Effect of Organic Amendments on Sweet Potato Yield in Calcareous Sandy Soil of Samoa

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Abstract: A five-month field experiment was conducted to investigate the effects of organic amendments (gliricidia, gliricidia + biochar and poultry litter along with a control) on two improved sweet potato cultivars (IB/PH/03 and IB/PR/13) on calcareous sandy soil in a factorial arrangement of treatments in a RCBD with four replications. Storage root yield, DM content and nutrient uptake were significantly improved when organic amendments were applied with the highest attained at the gliricidia + biochar treatment. Higher storage and DM and nutrient uptake of IB/PH/03 over IB/PR/13 proved of its higher adaptability.

Introduction: Calcareous soils in Samoa were developed from limestone sands recently (Wright, 1963). The prevalence of comparatively fertile soil types (latosols and lithosols) (Wright, 1963) made this soil rarely used for cropping as it has many limitations. In the foreseeable future, however, land scarcity due to competition from human occupations and agricultural developments would mean such marginal soil must not be left unused especially when food security is a pressing problem. To fully utilise this soil, a feasibly sound fertilisation scheme must be adopted.

Apparently, it is less-useful to promote synthetic fertilisers in Samoa where farmers' purchasing power are reduced by their exorbitant imported cost (Hunter *et al.*, 1997; Chand, 2002) and associated leaching problems. Therefore, amending soils with organic fertilisers could be a useful alternative. However, fertilising potential of copious organic resources are not known in Samoa. In addition, information on crop yield in response to such innovation is also scarce. Therefore, in this study responses of improved sweet potato cultivars to selected organic amendments were evaluated under a Samoa calcareous sandy soil.

Methodology: A relatively small area along the coastline of Savaii farm, sandy in nature was selected (see Appendix Figure 1). The properties of its soils are presented in Appendix Table 1. The experimental area belongs to tropical climate zone that receives an annual rainfall ranging from 2500 to 7000mm and mean temperature ranges between 24-29°C. The field was manually cleared using bush knife with rakes to remove plant debris and stones. Plots sizes of 3m x 2m were ploughed with digging forks and the sandiness of the soil made ploughing commendably less laborious. Plots were constructed with a one metre wide alleyway to separate the plots. Two improved cultivars of sweet potato (IB/PH/03 and IB/PR/13) were used in combination with three organic amendments (Gliricidia (*Gliricidia*

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sepium), gliricidia + biochar and poultry litter). Properties of organic amendments are presented in Appendix Table 2. Except for biochar which was co-applied at 5ton ha^{-1}, all amendments were applied as an N source at 100 kg N ha^{-1} equivalent rate.

On dry matter basis, the equivalent quantities per hectare of poultry litter, gliricidia and biochar applied were about 4.5 ton, 3.5ton and 0.056ton, respectively. These were applied uniformly on assigned plots before incorporation by digging forks. A plot without amendment is deemed the farmer's practice and therefore acted as control. The treatments were arranged in a factorial randomised complete block design with four replications, details in Appendix Table 2.

Fresh marketable (>100 g) and non-marketable (< 100 g) roots and dry matter (DM) content were determined at harvest, 5 months after planting. NPK uptake by roots determined by multiplying the percentage nutrient content by the dry matter yields were determined following Blakemore *et al.* (1987) and Daly *et al.* (1984).

All data collected were subjected to Analysis of Variance Tests using a Statistical Tool for Agricultural Research (STAR) software version 2.0.1 (STAR, 2014). Where a significant difference is detected, the least significant difference (LSD) test at $P = 0.05$ was used to separate the treatment means.

Results: Marketable and total storage root yield (in t ha^{-1}) were significantly increased by organic amendment over the control, see Appendix Table 3. Gliricidia + biochar treatment produced the highest marketable, non-marketable and total storage root yield followed by Gliricida and poultry litter. Total storage root yields were increased by 91.2 %, 98.1 % and 227.4 % over control in response to the Gliricidia, poultry litter, and the Gliricidia + biochar treatments, respectively. Regarding the marketable yield, the magnitude of yield increased were 134 %, 118 %, and 294 %, respectively.

The DM yield (in t $ha^{-1)}$ varied significantly with the maximum yield attained with Gliricidia + biochar treatment. Respectively, Gliricidia + biochar, poultry litter and Gliricidia increased DM yield by 235%, 105% and 85% over the control treatment. Cultivar IB/PH/03 outperformed IB/PR/13 by three fold and two fold with respect to marketable and total root yield, respectively. However, both cultivars showed similar non-marketable root yield. See details in Appendix Table 3.

The application of organic amendments increased nutrient (N, P, and K) uptake of storage root, with the highest effect significantly pronounced with Gliricidia + biochar treatment across all the nutrient parameters. These details are in appendix Table 4. The N and K uptakes by other organic treatments showed higher but statistically in par with the control. However, the latter had the least significant P uptake across all treatments. Cultivar IB/PH/O3 having higher storage root yield and dry matter content also surpassed IB/PR/13 in N, P, and K quantity uptake.

High storage root and DM yield of sweet potato under the organically treated plots indicated that sweet potato responded favorably to the applications of organic amendments, which provide important nutrients for crop (Stathers *et al.*, 2005). However, when Gliricidia was co-applied with biochar, it drastically increased yield and this may be due to the capacity of biochar to: (i) adsorb important nutrients (Glaser *et al.*, 2012; Liang *et al.*, 2006: Hossain *et al.*, 2017) (ii) supply K needed for root formation and development (O'Sullivan *et al.*, 2007; Siose and Guinto, 2017); (iii) improve physical biochemical soil properties (Asai *et al.*, 2009); and (iv) improve water holding capacity (Yang *et al.*, 2015). A combination of these attributes may have resulted in greater nutrient uptake of this treatment.

All the treatments revealed higher N and K uptake than the P values, however only Gliricidia and Gliricidi + biochar had K levels higher than N. The nutrient adsorption capacity of the soil was greatly enhanced following biochar application that explain higher nutrient availability particularly K (Rogovska *et al.*, 2011; Jindo *et al.*, 2012).

Given the high CEC (see Appendix Table 2), it can be asserted that nutrient uptake is higher when Gliricidia is co-applied with biochar, attributed to biochar that may have abated the nutrient leaching dynamics of the soil and supply more for plant uptake. The higher storage and DM yield of cultivar IB/PH/03 than IB/PR/13 proved the former to be highly adaptable to calcareous sandy soils of Samoa. Higher nutrient uptake of this superior cultivar is indicative of its better nutrient use efficiency and should be promoted for wider adoption.

Conclusion: The yields and nutrient uptake of sweet potato was greatly influenced by the application of organic amendments over control. However, greater yield and nutrient uptake by sweet potato were obtained when biochar was co-applied with Gliricidia. The optimum ratio and rate of Gliricidia and biochar and the underpinning high yielding mechanism needs to be investigated for sensibly sound application of this technology in the future. The experiments show that IB/PH/03 proved a better adaptable cultivar to IB/PR/13 under calcareous sandy soils of Samoa. Promoting this cultivar under similar agro-environment within the region and abroad is proffered but needs multi-locational field trials.

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Appendix

Table 1. Characteristics of the soil before planting

Soil properties	Values
Textural class	Sandy loam
Classification (USDA taxonomy)†	Typic Tropopsamment
pH	7.90
OC (%)	7.57
TN (%)	0.74
Available P (mg kg^{-1})	11.1
CEC (cmol (+) kg^{-1})	34.8
Exchangeable cation (cmol(+) kg^{-1})	
Ca	20.9
Mg	1.38
K	0.10

† Russell (1990)

Fig1. Location of on-farm research site

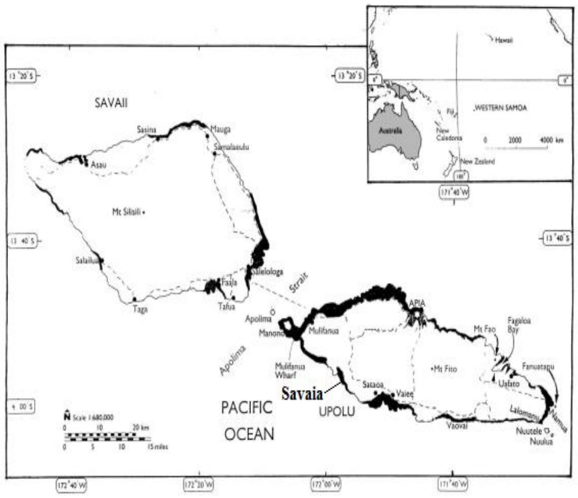

Table 2. Chemical characteristics of the organic amendments

Properties*	Organic amendments		
	Poultry litter	Gliricidia	Biochar
Total N (%)	2.23	2.84	1.12
P (%)	1.38	0.22	-
Ca (%)	0.02	0.32	0.09
Mg (%)	0.45	0.35	0.13
K (%)	0.14	†	1.21
CEC (cmol/kg)	-	-	171.9

* Determined following Blakemore *et al*. (1987) and Daly *et al*. (1984); - not determined; † below detection limits.

Table 1. Storage root yield and DM (t ha^{-1}) as by as affected by organic amendments and Sweet potato cultivars

Treatments	**Marketable**	**Non-marketable**	**Total**	**DM**
Organic amendments				
Control	5.0c	2.3b	7.3c	2.32c
Gliricidia	11.7b	2.2b	13.9b	4.28b
Gliricidia + biochar	19.7a	4.1a	23.8a	7.76a
Poultry litter	10.9b	3.5ab	14.4b	4.76b
LSD (0.05)	3.44	1.46	4.09	1.50
Cultivars				
IB/PH/03	17.8a	2.6a	20.4a	6.13a
IB/PR/13	5.8b	3.5a	9.3b	3.43b
LSD (0.05)	2.43	ns	2.89	1.06
Interaction	Ns	ns	ns	ns

Within a column, treatment means with similar letters are not significantly different at P=0.05; ns = not significant.

Table 4. Nutrient uptake (kg ha^{-1}) of storage root as affected by organic amendments and Sweet potato cultivars

Treatments	**N**	**P**	**K**
Organic amendments			
Control	8.46b	3.5c	7.6b
Gliricidia	11.5b	6.1b	19.2b
Gliricidia + Biochar	21.7a	10.5a	35.5a
Poultry litter	13.6b	6.6b	12.2b
LSD (0.05)	7.62	2.19	11.8
Cultivars			
IB/PH/03	16.8a	9. 1a	26.7a
IB/PR/13	10.9b	4.13b	10.5b
LSD (0.05)	5.39	1.55	8.38
Interaction	Ns	ns	ns

Within a column, treatment means with similar letters are not significantly different at P=0.05; ns = not significant.