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Rice husk biochar improves productivity of sandy soils in Central Coastal Vietnam

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Introduction

Central coastal Vietnam has more than 500,000 ha of sandy soils and a tropical monsoon climate characterized by 8-9 months of hot dry season. Most farmers use irrigation during the dry season to grow field and tree crops. The sands are very low in organic carbon and so have low water and nutrient holding capacities. Farmers in this region use animal manures and NPK fertilizers for soil improvement and are also amongst the poorest in Vietnam. Vietnam produces more than 20 M tonnes pa of rice which provides an organic waste resource of 3-4 M tonnes pa of rice husk. Rice husk stoves which produce a biochar byproduct have been used in Vietnam for many years. The biochar from these stoves is approximately 30% carbon. This research is evaluating this rice husk biochar (RHB) as an amendment for infertile sandy soils to improve crop productivity and farmer incomes.

A field trial was established in Binh Dinh in 2009 to evaluate the effect of rice husk biochar on peanut yields and nutrient use efficiency. The soil is an arenosol with more than 85% sand. The treatments were T1= nil NPK + nil manure, T2= NPK + nil manure, T3= nil NPK + manure, T4= NPK + manure, each applied with and without rice husk biochar giving a total of eight treatments. Fertilizer was applied as NPK (30N, 60P205, 90K20 kg/ha); manure at 5 t/ha and biochar at 20 t/ha. The manure and biochar were incorporated into the soil prior to planting. Lime (500 kg/ha) was applied to all plots. Treatments applied to 2x5 m plots and replicated 3 times in a random complete block design. The plots were irrigated using hand held hose every 2-3 days. Soil moisture was measured in each plot every 7-8 days at 0.1, 0.2 and 0.3 m depth during each crop production period using a portable soil capacitance probe. Soil was sampled at the end of each crop to assess soil organic matter (SOM) content (Walkely Black) and soil nutrients. Plant biomass and pod yield were assessed at harvest. Biomass was analyzed for nitrogen (N), phosphorous (P) and potassium (K) and nutrient uptake assessed from plant concentration and biomass amount.

Results and Discussions

This paper reports the effects of treatments on production, crop nutrient uptake soil moisture and SOM (Table 1). Peanut yields increased significantly ($p<0.05$) from 0.99 ton/ha in response to additions of NPK, manure and RHB with 2 ton/ha achieved when RHB, NPK and manure were combined. A similar response was observed in above ground plant dry matter assessed prior to harvesting with 1.47 ton/ha harvested from nil input plots, increasing to 2.59 tons/ha from soils amended with RHB + NPK + manure. Increases in crop production from adding biochars to soil have been observed in many studies however, this study is one of only a few to have demonstrated gains in production in response to soil amended with RHB.

The differences in crop uptake of N were relatively small between treatments, as would be expected with a legume that balances its N content by supplementing soil N with atmospheric N. A significant increase in crop uptake of N was observed for the RHB + NPK + manure treatment. This increase corresponded to a dry matter biomass response of a similar magnitude rather than an increase in plant concentration. Treatment responses to crop uptake of P and K were much more obvious especially when biochar and NPK were combined with each other (P=15.1 kg/ha; K=38.8 kg/ha) and biochar and NPK were combined with manure (P=15.5 kg/ha; K=42.3 kg/ha). The apparent improvement in crop uptake of fertiliser, P and K in particular, appears to have been the primary factor driving increased crop production in response to amending this low fertility sandy soil with RH biochar.

No differences in the status of soil macro nutrients were observed post-harvest which

indicates most nutrients added to the soil as fertiliser, manure or RHB were either leached or taken up by the crop. Evidence indicates that, to varying degrees, biochars slow nutrient leaching and improve soil nutrient retention by sorption and by holding water containing dissolved nutrients within their porous structure (Major et al. 2009). It is possible that both these processes were operating in the RHB amended soils sufficiently to extend the duration that nutrients were available for plant uptake. This provides a feasible explanation for gains in yield and biomass.

A repeated measures analysis of soil moisture indicated that there was a trend toward increasing soil moisture to 20cm depth in plots amended with manure and RHB over the 12 week period. A comparison of predicted mid-point (i.e. 6 week) soil moisture values (Table 1) indicated that only the nil input and RHB + NPK + manure treatments came close to being significantly different. The trend toward increasing soil moisture coincided with significant increases ($p<0.05$) in soil organic matter in manure and biochar amended soil. This indicates that a secondary benefit from amending sandy soil with RHB may be increased SOM which would lead to further improvements in soil water and nutrient retention over time. This will be explored further in future work.

Table 1. Production, crop nutrient uptake and soil responses to rice husk biochar, NPK and manure treatments.

Treatments			Production		Crop nutrient uptake			Soil	
Rice husk biochar	NPK	Manure	Pod yield (ton/ha)	Biomass[++] (ton/ha)	N (kg/ha)	P_20_5 (kg/ha)	K_20 (kg/ha)	SOM[+] (%)	Moist* (mm)
-	-	-	0.99	1.47	21.9	6.3	5.6	0.25	13.5
-	✓	-	1.53	1.80	20.1	10.6	22.4	0.33	14.6
-	-	✓	1.58	1.60	19.5	9.5	15.6	0.55	14.0
	✓	✓	1.60	1.96	19.0	11.2	27.2	0.58	15.1
✓	-	-	1.66	1.90	22.9	10.7	13.8	0.63	14.1
✓	✓	-	1.88	2.12	22.8	15.1	38.8	0.70	14.8
✓	-	✓	1.66	1.97	16.1	9.6	19.2	0.69	14.8
✓	✓	✓	2.00	2.59	30.6	15.5	42.3	0.84	15.5
LSD			0.30	0.23	7.7	4.1	10.8	0.11	2.2

[++] Biomass assessed as aboveground dry matter

[+] Walkley and Black soil organic matter

[*] Predicted mid-point soil water content to 20cm depth estimated from a repeated measures analysis.

Conclusions

Rice husk biochar appears to be an effective soil amendment for increasing the production of peanuts grown in infertile sandy soils through improving efficiencies in crop fertiliser uptake. Greatest yield improvement was found in the biochar plus NPK plus manure treatment. Other benefits such as increased soil organic matter, leading to improved soil water retention, may also result from amending sandy soils with rice husk biochar.

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[1] Major et al. 2009. In Lehman J, Joseph S. eds. Biochar for Environmental Management. Earthscan, London.