Prospects of Enhancing Cattle-Dung Manure's Effectiveness by Partial Substitution with Poultry Droppings-Compost Mix for Slash-and-Burn Managed Tropical Soils

P. O. Ogumba[1,2], B.O. Okorie[2,3], P.N. Eleke[2], L.O. Anyanwu[1], N.E. Ebido[2], M.I. Onwuka[1] and S.E. Obalum[2*]

[1] *Department of Soil Science & Land Resources Management, College of Crop & Soil Sciences, Michael Okpara University of Agriculture, Umudike, PMB 7267 Umuahia, Abia State, Nigeria*

[2] *Department of Soil Science, Faculty of Agriculture, University of Nigeria, Nsukka 410001, Nigeria*

[3] *Department of Plant Physiology, Biochemistry & Genetics, Agricultural University – Plovdiv, Bulgaria*

*Corresponding Author: *sunday.obalum@unn.edu.ng*

Abstract

Use of animal manure-based soil amendments may offset the detrimental effects of slash-and-burn practice by smallholder farmers. Cattle dung is relatively more abundant but mineralizes slower and hence less effective than poultry droppings which can be made even more effective by co-application with the more readily mineralized compost. This study evaluated the potential of a 50% substitution of the slow-release cattle dung with a mix of equal volumes of poultry droppings and fruit-waste compost (CD:PD&FWC) for restoring the fertility of slash-and-burnt tropical soils on the growth of mung bean as a test crop. Screenhouse soil fertility trials were carried out utilising slash-and-burn managed sandy-loam Ultisols from a Nigerian rainforest, with soil properties showing slight improvement over the unburnt soil. Treatments were CD:PD&FWC (10 t ha^{-1}), cattle dung (10 t ha^{-1}), NPK-15:15:15 (125 kg ha^{-1}), and unamended control. At the termination of crop growth after 10 weeks, CD:PD&FWC showed the highest soil pH (5.86), soil organic matter (33.70 g kg^{-1}), total nitrogen (2.00 g kg^{-1}), available phosphorus (25.15 mg kg^{-1}), and cation exchange indices. Soil content of exchangeable acidity showed a reverse trend with lowest values from CD:PD&FWC (0.36 cmol kg^{-1}) and highest from NPK-15:15:15/control (1.10 cmol kg^{-1}). Cattle dung gave longer plant roots than CD:PD&FWC, but the two produced higher root dry matter (2.74-3.27 g pot^{-1}) than NPK-15:15:15/control (0.70 g pot^{-1}). The CD:PD&FWC gave taller 10-week-old plants (30.69 cm), more root nodules (415) and higher shoot dry matter (37.80 g pot^{-1}) than cattle dung; NPK-15:15:15/control gave the lowest (14.77 cm, 26-37 and 5.95 g pot^{-1}, respectively). The CD:PD&FWC and, to lesser extents, cattle dung improved soil fertility and mung bean growth. Organic amendment CD:PD&FWC is, therefore, preferred to sole cattle-dung manure for improving the productivity of slash-and-burnt acid coarse-textured soils of the humid tropics.

Keywords: coarse-textured Ultisols, slashing and burning, cattle dung, poultry litter, fruit-waste compost, soil physicochemical properties, mung bean growth

Introduction

Different farmers in different parts of the world adopt different management practices to improve soil fertility and productivity. In southeastern Nigeria, slash-and-burn land clearing, which involves the cutting and burning of biomass, is a common practice. It is a convenient method of land clearing practiced by many smallholder farmers in Africa (Palm et al., 2005). When residues are burnt, irreplaceable ecosystem services are depleted (Dinesh et al., 2022). Thus, slash-and-burn practice adversely affects the environment via biodiversity loss due to the burning of natural vegetation, leaching losses, and soil erosion (Jara-Rojas et al., 2020; Doerr et al., 2022; Wang et al., 2022). Dinesh et al.

(2022) reported that biomass burning caused loss of ca. 2400 kg carbon, 35 kg nitrogen, 3.2 kg phosphorus, and 21 kg potassium from the soil. Such losses which are direct effects of biomass burning predispose the soil to a high risk of erosion (Doerr et al., 2022). The indirect effects could range from the accumulation of ash, alterations in vegetation coverage, and changes in water balance, ultimately influencing soil stability and the input of organic materials (Doerr et al., 2022). On the other hand, ashes are strongly alkaline which accounts for their ability to reduce soil acidity, boost microbial activity, and increase nutrients availability (Ohno and Erich, 2011). Several researchers have reported that slash-and-burn agriculture modifies the structure and physicochemical properties of the soil by improving the low inherent fertility status of soils (Are et al., 2009; Thomaz et al., 2014; Béliveau et al., 2015; Nwokeh et al., 2022), especially when ashes are added to the soil through burning practices. Ash addition to most acid tropical soils neutralizes the acid-forming cations to improve soil pH and ultimately crop growth (Paramisparam et al., 2021). Soil management practices such as use of organic amendments have been employed to further enrich and improve the productivity of soils affected by slashing and burning (Ojo et al., 2016; Khan et al., 2022; Onah et al., 2023). The benefits of this practice can last for months or years, emphasizing its impact on soil evolution, particularly in ecosystems that have developed to withstand regular fire disturbances (Doerr et al., 2022). Complementing slash-and-burn practices with organic amendments could thus potentially improve soil fertility on both short- and long-term bases, implying more sustainable agricultural productivity.

Cattle dung has been used as a soil amendment in agricultural systems for centuries. The addition of cattle-dung manure to soil provides several benefits by improving soil structure, low fertility, and increasing soil organic matter (McAndrews et al., 2006; Ezenne et al., 2019). Large amounts of organic matter from cattle dung provide energy sources for microbes and the microbes degrade macromolecular organic matter, promoting microbial nutrient recycling (Zhao et al., 2022). Onwuka et al. (2019) reported that cattle dung in its original form does not add much nutrients to the soil and takes time to release its nutrients unless they are transformed into other useable forms by converting it into compost or biochar. Cattle dung is usually of high carbon-nitrogen ratio of between 25 and 50 (Adubasim et al., 2018; Ndzeshala et al., 2023; Chukwuma et al., 2024), and fortifying it with nitrogen-rich inorganic fertilizers as urea can be even be more effective than its transformation (Ndzeshala et al., 2023). Because mineral fertilizers can have deleterious effects on the quality of the crop produced as well as on the environment (Basel and Atif, 2008), the potential of substitution of cattle dung with compatible organic amendments often used by smallholder farmers needs to be also investigated.

In soil fertility management under slash-and-burn agriculture, the potential of partially substituting cattle dung with more effective organic amendments relative to sole application of cattle dung has been poorly researched. In this study, we hypothesized that slashing and burning affects soil nutrients, and that cattle-dung manure could replenish the lost nutrients and improve soil productivity, more so when it is partially substituted with a mix of poultry droppings and fruit-waste compost. The objective was to explore the prospects of this substitution option for low-fertility soils of the humid tropics after slash-and-burn land-clearing practice by smallholder farmers, by agronomic evaluation (using mung bean as test crop) of the changes in soil physicochemical properties.

Materials and Methods

Study area, treatments, and experimental procedure

The study was carried out with soils from Lodu (7° 31' 27" N, 5° 30' 8" E) in Umuahia-North Local Government Area of Abia State, Nigeria. Lodu's climate is humid tropical, with the vegetation of a rainforest. The land was previously used to produce cassava and maize before leaving it under fallow for about 20 years. Using a soil auger, loose soils were collected from 0-20 cm depth of 10 randomly selected spots before smallholder woman mung bean (*Vigna radiata*) farmers cleared the bushy fallow by slashing and burning. This random sampling was repeated after the biomass burning, this time around, collecting larger quantities per spot. Pre- and post-burning soil samples were each bulked to get composite samples which were processed and preserved for laboratory analyses. The post-burning composite soil was used for screenhouse soil fertility trials at the Michael Okpara University of Agriculture (05° 29' N, 07° 33' E; 122 m asl), Umudike in Ikwuano Local Government Area of Abia State, Nigeria. Treatment for the study was implementation of four soil amendment options for the soil subjected to slash-and-burn practice by the smallholder farmers. The first was a 50% substitution of cattle dung with a mix of equal volumes of poultry droppings and fruit-waste compost (designated cattle dung with PD&FWC); others were cattle dung, NPK-15:15:15 and a control (burnt soil only). The two animal manures (cattle dung and poultry droppings) were sourced from the Teaching & Research Farm Unit of College of Animal Science & Animal Production, Michael Okpara University Agriculture, Umudike. They were cured by air-drying before use. The NPK-15:15:15 was sourced from the Ministry of Agriculture, Abia State, Nigeria.

Mung bean served as the test crop not just because of its cultivation by the smallholder woman farmers, but also because of its increasing popularity in tropical Africa as a major source of protein with numerous nutritional benefits (Opara and Agugo, 2014; Li et al., 2023). Viable seeds of the mung bean (variety, NM 94) used for the soil fertility trials were sourced from the Department of Agronomy, Michael Okpara University of Agriculture, Umudike.

The slash-and-burn affected soil for the screenhouse trials was air-dried, crushed and passed through a 2-mm-mesh sieve, after which 10 kg was placed into 12-L experimental pots (with each of height and internal diameter as 25 cm). Soil amendments were added two weeks before planting. Each of the cattle dung with PD&FWC and cattle dung alone was blended with the 10-kg soil at the rate of 10 t ha^{-1}, as recommended by Okutu et al. (2011), equivalent of which was 110 g per potted soil. The NPK-15:15:15 was also blended with the 10-kg soil at the rate of 125 kg ha^{-1} recommended by Omolayo and Ayodele (2009), the equivalent being 0.63 g per potted soil. Treatments were replicated five times in a completely randomized design and watered to field capacity. After two weeks in the nursery, three seedlings were transplanted per potted soil and later thinned down to two stands. The potted soils were watered to field capacity at two-day intervals till the end of the trials.

Determination of mung bean plant growth and yield parameters

At 2, 4, 6, 8, and 10 weeks after sowing, plant height was measured from the soil surface to the tip of the longest leaf using a standard meter rule. Mung bean plants were harvested 10 weeks after sowing. After washing to remove soil particles, the number of root nodules was manually counted, and the root length was measured. The fresh roots and shoots were placed in paper bags and oven-dried at 65 °C for 24 h after which the weights of the root dry matter and shoot dry matter were determined using an electronic balance.

Soil sampling at the termination of mung bean growth

Sampling of the potted soils was done at the end of the ten-week growth period of mung bean. These soil samples were air-dried to constant weight and then crushed. Together with those collected earlier from the field before and after burning which were processed and preserved, they were passed through a 2-mm mesh before laboratory analyses.

Analyses for soil physicochemical properties

The physical and physicochemical properties of the soil were determined following standard laboratory procedures as chronicled in Udo et al. (2009). Particle size distribution of the soil was determined by Bouyoucous hydrometer method using Calgon as a dispersing agent. Soil pH was determined in a 1:2.5 soil-water ratio using a combined glass electrode. Soil organic carbon was determined by the Walkley-Black wet dichromate-oxidation method, and the value multiplied by 1.724 to derive the soil organic matter. Available phosphorus was extracted using the Bray-I reagent and subsequently determined in the extract using the molybdate blue method. Total nitrogen was determined by the Macro-Kjeldahl method. Exchangeable bases (K^+, Ca^{2+}, Mg^{2+} and Na^+) were determined by extracting soil samples with 1N NH_4OAc buffered at pH 7.0. Exchangeable acidity was determined by the titrimetric method following extraction with IN KCl. Effective cation exchange capacity (ECEC) was calculated by summation of exchangeable bases and the exchangeable acidity (H^+ and Al^{3+}). Base saturation was calculated as the percentage ratio of the four exchangeable bases to the ECEC.

Statistical analysis

One-way analysis of variance suitable for a completely randomized design was done on the soil and agronomic data using the software GenStat Discovery Edition 1 Release 4.23 (Rothamsted Research Center, UK). In this inferential analysis of the data, mean separation was achieved by the least significant difference at a probability level of ≤ 0.05 ($LSD_{0.05}$).

Results and Discussion

Pre-amendment properties of the soil and properties of the organic amendments

Table 1 shows the properties of the soil before and after the biomass burning, as well as the properties of the cattle dung with PD&FWC and cattle dung. The texture class, sandy loam, is deemed generally suitable for mung bean production (SADAFF, 2010). Soil texture is not easily affected by burning since sand, silt and clay exhibit high-temperature thresholds (Alcaniz et al., 2018). The soil pH-H_2O of 5.90 is suitable whereas soil organic carbon and total nitrogen were rated low for most crops, according to Landon (1991). The slash-and-burn clearing of the land done before the screenhouse soil fertility trials increased the soil pH to 7.4, indicating that burning ameliorates soil acidification. Ubuoh et al. (2017) reported increased soil pH in burnt

TABLE 1

Physicochemical properties of the sandy-loam soil before and after burning and chemical composition of the organic amendments added to the burnt soil

Parameters	Soil before burning	Soil after burning	Cattle dung with PD&FWC	Cattle dung
Texture class	Sandy loam	Sandy loam	-	-
Sand (g kg^{-1})	726	788	-	-
Silt (g kg^{-1})	149	134	-	-
Clay (g kg^{-1})	125	138	-	-
Soil pH - H2O/KCl	5.9/5.1	7.4/4.9	6.80	6.40
Organic Carbon (g kg^{-1})	30.60	27.30	152.6	414.2
Total Nitrogen (g kg^{-1})	1.80	0.90	19.8	18.8
Avail. Phosphorus (mg kg^{-1})	19.80	16.50	1.83	1.72
Exch. Potassium (cmol kg^{-1})	0.30	0.32	2.49	2.26
Exch. Calcium (cmol kg^{-1})	5.00	5.60	0.89	0.83
Exch. Magnesium (cmol kg^{-1})	2.80	3.60	-	-
Exch. Sodium (cmol kg^{-1})	0.25	0.28	-	-
Exch. Acidity (cmol kg^{-1})	0.80	0.92	-	-
Exch. Aluminium (cmol kg^{-1})	0.26	0.32	-	-
ECEC (cmol kg^{-1})	9.15	10.72	-	-
% Base saturation	91.26	91.42	-	-

Cattle dung with PD&FWC stands for a 50% substitution of cattle dung with a mix of equal volumes of poultry droppings and fruit-waste compost plots relative to unburnt ones at 0-15 cm depth. Increases in pH of burnt soil relative to unburnt soil are because of ash deposits from burnt plants (Bird et al., 2000; Snyman, 2004; Badia et al., 2014), and this applies to slash-and-burn practice (Costa et al., 2022).

Also, the biomass burning slightly and pronouncedly decreased soil organic carbon and total nitrogen contents of the soil, respectively. Burning-induced changes in soil organic matter vary depending on burning type and intensity, available biomass, burning duration, and antecedent soil moisture content (Reyes et al., 2015). The more commonly reported observation is decreases in soil organic carbon and total nitrogen following biomass burning (Dinesh et al., 2022; Doerr et al., 2022). Costa et al. (2022) reported appreciable reductions in soil organic matter content after an intensive slash-and-burn practice. However, Ubuoh et al. (2017) reported an increased soil total nitrogen due to burning in a Nigerian rainforest zone.

Soil available phosphorus was only slightly reduced by the slash-and-burn practice, even with the increases in soil pH and organic carbon. This shows that such increases may not always cause the transformation of organic phosphorus to inorganic phosphorus and dissolution of phosphorus from ashbeds (Agbeshie et al., 2022). Contrary to our findings, Ubuoh et al. (2017) and Tanzito et al. (2020) reported that burning led to increases on available phosphorus. The cations exchange properties generally indicated similar values before and after the biomass burning. Soil ECEC was moderate, while base saturation was high (Landon, 1991). Our data contradict Tanzito et al. (2020) who reported increases in soil exchangeable bases following slashing and burning. In the present study, the burning slightly decreased soil organic carbon. The inability of the slash-and-burn practice to increase the exchangeable bases was probably because of this no increase in soil organic carbon to complement the elevated soil pH due to the associated addition of ash (Agbeshie et al., 2022).

Cattle dung with PD&FWC showed slightly higher values of pH in water, organic carbon and contents of plant nutrients compared with cattle dung (Table 1).

Treatment effects on soil pH, soil organic matter and nitrogen and phosphorus fertility

Soil pH, soil organic matter, total nitrogen, available phosphorus as affected by application of cattle dung with PD&FWC, cattle dung and NPK-15:15:15 to the sandy-loam Ultisols under the slash-and-burn land-clearing practice are shown (Table 2). These four soil physicochemical properties showed significant differences among the four treatments. The highest soil pH value was recorded with cattle dung with PD&FWC, followed by cattle, indicating that the former was the best for ameliorating soil acidity. The lowest value from the control (4.7) represented a drastic decrease from the initial value after burning (7.4; see Table 1). Residual ashes from slash-and-burn practices raise soil pH, increase basic cations, and enhance carbon content of the soil, during the initial months following the burning (Neto et al., 2019). The present

TABLE 2

Effects of cattle dung with PD&FWC, cattle dung and NPK-15:15:15 on soil pH and soil organic matter, total nitrogen and available phosphorus contents of the sandy-loam Ultisols subjected to slash-and-burn land-clearing practice in the tropical rainforest

Treatments	pH-H_2O	SOM content	Total nitrogen	Available phosphorus
		(g kg^{-1})		(mg kg^{-1})
Cattle dung with PD&FWC	5.9	33.70	2.00	25.15
Cattle dung	5.5	29.80	1.70	21.35
NPK-15:15:15	4.8	28.10	1.60	22.85
Control	4.7	14.20	0.70	16.53
$LSD_{(0.05)}$	0.10	0.80	0.10	0.57

PD&FWC - a mix of equal volumes of poultry droppings and fruit-waste compost; SOM - soil organic matter observation suggests that such effects can be ephemeral. However, there are two factors in soil acidity that cannot be neglected. The first is increases in soil acidity levels due to the influence of crop growth (Randrianarison et al., 2016). The second is the tendency for the conventional pre-analysis drying of soil samples to increase in soil acidity (Obalum and Chibuike, 2017), which was bound to be less evident for the burnt soil compared to the wetter potted soils.

Treatment affected soil organic matter content (Table 2). Cattle dung with PD&FWC gave the highest values, followed by cattle dung which was closely followed by NPK-15:15:15, while the un-amended control gave the lowest values. Soil total nitrogen varied significantly among the treatments in a somewhat similar manner as soil organic matter content. According to Amapu et al. (2018), the levels of total nitrogen in the amended potted soils are sufficient suggesting effective organic matter decomposition and nutrients release especially in those with organic amendments. The present slash-and-burn practice increased soil total nitrogen by over 27 times (see Table 1). Low content of soil total nitrogen may be attributed not only to leaching processes and runoff (Mulvaney et al., 2016), but also to volatilization particularly in the warm tropics. However, our data suggest that appropriate soil amendments are needed to partially compensate for losses in initially high soil total nitrogen induced by biomass burning.

There were significant differences in soil available phosphorus among the treatments (Table 2). It ranged from 16.53 to 25.15 mg kg^{-1} with cattle dung with PD&FWC recording the highest value followed by NPK 15:15:15 while the control recorded the lowest value. Because phosphorus availability influences root system architecture and nutrient uptake even in the short term, an adequate supply of phosphorus in the soil is essential for optimum mung bean growth and productivity (Htwe et al., 2023). Notably, burning caused a marginal decrease in soil available phosphorus (see Table 1), but complementing it with soil amendments significantly improved available phosphorus content of the soil.

Treatment effects on cation exchange properties under slash-and-burn practice

The data for the exchangeable bases, acidity, and effective cation exchange capacity (ECEC) are shown in Table 3. They all differed significantly among the four treatments. The content of exchangeable potassium (K^+) was higher in all amended soils relative to the control. Cattle dung with PD&FWC and the control gave the highest and the lowest K^+ contents of 0.43 and 0.23 cmol kg^{-1}, rated moderate and low, respectively by Amapu et al. (2018). Thus, unlike cattle dung with PD&FWC, the control represents inadequate potassium supply to plants.

The soil exchangeable calcium (Ca^{2+}) ranged from 3.30 cmol kg^{-1} in the control to 9.58 cmol kg^{-1} due to cattle dung with PD&FWC. Treatment also affected exchangeable magnesium (Mg^{2+}) of the soil. The highest and lowest values were recorded in potted soils that received cattle dung with PD&FWC (3.67 cmol kg^{-1}) and the unamended control (1 cmol kg–1). Application of cattle dung with PD&FWC and cattle dung increased the Mg^{2+} content of the soil. Because of the positive role of magnesium in seedling performance (Baiyeri and Aba, 2013), it can be considered an important index of soil fertility.

TABLE 3

Effects of cattle dung with PD&FWC, cattle dung and NPK-15:15:15 on soil exchangeable bases and acidity including the cation exchange capacity and base saturation under slash-and-burn land-clearing practice for sandy-loam soils of the tropical rainforest

Treatments	K^+	Ca^{2+}	Mg^{2+}	Na^+	EA	ECEC	% BS
	(cmol kg^{-1})						
Cattle dung with PD&FWC	0.43	9.58	3.67	0.33	0.36	14.37	97.49
Cattle dung	0.38	7.75	3.00	0.30	0.47	11.90	95.92
NPK-15:15:15	0.37	6.08	2.65	0.29	1.09	10.47	89.58
Control	0.23	3.30	1.00	0.17	1.10	5.79	81.06
LSD $_{(0.05)}$	0.01	0.40	0.19	0.004	0.03	0.36	0.49

PD & FWC - a mix of equal volumes of poultry droppings and fruit-waste compost;
EA - exchangeable acidity, ECEC - effective cation exchange capacity, BS - base saturation

This trend for the three plant-nutrient exchangeable bases (Ca^{2+}, Mg^{2+} and K^{+}) was sustained for the exchangeable sodium (Na^{+}) content of the soil. The exchangeable acidity of the treatment amendments was dominated by H^{+} with Al^{3+} occurring in traces. Lower values of the exchangeable acidity were recorded due to cattle dung with PD&FWC than cattle dung which in turn showed lower values than NPK-15:15:15 and the control. Apart from the control, all treatments showed ECEC of above 10 cmol kg^{-1}, differing thus NPK-15:15:15 < cattle dung < cattle dung with PD&FWC. Increases in soil contents of exchangeable bases following biomass burning have been shown not to be evident after one cropping season (Tanzito et al., 2020). The present study shows that the use of cattle dung with PD&FWC can contribute to improving the exchangeable bases contents of soils exposed to biomass burning.

The percent base saturation of the soil differed thus control < NPK-15:15:15 < cattle dung < cattle dung with PD&FWC (Table 3). The value due to NPK-15:15:15 of 89.58% is similar to the post-burning value of 90.90% (see Table 1), suggesting that soil amendments are needed to bring the base saturation to or above its post-burning values. Overall, our data suggest that cattle dung with PD&FWC or, where not feasible, cattle dung can be used to maintain high levels of soil fertility of coarse-textured tropical soils under slash-and-burn agriculture.

Treatment effects on mung bean plant height under slash-and-burn practice

During 2-10 weeks after sowing, potted soils that received cattle dung with PD&FWC and cattle dung alone showed taller mung bean plants compared to NPK-15:15:15 amended ones and the control (Figure 1). These differences were so distinct that, at 10 weeks after sowing, the plants in potted soils having cattle dung with PD&FWC were about 108% taller than those of the control. These results can be attributed to the improved soil nutrients availability and plant root development due to cattle dung with PD&FWC and cattle dung alone.

Treatment effects on mung bean root nodulation under slash-and-burn practice

The effects of soil amendments on the number of root nodules of mung bean showed significant differences (Figure 2). Potted soils that received cattle dung with PD&FWC gave the highest value of root nodulation (415), followed by cattle dung-amended potted soils. The NPK and control had the lowest values. These increases could be attributed to the higher release of nutrients in the cattle dung

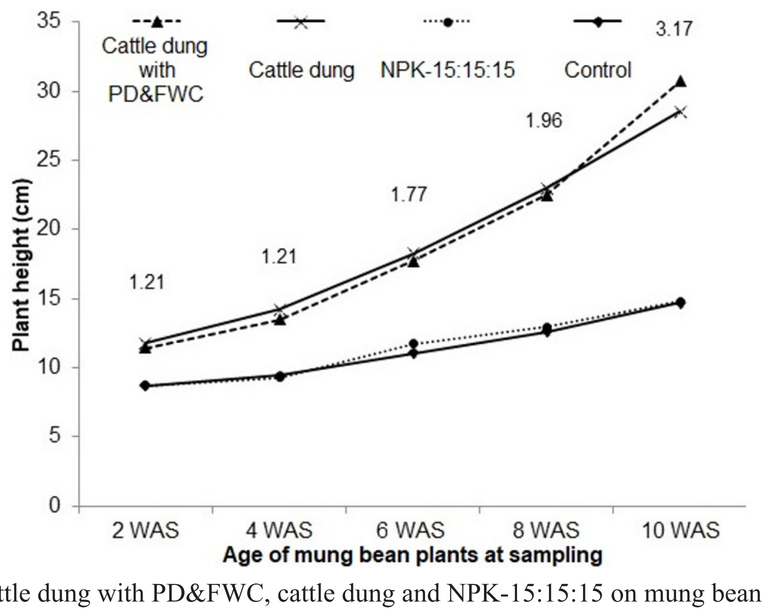

Fig. 1 Effects of cattle dung with PD&FWC, cattle dung and NPK-15:15:15 on mung bean plant height under slash-and-burn practice for sandy-loam soils of the tropical rainforest
PD&FWC - a mix of equal volumes of poultry droppings and fruit-waste compost; WAS - weeks after sowing
The numbers against the ages of the crop represent least significant difference at 0.05 ($LSD_{0.05}$)

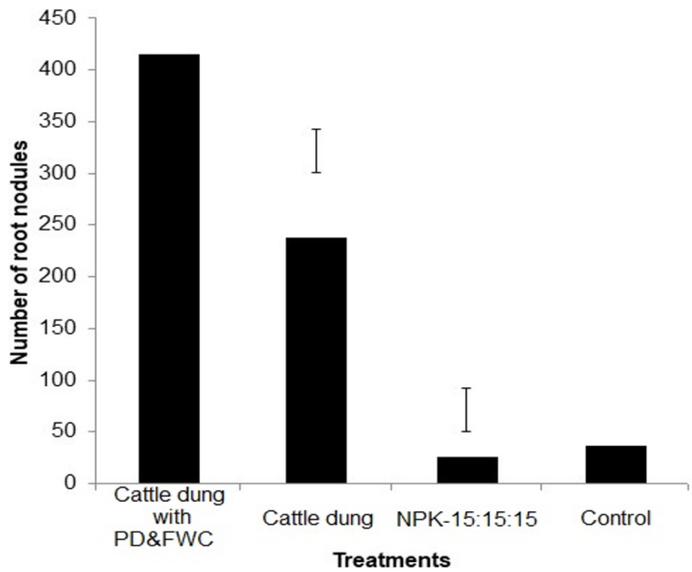

Fig. 2 Effects of cattle dung with PD&FWC, cattle dung and NPK-15:15:15 on mung bean root nodulation under slash-and-burn practice for sandy-loam soils of the tropical rainforest
PD&FWC - a mix of equal volumes of poultry droppings and fruit-waste compost
Least significant difference at 0.05 ($LSD_{0.05}$)

with PD&FWC and cattle dung. As noted by Htwe et al. (2023), an adequate supply of phosphorus influences the root system architecture of mung bean even in the short term. Our findings agree with Shrabani and Vipin (2012) who reported increases in root nodules and growth attributes of mung bean with a combination of bio-compost, vermicompost, fry ash, and bio-fertilizers compared to the control.

Treatment effects on mung bean biomass production under slash-and-burn practice

The effects of treatment on root growth attributes of the mung bean plants are shown (Table 4). Cattle dung resulted in longer roots compared to cattle dung with PD&FWC which was similar to NPK-15:15:15 but higher than the control treatment. However, both cattle dung and cattle dung with PD&FWC produced higher dry root biomass of mung bean plants compared to NPK-15:15:15 and the control. In sum, cattle dung application enhanced mung bean rooting, with application of cattle dung with PD&FWC as a very close substitute.

Treatment also affected shoot dry matter thus cattle dung with PD&FWC > cattle dung > NPK-15:15:15 = control. The NPK-15:15:15, by producing similar shoot dry matter as the un-amended control, was not effective in this study. The use of NPK fertilizers in mung bean production has been reported to improve soil quality and increase the productivity of the crop under West African conditions (Hussain et al., 2011). This was not the case in our study, suggesting that fertilizer application rate here (125 kg ha^{-1}) was rather low for the soil and/ or that such use of NPK fertilizers may not be

TABLE 4

Effects of cattle dung with PD&FWC, cattle dung and NPK-15:15:15 on mung bean rooting and dry matter under slash-and-burn practice for sandy-loam soils of the tropical rainforest

Treatments	Root length	Root dry matter	Shoot dry matter
	(cm)	(g pot^{-1})	
Cattle dung with PD&FWC	20.28	2.74	37.80
Cattle dung	22.50	3.27	23.20
NPK-15:15:15	18.89	0.75	6.10
Control	18.06	0.65	5.80
$LSD_{(0.05)}$	*2.12*	*0.87*	*10.34*

PD&FWC - a mix of equal volumes of poultry droppings and fruit-waste compost suitable in slash-and-burn farming. Somewhat contrary to our data from the current situation of burning in-situ to release/add ash to the soil before applying soil amendments, Nwite et al. (2013) reported that externally added ash was, in terms of crop response, not compatible with organic amendment but with NPK-15:15:15.

The effectiveness of cattle dung with PD&FWC in this study as regards mung bean growth and productivity could be linked to its nutrient composition and ability to improve soil health towards sustaining crop production in tropical soils (Gupta et al., 2016). This treatment being a 50% substitution of cattle dung with a mix of equal volumes of poultry droppings and fruit-waste compost surpassed cattle dung even as they were used at the same rate (10 t ha^{-1}). These results conform to the concept of facilitating the slow-mineralizing cattle dung towards enhancing its soil manurial value and hence utilization in agriculture (Ndzeshala et al., 2023). In their agronomic evaluation of the effects of some organic amendments using growth attributes of mung bean, Ard and Yasin (2017) reported that soil-incorporated manure was effective in increasing most of those crop growth attributes and yield of mung bean. Notably, cattle dung with PD&FWC and cattle dung alone were similar in terms of plant height, root length and root dry matter. This shows that, within the context of complete organic agriculture in the humid tropics, there is prospect in not complementing such hard-to-decompose organic waste as cattle dung with the universally effective poultry droppings, especially if ample time is allowed between their soil application and planting (Ugwu et al., 2020).

For soils of the humid lowlands of sub-Saharan Africa Pypers et al. (2012) demonstrated that slashing and burying (instead of burning) of the natural vegetation complemented with mineral fertilizers was, from agronomic production standpoint, superior to slash-and-bury or slash-and-burn practice without such complementation. The present study on soil amendment-based management of soils affected by the unsustainable slash-and-burn practice appears to suggest that mineral fertilizers are ineffectual in such soils. The composition of the alternative (organic amendments) is yet another factor. The cattle dung with PD&FWC used here which was a composite of cattle dung and poultry droppings cum fruit-waste compost generally outperformed cattle dung used solely. This suggests that mixing both slow- and fast-mineralizing manures which cattle dung and poultry droppings represent, respectively (Chukwuma et al., 2024) with the more readily mineralized composts is a viable option.

It could be, however, that the effectiveness of cattle dung with PD&FWC in this study lies with its PD&FWC component especially as this organic amendment mix represented equal volumes of poultry droppings (PD) and fruit-waste compost (FWC) (Ebido et al., 2024). Though this supposition appears to render skeptical the adoption of cattle dung with PD&FWC, we recommend it for soil fertility management of coarse-textured tropical soils regularly subjected to slash-and-bush practice or seasonal biomass burning, pending its validation. The research to validate cattle dung with PD&FWC for slash-and-bush agriculture has to include, as a treatment PD&FWC at half its soil application rate, among others, while also staggering the timing of application of cattle dung and poultry droppings because of their contrast in mineralization speed and pattern (Chukwuma et al., 2024).

Since it is all about enhancing the manurial value of the slow-mineralizing cattle dung, the suggested future study could also have 'cattle dung fortification with urea' as a treatment (Ndzeshala et al., 2023). This way, the cost and inconveniences associated with the different effective options for enhancing cattle dung's manurial value should be analyzed.

Conclusion

Our results show that slash-and-burn land-clearing method negatively impacts soil properties - lowering soil pH, soil organic matter, total nitrogen, available phosphorus, and base saturation. However, post-burning addition of cattle dung with poultry droppings cum fruit-waste compost (PD&FWC) improved soil pH, soil organic matter, total nitrogen, available phosphorus, and cations exchange thereby enhancing the overall fertility of the soil. These positive effects on soil properties reflected in mung bean performance. Cattle dung with PD&FWC is, therefore, recommended for improving the productivity of coarse-textured soils of the humid tropics under slash-and-burn agriculture. Sustainable crop production on these soils after the biomass burning thus requires a soil fertility management plan aimed at increased nutrients release from organic matter added via assorted agro-wastes with substrates of contrasting composition and mineralization attributes. It is only when this option is not possible that farmers can settle for sole application of cattle dung that is a slow-mineralizing manure. Further research is suggested to validate cattle dung with PD&FWC for slash-and-bush agriculture in the humid tropics.

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