

Performance of Cuba 108 variety of kenaf (*Hibiscus cannabinus* L.) as affected by arbuscular mycorrhiza and organo-chemical fertilizers

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ABSTRACT

This study investigated effects of arbuscular mycorrhiza, NPK (20:10:10), Purely Composted Market Waste (PCMW), Composted Market Waste Fortified With Superphosphate and Urea (CMWFWSAU) on the Root Colonization (RC), growth and fibre yield of Cuba 108. Experimental design was a 2 x 12 factorial in a Completely Randomized Design with three replicates. The treatments were with mycorrhiza (M^+) and without (M^-) and twelve levels of fertilizers: 0, NPK (60 kg N ha⁻¹), PCMW (20, 40, 60, 80 and 100 kg N ha⁻¹), and CMWFWSAU (20, 40, 60, 80 and 100 kg N ha⁻¹). Residual effect of the treatments was also determined on the growth, yield and RC. Data collected were analysed using descriptive and inferential statistics. Percentage RC ranged from 14.4 to 78.1. Inoculated Cuba 108 at 40 kg N ha⁻¹ of CMWFWSAU had significantly ($p < 0.05$) higher stem diameter (1.8 cm), plant height (275.2 cm), RC (79.8 %), bast (9.6 g pot⁻¹) and core (19.9 g pot⁻¹) yields. For the residual effect, M^+ 100 kg N ha⁻¹ of PCMW had significantly ($p < 0.05$) highest RC (58.5%), bast (6.2 g pot⁻¹) and core (11.1 g pot⁻¹) yields.

Keywords: kenaf, yield, fungi, soil amendments

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) stem produces two types of fibre, a coarser fibre in the outer layer (bast) and a finer fibre in the inner (core). Its economic importance include fibre and food (Bert, 2002; Zhang, 2003), medicine (Cheng, 2001), medium for mushroom cultivation (Cheng, 2001; Liu, 2003), phytoremediation (Bada and Kalejaiye, 2010; Bada and Raji, 2010; Bada and Umunnakwe, 2011), oil and chemical absorbents (Sameshima, 2000). In addition, the bast fibre can be converted to pulp for newsprint, hydro-carbon free bags, ropes and textiles (Kuchinda and Ogunwole, 2000; Webber, Bledsoe and Bledsoe, 2002). The primary purpose for which kenaf is grown as cash crop in

Nigeria is the production of bast fibre in the manufacture of kenaf sacks. Now that packaging and/or handling agricultural produce in synthetic bags has been banned, the manufacture of millions of kenaf bags is necessary. Kenaf generally gives the greatest response to nitrogen, followed by phosphorus (Wilson, 2003).

High and sustainable crop production requires the use of fertilizer. Continuous application of inorganic fertilizer on agricultural land results in acidification of the soils (Yaro *et al.*, 1997). The use of organic fertilizer is also limited by large quantities required to meet crop needs because of its low nutrients content, such large quantities are obviously not

obtainable and even if they were, transportation and handling costs would constitute a major constraint. In view of this, complimentary use of low chemical inputs and organic manure (Organomineral fertilizer) may be a cost effective economic strategy (Omueti, *et al.*, 2000). This system may offer a good opportunity to the small scale farmers to maintain yield at reasonable and sustainable cost levels. As a way of reducing total dependence on the use of fertilizer, an integrated fertility management system focusing on biological approach, which is eco-friendly and less expensive, is desirable. Mycorrhizal symbiosis is well recognized as a biological tool to enhance nutrient acquisition in most plants growing on deficient soils (Dare, *et al.*, 2008; Ibiremo and Fagbola, 2008).

Therefore, for sustainable kenaf production, there is need to study the effect of arbuscular mycorrhizal inoculation, NPK (20:10:10), purely composted market waste and composted market waste fortified with superphosphate and urea on the growth and fibre yield of kenaf.

MATERIALS AND METHODS

The screenhouse experiment was carried out at the Institute of Agricultural Research and Training (IAR & T) Moor Plantation, Ibadan on Latitude $7^{\circ} 22.5' N$ and Longitude $3^{\circ} 50.5' E$ in the rainforest of South-Western Nigeria.

Soil Sample Collection, Analysis and Description of Planting Materials

Representative topsoil (0 – 15 cm) samples were collected from research farm of IAR & T, Ibadan, Nigeria. Sub-samples were taken to determine the physical and chemical properties such as particle size, pH, organic matter, total nitrogen, available phosphorus and exchangeable

potassium using standard methods. Arbuscular mycorrhiza infective propagule was also determined using the 'Most Probable Number' (MPN) technique (Porter, 1979).

Two types of market waste-based fertilizers (produced by Pacesetter Fertilizer Company, Ibadan, Oyo State) were used: composted market waste fortified with superphosphate and urea (Grade A fertilizer) and purely composted market waste without any additive (Grade B fertilizer). Proximate analyses of the fertilizers were determined. However, N.P.K. 20:10:10 fertilizer at recommended rate of 60 kg N ha^{-1} (Ogunbodede and Adediran, 1996) was also used. Mycorrhizal inoculum (*Glomus mosseae*) was collected from the Soil Microbiology Laboratory, Department of Agronomy, University of Ibadan, Ibadan, Nigeria. Cuba 108 variety of kenaf suitable for different agro-ecological zones in Nigeria (IAR & T, 1997) was collected from IAR & T, Ibadan, Nigeria.

Effects of AM and Fertilizers on the Growth, Yield and Root Colonization of Cuba 108

Experimental Design

A 2×12 factorial experiment in a Completely Randomized Design (CRD) with three replicates was carried out to assess the effects of two levels of arbuscular mycorrhiza (with and without) and twelve levels of fertilizers: 0, NPK 20:10:10 (60 kg N ha^{-1}), purely composted market waste (20, 40, 60, 80 and 100 kg N ha^{-1}) and composted market waste fortified with Superphosphate and Urea (20, 40, 60, 80 and 100 kg N ha^{-1}) on the root colonization, growth and fibre yield of Cuba 108.

Soil Preparation and Sowing

After soil analysis, the soil samples collected were thoroughly mixed together and put in 72 pots (each pot contained 10 kg soil). Purely composted market waste (20, 40, 60, 80 and 100 kg N ha⁻¹) and composted market waste fortified with Superphosphate and Urea (20, 40, 60, 80 and 100 kg N ha⁻¹) fertilizers were thoroughly mixed with the soil while twenty grams of arbuscular mycorrhizal inoculum (*Glomus mosseae*) was blended into the central third of the soil (Carling *et al.*, 1978) before planting. Seeds of Cuba 108 were sown at the rate of 2- 3 seeds per pot. After germination, the plants were thinned to one per pot. Sixty kg N ha⁻¹ of N.P.K. 20:10:10 fertilizer was applied third week after planting by side placement.

Data collection

Plant height and stem diameter were taken at the sixth week after planting and continued at two weeks interval (for 2 months) until harvest (25% flowering) using Metre rule and Vernier caliper.

Harvesting and Determination of Percentage Root Colonization by AM Fungi

Kenaf was harvested 14 weeks after sowing by uprooting and later separated into root and shoot. Mycorrhizal colonization was quantified by the grid – line intersect method (Giovannetti and Mosse, 1980). After retting, outer fibre (bast) were separated from inner fibre (core).

Assessment of Residual Effects of AM and Fertilizers on the Growth, Yield and Root Colonization of Cuba 108

This was carried out to determine the residual effect of AM, purely composted market waste, composted market waste fortified with Superphosphate and Urea,

and N:P:K (20:10:10) fertilizers on the root colonization, growth and yield of Cuba 108.

Soil Preparation and Sowing

After harvesting, the soil in each pot was thoroughly mixed. Neither fertilizer nor AM was applied and kenaf seeds were then sowed. Other operations then followed.

Laboratory Analyses

Soil pH was determined in distilled water according to Thomas (1996) using a hand-held HANNA pH meter (Model number HI 98129, Hanna Instruments, California, USA). Soil organic carbon was determined by the chromic acid digestion method as reported by Sparks (1996). Total N was determined by the Macro-kjeldahl method according to Bremner (1996). Available P by Bray-I method as described by Kuo (1996). Exchangeable K was extracted with neutral normal ammonium acetate buffer and was determined using a Flame Photometer (Jenway, Gransmore Green, Felsted, Dunmow, Essex, CM6 3LB, England).

Statistical Analyses

Data were analysed using descriptive statistics and analysis of variance (ANOVA). Test of significance of the means was by the standard error.

RESULTS

Soil Characteristics and Proximate Analysis of Fertilizers

The soil texture, pH, organic matter, total nitrogen, available phosphorus and exchangeable potassium were sandy loam, 6.1, 15.0 g kg⁻¹, 1.5 g kg⁻¹, 2.1 mg kg⁻¹ and 0.2 cmol kg⁻¹ respectively before planting. Arbuscular mycorrhiza infective propagule density was 110 infective propagules per 100 g soil.

Composted Market Waste Fortified With Superphosphate and Urea (CMWFWSAU) had higher concentrations of nitrogen: 57.50 g kg⁻¹, phosphorus: 4.48 mg kg⁻¹ and potassium: 3.05 cmol kg⁻¹ than Purely Composted Market Waste (PCMW) of 10.50 g kg⁻¹, 0.95 mg kg⁻¹ and 1.00 cmol kg⁻¹ respectively.

Effects of AM and Fertilizers on the Growth of Cuba 108

Increase in the levels of Purely Composted Market Waste (PCMW) and Composted Market Waste Fortified With Superphosphate and Urea (CMWFWSAU) without arbuscular mycorrhizal inoculation resulted in the significant ($p < 0.001$) increase in stem diameter from 20 to 60 kg N ha⁻¹ of both PCMW and CMWFWSAU (Table 1). Without mycorrhizal inoculation, significantly ($p < 0.001$) higher stem diameter was observed at 60 kg N ha⁻¹ of CMWFWSAU. On the effects of arbuscular mycorrhizal inoculation and fertilizer application, stem diameter of inoculated Cuba 108 was significantly ($p < 0.001$) higher than the non-inoculated at 60 kg N ha⁻¹ of NPK, 40 kg N ha⁻¹ of PCMW, 40 and 60 kg N ha⁻¹ of CMWFWSAU from 6 to 14WAP (Table 1). Significantly ($p < 0.001$) higher stem diameter was observed at 40 kg N ha⁻¹ of CMWFWSAU in the inoculated Cuba 108 compared to other fertilizer levels with and without mycorrhizal inoculation.

Plant height of Cuba 108 was significantly influenced by arbuscular mycorrhizal inoculation and fertilizer application rates (Tables 2). Mycorrhizal inoculation significantly ($p < 0.001$) increased plant height of Cuba 108 (except 12WAP) at 0 fertilizer level compared to their non-

inoculated counterpart also at control. Among the various fertilizer levels without mycorrhizal inoculation, 60 kg N ha⁻¹ of CMWFWSAU had significantly ($p < 0.001$) higher plant height compared to other levels of fertilizer without mycorrhizal inoculation (Table 2).

Influence of AM and Fertilizers on the Yield and Root Colonization of Cuba 108

Inoculated Cuba 108 of control had significantly ($p < 0.001$) higher bast yield than their non-inoculated of control (Table 3). Increase in the levels of PCMW and CMWFWSAU without mycorrhizal inoculation significantly ($p < 0.001$) increased the bast yield from control to 60 kg N ha⁻¹ while at 80 kg N ha⁻¹ or more, a decline in bast yield occurred (Table 3). On the other hand, inoculated Cuba 108 had significantly ($p < 0.001$) higher bast yield than the non-inoculated at 60 kg N ha⁻¹ of NPK, 40 kg N ha⁻¹ of PCMW, 40 and 60 kg N ha⁻¹ of CMWFWSAU. Highest bast yield was observed at 40 kg N ha⁻¹ of CMWFWSAU in the inoculated Cuba 108 (Table 3). Without mycorrhizal inoculation, significantly ($p < 0.001$) higher core yield was observed at 60 kg N ha⁻¹ of CMWFWSAU (Table 3).

Inoculated Cuba 108 without fertilizer application had higher percentage mycorrhizal colonization than the non-inoculated counterpart without fertilizer application by 19.1% (Table 3). Application of fertilizers with mycorrhizal inoculation had significantly ($p < 0.001$) higher percentage mycorrhizal colonization than application of fertilizers without mycorrhizal inoculation at 40 kg N ha⁻¹ of PCMW and CMWFWSAU.

Table 1: Effects of AM and fertilizers on the stem diameter (cm) of Cuba 108

Mycorrhiza inoculation	Fertilizer application	6	8	10	12	14
		Weeks after planting				
With	0	0.48	0.55	0.70	0.72	0.80
	NPK	0.90	1.02	1.21	1.30	1.32
	PCMW20	0.50	0.62	0.72	0.78	0.85
	PCMW40	0.65	0.76	0.90	1.00	1.06
	PCMW60	0.61	0.75	0.84	0.98	1.03
	PCMW80	0.55	0.70	0.78	0.90	1.00
	PCMW100	0.60	0.71	0.80	0.94	1.00
	CMWFWSAU20	0.52	0.65	0.75	0.80	0.90
	CMWFWSAU40	0.98	1.30	1.45	1.65	1.75
	CMWFWSAU60	0.94	1.18	1.36	1.40	1.43
	CMWFWSAU80	0.72	0.85	0.92	1.06	1.10
	CMWFWSAU100	0.75	0.95	1.00	1.11	1.15
	Without	0	0.45	0.50	0.55	0.60
NPK		0.76	0.96	1.10	1.12	1.25
PCMW20		0.50	0.57	0.70	0.78	0.82
PCMW40		0.55	0.65	0.75	0.81	0.92
PCMW60		0.60	0.74	0.81	0.96	1.03
PCMW80		0.55	0.66	0.78	0.82	0.97
PCMW100		0.58	0.70	0.79	0.92	1.00
CMWFWSAU20		0.50	0.64	0.73	0.80	0.90
CMWFWSAU40		0.70	0.80	0.90	1.02	1.06
CMWFWSAU60		0.80	1.00	1.12	1.15	1.30
CMWFWSAU80		0.70	0.80	0.92	1.05	1.08
CMWFWSAU100		0.75	0.85	0.96	1.10	1.12
SE						
Mycorrhiza (M)		0.0032	0.0023	0.0018	0.0001	0.0023
Fertilizers (F)		0.0079	0.0056	0.0045	0.0001	0.0056
Interaction						
M x F		0.0111	0.0079	0.0064	0.0001	0.0079
ANOVA						
M		***	***	***	***	***
F		***	***	***	***	***
Interaction						
M x F		***	***	***	***	***

SE = Standard Error; *** = $p < 0.001$

Table 2. Effects of AM and fertilizers on the plant height (cm) of Cuba 108

Mycorrhiza inoculation	Fertilizer application	6	8	10	12	14
		Weeks after planting				
With	0	48.30	97.50	100.10	114.17	136.10
	NPK	103.17	156.53	168.03	200.17	236.17
	PCMW20	69.80	100.10	108.10	125.10	156.10
	PCMW40	87.27	115.57	127.17	153.17	188.17
	PCMW60	87.27	115.10	127.17	151.10	188.17
	PCMW80	78.30	108.10	123.17	145.17	176.10
	PCMW100	82.27	109.10	126.10	150.17	180.17
	CMWFWSAU20	75.63	105.10	119.80	143.10	167.10
	CMWFWSAU40	123.07	195.17	231.17	265.17	275.17
	CMWFWSAU60	115.23	165.37	203.17	239.17	246.17
Without	0	40.80	89.30	93.10	114.10	132.10
	NPK	96.30	144.37	155.17	186.03	207.03
	PCMW20	63.30	98.30	107.10	121.10	139.10
	PCMW40	76.27	107.17	120.17	144.10	172.77
	PCMW60	84.70	112.17	126.17	150.17	183.17
	PCMW80	76.50	107.37	121.10	144.17	175.10
	PCMW100	79.70	108.67	125.10	149.17	180.10
	CMWFWSAU20	74.20	100.10	118.10	140.10	165.17
	CMWFWSAU40	88.77	116.57	128.17	155.10	190.10
	CMWFWSAU60	102.67	150.17	166.17	196.17	225.17
	CMWFWSAU80	88.80	117.17	130.10	159.10	190.17
	CMWFWSAU100	96.20	123.30	138.10	177.10	200.10
SE						
Mycorrhiza (M)		0.8394	0.3436	0.0039	0.5731	0.6534
Fertilizers (F)		2.0561	0.8417	0.0096	1.4037	1.6006
Interaction						
M x F		2.9077	1.1903	0.0136	1.9851	2.2636
ANOVA						
M		***	***	***	***	***
F		***	***	***	***	***
Interaction						
M x F		***	***	***	***	***

SE = Standard Error; *** = $p < 0.001$

Table 3. Influence of AM and fertilizers on the root colonization, bast and core yield of Cuba 108

Mycorrhiza inoculation	Fertilizer application	Bast (g pot ⁻¹)	Core (g pot ⁻¹)	Mycorrhizal colonization (%)	
With	0	2.63	5.18	17.27	
	NPK60	7.08	14.23	71.30	
	PCMW20	2.92	7.09	19.60	
	PCMW40	4.09	9.64	43.00	
	PCMW60	3.91	9.14	34.63	
	PCMW80	3.51	8.21	24.50	
	PCMW100	3.65	8.44	26.87	
	CMWFWSAU20	3.07	7.30	21.67	
	CMWFWSAU40	9.55	19.85	79.80	
	CMWFWSAU60	8.85	15.48	74.83	
	CMWFWSAU80	4.62	10.37	57.63	
	CMWFWSAU100	5.18	10.85	63.10	
	Without	0	1.75	3.81	14.50
		NPK60	5.52	10.39	64.63
PCMW20		2.84	6.26	18.93	
PCMW40		3.41	7.30	23.27	
PCMW60		3.73	8.24	31.60	
PCMW80		3.49	7.49	23.30	
PCMW100		3.61	7.68	24.87	
CMWFWSAU20		2.97	6.50	20.57	
CMWFWSAU40		4.35	9.37	49.03	
CMWFWSAU60		6.24	12.77	67.43	
CMWFWSAU80		4.51	9.47	55.00	
CMWFWSAU100		4.69	9.97	58.70	
S.E.					
Mycorrhiza (M)		0.0530	0.1646	0.5648	
Fertilizers (F)		0.1298	0.4032	1.3835	
Interaction					
M × F		0.1836	0.5702	1.9566	
ANOVA					
M		***	***	***	
F		***	***	***	
Interaction					
M × F		***	***	***	

SE = Standard Error; *** = p < 0.001

Residual Effects of AM and Fertilizers on the Growth of Cuba 108

Stem diameter of Cuba 108 was affected by the residual of AM and fertilizer application rates (Table 4). Stem diameter of inoculated Cuba 108 without fertilizer

application was 10.5% higher than the stem diameter of the non-inoculated Cuba 108 without fertilizer application 14WAP. Stem diameter of non-inoculated Cuba 108 significantly (p < 0.001) increased as the levels of PCMW and CMWFWSAU

increased from 20 to 100 kg N ha⁻¹ (6 to 14WAP). On the residual effect of fertilizer application levels and mycorrhizal inoculation, significantly ($p < 0.001$) higher stem diameter were observed between inoculated and non-inoculated Cuba 108 with fertilizer application at 40, 60 and 100 kg N ha⁻¹ of PCMW, and 60 kg N ha⁻¹ of CMWFWSAU 14WAP (Table 4).

Residual effects of mycorrhizal inoculation and fertilizer application levels affected the plant height of Cuba 108 (Table 5). Inoculated Cuba 108 without fertilizer application had higher plant height than the non-inoculated counterpart without fertilizer application by 15.8%. The higher the levels of PCMW and CMWFWSAU applied without mycorrhizal inoculation, the higher were the residual effect on the plant height with 100 kg N ha⁻¹ of PCMW having significantly ($p < 0.001$) higher plant height 14WAP (Table 5).

Residual Effects of AM and Fertilizers on the Yield and Root Colonization of Cuba 108

Bast and core yields of Cuba 108 were significantly ($p < 0.05$) affected by the residual effects of mycorrhizal inoculation and fertilizer application rates (Table 6). Bast yield of inoculated Cuba 108 at 0 fertilizer application was higher than the non-inoculated counterpart at the same fertilizer level by 14.5%. Increase in the levels of PCMW and CMWFWSAU without mycorrhizal inoculation resulted in

the significant ($p < 0.001$) increase in bast yield at 100 kg N ha⁻¹ of PCMW and CMWFWSAU. Inoculated Cuba 108 had significantly ($p < 0.001$) higher bast yield than the non-inoculated counterpart at 80 and 100 kg N ha⁻¹ of PCMW, and also at 100 kg N ha⁻¹ of CMWFWSAU (Tables 6).

On the residual effect of PCMW and CMWFWSAU with mycorrhiza inoculation, significant ($p < 0.001$) increase in bast yield were observed at 60, 80 and 100 kg N ha⁻¹ of both PCMW and CMWFWSAU. Core yield of inoculated Cuba 108 without fertilizer application was 16.7% higher than non-inoculated counterpart at the same fertilizer rate (Table 6). Significant ($p < 0.001$) increase in core yield was observed as the levels of PCMW and CMWFWSAU increased without mycorrhizal inoculation up to 100 kg N ha⁻¹. Inoculated Cuba 108 with fertilizers application had significantly ($p < 0.001$) higher core yield than non-inoculated counterpart at 100 kg N ha⁻¹ of PCMW and CMWFWSAU.

Mycorrhizal colonization of inoculated Cuba 108 without fertilizer application was 5.9% higher than the non-inoculated counterpart without fertilizer application (Table 6). Increase in the levels of PCMW and CMWFWSAU without mycorrhizal inoculation resulted in the significant ($p < 0.001$) increase in the mycorrhizal colonization from 60 to 100 kg N ha⁻¹ of PCMW; and 80 to 100 kg N ha⁻¹ of CMWFWSAU.

Table 4. Residual effects of AM and fertilizers on the stem diameter (cm) of Cuba 108

Mycorrhiza inoculation	Fertilizers application	6	8	10	12	14	
		Weeks after planting					
With	0	0.40	0.50	0.54	0.60	0.63	
	NPK	0.41	0.55	0.60	0.65	0.68	
	PCMW20	0.42	0.61	0.65	0.74	0.77	
	PCMW40	0.50	0.65	0.72	0.80	0.83	
	PCMW60	0.50	0.71	0.75	0.90	0.95	
	PCMW80	0.58	0.80	0.87	0.98	1.03	
	PCMW100	0.70	0.90	1.00	1.10	1.16	
	CMWFWSAU20	0.42	0.60	0.62	0.71	0.74	
	CMWFWSAU40	0.45	0.64	0.70	0.76	0.80	
	CMWFWSAU60	0.50	0.70	0.74	0.88	0.93	
	CMWFWSAU80	0.52	0.80	0.85	0.95	1.01	
	CMWFWSAU100	0.65	0.88	0.90	1.00	1.06	
	Without	0	0.30	0.50	0.53	0.55	0.57
		NPK	0.40	0.52	0.55	0.63	0.66
PCMW20		0.42	0.60	0.65	0.71	0.74	
PCMW40		0.45	0.64	0.70	0.75	0.79	
PCMW60		0.50	0.70	0.74	0.84	0.89	
PCMW80		0.52	0.71	0.80	0.95	1.00	
PCMW100		0.62	0.88	0.90	1.00	1.05	
CMWFWSAU20		0.42	0.60	0.62	0.69	0.71	
CMWFWSAU40		0.43	0.62	0.67	0.75	0.78	
CMWFWSAU60		0.50	0.70	0.72	0.82	0.86	
CMWFWSAU80		0.51	0.71	0.75	0.94	0.99	
CMWFWSAU100		0.60	0.85	0.90	0.98	1.04	
SE							
Mycorrhiza (M)			0.0019	0.0023	0.0027	0.0022	0.0044
Fertilizers (F)		0.0047	0.0056	0.0067	0.0055	0.0108	
Interaction							
M x F		0.0067	0.0079	0.0095	0.0077	0.0152	
ANOVA							
M		***	***	***	***	***	
F		***	***	***	***	***	
Interaction							
M x F		***	***	***	***	***	

SE = Standard Error; *** = $p < 0.001$

Table 5. Residual effects of AM and fertilizers on the plant height (cm) of Cuba 108

Mycorrhiza inoculation	Fertilizers application	6	8	10	12	14
		Weeks after planting				
With	0	40.10	77.17	91.10	101.10	112.37
	NPK	42.17	86.10	98.17	110.17	119.00
	PCMW20	48.17	96.17	114.10	122.10	132.37
	PCMW40	58.17	103.10	124.10	142.10	153.37
	PCMW60	60.17	106.10	130.10	152.17	166.03
	PCMW80	67.10	112.17	135.17	170.17	182.10
	PCMW100	76.17	125.17	142.17	200.17	216.43
	CMWFWSAU20	44.17	94.17	110.17	120.10	129.77
	CMWFWSAU40	55.17	100.10	116.10	132.17	143.37
	CMWFWSAU60	60.10	105.10	128.17	152.10	161.77
	CMWFWSAU80	67.10	110.17	135.10	168.17	181.43
	CMWFWSAU100	74.10	120.17	142.17	185.17	201.43
	Without	0	36.10	65.10	80.10	92.17
NPK		41.10	82.17	92.17	110.17	116.43
PCMW20		45.17	95.10	112.10	120.17	129.77
PCMW40		51.10	100.10	115.10	132.10	142.43
PCMW60		59.10	104.10	128.17	150.17	161.43
PCMW80		62.17	107.17	135.10	160.17	174.37
PCMW100		70.10	115.17	140.17	184.17	198.10
CMWFWSAU20		42.17	90.10	100.17	120.10	129.70
CMWFWSAU40		50.10	98.10	115.10	132.10	142.37
CMWFWSAU60		58.17	103.17	125.17	145.10	157.03
CMWFWSAU80		62.10	106.17	132.17	158.10	170.43
CMWFWSAU100		68.17	113.10	138.10	178.10	194.37
SE						
Mycorrhiza (M)		0.6504	0.7030	0.6494	0.5721	1.3694
Fertilizers (F)		1.5931	1.7219	1.5908	1.4013	3.3544
Interaction						
M x F		2.2530	2.4352	2.2497	1.9817	4.7438
ANOVA						
M		Ns	***	***	***	***
F		***	***	***	***	***
Interaction						
M x F		**	***	***	***	*

SE = Standard Error; *, ** and *** p < 0.05, 0.01 and 0.001 respectively; ns = not significant

Table 6. Residual effects of mycorrhiza and fertilizers on the colonization, bast and core yield of Cuba 108

Mycorrhiza inoculation	Fertilizers application	Bast (g pot ⁻¹)	Core (g pot ⁻¹)	Mycorrhizal colonization (%)	
With	0	1.58	3.57	14.93	
	NPK60	2.01	4.03	16.80	
	PCMW20	2.33	4.49	20.57	
	PCMW40	2.51	5.42	23.37	
	PCMW60	3.10	6.50	33.77	
	PCMW80	3.92	7.85	46.53	
	PCMW100	6.15	11.08	58.50	
	CMWFWSAU20	2.21	4.47	19.13	
	CMWFWSAU40	2.45	5.18	22.17	
	CMWFWSAU60	2.96	6.32	30.73	
	CMWFWSAU80	3.50	7.31	43.33	
	CMWFWSAU100	4.98	10.22	54.90	
	Without	0	1.38	3.06	14.10
		NPK60	1.93	3.89	15.83
PCMW20		2.27	4.41	19.80	
PCMW40		2.35	4.98	22.23	
PCMW60		2.73	5.72	27.80	
PCMW80		3.27	6.91	40.07	
PCMW100		4.56	9.38	52.40	
CMWFWSAU20		2.07	4.32	16.93	
CMWFWSAU40		2.37	4.65	21.73	
CMWFWSAU60		2.43	5.57	24.83	
CMWFWSAU80		3.15	6.69	40.63	
CMWFWSAU100		4.27	8.49	49.10	
S.E.					
Mycorrhiza (M)		0.0468	0.0705	0.4955	
Fertilizers (F)		0.1145	0.1727	1.2138	
Interaction					
M × F		0.1620	0.2442	1.7165	
ANOVA					
M		***	***	***	
F		***	***	***	
Interaction					
M × F		**	*	ns	

SE = Standard Error; *, ** and *** p < 0.05, 0.01 and 0.001 respectively; ns = not significant

DISCUSSION

The soil was low in nutrients compared to organic matter and total N of 30 and 2.0 g kg⁻¹ respectively (FPDD, 1990). This might be due to the continuous cultivation of the land with continuous application of

inorganic fertilizer in the past. The infective propagule density was also low. However, inoculation increased the growth, AM colonization, bast and core yield compared to the non-inoculation. These better growth exhibited by the

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inoculated Cuba 108 might be due to a better uptake of nutrients, which in turn can be directly attributed to AM inoculation. This might also be due to the effectiveness of *Glomus mosseae* inoculated to absorb plant nutrient from soil solution for the growth and yield of the plant. Sieverding (1991) stated that mycorrhiza enhanced the efficiency of nutrient absorption from the soil solution. Increase in the levels of the fertilizers applied with mycorrhizal inoculation significantly ($p < 0.001$) increased mycorrhizal colonization, bast and core yield from 20 to 40 kg N ha⁻¹ of both PCMW and CMWFWSAU. This observation is consistent with the study of the mycorrhiza project on cassava where increasing N levels, P and K were added at constant rate, clearly inhibited the root colonization ratings of cassava (Sieverding, 1991). High amount of soil available P and total N may lower AM colonization (Treseder and Allen 2002; Johnson, *et al.*, 2003).

On the residual effect of AM inoculation and fertilizers application, percentage AM colonization, growth and yield parameters increased from 20 to 100 kg N ha⁻¹ of both PCMW and CMWFWSAU. PCMW had better yields than CMWFWSAU. This might be due to the gradual release of nutrients by the PCMW which make it to have better residual effect among the fertilizers used.

Significantly higher bast and core yield were obtained in the inoculated kenaf at 40 kg N ha⁻¹ of organo-chemical fertilizer compared to the recommended rate of 60 kg N ha⁻¹ of NPK (20:10:10)

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