

Bamboo for soil and water conservation





Outline

- Bamboo in natural stands (effects on soil & water conservation)
- Bamboo-Applied use (Remedy for soil & water issues)
- Case study
- Conclusion

Background



- *Bambusa balcooa*
 - *Bambusa vulgaris*
 - *Bambusa blumeana*
 - *Oxytenanthera abyssinica*
- and many more



Effects of Bamboo in Natural Stands on soil

- Biodiversity improvement for soil conservation

- Massive litter production for soil cover (mulch, soil moisture conservation)-soil temperature moderation/soil carbon improvement for soil micro-organisms activities.

- Fibrous root network (soil erosion check)

- Root rhizobia activities for soil fertility improvement

- Possible competition for soil water and nutrients (Bamboo being a 'feeder' plant)

Bamboo-Remedy for soil & water issues



**Siltation control/
prevents drying-up of
water/ soil erosion
control**



**Soil embankment
support/ road erosion
control**

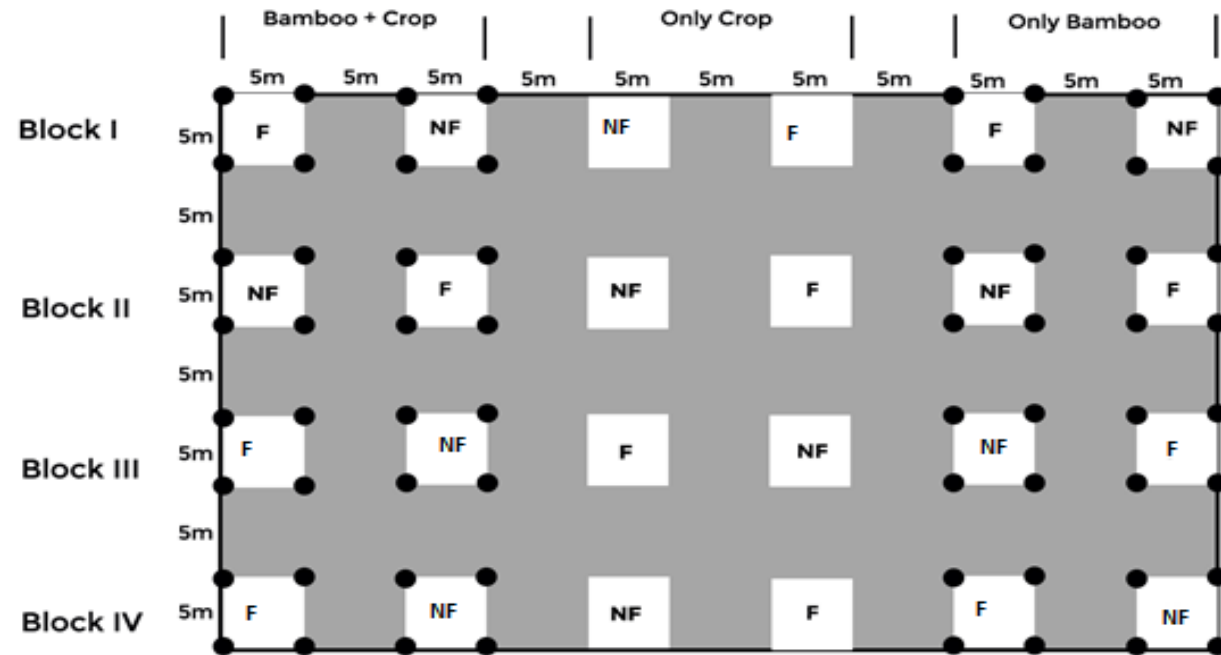


**Erosion control and slope
stabilization in soil bioengineering
(Guillermo et al., 2018).**



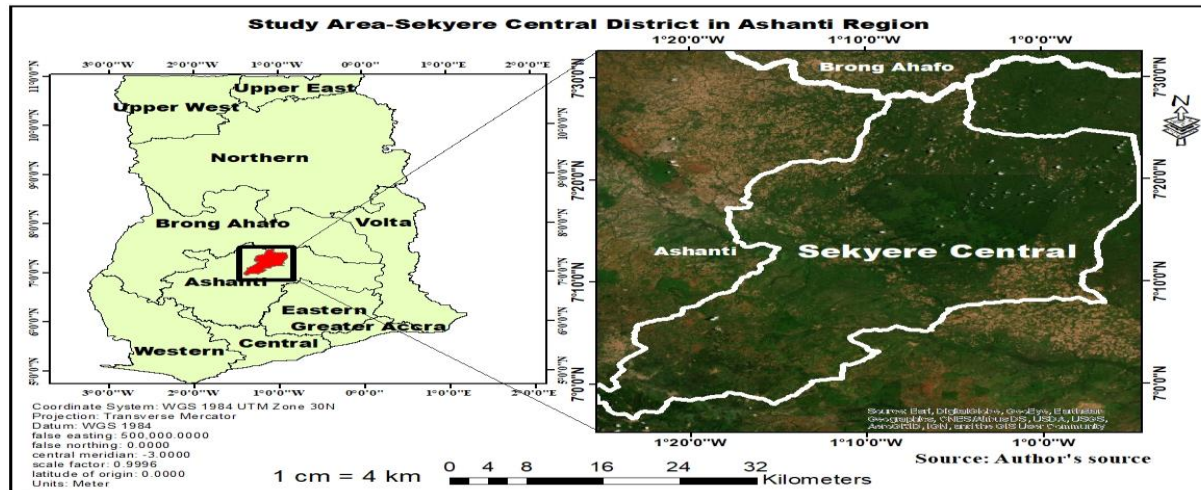
**Soil quality improvement for land
reclamation (Peprah et al., 2016)**

The Study: *'Towards bamboo agroforestry development in Ghana: effect of bamboo on soil and water conservation'*



F=Fertilizer application, NF=Non-fertilized

- Bamboo agroforestry to forestall forest/ land degradation in Ghana
- Scientific data necessary to elucidate bamboo potential
- Three crops (maize, cowpea, cassava)-intercropping and monocultural trials with fertilizer application/ or not in a split-plot design
- Study area-Dry semi-deciduous forest zone of Ghana



Methodology

Soil analysis

- Initial soil data
- 48 samples taken/ per annum for 3 yrs
- Lab. analysis for N, P, K, CEC, pH, soil moisture content
- Comparison between mono-cropping systems and bamboo agroforestry

STUDY RESULTS

TABLE 1

Soil characteristics as influenced by bamboo-based agroforestry and maize monocropping systems from 2014 to 2016.

Year and parameters	With fertilizer		Without fertilizer		P-value
	Agroforestry	Monocropping	Agroforestry	Monocropping	
2014					
Soil moisture (%)	4.34±0.01 ^a	4.33±0.01 ^a	4.32±0.03 ^a	4.29±0.05 ^a	0.724
CEC (cmolc kg⁻¹)	5.70±0.04 ^a	5.80±0.08 ^a	5.68±0.08 ^a	5.63±0.09 ^a	0.475
Total N (g kg⁻¹)	0.39±0.00 ^a	0.44±0.03 ^a	0.39±0.00 ^a	0.39±0.00 ^a	0.100
Available P (mg kg⁻¹)	4.75±0.03 ^a	4.78±0.03 ^a	4.73±0.03 ^a	4.73±0.03 ^a	0.487
Available K (mg kg⁻¹)	123.70±1.01 ^a	123.50±0.62 ^a	123.60±0.72 ^a	123.20±0.84 ^a	0.979
pH	5.78±0.03 ^a	5.83±0.04 ^a	5.73±0.03 ^a	5.80±0.04 ^a	0.122
2015					
Soil moisture (%)	4.26±0.03 ^a	4.26±0.02 ^a	4.31±0.03 ^a	4.25±0.03 ^a	0.593
CEC (cmolc kg⁻¹)	6.05±0.06 ^a	6.03±0.08 ^a	6.00±0.09 ^a	5.95±0.09 ^a	0.767
Total N (g kg⁻¹)	0.49±0.00 ^a	0.54±0.03 ^a	0.49±0.00 ^a	0.48±0.01 ^a	0.074
Available P (mg kg⁻¹)	4.55±0.10 ^a	4.50±0.10 ^a	4.58±0.13 ^a	4.40±0.04 ^a	0.539
Available K (mg kg⁻¹)	127.60±0.30 ^a	127.40±0.22 ^a	127.50±0.30 ^a	127.50±0.29 ^a	0.990
pH	5.83±0.05 ^a	5.84±0.04 ^a	5.80±0.04 ^a	5.78±0.05 ^a	0.769
2016					
Soil moisture (%)	7.13±0.06 ^b	4.27±0.02 ^a	7.01±0.07 ^b	4.25±0.03 ^a	<0.001
CEC (cmolc kg⁻¹)	6.65±0.10 ^b	5.93±0.03 ^a	6.68±0.08 ^b	5.85±0.09 ^a	<0.001
Total N (g kg⁻¹)	0.48±0.00 ^a	0.53±0.03 ^a	0.48±0.00 ^a	0.48±0.00 ^a	0.092
Available P (mg kg⁻¹)	4.90±0.11 ^b	4.79±0.20 ^b	4.83±0.21 ^b	4.20±0.04 ^a	0.010
Available K (mg kg⁻¹)	127.80±0.53 ^a	127.60±0.37 ^a	127.60±0.39 ^a	127.50±0.41 ^a	0.969
pH	5.98±0.09 ^b	5.45±0.09 ^a	6.00±0.11 ^b	5.40±0.17 ^a	0.011

Values are means of 4 replicates ± standard error. Values with the same letters in a row are not significantly different according to Tukey test at a 5% significance level.

TABLE 2

Soil characteristics as influenced by bamboo-based agroforestry and cowpea monocropping systems

Year and parameter	With fertilizer		Without fertilizer		P-value
	Agroforestry	Monocropping	Agroforestry	Monocropping	
2014					
Soil moisture (%)	4.04±0.05 ^a	4.01±0.04 ^a	3.97±0.10 ^a	3.89±0.09 ^a	0.150
CEC (cmolc kg⁻¹)	5.58±0.05 ^a	5.56±0.08 ^a	5.62±0.01 ^a	5.42±0.04 ^a	0.267
Total N (g kg⁻¹)	0.36±0.03 ^a	0.38±0.04 ^a	0.34±0.04 ^a	0.37±0.04 ^a	0.370
Available P (mg kg⁻¹)	4.64±0.02 ^a	4.68±0.02 ^a	4.66±0.08 ^a	4.64±0.06 ^a	0.776
Available K (mg kg⁻¹)	123.9±0.83 ^a	123.50±0.58 ^a	124.00±0.50 ^a	122.10±0.28 ^a	0.200
pH	5.75±0.04 ^a	5.68±0.03 ^a	5.68±0.03 ^a	5.69±0.03 ^a	0.601
2015					
Soil moisture (%)	4.26±0.19 ^a	4.27±0.12 ^a	4.25±0.12 ^a	4.15±0.06 ^a	0.655
CEC (cmolc kg⁻¹)	5.98±0.05 ^a	6.04±0.06 ^a	6.06±0.06 ^a	5.93±0.03 ^a	0.092
Total N (g kg⁻¹)	0.40±0.02 ^a	0.41±0.01 ^a	0.39±0.01 ^a	0.39±0.01 ^a	0.379
Available P (mg kg⁻¹)	4.57±0.08 ^a	4.56±0.07 ^a	4.67±0.07 ^a	4.51±0.10 ^a	0.436
Available K (mg kg⁻¹)	127.50±0.11 ^a	127.40±0.16 ^a	127.60±0.23 ^a	127.30±0.12 ^a	0.497
pH	5.72±0.03 ^a	5.73±0.06 ^a	5.70±0.03 ^a	5.70±0.04 ^a	0.811
2016					
Soil moisture (%)	7.06±0.05 ^b	4.13±0.04 ^a	7.03±0.05 ^b	4.22±0.11 ^a	<0.001
CEC (cmolc kg⁻¹)	6.64±0.13 ^b	5.71±0.07 ^a	6.71±0.07 ^b	5.65±0.08 ^a	<0.001
Total N (g kg⁻¹)	0.41±0.06 ^a	0.42±0.01 ^a	0.41±0.06 ^a	0.40±0.06 ^a	0.983
Available P (mg kg⁻¹)	4.96±0.07 ^b	4.82±0.18 ^b	4.73±0.16 ^b	4.14±0.06 ^a	0.002
Available K (mg kg⁻¹)	128.00±0.40	127.60±0.34	127.70±0.29	127.00±0.12	0.205
pH	5.94±0.09 ^b	5.36±0.12 ^a	5.88±0.10 ^b	5.41±0.09 ^a	0.003

Values are means of 4 replicates ± standard error. Values with the same letters in a row are not significantly different according to Tukey test at a 5% significance level.

TABLE 3

Soil characteristics as influenced by bamboo-based agroforestry and cassava monocropping systems

Year and parameter	With fertilizer		Without fertilizer		P-value
	Agroforestry	Monocropping	Agroforestry	Monocropping	
2014					
Soil moisture (%)	4.18±0.02^a	4.17±0.06^a	4.20±0.01^a	4.12±0.04^a	0.493
CEC (cmolc kg⁻¹)	5.58±0.03^a	5.65±0.03^a	5.58±0.12^a	5.54±0.02^a	0.503
Total N (g kg⁻¹)	0.46±0.00^a	0.45±0.01^a	0.45±0.00^a	0.44±0.01^a	0.452
Available P (mg kg⁻¹)	4.68±0.02^a	4.68±0.02^a	4.64±0.02^a	4.65±0.02^a	0.549
Available K (mg kg⁻¹)	121.60±0.43^a	121.10±0.63^a	121.10±0.73^a	120.30±0.53^a	0.605
pH	5.76±0.004^a	5.77±0.03^a	5.76±0.003^a	5.75±0.05^a	0.992
2015					
Soil moisture (%)	4.32±0.04^a	4.31±0.00^a	4.30±0.02^a	4.26±0.02^a	0.433
CEC (cmolc kg⁻¹)	5.40±0.09^a	5.50±0.11^a	5.50±0.09^a	5.27±0.03^a	0.289
Total N (g kg⁻¹)	0.43±0.01^a	0.44±0.00^a	0.44±0.00^a	0.43±0.01^a	0.544
Available P (mg kg⁻¹)	4.61±0.11^a	4.49±0.09^a	4.50±0.11^a	4.46±0.11^a	0.144
Available K (mg kg⁻¹)	118.90±0.61^a	118.90±0.87^a	119.10±0.77^a	118.50±0.68^a	0.922
pH	5.44±0.12^a	5.47±0.10^a	5.49±0.07^a	5.48±0.06^a	0.916
2016					
Soil moisture (%)	7.05±0.07^b	4.21±0.03^a	7.03±0.07^b	4.26±0.03^a	<0.001
CEC (cmolc kg⁻¹)	5.34±0.10^a	5.56±0.06^a	5.54±0.17^a	5.24±0.08^a	0.185
Total N (g kg⁻¹)	0.45±0.01^a	0.43±0.01^a	0.45±0.01^a	0.43±0.01^a	0.170
Available P (mg kg⁻¹)	4.33±0.17^a	4.73±0.27^a	4.63±0.15^a	4.38±0.28^a	0.581
Available K (mg kg⁻¹)	121.30±0.45^a	120.90±0.45^a	121.00±0.51^a	121.80±1.28^a	0.884
pH	6.10±0.07^b	5.88±0.03^a	6.11±0.01^b	5.95±0.03^a	0.006

Values are means of 4 replicates ± standard error. Values with the same letters in a row are not significantly different according to Tukey test at a 5% significance level. 10



Conclusions

Study Conclusion

- Regardless of fertilizer use, significant bamboo effects on soil properties were observed after two years of establishment.
- **($p < 0.05$) higher soil moisture, pH, CEC & P; but average levels of N & K.**
- Integrating bamboo into farming systems is not likely to impact negatively on soil properties; at least within three years of cultivation but enhance crop and soil productivity.

General Conclusion

- **Bamboo can have several effects(positive/negative) but is mostly dependent on cultural and management practices as well as purpose of use.**

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Towards bamboo agroforestry development in Ghana: evaluation of crop performance, soil properties and economic benefit

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Abstract In the quest to promote bamboo agroforestry in the dry semi-deciduous forest zone of Ghana, we evaluated changes in soil properties, crop productivity and the economic potential of a bamboo-based intercropping system. The intercropping system was established from 3-months old sympodial bamboo (*Bambusa balcooa*) seedlings planted at a 5 m × 5 m spacing and intercropped with maize, cassava or cowpea. Separate monocropping fields for maize, cassava, cowpea and bamboo were set up adjacent to the intercropped field. In both the intercropping and monocropping fields, plots were with fertilizer treatments and without. The experiment was laid out in a split plot design with four replicates and studied over three years. Economic analysis was conducted using the financial benefit–

cost ratio method. The results showed that regardless of fertilizer treatments, bamboo agroforestry and monocropped fields had comparable effects on soil properties and crop productivity within two years of establishment. In the third year, however, bamboo agroforestry had significantly ($p < 0.05$) higher soil moisture, pH and crop productivity levels. An intercropping advantage over monocropping was evident for all crops with respective partial land equivalent ratios for fertilized and non-fertilized intercropped systems as follows: cowpea (1.37 and 1.54), maize (1.38 and 1.36), and cassava (1.12 and 1.19). The economic evaluation also indicated marginal profitability of bamboo intercropping over monocropping systems. From the results obtained, there are clear indications that where bamboo is a prioritized woody perennial, integrated systems with crops may be encouraged.

Keywords Agroecology · Crop productivity · Food security · Soil productivity · Sustainable agriculture

Introduction

In Africa, forests provide important ecosystem services that support the environment and livelihoods. However current deforestation figures point to a dire situation for such important natural resources. FAO (2015, 2016) reports that Africa lost about 3.4

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