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Phosphorus Fertilizer use in Melon (*Egusi*) Seed Production: Effects on Yield, Oil and Protein Content and Nutrient Composition

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Abstract: Field experiments were conducted to study the effect of P application on egusi grown in two Alfisols soils at Ibadan in the subhumid zone of South-Western Nigeria. There were five P treatments (0, 10, 20, 30, 40 kg P.ha^{-1}), applied as single superphosphate (SSP, 18% P_2O_5). The treatments were replicated four times and arranged in a randomized complete block design. The result indicated that fruit and seed (egusi) yields increased significantly ($p>0.05$), 20 kgP.ha^{-1} produced highest yield in 1999 and did not differ from higher rates up to 40 kgP.ha^{-1} in 2000. Seed yield increased in relation to the significant improvement in fruit number plant^{-1}, average fruit size and weight. Yield components, leaf N, P, K and S, seed P and S, oil and protein content increased significantly with P application whereas leaf and seed Ca level declined. The substantial increases in seed yield, oil yield and protein content justify the recommendation of 16-20 kgP.ha^{-1} for optimum egusi seed production.

Key words: Alfisols, melon (*Egusi*), phosphorus, seed, protein, oil, nutrients

INTRODUCTION

Watermelon (*Citrullus lanatus*, Thunb. Mansf) has been cultivated as a crop for seed and water of the bitter pulp for over 4000 years. It originated in the tropical and subtropical parts of Africa and was introduced to West Africa, where several landraces of *C. lanatus* ssp *mucosospermum*, Fursa developed around the Sahelian/associated savannah centre of diversity, are cultivated for edible seeds (*Egusi*) used as condiment in soup[1,2]. In this form, *Egusi* is a vegetable whereas the closely-related *C. lanatus* sp v*ulgaris*, popular for the sweet and red pulp, eaten as a dessert[3] is a fruit exclusively named 'watermelon' in the word horticultural industry and trade.

The traditional food crop economy involves the cultivation of *Egusi* in various intercropping and interplanting systems with cassava, maize, millet, sorghum, yams, etc., on which the level of fertilizer use is still very low. The implication is that *Egusi* probably derives nutrient from the natural fertility of the soils needed, or nutrients in the little quantities of fertilizers applied, to grow these other component crops in the mixtures. This residual fertility and natural nutrient recycling in fallows of traditional production systems would not satisfy the nutritional needs of continuously high *Egusi* yields. In this situation, a fertilizer management schedule, to ensure high fertility levels, consistent with the rapid growth, optimum yield and quality of *Egusi*, must be part of the improved production package to be recommended.

The fertilizer recommendation for sole *Egusi*, established at 5000 plants.ha^{-1} is 200 kg of compound NPK 15-15-15 while 400 kg ha^{-1} NPK 15-15-15 is needed by yam-maize-cassava mixtures containing interplanted *Egusi* by IAR and T[4]. These recommendations are blanket and probably not based on systematic studies of responses to applied individual fertilizer nutrients. The few reported studies have indicated that *Egusi* significantly responded to Nitrogen (N) and potassium (K) fertilization in relation to soil nutrient status, which necessitated the recommendation of 50 kgN ha^{-1} supplied with Urea (46%N)[5] and 24-30 kg K_2O.ha^{-1}[6]. The Phosphorus (P) requirement is lacking and should be determined as a basis of evolving a balanced fertilizer recommendation for *Egusi* production. Therefore, the effects of P application rates were studied to provide yield response and nutrient composition data, as the informative needed for making appropriate P fertilizer recommendation in sole *Egusi* cropping systems.

MATERIALS AND METHODS

Experimental site: Field trials were laid out in the Vegetable Research Plots of the National Horticultural Research Institute, Idi-Ishin, Ibadan on two soils,

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Table 1: Characteristics of the surface layer (0-15cm) of soils used for the studies

Year	Soil series	Soil taxo-nomy	pH (in water)	Organic matter %	Total N %	Available P,mg. kg^{-1} soil	Exchangeable cations, cmol.kg^{-1} soil		
							Ca	K	Mg
1999	Iwo	Oxic Paleustalf	5.9	1.04	0.06	4.3	1.33	0.20	0.27
2000	Egbeda	Oxic Paleustalf	6.4	1.61	0.08	5.6	2.10	0.22	0.56

Table 2: Effects of P application on yield and yield components of *Egusi*

	P rates (kg.ha^{-1})				
	0	10	20	30	40
			1999		
Fruit yield, MT.ha^{-1}	16.0b	17.4b	21.7a	20.9ab	21.8a
Seed yield, MT.ha^{-1}	0.33c	0.37b	0.65a	0.60a	0.67a
Fruit size, kg	1.1c	1.1c	1.3ab	1.4a	1.2bc
Fruit number.plant^{-1}	2.6	2.8	3.4	3.0	3.3 NS
			2000		
Fruit yield, MT.ha^{-1}	17.1b	18.6ab	20.8ab	21.4ab	23.6a
Seed yield, MT.ha^{-1}	0.50c	0.53bc	0.65abc	0.70ab	0.82a
Fruit size, kg	1.4c	1.4c	1.6ab	1.7a	1.5bc
Fruit number.plant^{-1}	3.0b	3.4ab	3.7a	3.2ab	3.6a

Values in each year followed by same alphabets do not differ significantly (p=0.05) NS = Not significant

classified as Iwo and Egbeda series (Oxic Paleustalf), (USDA, 2003) in the early seasons of 1999 and 2000, respectively. Analysis of the surface layer (0-15 cm) samples shows that the soils are slightly acid with low to moderate organic matter, total N, available P and exchangeable bases (Table 1).

Field experiments: *Egusi* (Bara seed type with thick black edges) seeds were sown on ploughed and harrowed land, in 10x2 m plots at 2x1 m spacing and thinned to one, seedling. hill^{-1} after emergence, to attain the recommended 5000 plants.ha^{-1} population[7]. Treatments consisted of (0, 10, 20, 30, 40 kgP.ha^{-1}), applied as single superphosphate (SSP, 18% P_2O_5) which were replicated four times and arranged in a randomized complete block. Basal application of 25 kgN.ha^{-1}, as Urea and 30 kg K_2O.ha^{-1} as MOP were applied. Plots were weeded with hoe (manually) once before the vines closed up and sprayed with a mixture of permethrin and benomyl fortnightly to control insect pests and fungal diseases, respectively.

At early fruit set (49-56 D.A.P.), youngest fully mature leaf samples (petiole and lamina) in the middle of the plant (main stem) were taken for tissue analysis as recommended for watermelon[8]. After the vines had dried up, fruits in each plot were detached from the dried vines, counted and weighed. The fruits were broken with heavy sticks and left in heaps for some days to allow the pulp soften. Seeds were extracted from the pulp, washed with water, air-dried and weighed.

Laboratory analysis of plant samples: Leaf samples were dried in a ventilated oven at 70°C for 24 h and ground in a micro-hammer mill. Total N in the samples was determined with the micro-Kjeldahl method while total P, Ca, K and S involved perchloric acid digestion (wet oxidation). P in the plant tissue was determined with the vanado-molybdate colorimetric method, Ca and K were determined by flame photometry and S by the turbidimetric method[9]. Sample seeds were shelled and analysed for total P, Ca, K and S. Oil content was determined from ground seeds by extracting with petroleum extracts for 16 h in a Soxhlet and weighing the oil after evaporation of the solvent. Seed crude protein was estimated from the total N determined by the micro-Kjeldahl method[6].

Data collected were subjected to analysis of variance and treatment means were separated by DMRT and Least Significance Difference (LSD) as shown in Steele and Torrie[10].

RESULTS

Application of P increased *Egusi* fruit and seed yields significantly over the control (0 kgP.ha^{-1}) up to the 40 kg P.ha^{-1} in both years (Table 2). The highest fruit and seed yields were obtained from the 40kgP.ha^{-1} application in the two years. When the data of both years were combined, seed yield correlated significantly with fruit yield, fruit number.plant^{-1} and fruit size (r = 0.95**, 0.83**, 0.79**, respectively).

Egusi seed yield was best described by the Eq:

$$Y = 0.39 + 0.012x - 0.000077x^2$$

where Y = Seed yield, MT.ha^{-1}

x = rate of P applied, kgP.ha^{-1}

Table 3: Effects of P application on leaf nutrient content of *Egusi*

P application rates kg.ha^{-1}	% N	P	K	Ca	K
		1999			
0	2.83c	0.27d	1.38b	3.21a	0.23b
10	3.48b	0.30cd	1.51b	2.76b	0.24b
20	3.54b	0.33bc	1.53a	2.76b	0.34a
30	3.52b	0.34b	1.52a	2.64c	0.25b
40	3.84a	0.38a	1.53a	2.58c	0.23b
		2000			
0	2.63c	0.21c	1.05b	3.04a	0.23b
10	3.06b	0.26b	1.15b	2.67ab	0.24b
20	3.14ab	0.25b	1.13b	2.67ab	0.29a
30	3.12b	0.28a	1.17b	2.57b	0.29a
40	3.31a	0.29a	1.43a	2.53b	0.24b

Values in each column followed by the same alphabets do not differ significantly (p=0.05)

Table 4: Effects of P on nutrient composition of *Egusi* seeds

P rates (kgP.ha^{-1})	% P	K	Ca	S	Protein	Oil
		1999				
0	0.57b	0.64c	0.068a	0.22b	29.3b	33.3b
10	0.58b	0.68b	0.066ab	0.23b	30.4ab	36.0b
20	0.60b	0.72a	0.065ab	0.31a	31.0a	41.4a
30	0.72a	0.68b	0.062b	0.25b	30.6ab	40.6a
40	0.73a	0.72a	0.059b	0.23b	31.5a	40.4a
		2000				
0	0.58c	0.67	0.066	0.22	31.0	34.0b
10	0.63bc	0.67	0.064	0.23	31.9	41.2a
20	0.73a	0.70	0.064	0.24	31.3	41.8a
30	0.74a	0.69	0.061	0.25	31.1	42.5a
40	0.71ab	0.70	0.061	0.24	31.1	42.1a
		NS	NS	NS	NS	

Values for each year and in each column followed by the same alphabets do not differ significantly (p=0.05); NS = Not significant

From this Equation seed yield was calculated and interpreted with the Linear-Response-Plateau (LRP) model described in Waugh, *et al.*,[11] which gave optimum rate of 16kgP.ha^{-1}. Leaf N, P, K and S increased with P application in both years, while leaf Ca decreased (Table 3). Application of P increased seed P and K significantly ($p<0.05$) in 1999, while only the increase in seed P was significant in 2000. Seed Ca decreased in both years. Seed S was significantly increased with 20kgP.ha^{-1} application in 1999, but the increase was only slight in 2000. Protein content was improved by 7.5 and 2.9%, with the application of 40 and 10 kgP.ha^{-1} in 1999 and 2000, respectively. Oil content increased significantly, the highest values at 20 and 30 kgP.ha^{-1} rates represent 24.3 and 25.0% improvement in 1999 and 2000, respectively (Table 4).

DISCUSSION

Application of P increased *Egusi* seed yield; the highest responses obtained with 20 kgP.ha^{-1} would suggest this as the rate to recommend for *Egusi* cultivation. This response is readily attributed to the low available P status of the soils in the sites used for the study. Although correlation and calibration of soil available P with *Egusi* yield responses, to delineate the deficiency and sufficiency levels have not been done, the P status of the sites is much lower than established critical P established for food crops in Nigeria. The critical level is 6 mg kg^{-1} soil for cowpea and soyabean, 8.0 mg ha^{-1} soil for tomato and 8-15 mg kg^{-1} soil for maize[12].

The responses of several food crops to P application in soils of the forest and savannah zones of South-Western Nigeria have been studied and the results show significant increases in yield, especially at low P rates[12]. This is due to the fact that most soil P is held in the fallow vegetation and organic matter of the surface layer of soils. Organic matter mineralization would release inorganic P that can meet a substantial portion of the crops' requirements. Thus, methods of bush clearing fallow residue management and post-clearing soil management practices would influence the nature and extent of response to applied P.

Land development in the experimental sites involved mechanical clearing of the fallow bush dominated by woody leguminous species: *Gliricidia sepium, Leucaena* sp; Chromolaena odoratum, Aspilia africana and perennial grasses: Panicum maximum, Pennisetum sp. etc.

Table 5: Calculated *Egusi* seed oil yield as influenced by P application

	1999		2000	
Treatment P $kg.ha^{-1}$	Oil yield, $kg.ha^{-1}$	Increase %	Oil yield, $kg.ha^{-1}$	Increase%
0	43.29c	-	53.50d	-
10	51.48c	18.92	85.70c	60.19
20	104.95a	142.44	105.96bc	98.06
30	76.53b	76.79	116.03ab	116.88
40	82.01b	89.44	134.09a	150.64

Values followed by same alphabets in each column do not differ significantly (p=0.05)

The woody species were stumped and plant debris packed at the windrows and burnt. Strips were established across the slope and demarcated by contour bunds as soil conservation measures, to mitigate the negative effects of tractorised tillage (plough, harrow, ridge/bed) that precedes the cultivation of leafy and fruit vegetables. These crops, grown in established rotation, leave little or no plant residues for organic recycling. These conditions ensure rapid decline in organic matter levels, with mineralisation contributing substantial amounts of available P that can meet a substantial part of the crop's requirements[13]. Besides, the slightly acid to neutral, coarse-textured surface soils associated with basement complex rocks have low P fixation capacity. This means that native and applied P would remain in available forms. Thus, the crops would respond to low rates of applied P fertilizer.

From this study, optimum P rate is 20 $kgP.ha^{-1}$, slightly higher than the 16 $kgP.ha^{-1}$ established with the LRP model for interpreting the calculated seed yield. Therefore, the fertilizer management practice for *Egusi* must ensure the supply of 16-20 $kgP.ha^{-1}$. The lower value is equivalent to 36 $kgP_2O_5.ha^{-1}$ which compares with 30 $kgP_2O_5.ha^{-1}$ needed for maximum fruit yield of watermelon[14] and the rates recommended for most arable crops in Southwestern Nigeria[12]. The blanket compound NPK 15-15-15 fertilizer recommended for sole *Egusi* and mixture of staple food crops containing interplanted *Egusi* at 200 $kg.ha^{-1}$ and 400 $kg.ha^{-1}$ would supply 30 and 60 $kgP_2O_5.ha^{-1}$, respectively which cover the 36-45 $kgP_2O_5.ha^{-1}$ range obtained in this study. Fruit number $plant^{-1}$ increased significantly and was related to seed and fruit yield.

The relevance of this for high seed yield is, as observed by[15], that the green mottled fruits probably produce assimilates which nourish the fruits and seeds, since the phase of fruit development coincide with the period of rapid decline in leaf number and leaf area. In both years, leaf P increased, up to the highest rate of P addition. It was, therefore, possible to establish a relationship between leaf P and seed yield, whose analysis provided a tentative critical value of 0.28%. This compares with 0.28% phosphate-P obtained for watermelon petioles[8]. Although the responses could be explained by the low available P status of the soils used, further studies involving a wider range of soil tests for P and plant tissue data would be needed to establish reliable critical leaf levels for *Egusi*.

Application of P increased leaf-N, the resultant high N status of the plants probably enhanced the uptake of other nutrients, notably P, K and S. The ensuing higher fruit and seed yields were results of higher net photosynthetic activity, because N and P are chlorophyll constituents and whose development is influenced by S nutrition. The increases in leaf-N, P and S also reflected in protein and oil content of the seeds. First, proteins are plant tissue products in which these nutrients are mainly incorporated and second, oils are built up from the carbohydrates which resulted from the increased photosynthetic activity in the leaves. The higher nutrient status was reflected in the 25 and 7.5% increase in oil and protein, respectively. A significant correlation (r = 0.70*) was obtained between oil and protein content. With the available data, oil yield was calculated as a product of shelled *Egusi* (edible seed yield) and oil content (%). Table 5 shows that increase in oil yield were significant in both years, at 142 and 98% in 1999 and 2000, respectively with the addition of 20 $kgP.ha^{-1}$.

CONCLUSION

Since the economic attributes in *Egusi*-seed yield and oil-were significantly increased, attention should be paid, more to P nutrition through appropriate P fertilizer use practices, to attain higher productivity.

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REFERENCES

1. Burkill, H.M., 1985. The useful plants of West Tropical Africa. Families A-D. Royal Botanical Garden, Kew.
2. Siemonsma, J.S. and K. Piluek, 1994. Prosea. Plant Resources of South East Asia. Vegetables.

3. Schippers, R.R., 2000. African Indigenous Vegetables: An Overview of the Cultivated Species. National Resources Institute/ACP-EU Technical Centre for Agric. and Rural Cooperation, Cathan, U.K.
4. IAR and T, 1991. Report of the 14th Conference of the package of recommendations for food crops and livestock production in southwestern Nigeria. Institute of Agricultural Res. and Training, Moor Plantation, Ibadan.
5. Ayodele, O.J., C.O. Akinrinsola and F.O. Omolayo, 2005. Effects of Nitrogen fertilizer rates and sources in some aspects of yield in *Egusi* (Citrullus lanatus). Study 30th Annual Conference of Soil Science Society of Nigeria, University of Agriculture, Makurdi, pp: 5-9.
6. Pearson, D., 1976. The Chemical Analysis of Foods. 7th Edition. Churchill Livingstone, Edinburgh, London and New York, pp: 9-12.
7. Nihort, 1986. Advances in Fruit and Vegetable Research at NIHORT (1976-1986): A commemorative publication to mark the 10th anniversary of the National Horticultural Research Institute (NIHORT). Idi-Ishin, Ibadan.
8. Geraldson, C.M., G.R. Klacan and O.A. Lorenz, 1973. Plant Analysis as an Aid in Fertilizing Vegetable Crops. In: Soil Testing and Plant Analysis, Revised Edition, edited by Walsh, L.M. and Beaton, J.D. Soil Science Society of America Inc. Madison, Wiconsin, U.S.A.
9. IITA, 1979. Selected Methods of Soil and Plant Analysis. Manual series No. 1. International Institute of Tropical Agriculture, Ibadan.
10. Steele, R.G.D. and J.H. Torrie, 1980. Principles and procedures of statistics. McGraw Hill Book Inc. New York.
11. Waugh, U.L., R.B. Cate Jr. and L.A. Nelson, 1973. Discontinuous models for rapid correlation, interpretation and utilization of soil analysis and fertilizer response data. International Soil Fertility Evaluation Improvement Program. Tech Bull. 7. North Carolina State University, U.S.A.
12. FMANR, 1990. Literature Review on Soil Fertility. Investigations in Nigeria (in five volumes). Federal Ministry of Agric. and Natural Resources, Lagos.
13. Ayodele, O.J., 1986. Phosphorus availability in savannah soils of Western Nigeria. Trop. Agric. (Trinidad), 63: 297-300.
14. Bhosale, R.J., S.A. Khanvilkar and R.K. Andhale, 1978. Yield performance of watermelon (*Citrullus vulgaris*, Schrad) Variety Sugar Baby under graded levels of N, P and K. J. Maharashtra Agric. Uni., 3: 93-95.
15. Ogunremi, E.A., 1978. Effects of nitrogen on melon (*Citrullus lanatus*) at Ibadan, Nigeria. Exptl. Agric. 14: 357-365.