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Proximate, Mineral and Phenol Content of *Dioscorea Rotundata* Var. Amula, *Dioscorea Cayenensis* Var. Igangan-Alo from Farmers' Plots and Bounty-Fertilized, Infected with *Botryodiplodia Theobromae* Pat

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ABSTRACT

Fertilizer effects on infection and weight loss by *Botryodiplodia theobromae* Pat, was determined in white guinea yam *Dioscorea rotundata* variety Amula from the middle belt-region of Nigeria, and yellow guinea yam D. cayenensis variety Igangan/Alo from South West Nigeria. Tubers of both varieties were sourced from farmers' plots from within Ogun State (South West Nigeria) where they had been planted on three or more years previously fallowed plots, and harvested at six months after planting. Another lot of tubers of both varieties were sourced from a yam project plot at the Teaching and Research farms of the Directorate of University Farms (DUFARMS), Federal University of Agriculture (FUNAAB) Abeokuta, where they had been fertilized at the rate of 0.60 ml l^{-1} of Bounty fertilizer, an 8-mineral component fertilizer, and harvested also at six months after planting. Tubers of both varieties from farmers' plots were analysed for proximate content (dry matter, moisture, ash, fat, crude protein, crude fibre and carbohydrate) phenol content and ten minerals namely Ca, N, P, K, Mg, Fe, Mn, S, Zn and B. Another set of tubers of the two varieties from farmers plots, as well as those from the Bounty-fertilized yam project plot, were inoculated with *Botryodiplodia theobromae* in an infection and weight loss experiment. The infection and weight loss experiment was a 2 by 2 factorial arranged in RCBD (randomized complete block design) with 4 treatment combinations and 5 replications. Tubers of both varieties from both sources inoculated with a 7-day old pure culture of *B. theobromae* were the four treatment combinations. Incubation period was 3 weeks. Infection in Amula (white guinea yam) was over 2500% higher than in the yellow guinea yam, Igangan. Phenol (107.89 mg/100 gdm) and calcium (16.85 mg/100 gdm) were higher in Igangan than in Amula (89.04 and 16.70 mg/100gdm respectively), and is adduced as the reason for the high infection in variety Amula. Weight loss however was 154% higher in Igangan than in Amula. Crude fibre had a negative significant correlation with weight loss (r = -0.9285, P=0.001), and crude fibre with the value 4.49% dm was higher in variety Amula than in variety Igangan (4.02%dm). This is responsible for the higher weight loss in var. Igangan. Phenol content also had a significant negative correlation with weight loss (r = -0.9586, P = 0.05), suggesting that the effect of high crude fibre in reducing weight loss outweighs that of phenol in reducing weight loss. There was high reduction of infection in the Bounty-fertilized tubers, 3.72% compared to farmers' plot tubers which had 27.22%. Weight loss was

also 0% in Bounty-fertilized tubers compared to a high 63.54% in the tubers from farmers' plots. This indicates that the 8-mineral component fertilizer, Bounty will prolong shelf life in the white and yellow guinea yams Amula and Igangan. Five minerals namely Mg, K, Zn, Mn and B had significant correlation with weight loss (r = 0.9461, 0.9802, 0.9214, 0.9898 and 0.9122) respectively. Three of these minerals namely Zn, Mn and B content were all low with mean values of 0.25, 0.44 and 0.07 mg/100gdm respectively but Mg and K were relatively higher with mean values of 21.59 and 806.67mg/100gdm respectively. This suggests that mineral nutrition to enhance prolonged shelf life in *D. rotundata* var. Amula and *D. cayanensis* var. Igangan may be established with a balance of Mg, Zn, Mn and B in lower proportions than K, as potassium is essential in optimum yield in *Dioscorea* species.

INTRODUCTION

Yam (Dioscorea species) is produced throughout the tropical and sub-tropical regions of the world. The white and yellow Guinea yams are indigenous to the West African Savanna, while water or greater yam is the most widely distributed species globally (Onwueme *et al.*, 1991; FAO, 2006). *D. rotundata* Poir. (white guinea yam), *D. cayenensis* Lamk. (yellow guinea yam) and *D. alata* (water yam) are the most popular in Nigeria (Onwueme, 1991). West Africa accounts for about 95% of world production and 96% of the production area (FAO, 2006). Annual yam production globally is over 40 million Mt, with Nigeria being the largest producer (FAO, 2014). Food yams are grown primarily for their edible underground tubers, plus aerial bulbils. Yam broadens the food base and brings food security to 300 million people in the low-income, food-deficient countries of the tropics, providing them with about 200 kilocalories daily (Hahn *et al.,* 1987). Socio economic surveys conducted in Nigeria indicated that there was a positive elasticity of demand for yams at all expenditure levels, and that production research towards increasing yam supply will consequently increase quantities consumed at low-income levels in sub-Saharan Africa (Nweke *et al.,* 1992). *Dioscorea* species are not only known for their food value but also for their secondary metabolites, which are used for local poisons and pharmaceutical products (Degras, 1993).

A major constraint to yam production is tuber quality deterioration in storage (Onwueme, 1978). Many of the fungi responsible for the rots in storage such as *Aspergillus niger, Botryodiplodia theobromae* and *Rhizopus* species among others are being curtailed/controlled mainly by resistance breeding, biological control, chemicals or fungicide and cultural practices. Mineral nutrition for sustainable yam production including control of storage pathogens attacks is now being exploited.

This study was carried out to investigate the effect of mineral nutrition in the control of rot by *Botryodiplodia theobromae* in *Dioscorea cayenensis* var. Igangan, a popular yellow guinea yam cultivar in the South West region of Nigeria and *D. rotundata* var. Amula, also a popular white guinea yam cultivar in Nigeria's middle belt region. The objectives of the study were:

(1) To compare proximate content, phenol content and minerals (eight) in the two varieties from farmers' plots.
(2) To compare infection and weight loss in the varieties after mineral fertilization with those sourced from farmers' plots.

MATERIALS AND METHODS

Sourcing of tubers

Tubers of the two varieties were sourced from a yam project plot at six months after planting, at the Teaching and Research Farms of DUFARMS (Directorate of University Farms), Federal University of Agriculture Abeokuta (FUNAAB), Ogun State Nigeria, where they had been fertilized with Bounty fertilizer at three months after planting. Another set of tubers of the two varieties were sourced from farmers' plots within Ogun State, where they had been grown without fertilizer and harvested at six months after planting.

Composition of Bounty Fertilizer

Bounty fertilizer contains 8 minerals in the following combination: Calcium 7% w/w, Nitrogen 15% w/w, Magnesium oxide 0.5% w/w, Zinc 2% w/w, Iron 2% w/w, Manganese 1% w/w, Copper 0.5% w/w and Boron 0.0025% w/w.

Processing of Tubers and Tissue Analysis for Proximate, Phenol and Mineral Content

Tubers were washed in tap water without bruising them. They were air-dried under a low-speed ceiling fan on top of Laboratory benches in the Crop Protection Laboratory, COLPLANT (College of Plant Science and Crop Production), FUNAAB. They were then sliced into thin chips, in labelled plastic trays and transferred to dry in the trays on top of raised wooden netted storage structures inside the screenhouse (COLPLANT Building), shaded from direct sunlight. Each treatment was in triplicate. After 3 days, the dried chips were ground to powder with the Crop Processing Mill at the Central Workshop, COLENG (College of Agricultural Engineering), FUNAAB. The milled samples were packaged into new brown envelopes for analysis. Analysis of samples was done at the Biotechnology Centre and the Department of Biological Sciences Tetfund Laboratory FUNAAB. Proximate content analysis included dry matter, moisture, ash, crude fibre, fat, crude protein and carbohydrate, using standard methods, (Human Nutrition Laboratory Manual, University of Ibadan, A.O.A.C., 1990). Phenol content and the minerals namely Calcium, Magnesium, Potassium, Phosphorus, Nitrogen, Zinc, Manganese, Boron, Iron and Sulphur were analysed using Standard methods (A.O.A.C, 1990).

Storage experiment

The storage experiment was a 2 by 2 factorial arranged in randomized complete block design with 5 replicates. The 4 treatment combinations were Amula and Igangan tubers fertilized from the field plot at 0.60 ml l^{-1} Bounty fertilizer, and those sourced from farmers' plots. Inoculation of the tubers was carried out inside an Inoculation Hood Structure inside the Crop Protection Laboratory, Department of Crop Protection, COLPLANT Building, FUNAAB (Federal University of Agriculture, Abeokuta). Tubers were weighed before inoculation using a top loading mettler balance. Inoculation sites on each tuber were then surface-sterilized by swabbing with cotton wool dipped in 80% ethanol. Two cork borers of 5 mm and 3 mm diameter, scalpel and pair of forceps were surface-sterilized by flaming to red hot over a lighted spirit flame bottle. They were then allowed to cool, slanted over another cork borer on the laboratory bench. The 5 mm surface-sterilized cork borer was then used to bore a hole of about 10 mm depth into each tuber. The cut tissue was lifted out with the scalpel and forceps. A 3 mm agar (potato dextrose agar) disc of a 7-day old pure culture of *Botryodiplodia theobromae* (prepared earlier from a partially rotted Amula tuber) from a petri-dish was placed inside the hole in the tuber. The cut out tissue was then replaced and the incision sealed with vaseline (petroleum jelly). Inoculated tubers were transferred into a raised, wooden, netted yam storage structure inside the COLPLANT

Screenhouse for 3 weeks. After this period, tubers were weighed again after vaseline had been cleared from them with spatula and cotton wool. They were then cut open at the inoculation site with a steel knife and infected tissue pared away on to a pre-weighed petri-dish. Infected tissue weight was measured with an electronic balance.

Percent weight loss was calculated with the formula: % Weight loss (Y) $= \left(\frac{A-B}{A}\right) 100$, where A and B are weight of tuber at the beginning and at the end of the experiment respectively. Percent infection was calculated with the formula: % Infection $= \left(\frac{C}{A}\right) 100$, where C is corrected weight of infected tissue and A is weight of tuber at the beginning of the experiment. $C = \frac{100X}{100-Y}$; where X is weight of infected tissue; Y is percent weight loss (Otusanya and Jeger, 1994).

Data Analysis

Data were transformed appropriately before analysis of variance. Pearson's correlation analysis was performed for all parameters. Means were separated with Tukey's (HSD) test.

RESULTS

Infection and weight loss after incubation with Botryodiplodia theobromae

Variety Amula had significantly higher infection of 29.77% than variety Igangan (1.17%) (Table 1). Infection in the tubers sourced from farmers' plot was significantly higher (27.22%) than tubers from the Bounty-fertilized plot (3.72%). Interaction effects resulted in the highest infection of 53.65% in the Amula variety from farmers' plot, (Amula FPT + BT). The second highest infection was 5.88% in Bounty-fertilized Amula. Igangan Bounty-fertilized and Igangan from farmers' plots both had the lowest infection of 1.56% and 0.78% respectively (Table 1). Weight loss was higher in Igangan (38.54%) than Amula (25%) in the 3-week incubation. Bounty fertilizer effect in weight loss was 0% whereas weight loss in tubers from farmer's plots was 63.54%. Interaction effects for weight loss gave 0% each for Amula and Igangan Bounty-fertilized tubers, whereas Amula FPT + BT and Igangan FPT + BT were 50% and 77.083% respectively. Igangan FPT + BT was higher than Amula FPT + BT in weight loss.

Mineral content

Phosphorus and iron content of the two varieties were not significantly different (Table 2). Mean values were 55.74 mg/10 0gdm (Phosphorus) and 0.56 mg/100 gdm (Iron) respectively. Seven of the ten minerals were significantly lower in variety Amula than variety Igangan (Table 2). The values of the minerals in milligram per 100 g dry weight or dry matter, in the two varieties were as follows: Calcium 16.85 (Igangan) > 16.70 (Amula), Magnesium 21.87 (Igangan) > 21.31 (Amula), Potassium 809.40 (Igangan) > 803.93 (Amula), Zinc 0.26 (Igangan) > 0.23 (Amula), Manganese 0.48 (Igangan) > 0.39 (Amula), Boron 0.08 (Igangan) > 0.05 (Amula) and Sulphur 827.67 (Igangan) > 811.33 (Amula). However, Nitrogen was significantly higher in Amula with the value 719.33 mg/100 gdm than in Igangan which had the value 683 mg/100 gdm (Table 2).

Proximate and Phenol Content

In variety Amula, Fat content (0.55% dm) and Crude fibre (4.49% dm) were significantly higher than in Igangan which had the values 0.49% dm and 4.02% dm respectively. Ash, crude protein and carbohydrate were not significantly different in the 2 varieties and had mean values of

2.74% dm (ash), 4.38% dm (crude protein) and 88.19% dm (carbohydrate). (Table 2) Phenol was significantly higher in Igangan (107.89 mg/100 gdm) than in Amula (89.04 mg/100 gdm), as shown in Table 2. The values of Calcium are in the last column of Table 2, so as to compare their values relative to phenol content values. Calcium content is 18.756% and 15.617% of phenol content in Amula and Igangan respectively.

Correlations of proximate content, phenol content, infection and weight loss

Only significant correlations are indicated in Table 3. There were positive significant correlations in weight loss and some of the tuber minerals as follows:

Weight loss and Mg	(r = 0.9461)
Weight loss and Mn	(r = 0.9898)
Weight loss and K	(r = 0.9802)
Weight loss and B	(r = 0.9122)
Weight loss and Zn	(r = 0.9214)

P = 0.01 to 0.05

There were negative significant correlations between weight loss and crude fibre as well as weight loss and phenol. And also between phenol and carbohydrate as follows:

Weight loss and Crude Fibre	(r = -0.9285)
Weight loss and Phenol	(r = -0.9586)
Carbohydrate and Phenol	(r = -0.8631)

P = 0.01 to 0.05

Finally there were positive significant correlations in some proximate components, phenol, infection and weight loss as follows:

Carbohydrate and weight loss	(r = 0.8386)
Carbohydrate and infection	(r = 0.5986)
Fat and phenol	(r = 0.6155)
Crude fibre and phenol	(r = 0.9199)

P = 0.01 to 0.05

DISCUSSION

Infection in the white guinea yam Amula was over 2500% higher than that in the yellow guinea yam Igangan. Phenol and calcium content in the yellow yam Igangan was higher than that in the white yam Amula. Calcium fertilization ($CaCO_3$ and NPK) in two improved varieties of Dioscorea namely *D. rotundata* TDr 131 and *D. alata* TDa 92-2 reduced both infection and weight loss by *Botryodiplodia theobromae* (Otusanya *et al.,* 2016). Phenol and phenolics are also reported to increase resistance to infection in plants (Dube, 2014; Singh, 2002). But weight loss in the yellow yam Igangan was 154% higher than in the white yam Amula. Carbohydrate correlated positively with weight loss and infection in this study, but carbohydrate was comparable/similar in both Amula and Igangan. However crude fibre correlated negatively with weight loss, and crude fibre was higher in variety Amula than in Igangan. This may be responsible for the higher weight loss in Igangan. There was however a significant negative correlation between phenol content and weight loss. This suggests that the effect of high fibre in reducing weight loss probably outweighs that of phenol in reducing weight loss.

The effect of Bounty fertilizer in reducing both infection and weight loss very high. Infection in farmers' plot tubers was over 700% higher than in the Bounty-fertilized tubers. Weight loss was 0% in the Bounty-fertilized tubers compared to 63.54% in tubers from farmers plots. This underscores the role of the 8-mineral component fertilizer Bounty, in prolonging shelf life of the white and yellow yam varieties. Interaction effects emphasized the above mentioned facts also.

Five minerals namely Mg, K, Zn, Mn and B correlated significantly and positively with weight loss. Three of these minerals namely Zinc, Manganese and Boron were all low in the tubers, that is 0.25 mg/100 gdm, 0.44 mg/100 gdm and 0.07 mg/100 gdm respectively. Thus it may be said that there may not be any need to increase the content of these three in balanced mineral nutrition of varieties Amula and Igangan. However Mg and K were higher with a mean of 21.59 mg/100 gdm and 806.67 mg/100 gdm respectively. Potassium and Nitrogen are reported to be essential in tuber bulking and are thus usually high in fertilizer rates, for optimum yield in *Dioscorea* (Diby *et al.,* 2011). On the other hand, low uptake of Magnesium by *Dioscorea* species has been reported both in field and pot experiments (Obigbesan and Agboola, 1978; Diby, 2005). Therefore potassium may be prominent in mineral nutrition of Amula and Igangan as low magnesium is at the same time maintained. In summary a systematic mineral nutrition research is necessary to fine-tune which minerals are to be in high and low proportions (balanced mineral nutrition) in order to favour reduction in infection or weight loss in storage (prolonged shelf life) and optimum yield, in white and yellow guinea yams and the Dioscorea food cultivars in general.

References

Diby, L.N., Hgaza, V.K., Tie, T.B., Carsky, R., Girardin, O. and Assa, A. 2011. Mineral nutrients uptake and partitioning in *Dioscorea alata* and *Dioscorea rotundata. Journal of Applied Biosciences,* 38: 2531-2539.

Diby, N.L. 2005. Etude de l'eboration du rendement chez deux especes d'igname (*Dioscorea* species). These unique de Doctorat. Universite de Cocody, Abdijan.

Obigbesan, G.O. and Agboola, A.A. 1978. Uptake and distribution of nutrients by yams (*Dioscorea spp.)* in Western Nigeria. Experimental Agriculture, 14(4): 349-355.

FAO. 2006. FAOSTAT Agricultural database: agricultural production, crops primary, yams. Food and Agriculture Organization, Rome, Italy.

Hahn, S.K., Osiru, D.S.O., Akoroda, M.O. and Otoo, J.A. (1987). Yam production and its future prospects. *Outlook Agric* 16:105-110.

Nweke, F.I., Okorji, E.C. Njoku, J.E. and King, D.J. 1992. Elasticities of demand for major food items in a root and tuber-based food system: emphasis on yam and cassava in South-Eastern Nigeria. RCMP Research Monograph No 11, International Institute of Tropical Agriculture, Ibadan. Pp 11-19.

FAO, 2014. FAOSTAT Crop production Data. http://faostat.fao.org.

Singh, R. S. 2002. Introduction to Principle of Plant Pathology 4th ed. Oxford & IBH Publishing Company Pvt. Ltd. India 402pp.

Onwueme, I. C. and Sinha, T. D. 1991. Field Crop Production in Tropical Africa. CTA Ede. Netherlands.

Association of Official Analytical Chemists (A.O.A.C.) 1990. Official Methods of Analysis ed. Washington DC.

Otusanya, M. O. and Jeger, M. J. 1994. Infection of Yam Tubers by *Aspergillus niger* in relation to Isolate, Yam Species and Temperatures. *International Biodeterioration and Biodegradation* 319-331.

Otusanya, M. O. 1994. Studies on Yam (*Dioscorea* spp.) Tuber Rot caused by *Aspergillus niger* van Tiegh. M. Phil. Thesis University of Reading, U.K. pp119.

Dube, H. C. 2014. Modern Plant Pathology Second Edition. Published by Saraswati Purohit for Student Edition. Jodhpur pp 576.

Singh, R. S. 2002. Introduction to Principles of Plant Pathology. Fourth ed. Oxford & IBH Publishing Company. India pp 402.

FAO, 2014. FAOSTAT Crop production Data. http://faostat.fao.org.

Degras, L. 1993. The Yam. A Tropical Root Crop. Edited by Rene Coste. Macmillan Press Ltd. London and Basingstoke. 408pp.

Onwueme, I. C. 1978. The tropical tuber crops: Yams, Cassava, Sweet Potato and cocoyams. John Wiley and Sons Ltd. Chichester, U. K. pp 3-101.

Table 1: Infection and weight loss in tubers of *D. rotundata* var. Amula and *D. cayenensis* var. Igangan, Bounty-fertilized and from farmers' plot (not Bounty-fertilized) and inoculated with *Botryodiplodia theobromae* (BT) for 3 weeks.

VARIETY	% INFECTION	% WEIGHT LOSS
Amula	29.77 a	25.00 b
Igangan	1.17 b	38.54 a
BOUNTY FERTILIZER (ml l^{-1})		
0.60 ml l^{-1}	3.72 b	0.00 b
FPT: (From farmers' plot = No bounty fertilizer)	27.22 a	63.54 a
INTERACTION		
Amula 0.60 ml l^{-1} bounty + BT	5.88 b	0.00 c
Amula FPT (from farmers' plot) + BT	53.65 a	50.00 b
Igangan 0.60 ml l^{-1} bounty + BT	1.56 c	0.00 c
Igangan FPT (from farmers' plot) + BT	0.78 c	77.08 a

Means in a column followed by the same letter are not significantly different at P ≤ 0.05 (Tukeys HSD test).

Table 2: Proximate composition % dm, phenol mg/ 100 g dm and minerals mg /100 g dm in *Dioscorea rotundata* var. Amula and *D. cayenensis* var. Igangan/Alo from farmers' plots.

	DRY MATTER	FAT	ASH	CRUDE FIBRE	CRUDE PROTEIN	CHO	PHENOL	CALCIUM
AMULA FPT	85.667a	0.55a	2.86a	4.49a	4.49a	87.41a	89.04b	16.70b
IGANGAN FPT	81.637b	0.49b	2.62a	4.02b	4.27a	88.96a	107.89a	16.85a

	Calcium	Magnesium	Potassium	Nitrogen	Phosphorus	Zinc	Manganese	Boron	Iron	Sulphur
AMULA FPT	16.70b	21.31b	803.93b	719.33a	55.72a	0.23b	0.39b	0.05b	0.55a	811.33b
IGANGAN FPT	16.85a	21.87a	809.40a	683.00b	55.75a	0.26a	0.48a	0.08a	0.56a	827.67a

Means in any column followed by a common letter are not significantly different at P ≤ 0.05 (Tukey's Studentized HSD Test).

A Pearson's correlation test was carried out on minerals, phenol, proximate content, weight loss and infection. Only the significant correlations are presented below.

Table 3: Significant correlations in proximate content, phenol content and weight loss

Crude fibre and weight loss	r = -0.9285
Carbohydrate and Phenol	r = -0.8631
Weight loss and Phenol	r = -0.9586
Weight loss and CHO	r = 0.8386
Infection and Carbohydrate	r = 0.5986
Crude fibre and phenol	r = 0.9199
Fat and phenol	r = 0.6155
Weight loss and Mg	r = 0.9461
Weight loss and K	r = 0.9802
Weight loss and Zn	r = 0.9214
Weight loss and Mn	r = 0.9898
Weight loss and B	r = 0.9122

P = 0.01 to 0.05