Response of Cassava and Soyabean grown sole and intercrop to inoculation of *Arbuscular Mycorrhizal* Fungus *(AMF)* in Abeokuta, South Western Nigeria

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ABSTRACT

This study investigated the soil amendment potential of indigenous AMF for production of cassava (TMS 30572) and soyabean (TGx 1448-2E) grown sole or intercropped. A survey to identify the most prominent indigenous AMF species was conducted in Abeokuta, Nigeria 2000. The AMF species were identified using standard procedures. The two identified AMF-A and AMF-B species and their combination (AMFA+B in ratio 1:1) were bioassay on sole cassava and sole soyabean and their intercrop at 100g inoculums per10kg soil in the green house to determine growth and yield parameters. Experiment was laid out in a complete randomized design with three replicates. Growth and yield parameters taken were plant height(PH), leaf area(LA), number of leaves(NL), dry matter of leaf(DML), stem(DMS) and root(DMR), number of pod(NP), number of seeds(NS) and 100-seed weight(100-SD) were measured on soyabean while on cassava, the effect on plant height(PH), leaf area(LA), stem diameter(SD), fresh tuber weight(FTW) and number of tuber(NT) were measured. All data were analysed using ANOVA. The two most prominent AMF species were *G. mosseae* and *G. etunicatum*. In the greenhouse, AMF (A+B) significantly (P<0.05) increased DL (33%), DS (28%), and DR (31%), NP (26%), NS (28%), and 100-SD (25%) on soyabean (TGx 1448-2E) while on cassava (TMS 30572), LA (58.3cm^2), SD (2.1cm) and FTW (802.2 g/plant) were significantly (P<0.05) improved Application of AMF; *Glomus etunicatum* and *Glomus mossae* to soils has potential to increase production of soybean (24.5%) and cassava (33%).

Keywords: *Glomus etunicatum*, *Glomus mossae,* Cassava, Soyabean, Intercropping.

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INTRODUCTION

Cassava (Manihot esculenta Crantz) is a root crop ranked as the second most important stable foods in Africa (Nweke et al., 1988). Cultivation of cassava is by stem and it can tolerate wide range of soils (Hahn and Keyser, 1985). Cultivars can be differentiated by morphological line and hydrocyanic acid level (10mg/100gfresh weight or 5mg/100g fresh weight). Economically, it serves as a fodder for livestock and as industrial raw materials for industries. Soybean (Glycine max L.), is an annual herbaceous legume of the family fabaceae. It was introduced to Nigeria 1908 in Ibadan on experimental plots and it yield about 324kg dry grains/ha (FAO, 1986). Soyabean is one of the nature's most efficient protein source and unsaturated oil. It has the highest concentration of quality crude protein (38-42%) and 20% oil (IITA annual report, 1983). Unsaturated fatty acid is 85% and no cholesterol (Weingartner, 1987).

Intercropping is an aged agricultural practice in humid and subhumid tropics (Olukemi, et al., 2002). Intercropping with plants of differing maturities and or canopy height reduces weed growth, lowers soil diurnal temperature, control erosion and maximizes growth resources (Olasantan and Lucas, 1992). Culture of intercropping soybean with cassava is a new trend yet to be imbibed by the local farmers while cassava with other crops is very common. (Tijani-Eniola and Akinnifesi, 1996). Mycorrhizal is an association between fungi and roots of higher plants. In this association, plants supply the fungal with carbon and the fungus help the plant in the uptake of water and mineral nutrients in return (Bolan, 1991, Li et al., 1999)

In many countries especially developing ones like Nigeria, farmers intercrop with legumes or include them in the crop rotational cycle to enrich exhausted soils. This occurs mainly through nodule nitrogen fixation with little or no application of other fertilizer nutrients such as phosphorus (Benjamin, 1994). Supplementation of this agronomic practice with other soil and crop management practices geared towards yield improvement for example the application of basal phosphorus (Manjunath and Bagyaray, 1984). Mycorrhizal fungi is an important bio-fertilizer that pose no ecological threats and have long lasting effect on crops when managed properly (Mahdi and Atabani,1992). Mycorrhizal fungi form symbiotic association between plant and fungi that colonies the cortical tissues of roots during period of active plant growth (Harley and Smith, 1983). The benefits afforded plants is to increase their growth and yield potentials. Cassava (Manihot esculenta Cranzt) is a root crop. Its cultivation is by stem and it can tolerate wide range of soils (Hahn and Keyser, 1985). It can serve as a fodder for livestock and as industrial raw materials for industries. Soybean (Glycine max (L) Merril) is an important oil seed crop in the world. Its seeds contained forty percent protein and twenty percent oil (Foreign Agricultural Service, 1985, IITA, 1983). The objective of this work is therefore to determine the best indigenous VAM for cassava and soybean grown sole or intercropped.

MATERIALS AND METHODS

Soybean variety used in this experiment was TGX 1448-2E and cassava cultivar was TMS30572. An indigenous arbuscular mycorrhizal fungus (AMF) was isolated from the soil collected from research farm of the University of Agriculture, Abeokuta. The mycorrhizal fungi *Glomus mosseae* and *Glomus etunicatum* was isolated according to the method of Walker (1991) and identified based on spore size, hypae, colour, different wall types and reaction to melzers solution.The AMF were propagated on maize plant growing in pot culture in green house.

The experiment was conducted on Ultisol of Iwo series (Adetunji, 1994) at University of Agricultural, Abeokuta Research farm. The experimental design was 3x5 factorial fitted into a complete randomized design, replicated three times and repeated twice.

Treatments consist of cropping systems and soil amendment. The cropping systems were cassava sole, soybean sole, cassava and soybean intercropped. The crops were established the same day. The soil amendment consists of Glomus mosseae (GM), Glomus etunicatum (GE), combined Glomus (GM+GE), 100% P fertilizer (single super phosphate) and control. A total of forty five pot experimental plot was established. Ten kilogram soil was filled into bucket and 100g of crude mycorrhiza inocula were applied at 5cm below the soil surface while in the combined (GMGE), the stock applied were 25g of GM and 25g of GE to the test crop. Glomus (GM) contained 1542 spores per 100g soil while Glomus GE contained 1009 spores per 100g soil.

The crops in the mixture received 302kg/ ha. While cassava sole received 11 kg / ha. The fertilizer was broadcasted at sowing. Seeds of soybean were surface sterilized by soaking in 70% (V/V) ethanol for one minute and then washed several times with sterile distilled water. Three seeds of soybean were sown on each pot while cassava cuttings were mopped with cotton wool soaked in 70% (V/V) ethanol and washed with distilled water before planting.

Agronomic Measurements

For soybean, plant height were measured from 10cm from the base of the plant with a meter rule, leaf area (cm2) were calculated according to Hammer (1980) and modified by Lutalado (1986).

Pod dry weight(g),100-seed dry weight (g), number of pods, husk dry weight (g), seed dry weight, root (g), stem (g) and leaf dry weights (g) were determines while for cassava, plant height, leaf area (cm^2), number of leaf, stem girth (cm), number of tuber and tuber weight (g) were measured. All data were subjected to statistical analysis using SAS version 6 (SAS Institute, 1990). Means were separated using LSD at $P \leq 0.05$.

RESULTS AND DISCUSSION

The result of the soil physicochemical properties before planting is shown in table 1. The pH value was 6.63 at 20cm depth. The soil was ultisols (USDA-taxonomy) of Iwo series and contained878 gkg^{-1} sand,42 gkg^{-1}clay and 80 gkg^{-1}silt.The soil total nitrogen was 1.2gkg^{-1} , organic carbon 13.1 gkg^{-1} , available Phosphorus 6.35 $mgkg^{-1}$, with 1.32, 2.22, 0.26 $Cmolkg^{-1}$ of calcium ,magnesium and potassium respectively. Effect of cropping system and soil amendment on the following yield parameters of soyabean: pod weight, husk dry weight, number of pod, dry weight of stem, leaf and root of soybean were shown in tables 2 & 3. The cropping system and soil amendment gave significantly higher yield on some of the parameters of soybean determined except number of seed. Sole cropping system significantly gave higher yield of these determined parameters than the mixed cropping system except seed number, leaf dry weight and root dry weight. Inoculation with combined *Glomus* sp (GMGE) enhanced the entire yield parameters more, followed by GM, GE, and P and control the least.

Cropping system and soil amendment interaction improved the soybean parameters observed. The soybean plant inoculated with combined GMGE both in sole and mixed cropping systems gave better yield while control was the least (Table 2). Higher dry matters of leaf and root of soybean were enhanced in mixed cropping system while the stem dry weight was improved in sole cropping system. Dual inoculation (GMGE) had significant effect ($P<0.05$) on the leaf, stem and root dry weight of soybean followed by GM, GE, P and the least was control. Effect of dual inoculation irrespective of the cropping system adopted gave higher yield of all the parameters observed in the test crop (Table 3).The positive effect of cropping systems and soil amendment on seed dry weight, number of seeds and 100-seed weight were presented on table 4. Sole cropping system gave higher yield of both seed weight and 100-seed weight than mixed cropping system. Dual combination of soil amendment Glomus GMGE and the interactive effect with cropping systems gave higher yield of all the parameters under study.

Table 1: Some properties of the soil of the experimental site used

.pH (water)	6.63
N gkg^{-1}	1.2
C gkg^{-1}	13.1
Sand gkg^{-1}	878
Clay gkg^{-1}	42
Silt gkg^{-1}	80
Exchangeable base $Cmolkg^{-1}$	
K	0.26
Ca	2.32
Mg	2.22
Na	0.08
H+	0.13
C.E.C	4.02
Av. P ($mgkg^{-1}$)	6.35
Mn ($mgkg^{-1}$)	3.67
Soil series	IWO
USDA (Taxonomy)	ULtisol

Table 2: Effect of different cropping system and soil amendment on some yield parameters of *Glycine max*.

Cropping sys		Pod dry Wt/ plt (g)	Number of pod/plt	Husk dry wt/plt (g)
Mixed		7.02	14.40	2.48
Sole		7.66	16.33	2.74
LSD (P= 0.05)		0.19	3.14	0.16
SE (DF)		0.04 (20)	0.75 (20)	0.04 (20)
Treatment				
GMGE		11.25	19.66	4.42
GM		10.27	16.50	3.67
GE		7.48	15.50	2.16
P		5.20	13.50	1.93
ZERO		2.51	11.66	0.88
LSD (P= 0.05)		0.19	3.14	0.16
SE (DF)		0.02(20)	0.37 (20)	0.02 (20)
Cropping X Treatment				
Mixed	GMGE	10.76	19.01	3.58
	GM	10.15	15.00	4.17
	GE	7.05	14.33	2.04
	P	4.84	12.67	1.81
	ZERO	2.33	11.01	0.82
Sole	GMGE	11.74	20.33	3.78
	GM	10.39	18.06	4.68
	GE	7.92	16.67	2.29
	P	5.56	14.33	2.05
	ZERO	2.69	12.33	0.94
	LSD (P= 0.05)	0.19	3.14	0.16
	SE (DF)	0.02(20)	0.37 (20)	0.02 (20)

Table 3: Effect of different cropping system and soil amendment on some dry yield parameters of *Glycine max*.

Cropping		Leaf dry wt (g)	Stem dry wt (g)	Root dry wt (g)
Mixed		2.55	1.29	1.16
Sole		2.43	1.54	1.10
LSD (P= 0.05)		0.43	0.76	0.53
SE (DF)		0.10 (20)	0.18 (20)	0.12 (20)
Treatment				
GMGE		4.11	2.02	1.91
GM		3.14	1.92	1.21
GE		2.69	1.75	1.22
P		1.44	1.04	1.07
ZERO		1.07	0.35	1.01
LSD (P= 0.05)		0.43	0.76	0.53
SE (DF)		0.06 (20)	0.11 (20)	0.08 (20)
Cropping X Treatment				
Mixed	GMGE	4.02	2.74	2.24
	GM	3.17	1.55	1.03
	GE	3.1	1.41	0.78
	P	1.33	1.22	1.18
	ZERO	1.08	1.14	0.55
Sole	GMGE	4.12	2.10	1.60
	GM	3.11	1.96	1.27
	GE	2.24	1.25	1.11
	P	1.55	1.36	0.78
	ZERO	1.07	1.31	0.65
LSD (P= 0.05)		0.43	0.76	0.53
	SE (DF)	0.06(20)	0.11 (20)	0.08(20)

Table 4: Effect of different cropping system and soil amendment on some grain yield parameters of *Glycine max*.

Cropping		Seed dry wt/plt (g)	Number of seed	100 seed wt (g)
Mixed		4.55	31.20	14.67
Sole		4.94	31.00	14.99
LSD (P= 0.05)		0.12	1.73	0.29
SE (DF)		0.02 (20)	0.41 (20)	0.06 (20)
Treatment				
GMGE		8.08	41.66	19.18
GM		5.40	37.33	15.04
GE		5.26	35.50	4.85
P		3.36	24.00	14.42
ZERO		1.62	17.01	10.66
LSD (P= 0.05)		0.12	1.73	0.29
SE(DF)		0.02 (20)	0.26 (20)	0.04 (20)
Cropping X Treatment				
Mixed	GMGE	8.12	41.33	18.82
	GM	5.09	37.01	14.52
	GE	4.91	36.00	15.03
	P	3.13	23.67	14.57
	ZERO	1.51	19.04	10.46
Sole	GMGE	8.05	42.01	19.55
	GM	5.71	37.67	15.19
	GE	5.61	35.00	15.07
	P	3.60	24.33	14.28
	ZERO	1.73	16.00	10.87
LSD (P= 0.05)		0.12	1.73	0.29
	SE (DF)	0.02(20)	0.26 (20)	0.04 (20)

Table 5: Effect of different cropping system and soil amendment on some yield parameters of *Manihot esculenta*.

Cropping		Stem girth (cm)	Tuber weight (g)	Tuber number
Mixed		1.56	579.07	3.66
Sole		1.82	646.31	3.86
LSD (P= 0.05)		0.12	141.08	0.87
SE (DF)		0.029(20)	33.8 (20)	0.21
Treatment				
GMGE		2.10	802.22	4.66
GM		2.00	685.13	4.00
GE		1.56	618.88	3.66
P		1.50	538.73	3.50
ZERO		1.31	415.98	3.00
LSD (P= 0.05)		0.12	141.08	0.87
SE(DF)		0.029 (20)	21.38 (20)	0.13
Cropping X Treatment				
Mixed	GE	1.43	577.29	3.67
	GM	1.87	637.93	4.00
	GMGE	1.90	772.53	4.33
	P	1.37	509.13	3.33
	ZERO	1.27	393.50	3.00
Sole	GE	1.70	660.50	3.67
	GM	2.13	732.33	4.00
	GMGE	2.30	831.90	5.00
	P	1.63	568.33	3.67
	ZERO	1.37	438.47	3.00
LSD (P=0.05)		0.12	141.08	0.87
	SE(DF)	0.029 (20)	21.38 (20)	0.13(20.)

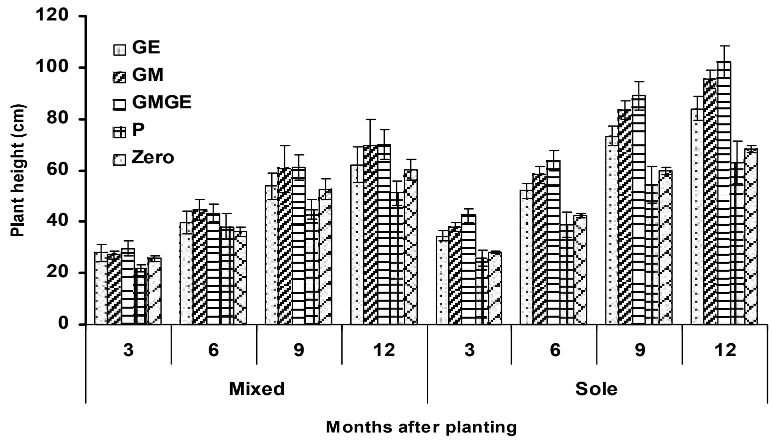

Fig. 1: Interactive effects of different soil amendments on cassava plant height under sole and mixed cropping GM=Glomus mosseae-like spore type,GE=Glomus etunicatum-like spore type,GMGE=combined Glomus, P=Phosphorus fertilzer, Zero= control

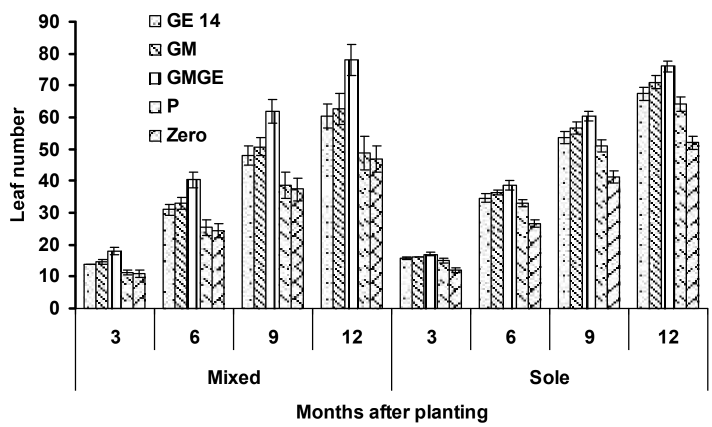

Fig. 2: Interactive effects of different soil amendments on cassava number of leaf under sole and mixed cropping GM=Glomus mosseae-like spore type,GE=Glomus etunicatum-like spore type,GMGE=combined Glomus, P=Phosphorus fertilzer, Zero= control

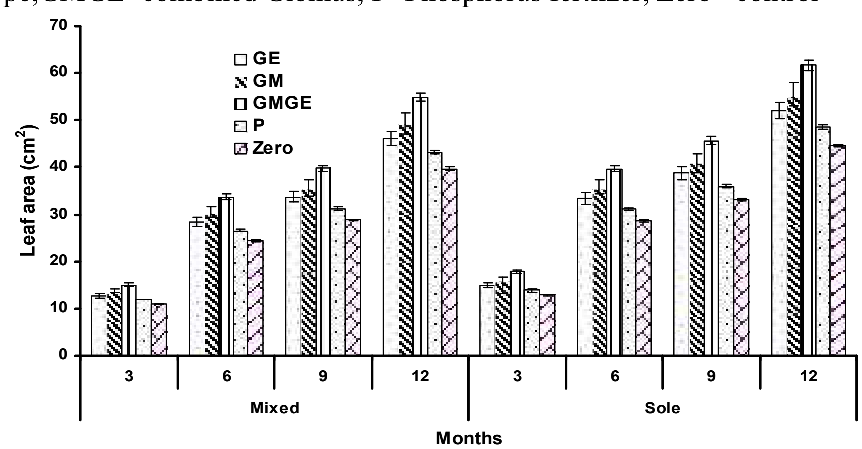

Fig. 3: Interactive effects of different soil amendments on cassava leaf area under sole and mixed cropping systems GM=Glomus mosseae-like spore type,GE=Glomus etunicatum-like spore type,GMGE=combined Glomus, P=Phosphorus fertilzer, Zero= control

The plant height, number of leaves and leave area of cassava were determined at 3, 6, and 9, and12 months after planting and the results is shown in fig 1, 2 and 3. Plant height, leaf number and leave area increased with months after planting both in sole and mixed cropping systems but the effects was more in sole than mixed cropping system. Inoculation with GMGE improved the plant height and leave area but not the number of leaves. This was closely followed by GM and least was recorded in the control both in sole and mixed cropping systems. In table 5, the stem girth, tuber weight but not number of cassava tuber was significantly increased in sole cropping system than mixed cropping system. Dual inoculation GMGE increased all the parameters more than any other treatment followed by GM, GE, P and control in this decreasing order. Interaction between cropping system and soil amendment gave the soyabean that received dual inoculation GMGE higher yield of above parameters while the least was recorded in control both in mixed and sole cropping systems.

Farmers in Africa recognized the role of intercropping as an insurance against crop failure strategy for meeting dietary needs. In this study, sole cropping was significantly affected the yield parameters such as husk dry weight, seed dry weight, number of seeds , 100 seed weight, leaf, stem and root dry weight of soybean and plant height, number of leaves, leaf area, stem girth, tuber weight and number of cassava tubers. The dual inoculation on soybean plant with indigenous G*lomus spp* GM and *Glomus* GE gave higher yield of plant height, leaf number, and leaf area than when applied singly on the cassava crop. This indicated that there is a synergetic effect (additive) of the combined *Glomus* spp (GMGE) irrespective of the cropping system adopted on the plant height, number of leave and leaf area of soyabean.

The soyabean that received the dual soil amendment GMGE grew morphologically stronger and better than others in the green house. They were taller with more leaves and wider leave area than others. These attributes were channeled by the plant into more production of photosynthate that made the plant to produce high number of pods, pod dry weight and husk dry weight. High number of seed per plant, seed dry weight, and 100 seed weight was recorded in the pot that received the dual soil amendment.

This better yield trait may be traced to the additive effect of indigenous *Glomus mosseae* (GM) and *Glomus etunicatum* (GE) in a sterile condition which was supported by Hertrick et al., (1986); Osonubi et al., (1992); Sonibare and Osonubi (2004) who opined that when they were applied in sterile condition, their ability to make use of carbohydrate and other potentials in the soil to the advantage of the recipient plant is maximized in the habitat by been able to produce large leaf area which created high interception of radiation and increased photosynthesis than others thus culminated to high flowering, and better pod formation of the mycorrhizal plant.

Bethlevfalvay and Yoder (1981), Bethlevfalvay, et al., (1985) and Murques et al. (2001) corroborate the possibility of synergetic effect of combined indigenouse mycorrhizal inoculant to increase both plant growth and yield potentials of mycorrhizal plants. The effectiveness of combined indigenous *Glomus* spp was supported by Powell (1977) in their studies that indigenous VAM fungi in 17 out of 20 cases raised and increased yield of recipient plant above the level obtained from plant infected with exotic species .

The dual interactive effect of soil amendment GMGE on leaf dry matter, stem dry matter and root dry weight is more effective in that higher yield of above parameters were obtained compared to other treatment in the green house trial. The yield differences may again be connected to the inherent advantage caused by the additional root-like structure from dual inoculation of GMGE which enabled the plant to extract P and other plant nutrients from low P-soils and maximized the efficiency of P in soil-plant system (Hayman, 1983; Plenchette et al., 1983). Again the ability of VAM to modify the root morphology such as root fineness and weight (Hetrick et al 1986, Koide et al 1988) and root-hair diameter, length and abundance (Manjunath and Habte 1988) which play major role in P and other mineral element uptake by the plant may not be ruled out.

Enhanced shoot and root growth of mycorrhizal plant that was observed, was also observed by Manjunath and Bagyaraji (1984) in their independent work on Cowpea and Pigeon Pea and Groundnut crop respectively. The advantage that came as a result of better association between the soybean plant and the dual GMGE, that give rise to good vegetative growth and root formation make the plant to maximized both water, nutrient and sunlight (photons) that were available to the crop at the period of growth and development. This observation corroborate the findings of Sonibare and Osonubi (2004) who in a similar work found out that root inoculaton with VAM fungi can increase efficiency of nutrient absorption and in turn enhance growth of mycorrhizal plant.

The higher yield obseved in sole cropping system over mixed cropping system may be the avalanche of water and plant nutrients resources that were available to both soyabean and cassava crop in 10kg soil bucket in the mixed cropping system which was supported by Brookes et al.,(1979) in similar work. The obtainable yield in sole cropping system showed that the two-way interactive effect gave over five percent (5%) higher yield increase than simple effect while it was over two percent(2%) higher yield in mixed cropping system. This was the general observation in the test crops.

CONCLUSION

Mycorrhizal plant (cassava and soyabean) performed better than non mycorrhizal plant. A luxuriant healthy vegetative growth was noticed as a peculiar trait in the mycorrhizal plant when compared with pot that contained only inorganic phosphorus or control which confirmed the work of Ba and Giussou 1996 who submitted that mycorrhizal plant has ability to absorb more soluble P and other available plant nutrients from the soil.

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