EFFECT OF NPK FERTILIZER ON THE PRODUCTIVITY AND NUTRIENT-USE EFFICIENCY OF POLYNESIAN ARROWROOT (*TACCALEONTOPETALOIDES*) IN SOUTHEASTERN NIGERIA.

***Nwokocha, C.C., Ironkwe, A.G., Amadi, C.O. and Njoku, N.R.**
National Root crops Research Institute, UmudikeUmuahia, Abia State Nigeria
*E-mail: chrisnwokocha@gmail.com

ABSTRACT
An experiment was carried out in the eastern farm of National Root Crops Research Institute, Umudike (Latitude 05^0, 29^1N, longitude 07^0, 33^1E and 122m above sea level) southeastern Nigeria in 2017/2018,to determine the response of Polynesian arrowroot to NPK fertilizer on a sandy loam *Ultisol.* The trial was laid out in a randomized complete block design (RCBD) with three replications. Seed tubers were planted in the dry season of November, 2017 on plots measuring 5 x 4 m, and at a plant spacing of 1 m between rows and 0.50 m within rows. Fertilizer treatments (0, 100, 200, 300, 400, 500 kg/ha NPK 15:15:15) were applied in April, 2018 (one month after sprouting). Data on growth parameters were measured at 1 and 2 months after fertilizer application (MAFA). Yield and yield parameters were determined at harvest (12 MAP). Application of 200 kg/ha NPK 15:15:15 optimally improved growth parameters (plant height (73.3 and 76.8 cm), tiller number (4 and 4 per plant), number of leaflets (10.5 and 11.0 per plant) at 1 and 2 MAFA, respectively and yield parameters (ware tuber yield (6.74 t/ha) and total tuber yield (6.85 t/ha). Application of 300 kg/ha NPK fertilizer was optimum for seed tuber production. Application of 200 kg/ha NPK fertilizer caused a percentage yield increase of 65.1% over the control (0 kg/ha fertilizer), and a comparatively high fertilizer response rate of 100.7, and is therefore recommended for the production of Polynesian arrowroot in Umudike, southeastern Nigeria.

Keywords: Fertilizer response rate, NPK fertilizer, Polynesian arrowroot, SoutheasternNigeria, *Ultisol.*

INTRODUCTION
The *Taccaleontopetaloides* L Kuntze otherwise known as Polynesian arrowroot or Amora in local parlance is a perennial flowering plant that is found naturally growing in the tropical rainforest and guinea savannah agro-ecologies of Nigeria. The plant is wider spread in the middle belt (Manek *et al*, 2005) and in the south western states (Borokini *et al*., 2014). Specifically, Pate *et al*.(2014) reported that it is found widely in Plateau and Nassarawa states of Nigeria. In spite of its importance as a food source in Nigeria and its use as starch in stiffening fabrics (Spennemann,1994), and as a panacea in the treatment of diarrhea and dysentery (John-Rey,1997), the production and use of this crop in Nigeria has been hampered by its inability to be domesticated (Pate *etal.*, 2014). This, coupled with the increasing recognition of the industrial quality of its starch (Kunle*et al*., 2003; Ukpabi, *et al*., 2009; Vu *et al*, 2017) have brought to thefore the need to domesticate the plant.To arrive at optimum tuber yield at specific environments, production packages should be based on information derived from field trials conducted in such environments. Roots and tuber crops are grown in all agro-ecological zones of Nigeria under varying levels of soil management (Nwokocha *et al*., 2009). Considerable evidence indicates that sub-optimal soil fertility is a growing problem in the acid sands of southeastern Nigeria (Nwokocha*et al*., 2013). Polynesian arrowroot is one of the minor tuber crops that are engaging the attention of researchers at National Root Crops Research Institute (NRCRI) Umudike. There is insufficient knowledge on the best way to produce the crop and the quantity and type of fertilizers required. Present status indicates that the crop is harvested in the wild by farmers and no conscious effort has been made to domesticate the production in Nigeria by farmers and researchers. A study was carried out in 2017/2018 cropping season to determine the effect of NPK fertilizer on the growth, yield and nutrient-use efficiency of Polynesian arrowroot grown in an open field at Umudike, southeastern Nigeria.

MATERIALS AND METHODS
Location
The experiment was carried out in the eastern farm of National Root Crops Research Institute, Umudike (Latitude 05^0, 29^1N, longitude 07^0, 33^1E and 122m above sea level) southeastern Nigeriain 2017/2018, to test the hypothesis that Polynesian arrowroot can be grown in an open field at Umudike and to determine the response of Polynesian arrowroot to NPK fertilization on an *Ultisol* at Umudike, southeastern Nigeria.

Experimental Protocol
The trial was laid out in a randomized complete block design (RCBD) with three replications. Tubers used as planting materials were collected from farmers in Benue State. Planting was done in the dry season of November 2017 on plots measuring 5 x 4 m, and at a plant spacing of 1 m between rows and 0.50 m within rows. Fertilizer treatments (0, 100, 200, 300, 400, 500 kg/ha NPK 15:15:15) were applied one month after sprouting. Herbicide was applied as pre-emergence at planting, with 2 manual weeding regimes at 4 and 12 weeks after sprouting (WAS). Pre-cropping soil sample was collected and analyzed for physico-chemical properties.

Laboratory Analysis

Total N was determined by the macro-Kjeldahl digestion method (Bremner and Mulvaney, 1982). Particle size distribution was measured by the hydrometer method as described by Gee and Bauder (1986). Percent organic carbon (%OC) was determined by the dichromate oxidation method of Walkley and Black method (Nelson and Sommers, 1982). Soil pH (H_2O) was measured (soil/water ratio of 1:2.5) with a digital pH meter (McLean, 1982). Available P was determined by the Bray 2 method according to Bray and Kurtz (1945). Cation exchange capacity (CEC) was determined by the NH_4OAc displacement method (Thomas, 1982) and exchangeable K in extract estimated by flame photometry. Exchangeable acidity was determined by the titrimetric method after extraction with1.0 M KCl (McLean, 1982). Effective cation exchange capacity (ECEC) was determined by the sum of the exchangeable bases and the exchangeable acidity. Data on growth parameters (plant height (cm), leaf stem/tiller height (cm), number of leaflets and number of leaf stems/tillers) were measured at 1 and 2 months after fertilizer application (MAFA). Yield and yield parameters were determined at harvest (12 MAP). Harvesting was done in November 2018. Nutrient-use efficiency of the applied fertilizer was evaluated as fertilizer response rate (increase in yield due to treatment per unit value of fertilizer applied) (Falusi, 1987).

Data Analysis

Data obtained were subjected to a one way analysis of variance in a randomized complete block design. Significant treatment means were separated using F-LSD at 5% probability level.

RESULTS AND DISCUSSION

Initial soil test values of the experimental farm (Table 1) indicated that the soil had a loamy sand texture and very low nutrient status, characterized by very low organic matter, total nitrogen and effective cation exchange capacity. The soil had an acidic soil reaction typical ofsoils derived from coastal plain sands. Available phosphorus content of the soil was moderate. Results obtained showed that rate of fertilizer application significantly influenced plant height at 1 and 2 months after fertilizer application (MAFA), tiller height at 2 MAFA, leaf number and tiller number at 1 and 2 MAFA (Table 2). Application of 200 kg/ha NPK15:15:15 fertilizer significantly produced tallest Amora plants at 1 and 2 MAFA (73.27 at $P < 0.01$ and 76.80 cm at $P < 0.05$, respectively). Plant height increased more at early stage of growth (1 MAFA) than at later stage (2 MAFA). This may be attributed to the effect of

Table 1. Soil physico-chemical properties of the experimental site at Umudike

Soil properties		Umudike site
Sand (g/kg)		789.0
Silt (g/kg)		99.0
Clay (g/kg)		112.0
Textural class*		SL
pH(H_20)		4.80
Organic Carbon (g/kg)		10.40
Total Nitrogen (g/kg)		0.39
C/N ratio		26.7/1
Avail. Phosphorus (mg/kg)	21.32	
Calcium (Cmol/kg)		2.60
Magnessium (Cmol/kg)		0.87
Potassium (Cmol/kg)		0.077
Sodium (Cmol/kg)		0.362
Total exch. Acidity (Cmol/kg)		0.86
Effective Cation Exch. Capacity (Cmol/kg)		4.77
Base Saturation (g/kg)	819.7	

- SL = Sandy loam;

Table 2. Effect of NPK fertilizer on the growth parameters of Polynesian arrowroot grown on an Ultisol at Umudike.

Fertilizer rate (kg/ha)	Plant height (cm)		Tiller height (cm)		Tiller number (cm)		Number of leaflets	
	1 MAFA	2 MAFA	1 MAFA	2 MAFA	1 MAFA	2 MAFA	1 MAFA	2 MAFA
0	48.30	56.10	44.34	46.17	2.0	2.0	8.5	9.5
100	62.88	67.00	47.46	51.00	3.0	3.0	8.5	9.0
200	73.27	76.80	43.09	44.34	4.0	4.0	10.5	11.0
300	67.05	69.50	40.42	41.92	3.0	3.0	8.0	9.5
400	61.60	63.20	46.02	50.50	3.0	3.0	8.5	9.3
500	60.50	67.20	44.67	47.45	3.5	3.5	9.5	10.0
$LSD_{0.05}$	5.72**	9.31*	NS	6.07*	0.4**	0.4**	1.2*	1.4*

*, ** = Significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level.

nitrogen when uninterrupted growth is needed (Borokin and Ayodele, 2012). Caddike*etal*. (2002) reported that young seedlings require phosphorus to stimulate early development and root growth, while potassium (John-Rey, 1997) plays vital role in the uptake of water for utilization by crops. Shortest plants (48.30 cm and 56.10 cm at 1 and 2 MAFA, respectively) were recorded from the control plots. Similarly, application of 200 kg/ha fertilizer produced significantly ($P < 0.05$) highest average number of leaflets/plant at 1 and 2 MAFA (10.5 and 11.0, respectively) and significantly ($P < 0.01$) highest average number of tillers at 1 MAFA, which did not differ from values obtained at 2 MAFA. Tiller height at 1 MAFA was not significantly affected by fertilizer rates at Umudike. The fertilizer nutrients (NPK) are essential components in the formation of meristematic cells and for cell division, the process which initiates growth. This was demonstrated when values of measured growth parameters at 200 kg/ha NPK fertilizer were compared with values obtained from the control plots. Beyond 200 kg/ha rate, there were noticeable decrease in plant height, tiller number/plant and number of leaflets/plant. Thus, 200 kg/ha NPK fertilizer rate was optimum for Polynesian arrowroot growth and development in the study area.

Ware tuber yield and total tuber yield recorded highest values of 6.74 t/ha and 6.85 t/ha, respectively from plots that received 200 kg/ha fertilizer (Table 3). Lowest total tuber yield (3.40 t/ha) was obtained from 500 kg/ha plots and did not differ significantly from total tuber yield (4.15 t/ha) obtained from the control plots (0 kg/ha). Ware tuber number/ha and total tuber number/ha were not significantly affected ($P > 0.05$) by fertilizer rate. Significantly ($P < 0.05$) lowest numbers of seed tuber/ha which did not differ significantly from each other wereobtained from 0 kg/ha plots (2778) and 200 kg/ha plots (3843). This is similar with the work of Spennenman(1994) who reported that more tubers were formed with adequate supply of fertilizers, which according to Bailey (1992) encourages mineral and water uptake.

Table 3.Effect of NPK fertilizer on yield and yield parameters of Polynesian arrowroot grown on an Ultisol at Umudike.

Fertilizer rate (kg/ha)	Ware tuber yield		Seed tuber yield		Total tuber yield	
	No/ha	t/ha	No/ha	t/ha	No/ha	t/ha
0	21270	4.11	2778	0.036	24048	4.15
100	16944	4.06	6125	0.188	25069	4.25
200	24112	6.74	3843	0.112	27955	6.85
300	18371	4.43	7786	0.266	26158	4.69
400	19166	4.09	7057	0.167	26222	4.26
500	17353	3.25	6440	0.151	23793	3.40
$LSD_{0.05}$	NS	1.63*	3742*	0.09**	NS	1.67*

*, ** = Significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level.

Application of >200 kg/ha NPK fertilizer increased seed tuber number/ha (6440 – 7786). For seed tuber production, application of 300 kg/ha NPK fertilizer was optimum in the study soil (Table 3). Application of 200 kg/ha NPK fertilizer caused a percentage yield increase of 65.1% over the control (0 kg/ha fertilizer), and a comparatively higher fertilizer response rate of 100.7, compared with 46.0, 31.3and 20.0 fertilizer response rates obtained with 300, 400 and 500 kg/ha fertilizer rates, respectively (Table 4). Although, the FRR of 100 kg/ha NPK fertilizer (125.0) was highest, its percentage yield increase over the control was very low (2.4%)(Table 4).

Table 4. Fertilizer responserate (FRR) of Polynesian arrowroot (*Taccaleontopetaloides* L Kuntze) as influenced by NPK fertilizer onan Ultisol at Umudike southeastern Nigeria.

Fertilizer rate (kg/ha)	Nutrients applied (kg/ha)	Total tuber yield (kg/ha)	Percentage increase in yield over control (%)	FRR
0	0	4150	-	-
100	34	4250	2.4	125.0
200	68	6850	65.1	100.7
300	102	4690	13.0	46.0
400	136	4260	2.7	31.3
500	170	3400	-18.1	20.0

CONCLUSION

Results obtained have shown that Polynesian arrowroot can be grown in an open field and that the soil and other environmental conditions at Umudike are favourable for its production. Growth and yield parameterswere optimized when 200 kg/ha NPK 15:15:15 fertilizer was applied. However, when seed production is the object of interest, application of 300 kg/ha NPK fertilizer is optimum. Application of 200 kg/ha NPK fertilizer to Polynesian arrowroot crop at Umudike yielded a comparatively high fertilizer response rate of 100.7. However, application of > 200 kg/ha NPK fertilizer depressed fertilizer response rate.

REFERENCES

Bailey,J.M.(1992). The Leaves we eat. Southern Pacific Commission Noumea, New Caledonia, 60p.

Borokin,T.I and Ayodele,A.E (2012). Phytochemical Screening of Taccaleontopetaloides(L.)Kuntze.Collectedf rom four Geographical locations in Nigeria.International Journal of Botany 2(4):97-102.

Borokini, T. I., Ayodele, A. E., and Akinloye, A. J. (2014) Morphological and anatomical studies onTaccaleontopetaloides(L.) Kuntze (Taccaceae) in Nigeria Research in Plant Biology, 4(5):28-44

Bray, R. H., and Kurtz, L. T. (1945). Determination of total organic and available forms ofphosphorus in soils. Soil Sci. 59, 39 – 45.

Bremner, J. M. and Mulvaney, C. S. (1982).Total nitrogen. In: Page, et al. (eds). Methodsof Soil Analysis, Part II. Am. Soc. Agron. 9, Madison, WI, USA.

Caddike,R.L.,Wilkin,P.,Rudall,P.J. Hedderson,A.J and Chase,M.W.(2002).Yams reclassified: Areciccumsription of Dioscoreaceae and Dioscoreales,Taxon 51,pp.103-114.

Falusi, A. O.(1987). Economic and technical efficiency of fertilizer use in agricultural production in Nigeria. In: Towards efficiency of fertilizer use and development in Nigeria. Proceedings of the National Fertilizer Seminar, held at Port-Harcourt. October 28 – 30 1987. Pp 222 – 238.

Gee, G.W. and Bauder, J.W. (1986). Particle size analysis.Methods of soil analysis. Ed. A. Klute.American Society of Agronomy.Madison, W.I. USA.

John-Rey,F.(1997).Cost-benefit analysis.Free Management Newsletter.Pp.1-2 In: Krauss,B.H.(1997).NativePlants used as Medicine in Hawaii.

Kunle, O.O., Ibrahim, Y.E., Emeje, M.O., Shaba, S., and Kunle, Y. (2003) Extraction, Physicochemicaland Compaction Properties of Tacca Starch — a Potential PharmaceuticalExcipient Starch55(7): 319-325 https://doi.org/10.1002/star.200390067

Manek, R.V., Kunle, O.O., Emeje, M.O., Builders, P., Rama Rao, G.V., Lopez, G.P., and Kolling WM.(2005) Physical, Thermal and Sorption Profile of Starch obtained from TaccaLeontopetaloides. Starch 57:55-61

Mclean, E. O. (1982). Soil pH and lime requirements. In: Page et al. (eds). Methods of SoilAnalysis, Part II. Am. Soc. Agron. 9, Madison, WI, USA.

Nelson, D.W. and Sommers,L.E. (1982). Total carbon organic carbon and organic matter. In: A.Z. Page et al. (eds.). Methods of soil analysis. Part 2, 2nd ed. ASA, SSSA, pp539- 579.

Nwokocha, C.C., Olojede, A.O. and Ano, A.O. (2013).NPK fertilizer requirements of Hausa potato production on an ArenicHapludult Southeastern Nigeria. Proceedings of the 47th Annual Conference of the Agricultural Society of Nigeria. Held at Federal College of Animal Health and Production Technology, Moor Plantation, Ibadan, Oyo State Nigeria. 4th – 8th Nov., 2013. Pp 75 – 78.

Nwokocha, C. C., Olojede, A.O., Ano, A.O., Chukwu, G.O, and Korieocha, D. S. (2009).NPK requirement for turmeric production on an ArenicHapludult in southeastern Nigeria. Proceedings of the 33rd Annual Conference of the Soil Science

Society of Nigeria. Held at University of Ado-Ekiti. 2009. Pp 166-171.

Pate, H.S., Badi, S.H., Dikwahal, H.D., Jibung, G.G. and Molchen, M.D. (2014). Response of Polynesian arrowroot Taccaleontopetaloidesto fertilizer and intra-row spacing at Garkawa.Journal of Biology, Agriculture and Healthcare.ISSN 2224=3208 *Paper). ISSN 2225-093X (Online). Vol. 4, No 11.Pp 97-101.

Spennemann,D.H.R.(1994).Traditional arrowroot production and utilization in the Marshall Islands.J.Ethnobiology.14(2):211-234.

Thomas, G. W. (1982). Exchangeable cations. In: Page et al. (eds). Methods of Soil Analysis,Part II. Am. Soc. Agron. 9, Madison, WI, USA.

Ukpabi, U.J., Ukenye, E. and A.O. Olojede, (2009). Raw-Material Potentials of Nigerian

WildPolynesian Arrowroot (Taccaleontopetaloides) Tubers and Starch. Journal of FoodTechnology, 7: 135-138.

Vu, Q.T.H, Le, P.T.K., Vo, H.P.H, Nguyen,T.T. and Nguyen, T.K.M. (2017) Characteristics of TaccaleontopetaloidesL. Kuntze collected from An Giang in Vietnam AIP Conference Proceedings1878, 020022 Published online 15th September 2017; https://doi.org/10.1063/1.5000190