Importance of various organic materials in lowland rice production systems in the forest zone of Ghana

Issaka R.N.,[1] Buri M.M.,[1] Nakamura S.,[2] Tobita S.,[2] and Essien A.[1]

[1] CSIR-Soil Research Institute, Academy Post Office, Kwadaso-Kumasi. Ghana.

[2] Japan International Research Center for Agricultural Sciences, Tsukuba, Japan.

INTRODUCTION

Low inherent soil fertility has been identified as a major cause for low rice yield in Ghana (Buri *et al*., 2009; Issaka *et al*., 1997). The problem is compounded by the fact that farmers are not able to control water and purchase sufficient mineral fertilizer owing to the high cost. Therefore, farmers mostly rely on natural soil fertility, which is not only low, but also declining, resulting in poor rice yields. Large amounts of organic materials that can be used either solely or in combination with mineral fertilizers in rice production are plentiful in the forest zone of Ghana (Issaka *et al*., 2011). These materials have shown to be effective in increasing rice yield, especially when combined with mineral fertilizer. Improving soil fertility necessitates that such cheaper alternative organic materials are identified. In this study, both on-station and on-farm investigations were conducted using such organic materials, and some of the results are presented herein.

MATERIALS AND METHODS

A survey was conducted in 2008 to determine the sources, types, and quantity of organic materials available in Ghana. A series of on-station and on-farm trials were also conducted between 2010 and 2012 at several sites by using various locally available organic materials listed in Table 1.

Table 1 Availability and sources of organic materials in Ashanti region

Organic material	Sources	Estimated quantities (t)
Poultry manure	Poultry farms	20,000
Rice straw	Rice fields	32,000
Rice husk	Rice mills	5,000
Saw dust	Saw mills, Carpentry shops	NA

Source: Issaka *et al*. (2011). NA: not available

Saw dust is abundant in Ashanti, Brong Ahafo, and the Western and Eastern regions of Ghana and is generally concentrated around saw mills. It is commonly disposed off through burning.

RESULTS AND DISCUSSION

Sources and availability of organic materials

Large amounts of organic materials (rice straw/husk, poultry manure (PM), and saw dust) are available in Ghana (Table 1). At present, poultry manure is widely used by both maize and vegetable farmers, but not by rice farmers. Rice straw is abundantly present on rice fields and is usually burnt or left to decompose around the edges of rice fields. Farmers do not attempt to incorporate it into their rice fields, but rather prefer mineral fertilizers. Because mineral fertilizers are very expensive, many farmers cannot afford them, leading to very low application rates.

Effect of organic material application on lowland rice yield

The effect of PM, saw dust char, and rice straw ash on rice yield is shown in Table 2. Application of rice straw ash (RS-Ash) or saw dust char (CHSD) significantly improved panicles·plant^{-1} and panicles·m^{-2}. Grain yield was significantly higher when organic material was applied. PM performed better than both CHSD and RS-Ash, which are cheaper alternatives to chemical fertilizer, because they are waste and generally burnt or allowed to decompose. Raw saw dust is not effective probably because it is very high in C/N and might require high rates of N to avoid poor plant growth.

Various organic resources showed significant positive effects (Tables 2 and 3). PM showed the highest effectiveness on lowland rice. RS and SD at appropriate levels also showed positive effect on improving lowland rice production.

Table 2 Effect of poultry manure, saw dust char, and rice straw ash on yield parameters.

On-station trial

Organic matter (OM)	Plant height (cm)	No. of stand·m^{-2}	Number of panicles·plant^{-1}	No. of panicles·m^{-2}	Stover yield (t·ha^{-1})	Grain yield (t·ha^{-1})
No-OM	129.6a	24.6a	2.0c	148c	4.5c	3.4c
CHSD	128.9a	24.7a	2.4b	167b	5.3b	4.3b
RS-ash	129.0a	24.7a	2.3b	161b	5.3b	4.3b
PM	130.1a	24.6a	2.9a	194a	6.6a	5.7a

No-OM: no organic matter applied; CHSD: charred saw dust; RS-ash: rice straw ash; PM: poultry manure. Within a column, values followed by the same letters are not significantly different by a margin of the standard error.

Table 3 Yield parameters affected by rice straw and charred saw dust.

On-farm trial

Organic material	Plant height (cm)	No. of stand ·m^{-2}	Number of panicles ·plant^{-1}	No. of panicles ·m^{-2}	Stover yield (t·ha^{-1})	Grain yield (t·ha^{-1})
Control	123b	28.0a	2.0b	198a	5.2c	3.4c
2 t·ha^{-1} RS	126a	27.0a	3.0a	216a	6.6b	5.8b
2 t·ha^{-1} CHSD	126a	27.0a	3.5a	241a	6.4b	5.4b
2 t·ha^{-1} PM	123b	26.0a	3.5a	200a	7.3a	6.3a

RS: rice straw; CHSD: char saw dust; PM: poultry manure. Within a column, values followed by the same letters are not significantly different by a margin of the standard error.

Application of rice straw and its derivatives (at 2 t·ha^{-1} + 30 kg N·ha^{-1}) showed comparable grain yield as that for mineral fertilizer (Figure 1), indicating that these organic materials can be used as alternative to mineral fertilizer.

The effect of integrating PM and sole application of poultry or mineral fertilizer on rice grain yield is shown in Figure 2. The application of 4 t·ha^{-1} PM + 30 kg N·ha^{-1}, 2 t·ha^{-1} PM + 22.5:15:15 kg N-P_2O_5-K_2O·ha^{-1}, and 90-60-60 kg N-P_2O_5-K_2O·ha^{-1} showed similar grain yield, which was

significantly higher than that obtained in the other treatments. Application of PM (4.0 t·ha^{-1} and above) showed strong residual effect, resulting in significantly higher yield than that after the application of sole mineral fertilizer. In contrast, 90-60-60 kg N-P_2O_5-K_2O·ha^{-1} showed definitely weak residual effect compared with that after the application of PM.

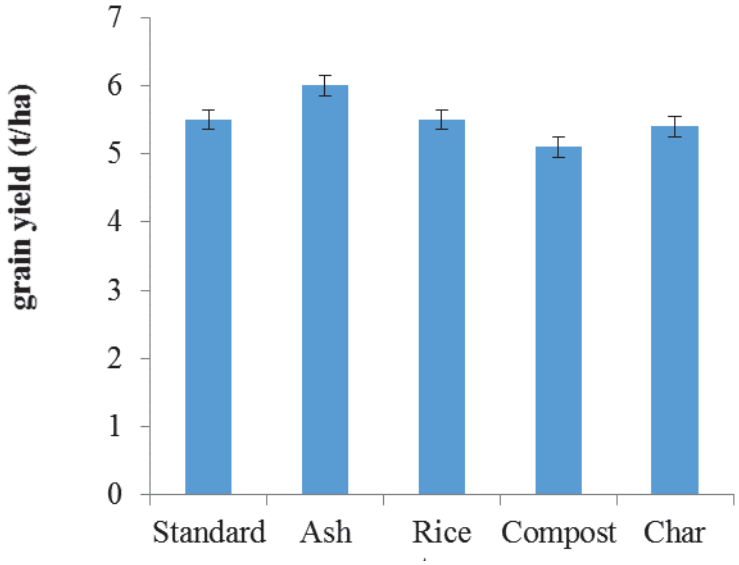

Figure 1 Effect of organic materials and mineral fertilizer on rice grain yield.
Standard: 90-60-60 kg N: P_2O_5: K_2O; Rice straw, Ash, Rice straw compost, and Saw dust char

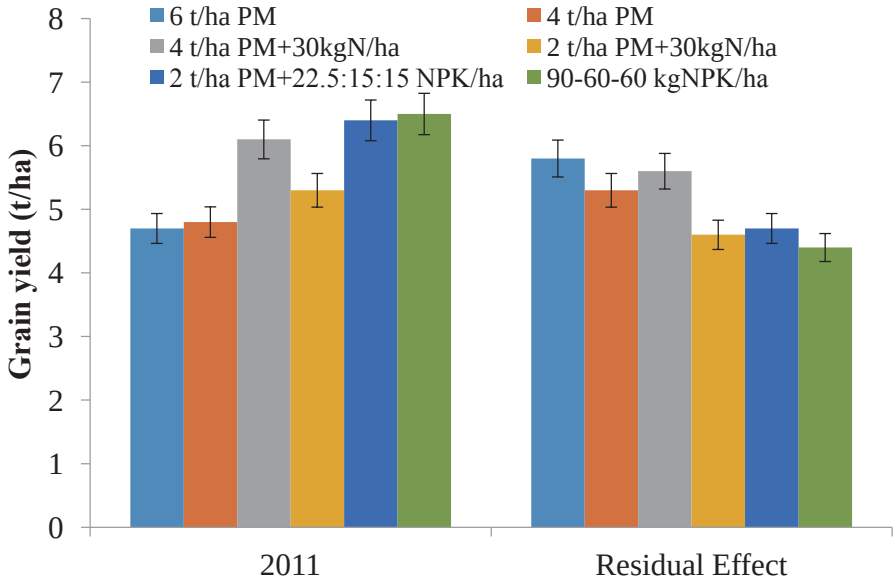

Figure 2 Effect of integrating mineral fertilizer and poultry manure on rice grain yield

CONCLUSION

Plant resources such as rice straw and saw dust were found to be useful as effective alternatives to mineral fertilizer for lowland rice cultivation in the forest zone. PM showed the highest effectiveness, followed by RS and SD; SD needs to be charred before application. Further investigations need to be performed to determine the appropriate rates for the application of these organic material combinations.

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