International Journal of
Advanced Studies in Ecology, Development and Sustainability
Hard Print: 2354-4252 Online: 2354-4260

July, 2016

Vol. 4, No. 2

Response of Cassava (Manihot Esculenta Crantz) to Arbuscular Mycorrhizal Fungi (AMF) and Organomineral Fertilizer as Soil Amendment

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Abstract

The used of different soil amendment to boost crop production has been attributed to the application of various chemical and organic fertilizers. Little or no information on the roles of arbscular mycorrhizal fungi and organomineral fertilizer (OMF) in cassava production was documented. Hence a field trial was conducted for two cropping seasons (2011 as 2012) using TME 1 (*oko-iyawo*) cassava cultivar at Department of Agronomy, Teaching and Research Farm, University of Ibadan. The experiment was 2 x 2 factorial experiment laid in complete randomized block design (RCBD) replicated three times, mycorrhizal inoculation at two levels (with and without). OMF application formed the major and sub – plots respectively and was applied at 0, and 2.5ha^{-1}. There was no significant influence of mycorrhizal inoculation at initial growth performance of cassava plant height and number of leaves. More so, no definite pattern of response from the cassava plant growth parameters to mycorrhizal inoculation as observed with OMF application with or without mycorrhizal inoculation. The results revealed that vegetative parameters of cassava towards the maturity stage were OMF dependent when compared to cassava plots inoculated with mycorrhiza without OMF. The tuber yield obtained under application of OMF and mycorrhizal inoculation at both cropping seasons were significantly increased when compared to cassava tuber obtained when cassava plant was not inoculated with mycorrhizal no OMF being applied. It can be deduced that the combination of both soil amendment is promising for cassava production hence, the AMF association in soil be encouraged through healthy soil fertility practices.

Keywords:
Cassava, Arbscular Mycorrhizal Fungi, Organomineral Fertilizer

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Background to the Study

Cassava (*Manihot esculenta* Crantz) is a perennial shrub, though harvested around a year. It is a member of *Euphorbiaceae* family. It is popularly grown for its tuberous root which consist about 15% peel, and 85% flesh. Cassava is essentially a tropical crop and does best with mean temperature of 25-29°C (Onwueme and Sinhna, 1999 and IITA, 2004). It is the most widely distributed tropical tuber crops found growing between latitude 30°N and longitude 30°S in areas where annual rainfall is greater than 500 mm and mean temperature is greater than 20°C (FIIRO, 2006). According to Yusuf *et al*. (2008), cassava based cropping systems are more prevalent than other cropping systems in several sub- Saharan Africa.

As a staple crop, cassava has certain inherent characteristics which make its cultivation attractive to smallholder farmers in the country. Such traits include ability to thrive on soils where other crops failed; cassava is regarded as a famine reserve crop which requires relatively low amounts of inputs. The crop can withstand stress such as drought, available all year round, cheap to cultivate and generates good income for peasant farmers, thus providing household food security (Okon *et al*., 2010). Nigeria is the highest producer of cassava in the world, followed by other countries such as Zaire, Tanzania, Ghana, Mozambique, Uganda, Madagascar, Angola, Cameroon, Cote d'Ivoire and Benin (FAO, 2012). Cassava is processed for various forms of utilization such as starch, dried cassava "*garri*," fermented and dried cassava pulp, wet pulp, smoked cassava balls, cassava bread, among other products obtainable from the tuber (FIIRO, 2006 and Muoneke and Mbah, 2007).

Among constrains to crop production in Nigeria, nutrient depletion in soils and yield decline have become serious challenges. The main causes of soil fertility problems in crop production is the shortened length of fallow resulting from human population pressure and other developmental needs on land (Nyathi and Campbell,1995 and Karl and Johannes, 1997). The reduced length of fallow causes deterioration of soil, when nutrients lost at previous cultivations are not fully replenished (Nair, 2014). Hence, alternative methods adopted are; intercropping and soil amendments on the limited available land for crop production (Ayoola, and Adeniyan, 2006). Cassava has been a well known tuber crop to be compatible with other arable crops for intercropping especially for soil fertility measures; such as with leguminous crop such as cowpea or soybean or groundnut with cassava because of their inherent advantages such as short growth period; low canopy structure, drought tolerant and nitrogen fixation and ability to suppress weeds infestation (Ayoola and Makinde, 2007; Olorunda, 2010 and Nair, 2014).

However, manure when efficiently and effectively used ensures sustainable crop productivity by immobilizing nutrients that are susceptible to leaching (Lombin *et al.,* 1991; Omueti *et al.,* 2000 and Ibiremo, 2010). The management and conservation of the soil to guide against decreased crop yields under intensive cropping have become major areas of agronomic research (Ayoola, and Adeniyan, 2006). The major component of soil fertility management in crop production is the use of fertilizers, but the use of fertilizers in cassava melon intercropping is fairly common among Nigerian peasant farmers where fallow has been abandoned as higher crop yields are usually obtained from plots with fertilizer application (Soumare *et al.,* 2003; Kiani *et al.,* 2005). In spite of all the advantages of mineral fertilizers in crop production there are problems such as; its availability to famers, the cost of procuring it and its effects on the environment (Haynes and Naidu, 1998; Castillo *et al*, 2003; Jadoon *et al*, 2003; Gilley and Risse, 2000).

As a way of reducing total dependence on the use of mineral fertilizer, an integrated soil fertility management system focusing on biological approach, which is eco- friendly and less expensive, is desirable. Hence, mycorrhizal symbiosis is well recognized as biological tool to enhance nutrient acquisition in most plants growing on nutrient deficient soils (Schuessler *et al*., 2001; Fagbola *et al*., 2001; Dalpe and Monreal, 2004). Moreover, the benefits from these associations to plants include: improved water and nutrients uptake, enhanced phosphorus (P) transport, and drought and diseases resistance. Benefits to fungi are the supply of photosynthates to the fungal network located in the cortrical cells of the plant and the surrounding soil.

All water, nutrients, and photosynthates exchanges occur via the fungal filament network that bridged plant rhizosphere and plant roots (Karl and Johunnes, 1997; Fagbola *et al*., 2001). Therefore, it can be used as biofertilizer and organic fertilizers within the framework of sustainable agriculture. Sustainable crop production in traditional farming systems such as intercropping with the use of fortified organic fertilizer; (organomineral fertilizer) and or biofertilizer, a key area that requires attention (Mahmood and Rizvi, 2010 and Dania *et al.,* 2013). Mycorrhizal application in farmer's field will go a long way in reducing the problem of nutrient acquisition especially on degraded soils at little or no cost. Short–fallow production systems appear to be a common practice for cassava cultivation. Hence, more effort is needed for sustainable increase in productivity in term of cassava production with natural resources found around such as soil micro organisms that are beneficial. Although in cassava production, nutrient demand is being hampered by limitation imposed by sole use of inorganic fertilizers whenever they are available. The use of organomineral fertilizer can be augmented with mycorrhizal inoculation for enhance nutrient uptake and cassava productivity. However, it is not yet well- established how cassava performs under tropical conditions with organomineral fertilizer mycorrhizal inoculation.

Objective of the Study

The objective of this work was to assess the response of cassava to Arbuscular Mycorrhizal Fungi (AMF) and organomineral fertilizer.

Methodology

Description of Experimental Location

The study was carried out for two cropping seasons, (2011 to 2012) at the Teaching and Research Farm, Parry Road, University of Ibadan, Ibadan. Ibadan is located on Latitude7.4°N and Longitude 3.9°E with about 3,080 km^{-2} land area and has a tropical wet and dry climate.

Experimental Materials and Procedures: The organomineral fertilizer, mycorrhizal inoculums and cassava cuttings (stems) *oko-iya* cultivar used for the experiment were obtained from the Department of Agronomy, University of Ibadan. Soil samples were taken from the experimental site prior to planting at a depth of (0 - 15cm for screen house work) and

0-30 cm and after the final harvest of melon and cassava to assess the nutrient status of the soil.

Land preparation and Planting Operations: The experimental site was manually slashed and debris was packed, then ridges were manually made at 1 m apart at the onset of rains in April 2011. Each micro plot was 16 m^2 with a metre gap between plots and blocks to facilitate field operations. Cassava was planted at 1 m x 1 m spacing giving 10,000 plants/ha. The experiment was repeated on the same land area in the 2012 cropping season.

Experimental Design and Treatments Application: The experiment was laid out in a randomized complete block design (RCBD) in split-split plots with three replicates. The main plots were with and without Mycorrhizal inoculation. The organomineral fertilizer (OMF) was applied at 2.5 t ha^{-1} evenly worked into the soil two weeks before planting.

Data Collection and Analyses: Data collected include: cassava plant height, number of leaves, number and weight of fresh tubers and processed (*garri*) tuber weight. All data collected were analyzed using analysis of variance (ANOVA) and means were separated using Duncan's Multiple Range Test (DMRT)

Results and Discussions

Table 1: Nutrient Composition of Organomineral Fertilizer

Parameters	Organomineral Fertilizer
Total N (g/kg)	44.2
Total P (g/kg)	11.0
Total K (g/kg)	7.0
Ca (g/kg)	7.0
Mg (g/kg)	0.57
Mn (mg/kg)	558.0
Fe (mg/kg)	8153.0
Cu (mg/kg)	275.0

Source: (2010) Soil Science Laboratory, Dept. of Agronomy University of Ibadan

From the above table, the composition of the orgamomeral fertilizer used for the experiment is highly rich in some of the elements analyzed for. The N, P and k available is adequate for cassava production. The analysis result revealed that the available micro – nutrients are adequate for crop production (Table 1).

From table 2, the soil used for the experiment showed that the N level at the beginning if the experiment was 1.8g/hg and decreased to 1.4g/kg. The exchangeable bases ranged from 0.2 – 2.3 cmol kg^{-1} for K and Ca respectively. Mn has the highest value 90.1 mg kg^{-1} compared to other micronutrients. The particle size revealed that the soil was sandy loam (Table 1). The available P decreased after the experiment by approximately 72.7%. Similarly the K reduction was approximately by 8.33%. However, there were increased in other exchangeable bases, this could be attributed to the levels of these elements in the applied fertilizer. The soil physical properties revealed that it was sandy loam soil with no considerable change in textural class at the end of the experiment (Table 2).

Table 2: Chemical and Physical Properties of the Soil before and after field Experiments; 2011 and 2012 cropping years

Parameters	Values	
	2012	2013
pH (H_2O)	6.7	6.4
Organic C (g kg^{-1})	17.4	14.3
Total N (g kg^{-1})	1.8	1.4
Available P (mg kg^{-1})	22.1	16.0
Exchangeable Bases (cmol kg^{-1})		
K	0.24	0.22
Ca	1.94	2.46
Na	0.28	0.30
Mg	0.33	0.39
Extractable Micronutrients (mg kg^{-1})		
Mn	94.5	100.8
Fe	58.4	64.8
Cu	4.22	4.61
Zn	2.07	3.87
C.E.C	3.34	3.87
Particle size distribution (g kg^{-1})		
Sand	812.0	812.0
Clay	48.0	48.0
Silt	140.0	140.0
Textural class	Sandy Loam	Sandy Loam

Source: (2010) Soil Science Laboratory, Dept. of Agronomy University of Ibadan

Table 3: Cassava plant height (cm) as influenced by OMF and AMF inoculation in 2011 and 2012 cropping years

Treatments	Months After Planting			
	3	6	9	12
	First Cropping year (2011)			
Plots without OMF application				
Without mycorrhiza	62.1ab	108.3a	128.1a	141.7d
With mycorrhiza.	58.8b	100.3a	134.2a	158.5ab
Plots with OMF application				
Without mycorrhiza	57.8b	98.7ab	129.5a	148.2cd
With mycorrhiza.	63.3ab	106.0a	132.5a	151.8c
		Second Cropping year (2012)		
Plots without OMF application				
Without mycorrhiza	54.8ab	93.2a	113.1a	150.2a
With mycorrhiza.	51.3ab	85.3a	119.2a	134.8b
Plots with OMF Application				
Without mycorrhiza	50.3abc	83.7ab	114.5a	138.7b
With mycorrhiza.	55.8a	91.0a	100.7bc	124.5cd
Mycorrhiza (M)	ns	ns	ns	ns
Fertilizer (OMF)	ns	ns	ns	ns
M x OMF	ns	ns	ns	ns

Under each column, numbers followed by similar alphabets are not significantly different at P= 0.05 according to Duncan's multiple range test.

Legend

M = Mycorrhizal inoculation OMF = Organomineral fertilizer

ns = not significant * = significant

Cassava plant Growth Variables

From table 3, the cassava plant height was not significant influenced at the initial stages of the growth in both cropping seasons, except cassava grown on plot with OMF application without mycorrhizal inoculation. At 6 month after planting, cassava plant height was not significantly different in the two cropping seasons. This showed that mycorrhiza and OMF application; at this stage showed no significant effect on cassava plant height. At 9 months after planting, mycorrhizal inoculation significant reduced cassava plant height at the second cropping season when compared to similar treatment at the first cropping (Table 3). Similarly, when OMF was applied to cassava plot with mycorrhizal inoculation, the plant height was significant reduce at 12 months after planting of the first cropping season. The reduction was significant when compared to similar treatment and when no OMF and mycorrhizal was applied at the second cropping season (Table 3).

Table 4: Number of cassava leaves as influenced by OF fertilizer and AMF in 2011 and 2012 cropping years

Treatments	Months After Planting			
	3	6	9	12
	First Cropping year (2011)			
Plots without OMF application				
Without mycorrhiza	50.7ab	68.6a	130.7ab	80.3a
With mycorrhiza.	44.7bc	66.6a	129.5bc	74.5b
Plots with OMF application				
Without mycorrhiza	55.7a	75.3a	129.3ab	86.0a
With mycorrhiza.	55.7a	75.0a	132.3ab	91.0a
	Second Cropping year (2012)			
Plots without OMF application				
Without mycorrhiza	45.7ab	63.3abc	120.7abc	80.3b
With mycorrhiza.	39.7ab	63.7abc	119.7abc	75.3bc
Plots with OMF Application				
Without mycorrhiza	50.7ab	70.3abc	122.0abc	85.3ab
With mycorrhiza.	50.7ab	70.0abc	122.3ab	91.7a
Mycorrhiza (M)	ns	ns	ns	ns
Fertilizer (OMF)	ns	ns	*	*
M x OMF	ns	ns	ns	ns

Under each column, numbers followed by similar alphabets are not significantly different at P= 0.05 according to Duncan's multiple range test.

Legend

M = Mycorrhizal inoculation OMF = Organomineral fertilizer
ns = not significant * = significant

At 3, 6 and 9 months after planting, the number of leaves of cassava plant at the first cropping season was not significantly different under similar treatment of OMF application with mycorhizal inoculation. However, at 12 months after planting, when mycorrhizal was applied, without OMF, the number of leaves was significantly reduced when compared to similar treatment during the second cropping season. At 3, 6, 9 and12 months after planting, the number of cassava leaves were not significantly different, except at 12 months after planting when OMF was applied with mycorrhizal inoculation (Table 4). Where the number of cassava leaves were significantly higher when compared to similar treatment (Table 4).

Table 5. Effect of Organomineral fertilizer and Mycorrhizal Inoculation on Cassava Productivity in 2011 and 2012 Cropping years

Treatments	Yield variables		
	Number of tuber (10,000 ha^{-1})	Tuber weight (t ha^{-1})	Processed cassava tuber (*garri* t ha^{-1})
	First Cropping year (2011)		
Plots without OMF application			
Without mycorrhiza	2.0c	4.6d	1.3c
With mycorrhiza.	5.3b	9.6bc	1.9c
Plots with OMF application			
Without mycorrhiza	4.3b	14.3b	3.6b
With mycorrhiza.	7.0a	22.3a	4.6ab
		Second Cropping year (2012)	
Plots without OMF application			
Without mycorrhiza	2.7a	5.4c	1.5c
With mycorrhiza.	3.0a	6.3c	1.5c
Plots with OMF Application			
Without mycorrhiza	2.7a	10.8bc	3.3ab
With mycorrhiza.	3.7a	11.9ab	3.6ab
Mycorrhiza (M)	Ns	ns	ns
			ns
Fertilizer (OMF)	Ns	ns	*
			ns
M x OMF	Ns	ns	ns

Under each column, figures followed by similar alphabets are not significantly different at P= 0.05 according to Duncan's multiple range test.

Legend

M = Mycorrhizal inoculation OMF = Organomineral fertilizer

ns = not significant * = significant

Cassava Yield Variables. The cassava yield in terms of number of tubers per plant was significantly increased by presence of mycorrhizal inoculation under OMF application in the first cropping seasons. Nevertheless, during the second cropping season, there was no significant different in number of cassava tuber per plant when OMF and mycorrhizal was applied when compared to when no OMF and mycorrhizal was applied. However, at the first cropping season, the presence of mycorrhiza and OMF application significantly increased cassava tuber weight when compared to tuber yield obtained when no mycorrhizal only and OMF only was applied but not significantly different from similar treatment in the second cropping season (Table 5). However, the processed cassava tuber (*garri*) yield was significantly reduced when no OMF and mycorrhizal was applied at the first and second cropping seasons when compared to processed cassava tuber (*garri*) obtained under application OMF and mycorrhizal inoculation (Table 5). Nevertheless, the (*garri)* yield obtained when both OMF and mycorrhizal was applied was not significantly different when compared to yield obtained when each was singly applied.

Summary, Conclusion and Recommendations

The optimum cassava tuber yield obtained at both cropping years was significantly higher under OF with mycorrhizal inoculation compared to other treatments. The highest tuber yield was obtained when cassava was cropped under mycorrhizal and OMF application at the first cropping year. This was also higher under the same treatment (mycorrhizal and OMF application) when cassava was planted at the second cropping year. The values obtained agreed with the reports of Onwueme and Sinha (1999) and Abiola and Daniel (2014). However, these cassava tuber yields were higher compared to a report that a yield of 10 to 15 tons per hectare is possible in Nigeria, in farmers' field, while research farm yield up to 25 - 40 tons per hectare (Ezulike *et al*., 2006 and FIIRO, 2006 and **Jimin *et al.*, 2013**). This can be possible with the use of OMF as organic source of fertilizer that releases nutrients steadily and slowly. This is in line with the finding of Ibiremo (2010), that organic fertilizer significantly improved crop growth and yield.

In conclusion, it can be deduced that OMF in combination with mycorrhizal inoculation increased cassava tuber yield and the processed tuber (*garri*); hence, it can be recommended that the soil fungi stimuli of arbuscular mycorrhizal be encouraged for its symbiotic association with cassava plant. Besides, farmland with OMF application with arbuscular mycorrhizal should be cultivated the second time for maximum utilization of the nutrients constituent of OMF and to prolong the symbiosis association of arbuscular mycorrhizal fungi to improve soil fertility especially where the indigenous AM fungi species are found.

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