ARPN Journal of Agricultural and Biological Science

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DRY MATTER YIELD AND NUTRIENT UPTAKE OF CASHEW SEEDLINGS AS INFLUENCED BY ARBUSCULAR MYCORRHIZAL INOCULATION, ORGANIC AND INORGANIC FERTILIZERS IN TWO SOILS IN NIGERIA

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ABSTRACT

Cashew productivity as a result of its wide adaptation has been greatly limited by poor soil fertility, pests and diseases etc. Hence, this study assessed the influence of organic fertilizer, phosphate fertilizer and Arbuscular mycorrhizal (AM) inoculation on the dry matter yield and nutrient uptake of cashew seedlings in two soils in Nigeria. The three factors investigated were organic fertilizer made from ground cocoa pod husk (CPH) applied at two levels (0 and 2.5t/ha), three sources of phosphate fertilizers (Single super phosphate - SSP, Sokoto rock phosphate - SRP and a control) and two levels of AM fungi inoculation (with and without). Cashew nuts were planted into 5kg top soil (0-30cm) obtained from the two sites. Dry matter yield and nutrient uptake were assessed. The results indicated that SSP significantly ($p < 0.05$) enhanced the accumulation of dry matter in Uhonmora soil compared to the control while in Ibadan soil phosphate fertilizers did not significantly affect the dry matter yield of cashew seedlings. The total N uptake of cashew seedlings increased by 25.5% and 43.9% as a result application of SSP and SRP respectively compared to the control in Ibadan soil while in Uhonmora soil, shoot N, P, K, Ca and Mg uptake by cashew seedlings were positively and significantly enhanced ($p < 0.05$) as a result of phosphate fertilizer application compared to the control. AMF inoculation and organic fertilizer did not affect cashew seedlings dry matter and nutrient uptake within the study period. Organic fertilizer application significantly ($p< 0.05$) improved the pH of Ibadan soil. The available phosphorus of Uhonmora soil was significantly ($p< 0.05$) increased as a result of organic fertilizer application by 11.7% compared to the control. In Uhonmora soil, the addition of phosphate fertilizers significantly ($p< 0.05$) increased the accumulation of inorganic P above the control but the reverse is the case for organic P where the application of phosphate fertilizers significantly ($p< 0.05$) decreased its accumulation. SRP had a comparable influence with SSP particularly under AM inoculation on cashew seedling growth performance in the two soils.

Keywords: cashew, arbuscular mycorrhizal, inoculation, nut size, phosphate fertilizer, dry matter, nutrient uptake.

INTRODUCTION

Cashew (*Anacardium occidentale* Linn) is an export-earning crop and is cultivated in many agro - ecological zones in Nigeria Cashew is grown for its nuts and pseudo-apple from which products such as cashew juice, wine, vinegar, jams, chocolate, cashew nut shell liquid (CNSL) and cooking oil are made (Ohler, 1979). The cashew tree's leaves and bark as well as the popular cashew apple possess herbal health benefits that include killing bacteria and germs, stopping diarrhea, drying secretions, increasing the libido, and reducing fever, blood sugar, blood pressure and body temperature. Nigeria produces 186,000MT of nuts per year representing 9% of the world production thus making Nigeria the 4th largest producing country in the world after Vietnam, India and Brazil (IFA, 2004). Cashew is grown in many soil types of the savanna zones of Nigeria. It is less selective and demanding in terms of soil types and fertility requirements compared with other plantation crops (Ohler, 1979). Cashew as a result of its wide adaptation is often grown in very poor soils and this has affected its survival and establishment in most fields. In many cashew plantations, the establishment could be as low as 45%, while in acute situations it could be less. There is paucity of information on the nutritional requirements of cashew. The neglect could be due to an earlier claim that cashew must be modest in its nutritional demands since it is found to be productive on soils too poor and dry for other crops (Ohler, 1979). The use of N, P and K fertilizers for cashew nutrition had been established (Owaiye and Olunloyo, 1990). Phosphorus is the second most limiting nutrient after nitrogen in the nutrition of cashew. Phosphorus plays an indispensable role as a universal fuel for all biochemical work in living cell and in particular root development which is very important to crop establishment in the field (Agbede, 2009). A very crucial aspect of improving and maintaining soil fertility is the application of deficient nutrients of which phosphorus is one of the most important nutrients. In tropical and subtropical soils, the application of phosphorus is important for most crops because of its low availability, which is not unconnected with fixation. The wide spread deficiency of phosphorus in Nigerian soils, constitutes a serious limiting factor in the production of major food and fibre crops. P-deficiency is often corrected through the use of inorganic phosphorus fertilizers such as single super phosphate, triple super phosphate, NPK fertilizers and other inorganic sources. Application of most of these P-chemical fertilizers on a long term basis often leads to reduction in pH and exchangeable bases thus making them unavailable to crops and the productivity of crop declines (Zainol *et al*., 1993). In addition, the problem of affordability of these chemical fertilizers to resource-poor farmers and other attendant problems of fertilizer procurement and distribution make the use of rock phosphate for direct application a viable option (Akande *et al*., 2008). Due to the inherent advantage of the use of rock phosphate, research scientists and organizations have advocated the direct application of rock phosphate with a significant content of less soluble P such as phosphate rock to recapitalize the soils (Adediran and Sobulo, 1995).

The use of organic fertilizer to grow tree crops, especially cocoa, coffee and oil palm has been reported by various workers (Aisueni *et al*., 2000., Obatolu, 1995). Application of compost improves the biological activity of the soil and has a direct impact on the sustainability of soil health (Nagaraj *et al*., 2000). Some of the materials used include animal manures such as cow dung, poultry droppings and plant residues, which include weed and crop residues. However, the use of these materials had not been extended to cashew production. Organic fertilizer application enhances the solubilization of rock phosphate that is made possible through microbially produced organic acids such as humic and fluvic acids and thus making phosphorus easily available to crops according to Laska *et al*., (1990). In many cocoa-producing states in Nigeria, cocoa pod husk (CPH) is a major farm waste and it constitutes more than 60% of fresh pod (Oguntuga, 1975). The manuring properties of cocoa pod husk had been studied (Oladokun, 1986). Hence, CPH can be converted to organic fertilizer to be used for growing cashew and other crops. CPH has low nutrient value especially N and P in comparison with other organic wastes such as stover of legumes and animal wastes. The efficiency of CPH could be improved through amendment with inorganic nutrient sources such as Sokoto rock phosphate and single super phosphate.

Arbuscular mycorrhizal fungi (AMF) are ubiquitous beneficial soil micro-organisms associated with roots of most plants (Howeler *et al*., 1982). They penetrate the living cells of plants without harming them and their hyphae can range far into the bulk soil establishing equally intimate contact with the micro-biota of soil aggregates and micro-sites. The fungi link plant and soil transporting mineral nutrients to the plant and carbon compounds to the fungi (Reid, 1990). The potential of Arbuscular mycorrhiza (AM) fungi to enhance crop production is well recognised (Fagbola *et al*., 2001). Phosphorus is generally considered to be most important plant-growing factor which can be supplied by mycorrhizal associations, because of the many abiotic and biotic factors which restrict its mobility in soils. Evidence exists that mycorrhiza may have a greater effect when P is present in less soluble forms. Many workers have shown the contribution of vesicular-arbuscular mycorrhizae in improving the P uptake of many crops (Howeler *et al*., 1982., Soedarjo and Habte 1993). It has been reported that the pre-inoculation of tree crop seedlings with the efficient AM- fungi has enhanced the growth, and reduced transplant shock and field survival in many cashew producing countries (Ananthankrishnan *et al*., 2004). Most studies involving the use of rock phosphate, organic fertilizers and Arbuscular mycorrhiza in Nigeria have focused mainly on arable crops (Fagbola *et al*., 2001) but information regarding the effect of these materials on tree crops especially cashew is very limited. World demand for cashew nuts is increasing steadily and the domestic demand is higher than supply. Hence, there is need to increase cashew nut production through well-articulated agronomic practices that will enhance field survival and establishment through fertilizer application.

Therefore, the objectives of this study were to determine the effect of AM fungi inoculation, organic and phosphate fertilizers on the dry matter yield and nutrient uptake of cashew seedlings and to determine the effect of the fertilizer amendments on the chemical properties of the two soils.

MATERIALS AND METHODS

The experiment was conducted in the greenhouse of Cocoa Research Institute of Nigeria in 2007/2008 seedling production. Soil samples (top soil) were collected randomly at the plantations of the two stations (Ibadan and Uhonmora) at 0-30 cm depth. The soil was air-dried and sieved using 2mm sieve. Sub-samples were analyzed for physical and chemical properties using standard laboratory procedures (IITA, 1982). The organic fertilizer (CPH) contained 0.95, 0.11, 4.30, 1.2 and 0.24 % of N, P, K, Ca and Mg respectively. SRP had 33.47, 44.23, 0.95 and 7.90 % for P_2O_5, CaO, MgO and $CaCO_3$, respectively while SSP had 18.02, and 27% for P_2O_5 and CaO, respectively. Five kilogrammes sieved soils were placed in 5-litre plastic pots and watered to field capacity before the nuts were planted. All pots were planted with two large nuts of cashew but after a month, the seedlings were thinned to one seedling per bucket. Twelve treatment combinations were formed comprising two levels of CPH (0 and 2.5 t/ha), three sources of phosphorus (control, Single super phosphate and Sokoto rock phosphate) and two levels of mycorrhizal inoculations (with and without). The AM used for the study was *Glomus clarum* (Nicolson and Schenck). The phosphate fertilizers were applied at rate equivalent to 11kg P_20_5 ha^{-1} which was equivalent to 5kg Pha^{-1} while 20g of the AM fungi containing spore, hyphae and roots of the cultural plant was applied just below the nuts at planting. The treatments were replicated four times and then arranged in a completely randomized design (CRD). Watering was done regularly thrice a week. Data on height stem diameter and number of leaves were taken monthly. At four months after planting (MAP), the plants were destructively sampled and separated into leaves, stem and roots. The fresh plant samples were dried in an oven to constant weight to determine the dry matter yield and the samples were milled using an electric hammer and nutrient analysis was carried out for major nutrients in the leaves, stems and roots. The nutrient uptake was calculated as the product of the concentration and dry matter yield according to Osonubi *et al*., 1991. Analysis of variance was performed on all data to test the treatment effect on different parameters measured using a SAS analytical package of 9.2 version.

RESULTS AND DISCUSSIONS

The soil of Ibadan is near neutral with a pH of 6.66 while that of Uhonmora was slightly acidic with pH of 5.83 (Table-1). The sand fraction of Uhonmora soil was 13.8% lower than that of Ibadan (Table-1). Conversely, the clay content of Uhonmora was 51.6% higher than Ibadan soil. Similarly, the water holding capacity (WHC) of Uhonmora was 40.4 % higher than that of Ibadan. The total soil nitrogen of both sites was adequate for cashew production while the available P is moderate for Uhonmora and Ibadan (Adeoye, 1986). However, the exchangeable K^+, Ca^{2+}, and Mg^{2+} are adequate for cashew production. The exchangeable sites have enough basic cations and thus resulting in very high base saturation values. The soils of Ibadan and Uhonmora are quite ideal for cashew production (Obatolu 1996).

The total dry matter yield (DMY) of cashew seedlings as influenced by phosphate fertilizers indicated that SSP significantly ($p<0.05$) enhanced the accumulation of DMY in Uhonmora soil (Figure-1a) compared to the control. Conversely, phosphate fertilizers did not significantly affect the DMY of cashew seedlings in Ibadan soil. In Ibadan, SSP and SRP application increased the DMY of cashew seedlings by 15 and 10%, respectively compared to the control (without P fertilizers). The lack of significant difference might be attributed to the levels of available P in the soil, which seemed to be adequate to take care of the cashew at that tender stage. This is in agreement with the findings of Falade, (1978) in which two sources of phosphorus fertilizers (SSP and TSP) did not show significant differences on the growth of cashew. Ayodele and Agboola, (1981) reported that most crops in Nigerian soils show no response to P if soil test is $15 mgkg^{-1}$ or more. Ogoke *et al.*, (2004) found that grain dry-weight of soybeans was significantly increased by P application at sites where initial soil test for P was $6.2\ mgkg^{-1}$ but where initial soil test P was high, the application of P depressed grain yield. Nevertheless, the performance of SSP in terms of dry matter accumulation and nutrient uptake in Uhonmora and Ibadan soils was significantly higher than that of SRP due to its higher solubility. Ghosh, (1999) found that application of finely ground rock phosphate was as effective as SSP, whereas some other reports by Haugen and Smith, (1993), showed that rock phosphate performed less than SSP. Organic fertilizer application and AM inoculation have no significant effect on the total DMY of cashew seedlings in the two soils (Figures 1b and c). AM inoculated cashew seedlings had 20% DMY increase compared to non-inoculated seedlings in Ibadan soil, whereas in Uhonmora soil, non-inoculated cashew seedlings had 10% increase in DMY compared to the inoculated ones. The result in Ibadan is consistent with the findings of Utkhede *et al*., (2008) in which AM inoculation enhanced the growth of apple seedlings in an un-pasteurized soil. The influence of organic fertilizers was not significant on DMY of cashew seedlings. Organic fertilizer application significantly ($p < 0.05$) enhanced the root N, K and Ca uptake in Uhonmora soil (Table-2). However, root uptake of P and Mg were not significantly improved as a result of organic fertilizer application. It was observed that organic fertilizer improved root uptake of Mg by 26.7% compared to the control. Similarly, the root P, K and Ca of cashew seedlings planted in Ibadan soil were significantly ($p < 0.05$) enhanced as a result of organic fertilizer application compared to the control. In Uhonmora soil in particular, organic fertilizer application improved shoot uptake of N, P and K by 9.9, 8.9 and 5.1 % respectively compared to the control but were not significant.

At 4 MAP, the root nutrient uptake (N, K, Ca and Mg) were not significantly affected as a result of phosphate fertilizers applied to cashew seedlings in Uhonmora soil (Table-3). The root K and Ca uptake of cashew seedlings were positively enhanced by organic fertilizer application. This is consistent with the findings of Brunner *et al.,* (2004) in which wood ash application positively enhanced the root Ca and root Mg of spruce in Norway. Application of SRP reduced the root nutrient uptake of cashew seedlings compared to SSP and the control in Uhonmora soil. However, at 4 MAP, phosphate fertilizer application significantly ($p < 0.05$) enhanced the root uptake of P, K, Ca and Mg in Ibadan soil. Mohd. Yussoff *et al*., (2007) obtained similar results in which phosphate fertilizer application significantly enhanced the P, K, Ca and Mg uptake by cocoa seedlings in Malaysia. The N uptake of cashew seedlings as a result of SSP application was increased by 25.5% compared to the control and 43.9% compared to when SRP was applied to cashew seedlings. Similarly, in Uhonmora soil, shoot N, P, K, Ca and Mg uptake by cashew seedlings were positively and significantly enhanced ($p < 0.05$) as a result of phosphate fertilizer application compared to the control. The shoot P and K uptakes were significantly ($p < 0.05$) enhanced by SRP application compared to the control in Ibadan soil (Table-3). SRP application improved the shoot N uptake compared to both SSP and the control in Uhonmora soil. In addition, shoot Ca and Mg uptake were improved (not significantly) through the application of phosphate fertilizers compared to the control in Ibadan soil. The influence of AM inoculation on the root nutrient (N, P, K, Ca and Mg) uptake of cashew seedlings was not significantly affected in both Ibadan and Uhonmora soils (Table-4). Arbuscular mycorrhizal inoculation improved the K, Ca and Mg uptake by 13.1, 13.3 and 17.8%, respectively compared to the control in Uhonmora soil. However, AM inoculation depressed the root N and P uptake in Uhonmora soil and root N, P, K, Ca and Mg in Ibadan soil. This might be due to the activity of the native mycorrhiza as there was no attempt at destroying the native AM at the onset of the trial. The marginal improvement observed on the dry matter yield and nutrient

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uptake of cashew seedlings due to AM inoculation in Uhonmora could further be attributed to the fact that the native mycorrhizae in Uhonmora were more active than those in Ibadan soil. The non-significant effect of AM inoculation may be due largely to the complementary role of native mycorrhizae in the soils particularly Uhonmora soil. This phenomenon was noticed with other field crops by Haugen and Smith, (1993). The effect of organic fertilizer application on pH of Uhonmora soil was not significant at the end of the study (Table-5). However, organic fertilizer application significantly ($p < 0.05$) improved the pH of Ibadan soil. The available phosphorus of Uhonmora soil was significantly ($p < 0.05$) increased as a result of organic fertilizer application by 11.7% compared to the control. Conversely, organic fertilizer did not significantly affect the available P in Ibadan soil. Organic fertilizer application caused 4.7% reduction in the available P of Uhonmora soil. The influence of organic fertilizer application on exchangeable H^+ and Al^{3+} was not significant in both Uhonmora and Ibadan soils at the end of the study (Table-5). In particular, organic fertilizer reduced the amount of exchangeable hydrogen ions in Ibadan soil by 17.2 % compared to the control. The inorganic P-fraction of Uhonmora soil was significantly ($p < 0.05$) improved by 16.2 % compared to the control as a result of organic fertilizer application. However, organic fertilizer negatively affected the organic P of Uhonmora soil (Table-5). In contrast, the inorganic, organic and total P-fractions of Ibadan soil were not significantly affected by organic fertilizer application. Organic fertilizer application increased the inorganic P-fraction of Ibadan soil by 4.9% and decreased the organic P by 1.6%. The total P of Uhonmora and Ibadan soils decreased as a result of organic fertilizer application. The total organic carbon (TOC) particulate organic carbon (POC) and relative particulate organic carbon (RPOC) of Uhonmora soil were not significantly influenced by organic fertilizer application (Table-5). Organic fertilizer increased the accumulation of TOC and POC in Uhonmora soil by 5.1% and 2.2%, respectively compared to the control. However, organic fertilizer application significantly ($p < 0.05$) decreased POC and RPOC but the TOC was not affected significantly in Ibadan soil (Table-5). The TOC in Ibadan soil was marginally decreased by 3.5% compared to the control. Organic fertilizer application did not significantly affect the total acidity and soil nitrogen of both Uhonmora and Ibadan. Organic fertilizer decreased the total acidity of Ibadan soil by 17.2 % compared to the control. Organic fertilizer application decreased the total soil nitrogen by 11.8% and 7.9% for Uhonmora and Ibadan soils respectively. The pH, available P, exchangeable H^+ and Al^{3+} were not significantly affected by phosphate fertilizer application in Uhonmora soil (Table-6). In Uhonmora soil, the addition of phosphate fertilizers significantly ($p < 0.05$) increased the accumulation of inorganic P above the control but the reverse is the case for organic P where the application of phosphate fertilizers significantly ($p < 0.05$) decreased its accumulation. However, the inorganic P, organic P and total P fractions for Ibadan soil and the total P of Uhonmora soil were not significantly affected by phosphate fertilizer application. Similarly, the soil organic carbon, POC, RPOC, total acidity and total soil nitrogen were not significantly affected by phosphate fertilizer application. Specifically, application of SRP reduced the total acidity by 21.9 % compared with the control in Uhonmora soil.

Total nutrient uptake (N, P, K, Ca and Mg) was significantly ($p < 0.05$) correlated with plant height in Ibadan soil (Table-7). However, they had low correlations with plant height in Uhonmora soil. The high correlation obtained was consistent with the findings of Isaac, *et al* (2007) and Hartemink, (2005) in which nutrient uptake correlated significantly with height and growth parameters of cocoa. Total Mg uptake in Ibadan soil had very low correlation with total N uptake of cashew whereas in Uhonmora soil, there was significant correlation ($r = 0.81^{**}$) with total N uptake of cashew. Similarly, total P, K and Ca uptake of cashew were significantly correlated with total Mg uptake in the soils of Ibadan and Uhonmora (Table-7). In Ibadan soil, total Ca uptake gave very low correlation ($r = 0.03$) with total N uptake but in Uhonmora soil, the correlation was significant ($r = 0.80^{**}$). Similarly, the Ca uptake of cashew seedlings had significant correlation with total P and K uptake in both soils of Ibadan and Uhonmora. Plant height was significantly correlated with dry matter yield of cashew seedlings in Ibadan ($r = 0.35^{*}$) and Uhonmora ($r = 0.50^{**}$). Total P uptake of cashew seedlings had significant correlation with total K uptake in Ibadan ($r = 0.91^{**}$) and Uhonmora ($r = 0.86^{**}$). However, total P uptake was not significantly correlated with total N uptake in Ibadan ($r = 0.08$) but was significantly correlated with total N uptake in Uhonmora soil ($r = 0.89^{**}$). AM infection was significantly correlated ($r = 0.36^{*}$) to total dry matter yield of cashew seedlings in Uhonmora soil but in Ibadan soil, it had low correlation ($r = 0.14$). The total soil organic carbon was significantly correlated ($r=0.35^{*}$) with total soil P in Ibadan soil but in Uhonmora soil, it gave negative correlation ($r =-0.32$). Similarly, AM colonization was negatively correlated with total N and K uptake of cashew seedlings in Uhonmora soil but in Ibadan soil the correlations were very low. The particulate organic carbon was significantly correlated ($p < 0.05$) with total organic carbon in Ibadan soil but in Uhonmora soil there were negative correlations ($r = -0.05$) with total organic carbon. AM colonization was negatively correlated ($r = -0.29$) with total organic carbon of the soil in Uhonmora soil but in Ibadan the correlation was very low ($r = -0.02$). In Uhonmora soil, AM colonization significantly correlated ($r = 0.45^{**}$) with total P uptake by cashew seedlings but the correlation ($r = 0.17$) was low in Ibadan soil.

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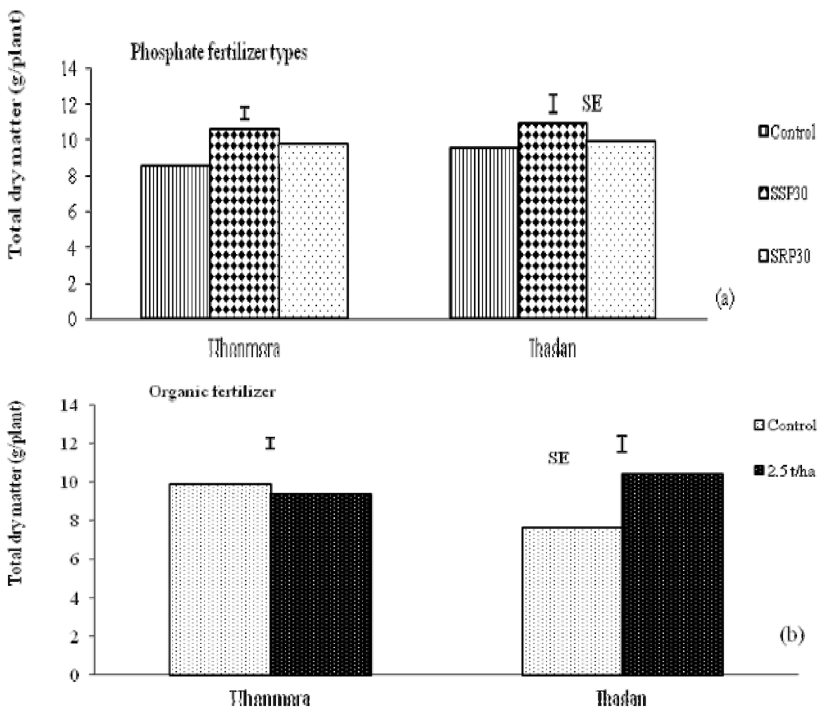
Table 1: Physical and chemical characteristics of the soils of Onigambari, Ibadan and Uhonmora at 0 – 30 cm

Soil Properties	Unit	Value	
Physical		Ibadan	Uhonmora
Sand	g kg^{-1}	694.00	610.00
Silt	“	149.55	152.85
Clay	“	156.45	237.15
Textural Class	-	Sandy loam	Sandy clay loam
WHC	%	38.60	65.06
Chemical			
pH (H_2O) 1:1	-	6.66	5.83
Organic Carbon	g kg^{-1}	1.81	2.95
Total Nitrogen	“	0.65	0.79
Available Phosphorus	mg kg^{-1}	8.87	9.81
Exch. Bases			
K^+	cmol kg^{-1}	0.67	0.57
Ca^{2+}	“	2.07	2.23
Mg^{2+}	“	2.01	2.95
Na^+	“	0.55	0.67
Mn^{2+}	“	0.03	0.06
Exch. Acidity			
Al^{3+}	“	0.13	0.10
H^+	“	0.04	0.27
ECEC	“	5.14	6.81
Base Saturation	%	96.76	94.47

ECEC - Effective Cation Exchange Capacity
WHC - Water Holding Capacity



 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

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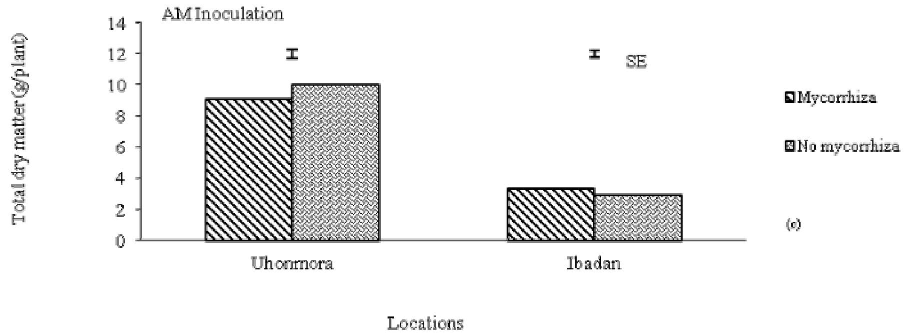

Fig 1: Dry matter accumulation of cashew as influenced by phosphate fertilizer types, organic fertilizer and AM inoculation in soils from two locations under greenhouse conditions

Table 2: Effect of organic fertilizer on the nutrient uptake by cashew seedlings grown in soils from two locations under greenhouse conditions at 4 MAP

Organic Fertilizer (t ha^{-1})	Nutrient Uptake mg/plant				
	N	P	K	Ca	Mg
			Uhomonra		
Root Nutrient Uptake					
0	19.92	3.08	11.25	8.79	5.39
2.5	25.69	2.43	15.08	12.10	6.83
LSD (0.05)	5.66	ns	3.43	2.66	ns
Total Nutrient Uptake					
0	176.69	12.40	80.72	43.41	23.82
2.5	197.69	12.58	87.46	44.11	24.82
LSD (0.05)	ns	ns	ns	ns	ns
			Ibadan		
Root Nutrient Uptake					
0	25.10	1.97	9.55	7.62	4.90
2.5	23.30	2.73	14.69	9.42	5.43
LSD (0.05)	ns	0.69	3.56	2.18	ns
Shoot Nutrient Uptake					
0	111.14	5.82	54.51	22.03	10.95
2.5	100.34	5.60	58.49	20.00	10.04
LSD (0.05)	ns	ns	ns	ns	ns
Total Nutrient Uptake					
0	140.10	7.59	62.96	29.43	15.74
2.5	123.50	8.25	73.31	29.51	15.54
LSD (0.05)	ns	ns	ns	ns	ns

LSD (0.05) = Least significant difference; ns = not significant

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Table 3 : Effect of phosphate fertilizers on the nutrient uptake by cashew under greenhouse conditions in soils from two locations at 4 MAP

P-fertilizer	Nutrient Uptake mg/plant				
	N	P	K	Ca	Mg
			Uhomonra		
Root Nutrient Uptake					
Control	25.58	3.30	12.79	11.21	6.73
SSP	22.34	2.71	13.36	11.21	6.73
SRP	23.51	2.25	13.14	8.91	4.86
LSD (0.05)	ns	0.87	ns	ns	ns
Shoot Nutrient Uptake					
Control	159.74	9.35	72.39	27.02	14.02
SSP	134.85	7.60	60.43	24.94	16.05
SRP	198.12	12.27	79.09	48.00	23.48
LSD (0.05)	41.30	2.40	17.40	9.00	4.67
Total Nutrient Uptake					
Control	182.31	12.65	73.99	38.23	22.78
SSP	157.19	10.30	86.05	36.14	20.76
SRP	224.63	14.52	92.23	56.90	28.34
LSD (0.05)	45.03	2.94	ns	10.88	5.69
			Ibadan		
Root Nutrient Uptake					
Control	18.80	1.88	12.77	9.17	5.29
SSP	23.60	3.19	13.58	8.84	5.55
SRP	16.40	1.89	9.90	7.50	4.58
LSD (0.05)	ns	0.84	1.69	1.62	0.75
Shoot Nutrient Uptake					
Control	106.55	5.85	57.53	19.31	9.50
SSP	94.04	4.88	48.32	22.62	10.09
SRP	116.73	6.44	64.48	21.13	11.92
LSD (0.05)	ns	1.42	13.47	ns	ns
Total Nutrient Uptake					
Control	126.30	7.71	70.64	28.38	14.82
SSP	189.60	8.07	61.90	31.45	15.64
SRP	129.40	8.13	71.87	28.57	16.47
LSD (0.05)	65.20	Ns	ns	ns	ns

LSD (0.05) = Least significant difference; ns = not significant

Table 4 : Effect of AM inoculation on the nutrient uptake by cashew seedlings grown in soils from two locations under greenhouse conditions at 4 MAP

AM Inoculation	Nutrient Uptake mg/plant				
	N	P	K	Ca	Mg
Uhonmora					
Root Nutrient Uptake					
M	21.07	2.81	13.97	11.09	6.61
NM	24.54	2.69	12.35	9.79	5.61
LSD (0.05)	ns	ns	ns	ns	ns
Shoot Nutrient Uptake					
M	175.57	10.51	76.61	40.97	21.21
NM	152.90	8.96	64.66	25.66	14.49
LSD (0.05)	ns	ns	ns	ns	ns
Total Nutrietn Uptake					
M	196.65	13.33	91.17	52.06	27.82
NM	177.44	11.66	77.01	35.45	20.10
LSD (0.05)	ns	ns	ns	8.89	4.62
Ibadan					
Root Nutrient Uptake					
M	19.80	2.11	12.29	7.89	5.04
NM	22.61	2.62	12.10	9.24	5.30
LSD (0.05)	ns	ns	ns	ns	ns
Shoot Nutrient Uptake					
M	114.27	6.41	61.74	24.14	11.85
NM	96.58	4.96	51.06	17.89	9.15
LSD (0.05)	ns	1.16	ns	4.06	2.02
Total Nutrient Uptake					
M	134.30	8.49	74.28	32.04	16.93
NM	189.30	7.45	61.99	26.90	14.35
LSD (0.05)	ns	ns	ns	ns	ns

M = with mycorrhizal inoculation, NM = without mycorrhizal inoculation
LSD (0.05) = Least significant difference; ns = not significant

Table 5 : Influence of organic fertilizer on some soil chemical properties of soils from two locations under greenhouse conditions at harvest (4 MAP)

Variables		Organic Fertilizer t ha^{-1}		LSD (0.05)
		0	2.5	
Uhonmora				
pH		5.84	5.84	ns
Available P	(mg/kg)	10.73	11.99	0.86
Exch. H	(c mol/kg)	0.26	0.27	ns
Exch. Al	(c mol/kg)	0.05	0.05	ns
Inorganic P	(mg/kg)	102.79	119.47	6.84
Organic P	(mg/kg)	140.22	123.18	7.72
Total C	(g/kg)	15.91	16.73	ns
Part. Organic C	(g/kg)	8.71	8.90	ns
Rel. Part. Organic C	(g/kg)	0.55	0.53	ns
Total N	(g/kg)	0.93	0.82	ns
Total acidity	(c mol/kg)	0.31	0.32	ns
Ibadan				
pH		6.20	6.28	0.06
Available P	(mg/kg)	5.51	5.26	ns
Exch. H	(c mol/kg)	0.29	0.24	ns
Exch. Al	(c mol/kg)	0.05	0.05	ns
Inorganic P	(mg/kg)	33.70	35.35	ns
Organic P	(mg/kg)	144.83	142.83	ns
Total C	(g/kg)	9.43	9.41	ns
Part. Organic C	(g/kg)	3.90	2.67	1.19
Rel. Part. Organic C	(g/kg)	0.41	0.27	0.12
Total N	(g/kg)	0.76	0.70	ns
Total acidity	(c mol/kg)	0.34	0.29	ns

ns = not significant

Table 6: Influence of P-fertilizer sources on some chemical properties of soils from two locations under greenhouse conditions at harvest (4 MAP)

Variables		P-Sources			LSD (0.05)
		Control	SSP	SRP	
			Uhonmora		
pH		5.86	5.85	5.82	ns
Available P	(mg/kg)	11.38	11.32	11.38	ns
Exch. H	(c mol/kg)	0.26	0.32	0.21	0.07
Exch. Al	(c mol/kg)	0.06	0.05	0.04	ns
Inorganic P	(mg/kg)	104.03	113.81	115.53	8.38
Organic P	(mg/kg)	139.09	127.55	128.47	9.46
Total C	(g/kg)	16.35	16.52	16.10	ns
Part. Organic C	(g/kg)	9.70	8.14	8.58	ns
Rel. Part. Organic C	(g/kg)	0.60	0.50	0.53	ns
Total N	(g/kg)	0.89	0.90	0.84	ns
Total acidity	(c mol/kg)	0.32	0.37	0.25	ns
			Ibadan		
pH		6.25	5.39	5.34	ns
Available P	(mg/kg)	5.41	5.39	5.34	ns
Exch. H	(c mol/kg)	0.26	0.25	0.29	ns
Exch. Al	(c mol/kg)	0.05	0.05	0.05	ns
Inorganic P	(mg/kg)	32.62	33.18	37.77	4.80
Organic P	(mg/kg)	148.17	141.47	141.44	ns
Total C	(g/kg)	9.92	9.10	9.24	ns
Part. Organic C	(g/kg)	3.89	2.78	3.19	ns
Rel. Part. Organic C	(g/kg)	0.40	0.30	0.34	ns
Total N	(g/kg)	0.75	0.83	0.60	0.18
Total acidity	(c mol/kg)	0.31	0.30	0.34	ns

ns = not significant

Table 7: Relationship among plant and soil variables as affected by organic fertilizer, phosphate fertilizers and AM inoculation under greenhouse conditions in soils from Ibadan (above diagonal) and Uhonmora (below diagonal)

Variables		1	2	3	4	5	6	7	8	9	10	11	12
Total Soil P	(1)		0.35	0.11	0.04	0.00	0.19	0.16	0.07	0.17	0.12	0.10	-0.02
Total Organic C	(2)	-0.32		0.34*	0.12	-0.18	0.35*	-0.14	-0.23	-0.24	-0.17	0.06	-0.29
Part. Organic C	(3)	0.14	-0.05		0.97**	0.05	0.11	-0.27	-0.32	-0.20	0.11	0.05	-0.47**
Rel.Part.Organic C	(4)	0.17	-0.29	0.97**		0.13	-0.21	-0.25	-0.29	-0.15	0.17	0.04	-0.44**
Total N Uptake	(5)	0.06	0.00	0.22	0.19		0.08	-0.08	0.03	0.07	0.39*	0.14	0.10
Total P Uptake	(6)	-0.03	-0.04	0.19	0.18	0.89**		0.91**	0.83**	0.90**	0.45**	0.26	0.17
Total K Uptake	(7)	-0.01	-0.01	0.24	0.22	0.91**	0.86**		0.83**	0.89**	0.42*	0.26	0.23
Total Ca Uptake	(8)	-0.07	-0.17	0.20	0.23	0.80**	0.82**	0.83**		0.87**	0.29	-0.02	0.20
Total Mg Uptake	(9)	0.04	-0.08	0.23	0.23	0.81**	0.83**	0.88*	0.94**		0.41*	0.26	0.21
Plant Height	(10)	-0.05	0.14	0.12	0.08	0.04	-0.07	0.03	0.15	0.17		0.35*	-0.03
Total dry matter	(11)	-0.03	0.08	-0.06	-0.07	-0.12	-0.17	-0.12	0.14	0.10	0.50**		-0.14
AM colonization	(12)	-0.10	0.02	0.15	0.15	-0.46**	-0.45**	-0.37*	-0.26	-0.21	0.08	0.36*	

*, ** Significant at 5 and 1% respectively.

CONCLUSIONS

Sokoto rock phosphate had comparable influence with SSP on the growth of cashew seedlings. Hence, when SSP is not available, Nigerian Sokoto rock phosphate is a viable option for cashew production. Inoculation of cashew with exotic AM may not be necessary because cashew easily forms association with native mycorrhiza in the soil and thus making the external addition of AM to increase the cost of input to cashew production. Organic fertilizer amended with phosphate fertilizer and AM inoculation has positive influence on the growth of cashew and the chemical properties of the soil.

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