At Epe, cow dung and wood ash had significant ($P<0.05$) effects

Table 1: Physico-chemical characteristics of the experimental soils and the amendments

Properties	Epe	Ijebu-waterside	Wood ash	Cow dung
pH (H_2O)	5.3	5.5	11.3	8.1
Sand (g kg^{-1})	892	900		
Silt (g kg^{-1})	42	40		
Clay (g kg^{-1})	66	60		
Textural class	Loamy Sand	Loamy sand		
Organic carbon (g kg^{-1})	5.4	20.8	8.8	44.3
Total nitrogen (g kg^{-1})	0.9	1.8	0.9	3.6
C:N	6.0	11.6	9.8	12.3
Available P (mg kg^{-1})	13.2	7.99	26.98	85.32
Exchangeable acidity (cmol kg^{-1})	0.05	0.04		
Exchangeable Ca (cmol kg^{-1})	2.78	0.62	4.56	4.68
Exchangeable Mg (cmol kg^{-1})	1.21	0.31	2.83	2.92
Exchangeable K (cmol kg^{-1})	0.42	0.20	4.1	16
Exchangeable Na (cmol kg^{-1})	0.93	0.35	1.7	8.9

Table 2: Soil pH of Epe and Ijebu-waterside fields as affected by single application of cow dung and wood ash.

Amendments (t ha^{-1})	Soil pH	
	Epe	Ijebu-waterside
C_o	6.37a	6.33
C_5	6.08ab	6.41a
C_{10}	6.18b	6.30a
W_o	5.99b	6.15b
W_{25}	6.29a	6.42
W_{50}	6.35a	6.46a

Values with different letters in columns are significantly (P<0.05) different
C = Cow dung; W = Wood ash; 0, 2.5, 5.0 and 10 rates of amendments, t ha^{-1}, ns = not significant (P>0.05).

(P<0.05) effects on the soil pH. Wood ash application significantly (P<0.05) increased the soil pH over the control. Although there was no significant (P>0.05) difference between 2.5 and 5.0 t ha^{-1} application rates, the trend, however, showed an increase as the level of application increased. At Ijebu-waterside, the soil pH was not significantly (P>0.05) affected by the cow dung application. Wood ash application, on the other hand significantly (P<0.05) affected the soil pH. It was lowest in the control with the highest pH obtained at 5.0 t ha^{-1} W applications. There was, however, no significant (P>0.05) difference in soil pH at 2.5 and 5.0 t ha^{-1} W applications.

Effect of cow dung application on some agronomic parameters of soybean

The height of soybean was significantly (P<0.05) affected by cow dung (C) applications at Epe and Ijebu-waterside (Table 3). At Epe, the plant height was significantly affected by C application only at 4 WAP. The greatest value for plant height was obtained at 10 t ha^{-1} and the lowest was in the control (0 t ha^{-1}). This was, however, not significantly different from 5 t ha^{-1} C application. At Ijebu-waterside, C application had significant (P<0.05) effect on plant height only at 8 WAP. This followed similar pattern with that observed in Epe at 4 WAP, in which the tallest plant was obtained with the C application of 10 t ha^{-1} C and the shortest in the control (0 t ha^{-1}). There was, however, no significant difference between 5 and 10 t ha^{-1} applications. The trend showed increasing plant heights with increasing rates of C application.

Table 3: Some agronomic parameters of soybean as affected by cow dung application at Epe and Ijebu-waterside sites

Cow dung (t ha^{-1})	Plant height (cm)		Shoot dry matter yield (g plant^{-1})		Root dry matter yield (g plant^{-1})		Shoot/root ratio	
Epe	**4 WAP**	**8 WAP**	**4 WAP**	**8 WAP**	**4 WAP**	**8 WAP**	**4 WAP**	**8 WAP**
0	13.13b	24.48	0.32	1.45b	0.10b	0.31b	3.13	4.68
5	13.99ab	25.11	0.33	1.47b	0.12ab	0.33ab	2.96	4.46
10	14.88a	27.03	0.38	1.95a	0.14a	0.40a	2.79	4.93
		ns	Ns				ns	ns
Ijebu-waterside								
0	16.37	30.19b	0.47b	2.20	0.16	0.46	3.25	4.70
5	17.19	33.11ab	0.58a	2.19	0.18	0.46	3.29	4.84
10	17.60	34.24a	0.56a	2.46	0.19	0.52	2.99	4.73
	Ns			ns	ns	ns	ns	ns

Values with different letters in columns are significantly (P<0.05) different
C = Cow dung; W = Wood ash; 0, 2.5, 5.0, and 10 rates of amendments, t ha^{-1}, ns = not significant (P>0.05).

At Epe, the effects of cow dung on shoot dry matter yields (SDMY) were only significant (P<0.05) at 8 WAP (Table 3). At 8 WAP, SDMY was highest at 10 t ha^{-1} of C application and lowest in the control. The trend showed an increase in dry matter yield as the C application was increased. A similar trend was observed at 4 WAP although these were not significantly (P>0.05) different. The increase of the highest SDMY over the control was 35%. At Ijebu-wasterside, the shoot dry matter yield varied significantly (P<0.05) at 4 WAP only. At 4 WAP, 5 t ha^{-1} C application produced plants with greater shoot dry matter yields than the control. The increase over the control was 23%. However, there was no significant (P>0.05) difference between 5 and 10 t ha^{-1} C applications. At 8 WAP, no significant difference in yields was observed with respect to C applications.

Cow dung significantly affected root dry matter yield (RDMY) at both 4 and 8 WAP only in Epe (Table 3). At 4 and 8 WAP, RDMY was highest at 10 t ha^{-1} C application rate and lowest in the control. There was, however, no significant difference between 5 t ha^{-1} and other application rates. The increase of the highest RDMY over the control was 29%. At Ijebu-waterside, the root dry matter was not significantly affected by C application at 4 and 8 WAP. However, RDMY tended to follow similar pattern observed in Epe.

Cow dung application did not significantly (P>0.05) affect the shoot/root ratio throughout all the observation periods at Epe and Ijebu-waterside (Table 3).

Effect of wood ash application on some agronomic parameters of soybean

At Epe, the heights of soybean were not significantly (P>0.05) affected by wood ash (W) application at 4 and 8 WAP (Table 4). At Ijebu-waterside, on the other hand, the plant height varied significantly (P<0.05) in response to wood ash application only at 4 WAP. At 4 WAP, the greatest value for plant height (17.9 cm) was obtained at 5 t ha^{-1} W application and the lowest was in the control. However, 2.5 and 5 t ha^{-1} were not significantly (P>0.05) different.

Wood ash application at Epe affected the shoot dry matter yield significantly (P<0.05) only at 4 WAP (Table 4). The shoot dry matter yield was highest at 2.5 t ha^{-1} application rate and lowest in the control. The increase of the highest SDMY over the control was 23%. However, no significant (P>0.05) difference in SDMY was observed between 2.5 and 5.0 t ha^{-1} WA application rates. A similar trend was also observed at 8 WAP, although the differences between these were not statistically significant. At Ijebu-waterside, the SDMY was significantly (P<0.05) affected at 4 WAP only by W application. At 4 WAP, the highest yield was obtained with both 2.5 and 5.0 t ha^{-1} of W applications while the lowest was in the control. The increase of the highest SDMY over the control was 21%. At 8 WAP, SDMY were not significantly (P>0.05) affected by the W applications.

The RDMY was significantly (P<0.05) affected by wood ash only at 4 WAP at Epe (Table 4). The highest root dry weight was recorded at 2.5 t ha^{-1}W application rate and the lowest in the control. The increase of the highest RDMY over the control was 40%. However, there was no significant difference in root dry weight between 2.5 and 5 t ha^{-1} and W application rates. Wood ash did not significantly affect the RDMY at both periods of 0 and 5 t ha^{-1}. Wood ash application had significant (P<0.05) effect on shoot/root ratio (S/RR) only at 8 WAP at Epe (Table 4). The S/RR was highest at 2.5 t $^{ha-1}$ followed by 5 t ha^{-1} and lowest in the control. The increase of the highest S/RR over the control was 18%. However, there was no significant (P>0.05) difference between 0 and 5 t ha^{-1} and between 2.5 and 5.0 t ha^{-1} application rates. Wood ash significantly affected (P<0.05) S/RR at 4 WAP only at Ijebu-waterside. The S/RR was highest at 2.5 t ha^{-1} W and lowest in the control. The increase of the highest S/RR over the control was 36%. There was, however, no significant difference between 2.5 and 5.0 t ha^{-1} W application rates.

Effects of the combined applications of cow dung and wood ash on some agronomic parameters of soybean at 4 WAP.

The amendments significantly (P<0.05) affected the plant height only at Epe (Table 5). The highest height was obtained at the 10 t ha^{-1} C application without W application (i.e. at 0 t ha^{-1}) with the lowest in the control. The effect of all other amendments were not significantly (P>0.05) different. However, it was observed that plant height increased with increasing rates of C application in the absence of wood ash. At Ijebu-waterside, plant heights were not significantly affected by C and W applications.

The amendments significantly (P<0.05) affected the SDMY at both locations (Table 5). At Epe, the highest shoot dry matter yield was obtained with the combined application of C and W at 5 and 2.5 t ha^{-1}, respectively and the lowest in the control.

Table 4: Some agronomic parameters of soybean as influenced by wood ash application at Epe and Ijebu-waterside sites.

Cow dung ($t\ ha^{-1}$)	Plant height (cm)		Shoot dry matter yield (g $plant^{-1}$)		Root dry matter yield (g $plant^{-1}$)		Shoot/root ratio	
Epe	4 WAP	8 WAP	4 WAP	8 WAP	4 WAP	8 WAP	4 WAP	8 WAP
0	13.53	24.43	0.31b	1.60	0.10b	0.38	3.19	4.26b
5	14.67	25.84	0.38a	1.68	0.14a	0.32	2.80	5.03a
10	13.81	26.34	0.35ab	1.59	0.12ab	0.33	2.90	4.77ab
	ns	ns		ns		ns	ns	
Ijebu-waterside								
0	16.37b	31.62	0.47b	2.22	0.19	0.49	2.65b	4.45
5	16.92ab	31.78	0.57a	2.26	0.18	0.46	3.60a	4.93
10	17.88a	34.14	0.57a	2.36	0.17	0.48	3.29a	4.88
		ns		ns	ns	ns		Ns

Values with different letters in columns are significantly ($P<0.05$) different
C = Cow dung; W = Wood ash; 0, 2.5, 5.0 and 10 rates of amendments, $t\ ha^{-1}$, ns = not significant ($P>0.05$).

Other amendments were not significantly different from each other. At Ijebu-waterside, the highest SDMY was obtained at $C_5W_{2.5}$ and the lowest in the control. All the other treatment combinations were not significantly different.

Cow dung and wood ash significantly ($P<0.05$) affected the root dry weight at both locations (Table 5). At Epe, the highest RDMY was obtained at $C_{10}W_{2.5}$ and the lowest was obtained in the control. All the other application rates were not significantly ($P>0.05$) different from each other. At Ijebu-waterside, the highest RDMY was obtained at $C_{10}W_o$ and the lowest at $C_oW_{2.5}$. All the other treatment combinations were not significantly different.

The amendments significantly ($P<0.05$) affected the shoot/root ratio at both locations (Table 5). At Epe, SRR was highest at C_oW_5 and lowest at $C_{10}W_{2.5}$. All the other application rates were not significantly ($P>0.05$) different. At Ijebu-waterside, the SRR was highest at $C_oW_{2.5}$, and lowest at $C_{10}W_o$. All the other treatment combinations were not significantly different.

Effects of the combined applications of cow dung and wood ash on some agronomic parameters of soybean at 8 WAP

At Epe, C and W combined did not significantly ($P>0.05$) affect the height of soybean at 8 WAP (Table 6). However, at Ijebu-waterside, plant height was significantly ($P<0.05$) affected by the applications of C and W at 8 WAP. It was highest at C_5W_5 and lowest in the control. All the other treatment combinations were not significantly ($P>0.05$) different.

Table 5: Some agronomic parameters of soybean as influenced by the combined applications of cow dung and wood ash at 4 WAP

Amendments (t ha^{-1})	Plant height (cm)		Shoot dry matter yield (g plant^{-1})		Root dry matter yield (g plant^{-1})		Shoot/root ratio	
	Epe	Ijebu	Epe	Ijebu	Epe	Ijebu	Epe	Ijebu
C_oW_o	12.67b	15.70	0.25b	0.38c	0.08c	0.18ab	3.03ab	2.53b
C_5W_o	12.87ab	16.67	0.29ab	0.53abc	0.11ab	0.18ab	2.75ab	3.07ab
$C_{10}W_o$	16.17a	17.40	0.39ab	0.52abc	0.12ab	0.21a	3.41ab	2.49b
$C_oW_{2.5}$	13.60ab	16.07	0.25b	0.46bc	0.09ab	0.11b	2.69ab	4.39a
$C_5W_{2.5}$	15.77ab	16.70	0.43a	0.65a	0.14ab	0.18ab	3.09ab	3.69ab
$C_{10}W_{2.5}$	15.47ab	17.27	0.29ab	0.51abc	0.15a	0.16ab	2.44b	3.19ab
C_oW_5	13.57ab	17.83	0.35ab	0.48abc	0.10ab	0.19ab	3.55a	2.66b
C_5W_5	14.40ab	17.30	0.29ab	0.59ab	0.12ab	0.17ab	2.45b	3.65ab
$C_{10}W_5$	14.40ab	18.17	0.35ab	0.60ab	0.13ab	0.19ab	2.75ab	3.22ab
		ns						

Values with different letters in columns are significantly ($P<0.05$) different
C = Cow dung; W = Wood ash; 0, 2.5, 5.0 and 10 rates of amendments, t ha^{-1}, ns = not significant ($P>0.05$).

Table 6: Some agronomic parameters of soybean as influenced by the combined applications of cow dung and wood ash at 8 WAP

Amendments (t ha^{-1})	Plant height (cm)		Shoot dry matter yield (g plant^{-1})		Root dry matter yield (g plant^{-1})		Shoot/root ratio	
	Epe	Ijebu	Epe	Ijebu	Epe	Ijebu	Epe	Ijebu
C_oW_o	22.90	29.37b	0.90c	2.18abc	0.20b	0.51abcd	4.48ab	4.11c
C_5W_o	24.53	36.33ab	0.96bc	2.44abc	0.23b	0.60a	4.04b	4.17bc
$C_{10}W_o$	27.90	32.93ab	1.87a	2.08abc	0.42a	0.46abcd	4.40ab	4.60abc
$C_oW_{2.5}$	25.67	32.17ab	1.43abc	2.08bc	0.35ab	0.40bcd	4.01b	4.42abc
$C_5W_{2.5}$	26.53	31.00ab	1.21abc	1.94abc	0.27ab	0.35d	4.47ab	5.52a
$C_{10}W_{2.5}$	25.67	37.67a	1.67ab	2.74ab	0.33ab	0.58ab	5.07ab	4.70abc
C_oW_5	28.73	30.76ab	1.63ab	2.10abc	0.31ab	0.45abcd	5.10ab	4.66abc
C_5W_5	24.93	38.17a	1.02bc	1.68c	0.25b	0.38cd	4.08b	4.43abc
$C_{10}W_5$	27.47	33.50ab	1.79a	2.86a	0.33ab	0.54abc	5.74a	5.23ab
	ns							

Values with different letters in columns are significantly ($P<0.05$) different
C = Cow dung; W = Wood ash; 0, 2.5, 5.0, and 10 rates of amendments, t ha^{-1}, ns = not significant ($P>0.05$).

The shoot dry matter yields of soybean were significantly ($P<0.05$) affected by the combined applications of C and W at both locations (Table 6). At Epe, the highest shoot dry weight was obtained at C and W application rates of 10 and 0 t ha^{-1}, respectively (i.e. $C_{10}W_o$) and the lowest was in the control. All the other application rates were similar in their effects on SDMY. It was further observed that in the absence of wood ash, the SDMY increased with the increasing rates of C. A similar pattern was also observed at 0 t ha^{-1} C application rate, where SDMY was found to increase with increasing rates of W applications. The shoot dry matter yields of soybean at Ijebu-waterside, on the other hand, were highest at $C_{10}W_5$ and lowest at C_5W_5. All the other treatment combinations were not significantly different.

The root dry matter yields of soybean were also significantly ($P<0.05$) affected by the combined application of C and W at both locations (Table 6). At Epe, the highest RDMY was obtained at 10 t ha^{-1} C and 0 t ha^{-1} W application rates (i.e $C_{10}W_0$) while the lowest was in the control. All other application rates were not significantly ($P >0.05$) different in RDMY. However, a progressive increase was observed at 0 ha^{-1} W application rates as the C application was increased. The RDMY of the un-inoculated soybean planted at Ijebu-waterside was highest at C_5W_o and lowest at $C_5W_{2.5}$. All other application rates were not significantly ($P>0.05$) different.

The shoot/root ratios of soybean were significantly ($P<0.05$) affected by the combined applications of C and W at both locations (Table 6). At Epe, the highest SRR was obtained at 10 and 5 t ha^1 (i.e $C_{10}W_5$) while the lowest was at 0 and 2.5 t ha^{-1} ($C_oW_{2.5}$) of C and W application rates, respectively. All the other treatment combinations were not significantly ($P>0.05$) different.

Effect of single applications of cow dung and wood ash on grain yield of soybean

The grain yield of soybean was significantly ($P<0.05$) affected only by wood ash application at Epe field (Table 7). The grain yield was highest (890.6 kg ha^{-1}) at the wood ash application rate of 2.5 t ha^{-1} and lowest in the control. The increase in grain yield over the control was 46%. The grain yield at 5.0 t ha^{-1} was, however, not significantly different from that of 2.5 t ha^{-1} and the control. A similar yield pattern was observed at Ijebu-waterside but the values were not significantly different.

Effects of combined applications of cow dung and wood ash on the grain yield of soybean under field conditions at Epe and Ijebu-waterside.

At Epe, the combined application of the amendments had significant ($P<0.05$) effect on the grain yields of soybean (Table 8). The greatest grain yield of soybean was obtained at the combined application of 5 and 2.5 t ha^{-1} of C and W, respectively ($C_5W_{2.5}$) while the least was obtained in the control. All the other treatment combinations were not significantly different. The increase in grain yield over the control was 110% at Epe. At Ijebu-waterside, on the other hand, C and W did not significantly ($P>0.05$) affect the grain yields of soybean. However, the grain yield was apparently highest at C_5W_5. The increase of the highest grain yield over the control was 58%.

Table 7: Grain yield of soybean as affected by the application of cow dung and wood ash under field conditions at Epe and Ijebu-waterside.

Amendments (t ha^{-1})	Grain yield (kg ha^{-1})	
	Epe	**Ijebu-waterside**
C_o	772.2	1340
C_5	746.7	1470
C_{10}	717.8	1770
	ns	ns
W_o	608.3b	1350
$W_{2.5}$	890.6a	1730
$W_{5.0}$	737.8ab	1510
		ns

Values with different letters in columns are significantly ($P<0.05$) different
C = Cow dung; W = Wood ash; 0, 2.5, 5.0, and 10 rates of amendments, t ha^{-1}, ns = not significant ($P>0.05$).

Table 8: Grain yield of soybean as affected by the combined applications of cow dung and wood ash under field conditions at Epe and Ijebu-waterside.

Amendments (t ha^{-1})	Grain yield (kg ha^{-1})	
	Epe	Ijebu-waterside
C_oW_o	1146.7	456.7b
C_5W_o	1694.0	786.7ab
$C_{10}W_o$	1272.7	643.3ab
C_oW_{25}	1277.3	1003.3a
C_5W_{25}	1118.7	956.7a
$C_{10}W_{25}$	1078.7	846.7ab
C_oW_5	1241.3	846.7ab
C_5W_5	1806.7	590.0ab
$C_{10}W_5$	1441.3	843.3ab
	Ns	

Values with different letters in columns are significantly (P<0.05) different
C = Cow dung; W = Wood ash; 0, 2.5, 5.0, and 10 rates of amendments, t ha^{-1}, ns = not significant (P>0.05).

DISCUSSION

The findings that the soil pH was highest at 6 t ha^{-1} W application at both locations could be due to the fact that soil pH tends to increase with increase in the amount of ash applied (Owolabi *et al.*, 2003). The addition of W must have contributed greatly to the availability of basic cations which favoured the pH increase as observed by Owolabi *et al.* (2003, 2005).

Generally at Epe, most of the growth parameters were highest at 10 t ha^{-1} cow dung application and lowest in the control at 4 and 8 WAP. This could be attributed to the fact that the addition of manure supplied the nutrients needed by the crop and provided favourable environment for improved microbial activities. This is in agreement with the works of several authors who found increases in the growth of legumes with the application of manure (Ismail *et al*. 1996; Lopes *et al.*, 1996; Yamagata and Otami, 1996). The corresponding general increase in some agronomic parameters with the increasing rate of cow dung at Ijebu-waterside (Table 6) was also consistent with the findings of these authors. The improved grain yield observed with respect to increase in the rate of cow dung application was also in agreement with the works of Oliviera *et al.* (1980) and Yamagata and Otami (1996). Oliviera *et al.* (1980) found that cowpea grown with farmyard manure yielded significantly more than without it. Yamagata and Otami (1996) also found that the application of organic manure increased the yields of upland rice, soybean and potato.

Wood ash applied at the rate of 2.5 t ha^{-1} produced plants with the highest growth parameters in the field at Epe. Generally, there was a reduction in most growth parameters at the higher rate of wood ash addition. This could be attributed to the liming properties of wood ash which tend to inhibit nodulation in legumes when applied in excess. Butler (1993) had earlier observed that nodulation in a loam at the high rate of liming remained poor and that further liming of the loam released enough inorganic N from the organic N pool to have the potential to inhibit nodulation of the subclover.

The combined effects of the amendments resulted in the greatest grain yield generally at 5 t ha^{-1} and 2.5 t ha^{-1} of cow dung and wood ash applications, respectively. The grain yield was more than 50% over the control at each of the locations. This indicated the optimum combinations of C and W needed to improve the growth and development of soybean in these acid soils.

CONCLUSION

This study confirms the potentials of cow dung and wood ash, either singly or combined, to significantly improve the growth and yield of soybean in tropical acid soils, especially in south-western Nigeria. More than 50% grain yield increase was recorded at each of the experimental sites as a result of the combined amendments applied.

Wood ash applied singly at the rate of 2.5 t ha^{-1} improved the growth and yield of soybean. Cow dung application at 5 t ha^{-1} in combination with 2.5 t ha^{-1} wood ash significantly improved soybean yield. The study further demonstrates that the efficiency of cow dung will be enhanced when combined with wood ash in tropical acid soil for improved soybean production.

ACKNOWLEDGEMENTS

Financial assistance in the form of A. G. Leventis scholarship grant to the corresponding author in the course of this study is gratefully acknowledged.

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