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Effects of phosphate fertilizers and maize plant density on productivity of cassava/maize/ egusi-melon mixtures on Alfisols of Ekiti State, South-Western Nigeria

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Abstract

Ground phosphate rock, GPR (9% P) and GPR-fortified organic wastes (organo-mineral fertilizer, OMF, 11% P) were evaluated for cassava, maize and egusi-melon production (in mixtures of varied maize population), using single super phosphate, SSP (7.7%P) as standard. P-source (4 replications in RCBD) were applied @ 0, 26 and 52 kg P ha^{-1} (1st year); reduced to 0 and 26 kg P ha^{-1} (2nd year) and no addition in the 3rd year to elucidate residual effects. Maize biomass partitioning revealed stovers > grains > roots, cassava had roots > stems > leaves while biomass and P uptake was reduced with increasing maize density. Treated crops consistently performed better than control but highest with GPR application. It is clear that GPR and OMF could be used to advantage by resource-poor farmers for increased productivity of cassava/maize/egusi-melon mixtures on the Alfisols.

Key words: Ground phosphate rock, cassava/maize/egusi-melon mixture, biomass production, P uptake partitioning, Alfisols.

Introduction

The deregulation policy and working below installed capacity utilization of manufacturing plants in many developing nations limit the scope of meeting future fertilizer demands. Sridhar *et al.*[12], Obigbesan [7] and Omueti *et al*. [9] opined that the future of agriculture lies in the development of organic-based fertilizers.

Adeoye *et al.* [1] observed that farmyard manure (FYM) improves yam production better than mineral fertilizers as the crop is not capable of optimizing single application of inorganic fertilizers but prefers slow continuous release of nutrients that is possible with the use of organic manure. Aerobic composting of wastes in windrows has proved very effective in reducing problems associated with organic fertilizer production besides enhancing crop yields [9, 12]. This is more so when the organic manure produced is fortified with phosphate rocks [8].

The need to substitute inorganic P fertilizers with ground rock phosphate (GPR) and organo-mineral fertilizers (OMF) at different agro-ecologies in Nigeria prompted the study being reported here. Specifically, the productivity of cassava/maize/egusi-melon mixture under the influence of GPR and OMF were compared using SSP as reference fertilizer on two Nigeria Alfisols.

Materials and Methods

Soil samples (0-20 cm depth) were collected from farmers' plots of about 0.25 ha in two locations within Nigeria - Ikere (forest agro-ecology) and Omuo (savanna agro-ecology). They were bulked, air-dried, crushed, thoroughly mixed, passed through a 2 mm sieve and subjected to routine laboratory analysis using IITA procedures [6].

In field trials (2001 to 2004) on cassava/maize/egusi-melon mixtures at the two locations, P sources were applied using % P composition based on fertilizer application rate of NPK 15-15-15 400 kg ha^{-1} to maize that is common in the study areas. Phosphorus sources were applied in Randomized Complete Block Design (RCBD) of four replications at P 0, 26 and 52 kg ha^{-1} in the first year but reduced to 0 and 26 kg ha^{-1} in the second year and without application in the third year in order to test the residual effects. Basal nutrients were applied as urea (N 100 kg) and K (K_2O 60 kg ha^{-1}) was applied as muriate of potash (KCl). Melon and maize were planted at 20,000 plants ha^{-1} while cassava was planted at 10,000 plants ha^{-1} in the first year. In the second and third years, maize population varied from 20,000 to 25,000 and 35,555 plants ha^{-1}.

Plant samples were taken at various growth stages. Cassava whole plants were collected at 28 and 48 weeks after planting (WAP) and subsequently partitioned into leaves, petioles, stems and roots. Ear leaves of maize were sampled at 50% tasseling (6 WAP) while leaves and seeds were sampled at full maturity (12 WAP). Melon leaves were sampled at 50% flowering (6WAP) and whole plants (partitioned into stovers, seeds and roots) 12 WAP for full physiological growth evaluation. The cassava and maize varieties used were TMS-30572 and Suwan-2-SR, respectively, while a local variety of melon was used.

Each plant sample was weighed fresh. Sub-samples (200 g) were also oven dried at 70°C for 48 h, weighed, milled and passed through a 2 mm sieve prior to digestion with a mixture of acids (HNO_3, $HClO_4$ and HCl) to extract P. Phosphorus contents were

determined using Spectronic 20 colorimeter. P uptake was determined by multiplying P content with the respective dry weight.

Results and Discussion

The physico-chemical characteristics of the experimental sites have been documented [8] based on nutrient critical levels suggested by Singh and Uriyo [10] as well as Sobulo and Osiname [11]. Available P was considered low at Ikere location while total N was low in both soils.

Data on biomass yield, P uptake and partitioning that were used as crop performance indices to evaluate P fertilizer treatment (sources and rates) and maize plant population effects on the component crops of the mixture are summarized in Tables 1, 2 and 3 for egusi-melon, maize and cassava, respectively. Positive effects of GPR and OMF application were indicated by increased biomass accumulation and P uptake in roots, stems, leaves and grains as well as the total dry matter produced in respect of each of crop and P uptake by them. Values obtained for GPR and OMF fertilized plots were significantly ($p<0.05$) higher than those without fertilizer application at the two experimental locations. These are generally indication of improved phosphate availability to P-treated plots of component crops of the cassava-based cropping system compared with the untreated ones. The responses suggest good advantage derivable from the use of the fertilizer materials.

Biomass partitioning in maize during the growth periods was decreasingly ordered as stovers > grains > roots while the order was roots > stems > leaves for cassava. This confirms that the tops (aerial plant portion) (grains, stems and leaves) have higher priority as sinks (in nutrient and assimilate allocation) than roots (underground plant portion). The reverse is true for cassava. This agrees with several other previous reports [2, 4, 5]. The reason for the compatibility of the cassava-maize cropping system is also quite evident.

It is believed that increased uptake of P is attributable to improved availability of the nutrient arising from increase in the readily available labile pool [3].

Conclusions

Results of this investigation represent a concluding field attestation to the high potentials of GPR and OMF in the forest and savanna agro-ecologies of Nigeria. Residual effects are, however, better reflected in GPR than in OMF used in this study. Yet, it is obvious that the two phosphate fertilizer sources could be employed for the improvement of soil P fertilizer management by resource poor farmers in the study areas.

Table 1. Effects of phosphorus fertilizer sources and rates on biomass production, phosphorus uptake and partitioning in egusi-melon of the cassava-based crop mixtures at Ikere and Omuo during 2001/2002 cropping seasons.

Phosphorus fertilizer treatment		Weeks after planting			
		6		12	
P source	Rate (P kg ha^{-1})	Biomass (Mg ha^{-1})	P uptake (kg ha^{-1})	Biomass (Mg ha^{-1})	P uptake (kg ha^{-1})
			Ikere		
Control	0	0.06	0.30	0.14	3.55
G P R	26	0.15	1.65	0.32	4.65
	52	0.14	2.43	0.34	5.80
OMF	26	0.22	1.73	0.34	4.68
	52	0.32	2.65	0.42	5.75
SSP	26	0.13	1.68	0.36	4.75
	52	0.33	2.80	0.43	5.63
LSD (0.05)		0.06	0.20	0.05	0.24
CV (%)		21.19	7.07	10.14	2.59
			Omuo		
Control	0	0.07	0.25	0.22	3.25
G P R	26	0.27	1.60	0.37	4.63
	52	0.32	2.18	0.37	5.13
OMF	26	0.28	1.65	0.35	4.70
	52	0.33	2.25	0.40	5.25
SSP	26	0.30	1.70	0.37	4.10
	52	0.32	2.25	0.39	4.56
LSD (0.05)		0.04	0.15	0.03	0.14
CV (%)		0.79	5.85	6.83	2.06

GPR = Ground phosphate rock; OMF = Organo-mineral fertilizer; SSP = Single super phosphate.

Table 2. Effects of phosphorus sources and maize plant density on biomass production, phosphorus uptake and partitioning in maize of the cassava-based crop mixtures at Ikere and Omuo during 2002/2003 cropping seasons.

P source	Maize density (plants ha^{-1})	Weeks after planting							
		6				12			
		Leaf		Stover		Leaf		Stover	
		DM (Mg ha^{-1})	P uptake (kg ha^{-1})	DM (Mg ha^{-1})	P uptake (kg ha^{-1})	DM (Mg ha^{-1})	P uptake (kg ha^{-1})	DM (Mg ha^{-1})	P uptake (kg ha^{-1})
					Ikere				
Control	20,000	0.80	0.25	3.57	5.63	0.63	0.63	2.60	4.20
	25,000	0.60	0.17	3.33	5.40	0.30	0.43	2.43	4.73
	35,555	0.47	0.43	3.20	3.63	0.73	0.67	2.10	3.37
GPR	20,000	1.83	1.33	5.77	6.57	0.50	0.57	3.60	5.50
	25,000	1.53	1.13	3.37	5.43	0.73	0.83	2.43	4.47
	35,555	1.37	1.60	3.73	4.73	0.40	0.57	2.57	3.53
OMF	20,000	1.53	1.37	5.77	6.33	0.57	0.60	3.37	5.50
	25,000	1.40	1.40	4.20	5.30	0.57	0.60	3.30	4.23
	35,555	1.30	1.70	3.10	4.60	0.27	0.33	2.57	3.43
SSP	20,000	1.70	1.07	5.47	6.57	0.53	0.47	3.33	5.60
	25,000	1.17	1.08	4.27	5.43	0.20	0.70	3.53	4.53
	35,555	1.30	1.67	4.47	4.13	0.67	0.70	3.60	3.63
LSD (0.05)		0.11	1.17	0.49	0.56	0.37	0.44	0.50	0.57
CV (%)		5.11	8.64	6.93	6.28	13.21	14.01	9.97	6.80
					Omuo				
Control	20,000	0.80	0.80	3.77	3.77	0.40	0.40	2.30	2.30
	25,000	0.57	0.57	3.53	3.53	0.20	0.20	2.50	2.50
	35,555	0.37	0.37	3.30	3.30	0.37	0.37	2.00	2.00
GPR	20,000	1.60	1.60	3.77	5.37	0.80	0.80	3.63	3.63
	25,000	1.40	1.40	4.60	4.60	0.17	0.17	3.40	7.00
	35,555	1.20	1.20	4.37	4.37	0.17	0.37	2.60	2.60
OMF	20,000	1.90	1.90	4.10	4.10	0.83	0.83	3.83	3.83
	25,000	1.40	1.40	4.23	4.23	0.30	3.30	4.50	4.50
	35,555	1.30	1.30	4.47	4.47	0.10	0.10	2.53	2.53
SSP	20,000	1.90	1.90	5.20	5.20	0.80	0.80	3.50	3.50
	25,000	1.40	1.70	4.47	4.47	0.40	0.40	3.33	6.33
	35,555	1.17	1.17	4.20	4.20	0.67	0.67	2.33	2.33
LSD (0.05)		0.18	0.93	0.51	0.43	0.37	0.32	0.72	0.33
CV (%)		8.41	6.44	7.04	7.48	13.56	16.70	11.96	7.93

GPR= Ground phosphate rock; OMF = Organo-mineral fertilizer; SSP = Single super phosphate; DM = Dry matter.

Table 3. Residual effects of phosphorus sources on biomass production, phosphorus uptake and partitioning in cassava of the cassava-based mixture (with varied maize plant population) at Ikere and Omuo during 2003/2004 cropping season.

P source	Maize density (plants ha^{-1})	Weeks after planting											
		28						48					
		Leaf		Stem		Root		Leaf		Stem		Root	
		DM	PUP	DM	PUP	DM	PUP	DM	PUP	DM	PUP	DM	PUP
							Ikere						
Control	20,000	0.47	0.90	0.67	0.24	3.61	3.57	0.60	0.60	0.70	0.26	2.87	2.90
	25,000	0.67	0.87	0.77	0.25	3.18	3.40	0.50	0.80	0.57	0.24	2.70	2.90
	35,555	0.60	0.90	0.55	0.33	3.62	3.63	0.43	0.70	0.30	0.25	2.47	2.80
GPR	20,000	1.73	1.37	0.30	0.37	4.40	4.57	2.00	1.63	0.84	0.20	5.91	5.53
	25,000	1.60	1.33	0.44	0.50	3.53	3.47	2.00	1.77	0.81	0.37	5.94	5.40
	35,555	1.43	1.67	0.33	0.46	3.47	3.30	2.47	1.60	0.78	0.67	5.67	4.57
OMF	20,000	1.57	1.37	0.47	0.63	4.57	4.63	2.50	1.70	0.27	0.50	5.37	5.60
	25,000	1.73	1.53	0.57	0.33	3.17	3.63	2.50	1.70	0.27	0.47	5.37	5.57
	35,555	1.37	1.47	0.60	0.47	3.50	3.53	2.33	1.50	0.50	0.50	5.40	5.43
SSP	20,000	1.60	1.60	0.20	0.40	4.50	4.63	2.60	1.53	0.61	0.53	5.77	5.47
	25,000	1.43	1.70	0.63	0.37	2.87	6.30	2.10	1.43	0.30	0.60	5.20	5.20
	35,555	1.53	1.61	0.67	0.83	2.23	4.90	2.23	1.63	0.50	0.33	5.13	5.37
LSD (0.05)		0.38	1.21	0.35	0.76	1.21	0.36	1.22	0.76	1.28	0.52	2.21	0.36
CV (%)		23.15	15.31	6.73	12.79	7.35	11.85	9.26	14.51	6.25	13.49	7.21	15.74
							Omuo						
Control	20,000	0.53	0.30	0.90	0.33	2.07	3.60	0.71	0.80	0.70	0.24	3.33	3.90
	25,000	0.53	0.30	0.63	0.33	2.07	3.60	0.73	0.80	0.70	0.25	3.33	3.90
	35,555	0.53	0.30	0.70	0.33	2.57	3.60	0.71	0.80	0.70	0.26	3.33	3.90
GPR	20,000	1.43	1.50	0.87	0.50	4.67	4.53	2.27	1.73	0.77	0.43	4.96	5.70
	25,000	1.43	1.50	0.90	0.50	4.67	4.53	2.27	1.73	0.77	0.63	4.97	5.70
	35,555	1.63	1.07	0.83	0.50	4.67	4.53	2.20	1.73	0.70	0.43	4.83	5.70
OMF	20,000	1.47	1.33	0.70	0.47	4.37	4.37	2.53	1.90	0.43	0.40	4.37	6.47
	25,000	1.47	1.33	0.60	0.47	4.00	4.37	2.70	1.90	0.53	0.40	4.25	6.47
	35,555	1.47	1.33	0.70	0.47	4.37	4.37	2.67	1.90	0.43	0.40	4.80	6.47
SSP	20,000	1.60	1.43	0.50	0.37	4.47	5.23	2.53	1.80	0.66	0.70	4.20	6.60
	25,000	1.60	1.43	0.57	0.57	4.47	5.23	2.53	1.80	0.57	0.70	4.37	6.60
	35,555	1.60	1.43	0.50	0.37	4.47	5.23	2.07	1.80	0.57	0.70	4.37	6.60
LSD (0.05)		1.31	0.78	1.49	1.62	1.21	2.51	1.24	3.20	1.21	1.79	1.21	1.83
CV (%)		5.28	16.83	23.10	11.99	8.64	14.07	7.86	11.68	10.95	12.31	7.76	13.83

GPR = Ground phosphate rock; OMF = Organo-mineral fertilizer; SSP = Single super phosphate; DM = Dry matter (Mg ha^{-1}); PUP = P uptake (kg ha^{-1}).

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References

[1]Adeoye, G.O., Sridhar, M.K.C. and Reeve, Z.O. 1993. Compost for the cultivation of yams. (Unpublished data listed in Sridhar *et al.* 1993.)

[2]Eduardo, C.O. and Gomez, M. 1990. Mineral nutrition of soybean (*Glycine max* (L) Meril) and its relation with phosphorus and potassium fertilization in a soil of Guárico state, Venezuela. Agonomia Tropical **40**:1-3.

[3]Haggar, J.P., Warren, G.P., Beer, J.W. and Klass, D. 1991. Phosphorus availability under cropping and mulched sole cropping system. Plant and Soil **137**:275-283.

[4]Hanway, J.J. and Weber, C.R. 1971a. Dry matter accumulation in soybean (*Glycine max* L. Merril) plants as influenced by N, P and K fertilization. Agronomy Journal **63**:263-266.

[5]Hanway, J.J. and Weber, C.R. 1971b. Accumulation of N, P, and K by soybean (*Glycine max* L. Merril) plants. Agronomy Journal **63**:406-408.

[6]Juo, A.S.R. 1975. Selected Methods for Soil and Plant Analysis. Manual Series No.1, IITA, Ibadan.

[7]Obigbesan, G.O. 1999. Fertilizer - Nigerian farmers' dilemma. Inaugural lecture. 14th October, 1999. University of Ibadan, Nigeria.

[8]Oluleye, A.K., Akinrinde, E. A. and Obigbesan, G.O. 2008. Phosphorus dynamics in forest and savannah agro-ecological Alfisols incubated with different phosphorus fertilizers. Journal of Food, Agriculture & Environment **6**(3&4):534-537.

[9]Omueti, J.A.I., Sridhar, M.J.C., Adeoye, G.O., Bamiro, O. and Fadare, D. A. 2000. Organic Fertilizer Use in Nigeria. Our Experience. Agronomy in Nigeria. University of Ibadan, Nigeria.

[10]Singh, B.R. and Uriyo, A.P. 1980. The relationship between response to N and P fertilizers. Soil N and P. Journal Agricultural Science Cambridge **94**:247-249.

[11]Sobulo, R.A. and Osiname, O.A. 1981. Soil fertility and fertilizer use in western Nigeria. Bulletin 11, IAR&T, Ibadan, Nigeria.

[12]Sridhar, M.K.C., Adeoye, G.O., Omueti, J.A.I., Yinda, G. and Reece, Z.D. 1993. Waste recycling through composting in Nigeria. Compost Science and Utilization **1**:69–74.