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Effect of Mineral Fertilizater on Sweet Potatoes [*Ipomoea Batatas* (L.)] Yield in the Sudan Savannah Agro-Ecological Zone of Ghana

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Abstract **– Sweet potatoes [*Ipomoea batatas* (L.)] is a major non-traditional export crop in the Upper regions of Ghana. One major constraint to achieving higher tuber yields is inherent low fertility status of these soils. A study to look at effective ways of increasing sweet potatoes production through the use of mineral fertilizer was conducted. Treatments were designed to establish the most limiting nutrient for sweet potatoes production and responses to increasing rates of N, P and K. Results showed that both tuber and vine production were significantly reduced when P was limiting. At 45 kg P_2O_5/ha, tuber, vine production and number of tubers/ha were significantly higher than when P was not applied. Both tuber and vine yields increased significantly over 0 kg N ha^{-1} at 75 kg N ha^{-1}. Tuber yield significantly declined when N was increased to 90 kg N ha^{-1}. Increasing K levels from 0 to 90 kg ha^{-1} significantly reduced number of tubers produced and /or tuber size resulting in significant decrease in tuber production. In order of importance phosphorus is the most limiting nutrient in these soils for sweet potatoes production (P>>N>K). The following nutrient combinations gave comparable yields: 30-45-60, 75-60-90 and 90-45-90 kg/ha N-P_2O_5-K_2O. Tentatively 30-45-60 kg/ha N- P_2O_5, -K_2O, is recommended.**

Keywords **– Ghana, Limiting Nutrient, Mineral Fertilizer, Sudan Savanna, Sweet Potato.**

I. Introduction

Food availability and the general socio-economic status of most Ghanaian farmers are not encouraging. This problem is more serious for farmers in the Upper-East Region, which is considered as the poorest region in the country. High population density, poor soils and erratic rainfall are factors that contribute to worsen the situation of the ordinary farmer. Sweet potatoes (*ipomoea batatas*) is perhaps the major tuber crop in this region. The crop has a high ability to tolerate draught and hence withstands the rather hash environmental conditions characteristic of this agro-ecological zone.

Tubers are usually cooked, fried or roasted. In some communities it becomes a major source of food during lean seasons while other communities export the crop to neighbouring countries (Burkina Faso and Togo). In Ghana, farmers generally do not apply mineral fertilizers to root and tuber crops but rely on natural bush fallow to restore soil fertility [1]. This practice has become unsustainable due to land degradation and increased pressure on land as a result of increased population. Length of cropping and fallow periods depends on inherent soil fertility and nutrient amendments that are available[2]. Fertilizer use may allow more years of cultivation before fallow is needed. In an on-farm study in the five districts of the Upper East region, significant increase in tuber yield was observed [3] (18 – 30 t/ha) when mineral fertilizer (30-30-30 kg/ha N-P_2O_5-K_2O) or compost (6.0 t/ha) was used (a local variety, Bawku red was used for this study). Positive effects of mineral fertilizer on yam and cassava have similarly been reported [1], [4]. [5], [6] . Due to high endings from exported tubers some farmers within the Sudan savannah agro-ecological zone apply mineral fertilizers, manures or a combination of these sources of fertilizers. To improve on sweet potatoes production in this region and recommend suitable levels of fertilizer, this study was conducted. The objectives include identifying the major nutrients that limit sweet potatoes production and response of the crop to various levels of mineral fertilizer.

II. Materials and Methods

Experimental site: The experiment was conducted at Manga Research Station (lies between latitude 11 ^{o} N and 12 ^{o} N and on longitude 0^o) in the Bawku East district of the Upper East Region of Ghana. The station is located in the Sudan savannah agro-ecological zone. The site was cultivated to millet for three years. Undetermined amount of ammonium sulphate was applied to millet during this period.

Experimental design: A random complete block design with three replications was used. Treatments were (0-45-45; 45-0-45; 45-45-0 and 45-45-45 kg/ha N, P_2O_5, K_2O) to evaluate the missing nutrient effect, (0-60-90; 45-60-90; 75-60-90 and 90-60-90 kg/ha N, P_2O_5, K_2O) for response to N, (90-0-90; 90-45-90 and 90-60-90 kg/ha N, P_2O_5, K_2O) for response to P, and (90-60-0; 90-45-60; 90-60-60 and 90-60-90 kg/ha N, P_2O_5, K_2O) for response to K. An absolute control (0-0-0 kg/ha N, P_2O_5, K_2O) and a recommendation based on previous results (30-45-60 kg/ha N, P_2O_5, K_2O) were included. The 90 kg/ha K_2O for the 90-45-90 and 90-60-90 were reduced to 60kg/ha K_2O to give an additional two treatments. A total of 16 fertilizer combinations were used.

Management practices: Plot size was 10.0m x1.0m. Ridges were 0.50m high. Plants were spaced at 30cm x 30cm with each vine containing three nodes. FARA an introduced variety was used for the study. Lime (CaO: 0.5

t/ha) and 20 kg/ha MgSO4 were broadcast and worked into the soil two weeks before transplanting. Mineral fertilizer was applied two weeks after transplanting and by side placement. Mineral fertilizer sources were Urea (46% N), Triple Super Phosphate (45% P_2O_5) and Muriate of Potash (60% K_2O). Ridges were occasionally reshaped when washed off by rain and when tubers were exposed for protection against rodent attack. Weeds were removed by hand. At maturity, 1.0 m^2 area per treatment was demarcated and harvested. Statistical software, Statistix 8, was used for data analysis. Standard error (SE) was used as mean separator.

Soil sampling and analysis: Soil samples were collected before fertilizer application at 0-20cm depth. Samples were collected at five spots from the top of the ridge. Soil samples were air-dried, ground and passed through a 2mm sieve. Soil pH was measured using a glass electrode (pH meter) in a soil to water ratio of 2:1[7]. Organic carbon was determined by wet combustion[8] and total nitrogen by the Macro-Kjeldahl method[9]. Available phosphorus was also determined[10]. Exchangeable cations (Ca, Mg, K) were extracted with 1.0 M ammonium acetate solution and their levels determined by atomic absorption spectrometry[11].

III. Results and Discussion

Initial soil characteristics of the study site are shown in Table 1. The soil was sandy and characteristically low to very low in available P and exchangeable cations (Ca, Mg).

Effect of missing nutrient on yield

It is justified that single element fertilizers or a change in the formula of compound fertilizers be made to better reflect the needs of the crop if any one or two nutrients is limiting yield. The effect of missing nutrient on yield and yield components is presented in Table 2. In the absence of P (45-0-45 kg/ha N, P_2O_5, K_2O) both tuber and vine production were significantly reduced. Tuber size was significantly smaller when P was missing than when N or K was missing. Complete fertilization (45-45-45 kg/ha N, P_2O_5, K_2O) gave similar and/or lower tuber and vine yields as when N or K was missing. These observations suggest that N and K are less limiting while P is the most limiting nutrient for potato production in these soils. The very low values of P coupled with the low soil pH of these soils may partly explain this observation. Tuber yield was generally low and the initial K status was probably adequate. Soils with less than 1.0 g/kg N, 10 mg/kg P and 0.15 cmol(+)/kg K could be considered deficient and may show positive response to fertilizer [12].

P and K were the most deficient nutrient elements at Wenchi (Guinea savanna) after six years of continuous cropping [13]. They authors further observed that K might also become deficient at Ejura (Forest/savanna transition) after several years of cropping. In a nutrient balance estimation over a one-year period, K deficit is much more likely than an N deficit in a Gliricidia intercropping or cut-and-carry system [14]. It has also been shown that K becomes limiting in long-term cassava trials [15].

Sweet potatoes tuber yields were generally low and this also explains why the N and K did not show any effect. Tuber yield as high as 20 t/ha were obtained from on-farm trials using a local variety [3]. In the absence of K, few but bigger tubers were produced.

Response to increasing nutrient levels (N, P, K)

Increasing N rates from 0 to 75 kg/ha resulted in increased tuber yield (Table 3a). However, there was a decrease in tuber yield when N was further increased 90 kg/ha. Both 45 and 75 kg/ha N gave similar and significantly higher tuber and vine yields than the control. Nitrogen at 90kg/ha only resulted in the production of many but smaller tubers. The levels of N needed for maximum tuber yield (≤ 75 kg/ha) were similar to earlier findings [16]. The author observed that up to 67.2 kg/ha N was necessary for obtaining maximum yam yields in northern Ghana. In contrast to this study doubling N inputs from 45 to 90 kg/ha doubled tuber yield of yam [17]. In this study, it is not clear why vine production was lower at 90kg N/ha than 75 kg N/ha

Table 3b shows the effect of increasing P rates on tuber and vine yields. Phosphorus at 45 kg/ha gave significantly higher tuber and vine yield/ha. When P was not applied the number of tubers/ha were significantly reduced. The positive response to P could be explained from the low levels of soil P (Table 1).

Increasing K rates showed a decreasing trend of both tuber and vine yield (Table 3c). At 45 and 60 kg K/ha number of tubers/ha fell significantly. This partly explains the low tuber yield observed. Tubers size were significantly smaller when K was applied at 60 and 90 kg/ha. The low or no response to K could be due to the initial high level of soil K[12]. However, K could become limiting with continuous cultivation.

Response to different nutrient combinations:

Sweet potatoes response to various nutrient combinations of N, P and K are presented in Table 4. Fertilizer recommendation based on previous study (30-45-60 kg/ha N, P_2O_5, K_2O) was among the combinations that gave about the best tuber yield, thus 30-45-60, 75-60-90 and 90-45-90 kg/ha N, P_2O_5, K_2O respectively gave comparable tuber yield.

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Table 1: Selected Soil Chemical Properties of the Study Site

Parameter	Measured value
pH (H_2O)	5.1
Org. C (g kg^{-1})	5.6
TN (g kg^{-1})	0.4
Av. P (mg kg^{-1})	3.8
Ex. Ca {cmol (+) kg^{-1}}	2.02
Ex. Mg {cmol (+) kg^{-1}}	0.32
Ex. K {cmol (+) kg^{-1}}	0.16
Depth (cm)	0-20
Texture	Sandy loam

Table 2: Effect of missing nutrient element on yield and yield components

Treatments*	Tuber Yield (t/ha)	Vine Yield (t/ha)	No. Tubers/ha	Weight/ Tuber (g)
0-45-45	8.0	13.4	57083	145
45-0-45	5.5	8.5	52083	96
45-45-0	8.3	11.7	37500	209
45-45-45	6.9	14.4	55000	127
SE	1.3	2.6	8852	48
CV	20.0	20.0	18	33

* N-P_2O_5-K_2O kg/ha

Table 3: Effect of increasing nutrient rate on yield and yield components

A: Nitrogen

N rates	Tuber Yield (t/ha)	Vine Yield (t/ha)	No. Tubers/ha	Weight/ Tuber(g)
0	5.6	11.5	61250	107
45	8.0	13.4	66667	127
75	9.8	22.5	62500	159
90	5.3	11.7	70000	80
SE	1.8	4.9	4002	33
CV	20	30	6	28

All treatments received 60Kg P_2O_5/ha and 90kg K_2O/ha

B: Phosphorus

P rates	Tuber Yield (t/ha)	Vine Yield (t/ha)	No. Tubers/ha	Weight/Tuber (g)
0	4.7	8.6	40000	124
45	10.2	22.1	63750	149
60	5.2	11.7	70000	80
SE	3.0	7.1	15827	35
CV	50	50	27	30

All treatments received 90Kg N/ha and 90kg K_2O/ha

C: Potassium

K rates	Tuber Yield (t/ha)	Vine Yield (t/ha)	No. Tubers/ha	Weight/ Tuber (g)
0	8.5	19.4	65000	135
45	5.0	16.5	39167	133
60	3.2	8.4	42500	72
90	5.2	11.7	70000	80
SE	2.2	4.9	15590	34
CV	40	40	29	32

All treatments received 90N kg/ha N and 60Kg P2O5/ha

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Table 4: Effect of various nutrient combinations on yield and yield components

N rates	Tuber Yield (t/ha)	Vine Yield (t/ha)	No. Tubers/ha	Weight/ Tuber (g)
0-0-0	4.8	8.3	53333	85.2
0-45-45	8.0	13.4	57083	144.5
45-0-45	5.5	8.5	52083	96.4
45-45-0	8.3	11.7	37500	208.5
45-45-45	6.9	14.4	55000	126.8
30-45-60*	9.4	23.3	73333	153.7
0-60-90	7.6	13.5	61250	106.5
45-60-90	8.2	13.4	66667	127.0
75-60-90	9.8	22.5	62500	158.6
90-60-0	8.5	19.4	65000	134.6
90-60-45	5.0	16.5	39167	132.8
90-60-60	3.3	8.4	42500	72.3
90-45-60	8.2	18.8	48333	160.5
90-0-90	4.7	8.6	40000	124.1
90-45-90	10.2	22.1	63750	149.2
90-60-90	5.2	11.7	70000	79.5
SE	3.1	6.3	21708	35.1

* Recommendation based on an earlier experiment.