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Effects of Potassium Fertilizer on Yield Components and Nutrient Composition of Egusi (*Citrullus lanatus*)

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Abstract: This study evaluated the effect of potassium fertilizer on the yield and nutrient composition of egusi (melon: *citrullus lanatus*) in southwestern Nigeria. Two soil medium classified as Iwo series (Oxic Paleustalf and Egbeda series (Oxic Paleustalf were used. The fertilizer materials were applied at 0,20,40,60 kgK.ha^{-1}, as muriate of potash (MOP, 60% K_2O) and were replicated four times in a randomized complete block design. Egusi (melon: *Citrullus lanatus*) fruit and seed yield increased significantly with rates of potassium (K) applied. Low soil exchangeable K could explain the significant responses in two years whereas the increase was slight in 2003 when the site contained higher exchangeable K and organic matter. The 20 kgK.ha^{-1} rate is optimum for egusi seed yield, in relation to the significant increase in fruit yield components: fruit number plant^{-1} and average fruit size (weight). Leaf N, P, K and S; seed P, K, S, oil and protein content increased significantly while leaf Ca decreased and seed Ca was not affected. The increases in seed and oil yield were substantial to justify the inclusion of 20 kgK. ha^{-1} in the fertilizer recommendation for sole Egusi production systems.

Key words: Alfisols, potassium, seed yield, southwest Nigeria

INTRODUCTION

Smallholder farmers in Nigeria obtain about 0.15-0.40 Metric Tonnes (MT). hectare (ha)$^{-1}$ seed yield of melon (egusi: *Citrullus lanatus*, Thunb, Mansf; *Colocynthis Citrullus*, Kuntze). And so operate at <20% productive efficiency, when compared with 1-2.5 MT. potential yield that can be obtained through the adoption of improved varieties, optimum spacing, crop protection measures and higher levels of nutrition[1,2]. Higher productivity is consistent with operations on medium to large-scale, farms that emphasise continuous land use and sole cropping, to the extent possible. On these farms, reliance on nutrient and organic matter build-up in fallow and nutrient recycling processes would not adequately satisfy the nutritional needs for high Egusi seed yields. Herein, lies the relevance of fertilizers, in providing the additional nutrients needed for high, stable and sustainable yields.

Egusi seed yield is a function of fruit size and number of fruits produced per plant[3] that can be enhanced by application of Nitrogen (N)[4-6] and Phosphorus (P) fertilization[7]. There is no information on the potassium (K) requirements of Egusi, as the basal quantities added in reported fertilizer trials are arbitrary, based on recommendations for cereals or included to ensure a seemingly balanced fertilization. Field trials were, therefore, conducted to evaluate Egusi fruit and seed yield responses to K fertilization and so obtain the information needed for making an appropriate recommendation for the crop.

MATERIALS AND METHODS

Field experiment: The experiments were conducted in the Vegetable Research/Seed Multiplication, Plots of National Horticultural Research Institute, Idi-Ishin, Ibadan (longitude 3°50'E, latitude 7°23'N) during the early seasons of 2001-2003. A new site was used at each planting on soils classified as Iwo series (Oxic Paleustalf in 2001-2002) and Egbeda series (Oxic Paleustalf in 2003). The land was ploughed and harrowed and Egusi seeds (Bara cultivar: seeds with thick black edges) were sown in 4x4 m plots at 2x2 m spacing and thinned to 2 seedlings. hill^{-1} to attain the recommended 5000 plants.ha^{-1} population[5]. Four levels of K application: 0, 20, 40,60 kgK.ha^{-1}, as muriate of potash (MOP, 60% K_2O) were replicated four times and treatments randomised within each replicate (Randomised Complete Block Design). The

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whole K fertilizer was mixed with 25 kgN.ha^{-1} as urea (46% N) and 20 kgP.ha^{-1} as single superphosphate (SSP, 18% P_2O_5) and applied by banding on both sides of the seedlings about 10 days after emergence. The remaining 25 kgN.ha^{-1} was banded at about 50% flowering, taking care to avoid the vines. Plots were weeded manually once before the vines closed up. Vines were carefully restrained within respective plot areas. The plants were sprayed fortnightly with Permethrin and Benomyl, to control leaf-eating insects and foliar fungal diseases, respectively.

At early fruit set (49-56 days after plantings), youngest fully mature leaves (petiole and lamina) in the middle of the plant (main stem) were sampled[8], washed in distilled water, oven dried at 80°C for 48 h, ground with a micro-hammer mill and stored for analyses. Matured fruits 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 pulps often. Seeds were extracted from the pulp, washed with water, air-dried and weighed.

Laboratory analysis: Soil samples were analysed for pH (in water), particle size distribution, organic matter, total N, available P, exchangeable cations and exchangeable acidity[9]. The ground leaf samples were digested with concentrated nitric-perchloric-sulphuric acid mixture, N and P in the digest were determined in an auto-analyser, K and Ca by flame photometry and S by the turbidimetric method[9]. Sample seeds were shelled, ground and digested for determination of P, K, Ca and S. Protein was estimated from the total N determined by the micro-Kjeldahl method while oil was determined from ground seed samples by extracting with petroleum extracts for 16 h in a soxhlet and weighing the oil after evaporating the solvent[10].

Data of yield and yield components, leaf and seed nutrient composition were subjected to analyses of variance and treatment means separated by Least Significant Difference (LSD) using the procedures outlined in Steele and Torrie[11].

RESULTS

Table 1 shows that the topsoil (0-15 cm) samples are slightly acid, loamy sands with low organic matter, total N, available P and exchangeable cations. Fruits yield increased significantly in 2001 and 2002 with highest values obtained at 60 kg K.ha^{-1} in 2001 and 2003 but at 40 kg K.ha^{-1} in 2002 Table 2. However, fruit yield over the 20-60 kg.ha^{-1} range did not significantly indicating that 20 kg K.ha^{-1} is optimum rate. Seed yield followed the same trend, with the values at 20 kg K.ha^{-1} a reflection of the fruit yield components: fruit number. plant^{-1} and average fruit size, which were highest at this rate Table 3,

Table 4 shows that K application increased leaf N significantly in all years, while increase in leaf P was not significant in 2003. Leaf K increased linearly till 60 kg K.ha^{-1}, but with the 20-60 kg K.ha $^{-1}$range not significantly different. The increase in leaf S was significant in 2001 only, while leaf Ca decreased. Seed nutrients, protein and oil content increased with K application in the following pattern: significant increases in K and oil content in all years, significant increases in P, S and protein in 2001 and 2002 while increase in Ca was significant in 2002 only.

Simple correlation analysis between yield components and the nutrient composition ins all possible combinations, shows the following significant correlation coefficients: Applied K with leaf K, oil and protein (r = 0.80**, 0.88** and 0.81**, respectively);) leaf N with leaf S, seed K, oil and protein (r = 0.88**, 0.91**, 0.92** and 0.84**, respectively) and seed yield with fruit number plant^{-1} and fruit size (r = 0.82**, 0.86**). There were also significant correlations between these pairs: leaf and seed K (r = 0.73**), seed S and oil, (r = 0.85**), seed S and protein (r = 0.76**), oil and protein (r = 0.77**) leaf S and oil (r = 0.86**) and leaf S and protein (r = 0.86**).

DISCUSSION

Response to added nutrient in a fertilizer is expected and easy to explain when the critical level of the nutrient exceeds the content in the soil. Unfortunately, critical exchangeable K level has not been established for Egusi, so the tendency is to use critical levels for maize (0.18-0.20 cmol kg soil^{-1}) and cassava or yam (0.15-0.20 cmol. kgsoil^{-1})[12] to interprete soil available K and responses to K fertilization.

This study involved strongly weathered soils derived from basement complex rocks richer in K minerals than soils developed on sandstones and sediments[13]. Surface layer exchangeable K is low to marginally adequate due to intensive leaching, predominantly kaolinltic clay mineralogy and low K reserves such that organic matter makes very important contributions to K retention and nutrition[12]. However, continuous cultivation, in which tractorised operations are the rule, rapidly depletes the organic matter[14] and the exchangeable K. Thus, the combination of low organic matter content and low exchangeable K in the Iwo soil series in 2001 provides explanation for the significant Egusi yield response to K fertilization. In 2002, exchangeable K was higher than the critical levels for main arable crops, but low organic matter and poor rainfall distribution during the season were

Table 1: Physical and chemical characteristics of the soils used for the study

Soil characteristics	2001	2002	2003
pH (water)	6.1	5.9	6.2
Organic matter, %	0.85	1.43	2.13
Sand, %	81	83	79
Silt, %	10	10	12
Clay, %	9	7	9
Total N, %	0.05	0.09	0.10
Available P, mg.kg^{-1}.soil	5.7	4.3	6.0
Ca.cmol. kg^{-1}.	4.3	3.8	3.9
K cmol. kg^{-1}.	0.14	0.23	0.32
Mg.cmol. kg^{-1}.	1.6	1.8	1.8
Na.cmol. kg^{-1}.	0.01	0.17	0.18
ECEC cmol. kg^{-1}.	6.20	6.15	6.34
Textural class	LS	LS	LS
Soil series	Iwo	Iwo	Egbeda

LS: Loamy sand

Table 2: Effect of K application on Egusi fruit and seed yield

	K rates applied kg.ha^{-1}	Fruit yield MT. Ha^{-1}	Seed yield MT. ha^{-1}
2001	0	12.4c	0.34b
	20	19.2ab	0.44ab
	40	19.1b	0.52ab
	60	22.6a	0.57a
2002	0	12.3c	0.32b
	20	19.8b	0.60a
	40	22.5a	0.70a
	60	20.7b	0.67a
2003	0	17.8	0.42
	20	18.4	0.43
	40	19.0	0.48
	60	21.0	0.52
		NS	NS

Values in each column and for each year followed by same alphabets do not differ significantly ($p<0.05$). NS: Not significant

Table 3: Effect of K application on Egusi fruit yield components

K rates kg. ha^{-1}	Fruit number plant^{-1}	Fruit size (kg)
0	2.4b	0.74b
20	3.2a	1.30a
40	3.2a	1.26a
60	2.7b	1.03ab

Means in each column followed by same alphabets do not differ significantly ($p<0.05$)

Table 4: Effects of K application on foliar nutrient composition of Egusi

K applied Kg.ha^{-1}	N	P	K %	Ca	S
		2001			
0	3.2c	0.24b	1.07b	3.20a	0.22b
20	3.76b	0.36a	1.13ab	3.18a	0.28a
40	3.81ab	0.37a	1.18ab	2.93b	0.30a
60	3.87a	0.39a	1.25a	3.11ab	0.29a
		2002			
0	3.27b	0.25b	1.06b	3.35a	0.24a
20	3.90a	0.28b	1.17ab	3.33a	0.29a
40	3.82a	0.35a	1.25a	3.00ab	0.26a
60	3.86a	0.31a	1.35a	2.91b	0.28a
		2003			
0	3.58b	0.30a	1.20b	3.20b	0.23a
20	3.73a	0.36a	1.26ab	3.34a	0.27a
40	3.78a	0.39a	1.30a	3.11b	0.29a
60	3.76a	0.37a	1.31a	3.12b	0.28a

Values in each column, for each year followed by same alphabets do not differ significantly ($p<0.05$), NS=Not Significant

probably responsible for the significant response to K.[15] had reasoned that slow diffusion rate and low moisture content caused more pronounced responses of maize to K in dry years. Higher K levels in the soil, especially from K fertilization, help to overcome the slow uptake of K caused by dry soil conditions and so give higher and profitable soyabean yields[16]. The site in 2003 had high organic matter and more K rendered available following the period of fallow and so did not respond to K fertilizer.

Egusi, an oilseed crop, benefited from K application in terms of increased seed yield, similar to results obtained for sunflower[17], mustard and sesame[18], soyabean and groundnut[19,20]. Optimum seed yield was obtained at 20 kg.K.ha^{-1} in relation to the increases in fruit yield, fruit number. plant^{-1} and average fruit size. These same yield components were enhanced with N application[4,-6] and P fertilization[6] to increase Egusi seed yield.

Leaf N and K increased significantly with K fertilization, as reported for maize[15] and groundnut[21]. A relationship of leaf K to fruit and seed yields produced 1.2% as tentative critical value, however, further studies are needed to make this a tool for evaluating responses to K and making adequate fertilizer recommendation. Application of K increased leaf P and S with 20kg.K.ha^{-1} as optimum rate. This is probably in relation to the higher N status. The better crop nutrient status ensured increase on fruit and seed yield, on account of greater net photosynthesis activity since N and P are chlorophyll constituents while S content influences chlorophyll development. The nature of increase in N, P and S also reflected in protein content, since proteins are compounds in which these nutrients are incorporated in the plant tissues. The influence of applied K on crop quality is due to better N utilization and increased protein formation[22]. The 17.4-22.5% increase in oil content means that K fertilization should be given adequate attention in this crop whose economic portions are seed and oil yields. Similar positive influences of K fertilizer on oil content have been reported for copra, groundnut, mustard, sesame, soyabean and sunflower[19,20,22].

CONCLUSION

From this study, 20 kg.K.ha^{-1} which gave fruit and seed yield, foliar and seed nutrient composition, protein and oil content that are not significantly different from the higher 40 and 60 kg.K.ha^{-1} rates should be recommended for Egusi cultivation. The rate is equivalent to 24 kg. K_2O.ha^{-1} which should be supplied in appropriate compound NPK fertilizers, such as NPK 20-10-20, 27-13-13 formulation being produced in Nigeria[23]. This recommendation is low compared with 60-112 kg.K.ha^{-1} requirements for the major oil seed crops, but should satisfy Egusi's K need in continuously cropped plots and land newly cleared from short fallows.

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