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Assessing *Ipomoea batatas* ([L.] Lam) Varieties and Spacing for Critical Nutritional Tuber-N P K Mineral Nutrients

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Abstract

A field experiment was conducted to study the tuber-nitrogen (N), phosphorus (P) and potassium (K) mineral nutrients of *Ipomoea batatas* using 2 varieties (white fleshed *Ipomoea batatas* [WFIB] and orange fleshed *Ipomoea batatas* [OFIB]) and 3 intra-row spacing (30, 45 and 60cm) with 60cm kept constant as inter-row spacing. These 2x3-experimental factors were combined and laid in a randomized complete block design (RCBD) with 4 replications at the Abubakar Tafawa Balewa University, Teaching and Research Farm, Bauchi, Nigeria during the 2007-2009 wet seasons. Results revealed that tuber-NPK mineral nutrients of WFIB and OFIB were specifically at par to each other with critical values within permissible limits considered fit human consumption. Tuber-NPK mineral nutrients increased from 30 to 60cm spacing with the exception of tuber-N in 2007 and 2009, tuber-P in 2007 and tuber-K in 2007 and 2009 where these *Ipomoea batatas* critical nutritional tuber mineral nutrients were especially similar from one spacing to another. Interaction in tuber-NPK mineral nutrients between *Ipomoea batatas* varieties and spacing was not significant. Implying that WFIB and OFIB responded similarly and linearly to corresponding changes due to spacing.

Keywords: *Assessing; Ipomoea batatas; Varieties; Spacing; Critical Nutritional Tuber-NPK Mineral Nutrients*

Introduction

Ipomoea batatas is grown in many of the poorest region of the world mainly for human nutrition as in food and income [1-3]. It is a poor resource farmer's crop because of its low inputs requirements, ease of production, ability to produce under adverse weather and marginal soil conditions [1,4]. Wide variability in *Ipomoea batatas* cultivation and productivity has been attributed to variety, propagation methods and materials, location or environment, season, soil factors and spacing or density [5-11]. In a work on field varieties of *Ipomoea batatas*, performance of *Falaha*, *Bareda*, and *Awasa*-83 varieties were studied by [12]. The worker showed that quantity and pattern of dry matter contents (DMC) produced and partitioned in the three varieties he worked with differed. *Bareda* variety produced the highest tuber dry matter contents while *Awasa* and *Falaha* varieties were at par DMC-wise. He further observed that *Falaha* was most efficient in partitioning dry mass to tubers, followed by *Bareda* and *Awasa*-83 varieties. Similarly, [13] studied nine exotic varieties (Regal, NC-262, NC-1508, *Kafr El Zayat* No. 1, *Yan Shu*-1 and *Fongsu* No. 1; *Tamayukata*, *Kyukei* No. 63 and *Satsuma hikari*) with two local varieties (*Hatay Kırmızı* and *Hatay Beyaz*) for two years between 2000 and 2001 in Turkey. Their results also showed that, DMC including protein and total carotenoid contents (P&TCTs) of exotic varieties were influenced significantly. *Kyukei* No. 63 was an outstanding variety with the highest DMC. More so the local varieties (*Hatay Kırmızı* and *Hatay Beyaz*) had considerably high DMC. Result on insoluble solids contents (AISCs) of exotic varieties [13], which is a strong and good indicator of available mineral nutrients in *Ipomoea batatas* tubers based on [14] and [15], showed ranking patterns similar to DMC. The highest AISCs was recorded in *Kyukei* No. 63, whereas Regal, *Yan Shu*-1, *Kafr El Zayat* No. 1 and *Fongsu* No. 1 gave low AISCs respectively [16] reported that carotenoid which is a precursor of vitamin A in *Ipomoea batatas*, depends on tuber flesh colour of varieties. Dark orange fleshed- coloured varieties are rich sources of β-carotene, the most active provitamin A carotenoid, while yellow or light orange-fleshed ones supplies moderate amounts of β- carotene [17]. However, [18] recorded significantly wider variations in β- carotene contents among cultivars with much darker orange flesh colour compared to white fleshed varieties. Advancing reasons for significant increases in TCTs and other important yield properties among *Ipomoea batatas*, [19] reported that varietal differences, growing conditions with location and seasonal variations might be implicated.

Plant spacing is one of the most important factors contributing to critical tuber-yield properties in *Ipomoea batatas* [20-24]. Studies on spacing have been carried out for several varieties and recommendations for most of them varied widely. Earlier, [25] recommended closer spacing in order to obtain maximum performance for *Ipomoea batatas* varieties. While, [26] reported that wider plant spacing increase tuber yield contents (TYCs) of varieties per unit area. Therefore, proper spacing in *Ipomoea batatas* is still a very strong controversial issue among *Ipomoea batatas* growers worldwide [27,28]. A spacing of 30 - 60 cm between rows and 15 - 20 cm between plants gave maximum TYCs in different parts of India [25]. In Uganda, a significant reduction in TYCs due to much closer spacing was recorded [29]. In Cameroon, TYCs increases with increase spacing [16]. In Bangladesh, maximum TYCs was obtained when *Ipomoea batatas* vines were planted at a spacing of 60×30cm and when further increased to 60×45 cm [30,31]. In a 2-year work conducted to test different field row spacing that contained multiple rows of *Ipomoea batatas* and different plant spacing within rows, [32] found out that closer spacing produced lesser TYCs than did the narrow and wider spacing. This particular response they associated it to the amount of moisture and nutrients availability and rate of uptake of these plant nutrients in *Ipomoea batatas*. Closer spacing gave the highest plant density and produced more tubers that could not synthesized great critical *Ipomoea batatas* assimilates before harvest date. They further illustrated that this might have been due to competition for moisture and nutrients. Large size tubers with the widest spacing treatment suggest lowest plant population. Competition was reduced at lower populations. A definite trend towards small and large sized-tubers as a measure of tuber-mineral nutrient sink with respective closer and wider *Ipomoea batatas* spacing have been simultaneously reported by [20] and [10]. The aims of this study were therefore to evaluate common cultivated *Ipomoea batatas* varieties and their possible interaction with varied plant spacing for maximum and permissible levels of tuber-NPK mineral nutrients in Bauchi, Nigeria.

Materials and Methods

Field experiment was conducted during the wet seasons of 2007 - 2009 at the Abubakar Tafawa Balewa University, Teaching and Research Farm, Bauchi, Nigeria (10^0 17"N, 9^0 49"E and 609.3m above sea level) in the Northern Guinea Savanna ecological zone of Nigeria [33]. Two different sites were used during the experiments. In 2007, the field used was cropped with *Zea mays* L. in 2006. The field used for 2008 and 2009 however, was cropped with *Vigna unguiculata* Walp. in 2007. A most popular indigenous white-fleshed *Ipomoea batatas* (WFIB) and an improved orange-fleshed *Ipomoea batatas* (OFIB) varieties [34] were used throughout the period of the study. The vines for the two *Ipomoea batatas* varieties were obtained from a community based vine producer in *Sabon-Kaura* area of Bauchi, Nigeria.

In each year, standard 60cm vine lengths of WFIB and OFIB were subjected to 30, 45 and 60cm plant spacing as treatments, with a constant 60cm row spacing. Factorial combinations of these treatments were arranged in a randomized complete block design with 4 replications. Land was demarcated into plots of 4 x 3.6m with 6 ridges using a measuring tape, lines, pegs and hand-type plough. A distance of 1.0m and 1.5m were allowed between plots and replicates. However, in 2009 the experimental area was incidentally tractor- ploughed before demarcating into plots. Planting of *Ipomoea batatas* varieties were done manually in third week of June of each season (after rain has established) using single vine transplanted per hill as opined by [35]. Weeds were controlled manually with simple hoes under two weeding regimes at 4 and 6 weeks after planting (WAP).

No diseases and pests infestation were observed on the plants. The crops were harvested manually, once at physiological maturity using hand diggers and hoes. In each year's experiment, composite soils samples were taken randomly before ploughing at 0 - 50 cm depth, using a tubular auger. The samples were analysed to determine their physico-chemical properties based on standard procedures described by [36]. Results of the analysis revealed that soil of the experimental sites was sandy loam, slightly acidic in water and more acidic in CaCl2, low in organic carbon, total nitrogen and available soil phosphorus with very low cation exchange capacity (CEC). The basic cations (Ca, Mg, K and Na) are very high, probably due to previous cultivation practices. Yearly harvested tubers were bulked treatment wise and from each treatment-bulked, samples of tubers were picked at random for mineral nutrients analysis as in tuber- nitrogen (N), phosphorus (P) and potassium (K) concentrations following Micro- Kjeldahl digestion method and values read with the atomic Absorption Spectrophotometer (AAS) [37]. Data collected were subjected to analysis of variance to test the treatment effects for significance using the 'F' test [38]. Duncan multiple range test (DMRT) was used to compare significant differences among means [39].

Results

Varieties had no significant effect on *Ipomoea batatas* tuber-N in 2007, 2008 and 2009 respectively. The tuber-N mineral nutrients was observed to be statistically the same in the 3-year study. However, spacing had a significant effect on *Ipomoea batatas* tuber-N as it increased significantly with spacing with the exception of spacing between 30 and 45cm, especially in 2007 and 2009 wet seasons. The treatment-interaction recorded in tuber- N was not significant (Table 1). Varieties of *Ipomoea batatas* had no significant effect on tuber-P in 2007- 2009. Yearly tuber-P nutrients obtained was generally at par amongst varieties, but significantly increasing trend was derived with spacing, except in 2007 wet season, where corresponding increases in tuber-P nutrients was similar from one spacing to another. There was no significant interaction between treatments in tuber-P nutrients (Table 2). Tuber-K of *Ipomoea batatas* varieties in the 3 consecutive wet seasons study was not significant. Spacing had a significant effect on tuber-K nutrients of *Ipomoea batatas*. But tuber-K nutrients in 2007 growing season between 30 and 45 including 45 and 60cm spacing was similar. Highest tuber-K nutrients was realized with 60cm spacing in 2008. Similar trend was recorded in 2009 (except between 45 and 60cm spacing). The *Ipomoea batatas* varieties and spacing interaction between varieties and spacing in tuber-K nutrients was also not significant (Table 3).

Treatments	Year		
	2007	2008	2009
Variety			
White-Fleshed *Ipomoea batatas*	6.4	8.0	16.7
Orange-Fleshed *Ipomoea batatas*	6.6	8.3	17.2
LS	NS	NS	NS
SE±	0.3	0.3	1.6
Spacing (cm)			
30 x 60	5.6b	6.7c	13.4b
45 x 60	6.4ab	8.2b	16.4ab
60 x 60	7.6a	9.5a	21.0a
LS	*	*	*
SE±	0.4	0.3	2.0
Interaction			
Variety x spacing	NS	NS	NS

Table 1: *Effect of variety and spacing on tuber-N nutrient contents (g kg^{-1}) of Ipomoea batatas during the 2007- 2009 wet seasons at Bauchi, Nigeria.*

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT.

*LS. Level of significance NS. Not significant *Significant at 5% SE ± Standard error.*

Treatments	Year		
	2007	2008	2009
Variety			
White-Fleshed *Ipomoea batatas*	4.5	6.0	11.1
Orange-Fleshed *Ipomoea batatas*	5.2	6.4	11.8
LS	NS	NS	NS
SE±	0.3	0.2	0.3
Spacing (cm)			
30 x 60	3.8b	5.0c	8.9c
45 x 60	4.9ab	6.3b	11.1b
60 x 60	5.9a	7.4a	14.3a
LS	*	*	*
SE±	0.4	0.3	0.4
Interaction			
Variety x spacing	NS	NS	NS

Table 2: *Effect of variety and spacing on tuber-P nutrient content (g kg^{-1}) of Ipomoea batatas during the 2007-2009 wet seasons at Bauchi, Nigeria.*

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT.

*LS. Level of significance NS. Not significant *Significant at 5% SE* ± Standard error.

Treatments	Year		
	2007	2008	2009
Variety			
White-Fleshed *Ipomoea batatas*	5.1	6.7	14.2
Orange-Fleshed *Ipomoea batatas*	5.4	7.0	14.9
LS	NS	NS	NS
SE±	0.4	0.1	0.9
Spacing (cm)			
30 x 60	4.0b	5.3c	11.2b
45 x 60	5.4ab	6.9b	14.8a
60 x 60	6.4a	8.4a	17.6a
LS	*	*	*
SE±	0.5	0.2	1.1
Interaction			
Variety x spacing	NS	NS	NS

Table 3: *Effect of variety and spacing on tuber-K nutrient contents (g kg^{-1}) of Ipomoea batatas during the 2007- 2009 wet seasons at Bauchi, Nigeria.*

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT.

*LS. Level of significance NS. Not significant *Significant at 5% SE ± Standard error.*

Discussion

Tuber-NPK elements considered as key indicators of minerals in *Ipomoea batatas* [40] revealed that *Ipomoea batatas* varieties generally showed no significant and peculiar differences among them with regards to these important nutritional properties. Values recorded in this study ranged from 4.5 - 17.2 g kg^{-1} which fall within the permissible limits reported fit for human nutrition and health [41]. The non-significant differences observed for tuber-NPK nutritional elements among respective varieties in this work may not be unconnected with the fact that each variety has the capacity to synthesize the nutrient elements appreciably, so that subjecting them to the same field-spacing conditions as a typical cultivation practice [42] could not bring about any variation. However, numerically, it was observed that tuber-NPK concentrations in all years of study were slightly higher in orange-fleshed *Ipomoea batatas* compares to white-fleshed *Ipomoea batatas*. This may be attributed to orange fleshed colour of the variety. Earlier, [42] reported a similar case in light fleshed coloured *Ipomoea batatas* with tuber dry matter contents. The current work also contradicts the findings made by [13,16-18]. These workers specifically reported that *Ipomoea batatas* differed in nutritional properties depending on the cultivable variety and season of production.

Spacing showed a significant influence on the tuber-NPK mineral nutrients of *Ipomoea batatas* varieties. The recorded highest critical tuber values of these nutrient elements of *Ipomoea batatas* which ranged from 3.8 - 21.0 g kg-1 was in the order of 60<45<30 cm respectively. Reasons may not be far-fetched. The plant population due to each field-spacing regime [10,12,20,31,43] and their associated competition for growth factors [41] including air and space led to the trend in tuber-NPK mineral nutrients obtained in the current work. Intermittent responses of *Ipomoea batatas* varieties to tuber-NPK mineral nutrients due to spacing in this report was similarly observed by [41] when they used two vine lengths and inorganic fertilizers on *Ipomoea batatas*. The workers attributed their observation to limitations sets by the different length of vines, despite rational use of fertilizers. In the same vein, irrespective of genetic feat and other important productive or performance peculiarities of the two *Ipomoea batatas* varieties studied, spacing adopted here in conjunction with soil physico-chemical nature of the area, set a definite pattern of physiological behaviour for the manufacture of nutritional tuber-NPK mineral elements, which use of 60cm spacing appeared (Tables 1-3) favourable in this regard.

Conclusion

This study showed that agronomic practices such as use of varieties and spacing have influenced *Ipomoea batatas'* tuber-NPK mineral nutrients in the area of study. Particularly, establishing either white-fleshed *Ipomoea batatas* or orange-fleshed *Ipomoea batatas* in the field using 60 cm spacing with a standard 60 cm long vines. The average *Ipomoea batatas'* tuber-NPK mineral nutrients obtained in this work ranged from 4.2 - 19.1 g kg^{-1}. The range of tuber-NPK nutrients are appreciable and excellently within permissible limits considered fit for human nutrition and health. Therefore, field use of either white-fleshed *Ipomoea batatas* or orange-fleshed *Ipomoea batatas* as common varieties spaced at 60 cm with a standard 60 cm long vines planted at single vine per hill is recommended for maximal manufacture and ingest of tuber-NPK mineral nutrients among households and families in Bauchi and related environment for improved standard of leaving.

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