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Research Article
Evaluation of Three Ware-yam Cultivars under Rain-fed Conditions in Hot Humid Tropics, Umudike, Nigeria

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Abstract

Background and Objective: A 2 year pot-field experiment was carried out to evaluate the yield performance of three ware-yam cultivars (Alumaco, Nwopoko, Hebamkwase) at National Root Crops Research Institute, Umudike, Abia State, Nigeria (05°29' N, 07°32' E,122 m a.s.l.) in 2014 and 2015 cropping seasons. **Materials and Methods:** The pot experiment was laid out in a completely randomized design with three replications. **Results:** The results indicated that all the tested variables were significant in both years except number of seed-yam tubers/plot in 2014 cropping season. Alumaco ware-yam cultivar gave the highest fresh tuber yield compared with the other cultivars studied and exhibited the least percentage of nematode incidence in both years. The combined analysis indicated that the mean sequence of tuber yield of the ware-yam cultivars is in the order: Alumaco>Hebamkwase>Nwopoko. Fresh tuber yield (t ha^{-1}) indicated highly significant ($p \leq 0.01$) and positive correlation with all the yield attributes, especially weight of tubers/plot and bulking rate in both Pearson's and Spearman's ranked correlation analysis. Also, the regression analysis showed a poly-linear and positive relationship between fresh tuber yield and number of ware-yam tubers/plot as well as fresh tuber yield of ware-yam and nematode incidence. **Conclusion:** Alumaco ware-yam cultivar was the highest yielder, hence adjudged to be better endowed genetically to be recommended to farmers within the agro-ecological zone of the study area.

Key words: *Dioscorea rotundata*, humid zone, nematode, tuber yield. ware-yam

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Yam (*Dioscorea* spp.), which produces an edible sub-terranean or aerial tubers that are greatly of food, economic and security values is an annual or perennial crop widely grown in the savannah and tropics of sub-sahara Africa according to Ikeorgu[1] and Behera *et al*.[2]. Furthermore, Shanthankumari *et al*.[3] and IITA[4] Annual Report submitted that yam is a veritable source of carbohydrate with about 50-80% starch or dry matter yield and about 1-2% dietary protein, which is high compared with other tropical root crops as reported by Udensi *et al*.[5] and Arinathan *et al*.[6] in previous studies on nutritional and anti-nutritional attributes of yam. Ikeorgu[1], IITA[4] Annual Report and Ugwu[7] submitted that yam is a veritable source of good dietary energy for human consumption in the humid tropics.

One of the most cultivated and accepted species of yam in Nigeria is *Discorea rotundata* (white yam) and its production is constrained by many challenges such as high cost of production and poor yield. According to Orkwor and Asadu[8], edible tubers of yam are normally used in propagation hence the production cost is usually high, which therefore constitutes a strong discouraging factor in production. More so, the crop is plagued by nematode among other pests' attack singly or in combination. Though studies by Marfo *et al*.[9] and Behera *et al*.[10] have shown that yam tubers naturally have a periderm, such that micro-organisms cannot penetrate, it is easily scared by nematodes, rodents and man during weeding and harvesting leading to microbial attack on the tuber crop. These constrains, lead to recorded poor tuber yields from cultivated yams across the agro-ecosystem. More so, there is little information on the yield performance of some improved yam cultivars in the low land tropics of Umudike, southeast Nigeria.

The aim of the study therefore was to evaluate the yield performance of three improved ware-yam cultivars under rain-fed Umudike agro-ecological conditions.

MATERIALS AND METHODS

Experimental site: A rain-fed pot experiment was conducted at the yam programme, National Root Crops Research Institute, Umudike, Nigeria (latitude 05°28' N, longitude 07°29' E and altitude 122 m above sea level) in the humid tropics of south eastern Nigeria. The location is characterized by a mean annual rainfall of 1,800-2,200 mm, which begins in April, peaks in July with a brief dry period in August and ends towards October and early November.

The total rainfall amount and rain-days during the period of investigation was 1107.4 mm and 67 days, respectively (2014) and 928.1 mm and 68 days, respectively (2015) (Table 1). The soil used for the experiment was sandy loam belonging to the order ultisol and classified as Typic (Paleulstult). It had low humus content with top sandy texture. It was acidic.

Yam cultivars, planting and experimental design: The treatments comprised three cultivars ware-yam (Nwopoko, Hembamkwase and Alumaco). The experimental treatments were laid out in a completely randomized design and there were three replications. Clean seed yam tubers of the cultivars were planted in perforated baggco pots filled with 15 kg sieved top soil and kept in the field under rain-fed conditions (4th and 7th March, 2014 and 2015 cropping seasons, respectively). The sprouted setts were checked early mornings three times weekly until the vines were properly established. Staking of the vines was done using the trellis method to ensure even distribution of the leaves for better interception of sun light and aeration.

Cultural practices: The experimental plots were kept clean by hand picking of the weeds as they appear in the pots while a compound fertilizer (NPK 15:15:15) was applied at the rate of 400 kg ha^{-1} at 8 weeks after planting. The growing main and lateral vines were periodically and systematically trained on the stakes during the vegetative period.

Data collection: At harvest, data such as number of seed yams/plot, number of ware yam tubers/plot, fresh tuber weight/plot and fresh tuber yield (t ha^{-1}) were collected. Bulking rate was calculated as the ratio of tuber yield to the duration of tuberization of the ware-yam while nematode incidence recorded was calculated thus:

$$\text{Incidence (\%)} = \frac{\text{Number of tubers infected}}{\text{Total number of plants on the plot}}$$

Statistical analysis: The data collected were subjected to analysis of variance procedures using the statistical software Genstat Discovery Edition[11] 4 while treatment mean comparisons were achieved by following the procedure outlined by Obi[12] using Fisher's method where a probability level ≤ 0.05 was considered significant. Correlation was performed using SPSS 17 for windows soft ware. Combined Pearson and Spearman's ranked correlation coefficients of

Table 1: Meteorological data of the experimental site (Umudike, latitude 05°29' longitude 07°33'E, altitude 122 m above sea level) in 2014 and 2015 cropping seasons

	2014					2015				
	Rainfall (mm)		Mean max air temperature	Relative humidity (%)		Rainfall (mm)		Mean max air temperature	Relative humidity (%)	
Months	Total amount	Days	(°C)	0900 h	1500 h	Total amount	Days	(°C)	0900 h	1500 h
April-May	327.9	22	32.1	80	67.5	154.3	9	33.1	79.5	60.5
June-July	198.4	13	30.0	83.5	76.5	237.7	20	28.6	87.5	78.5
Aug.-Sept.	424.8	21	29.8	85	79	321.1	21	29.0	87	78
Oct.-Nov.	156.3	11	31.6	81	66	215	18	32.0	82	67
December	0.0	0	32.7	65	47	0.0	0	29.5	35	34
Total	1107.4	67	-	-	-	928.1	68	-	-	-

Meteorological station, National Root Crops Research Institute, Umudike, Nigeria

ware-yam fresh tuber yield to other plant parameters were performed to assess the correlation amongst them and the significance tested by referring to the standard table following the procedure of Snedecor and Cochran[13] with n-2 degrees of freedom, where n is the total number of observations.

RESULTS AND DISCUSSION

Fresh tuber yield of yam cultivars: Combined analysis of variance across the two cropping seasons (Table 2) for the variants evaluated were all significant. Alumaco yam cultivar exhibited the highest number of seed-yam tubers/plot, number of ware-yam tubers/plot, weight of fresh tubers/plot, bulking rate and fresh tuber yield compared to the other yam cultivars. Fresh tuber yield of Alumaco (12.67 Mt ha^{-1}) yam cultivar was higher by 29.8 and 56.1% relative to Hebamkwase (8.89 Mt ha^{-1}) and Nwopoko (5.56 Mt ha^{-1}) yam cultivars, respectively. Similar studies by Ikeorgu[1], Udensi[5], Balogun *et al.*[14] and Nwosu and Okoli[15] have indicated cultivar variations in yam production in the humid tropics. However, the highest nematode incidence was recorded under Hebamkwase closely followed by Nwopoko yam cultivars while Alumaco had the least incidence. The mean sequence of tuber yield of the ware-yam cultivars was in the order: Alumaco>Hebamkwase>Nwopoko in both years and in the combined analysis. The findings from the study corroborate similar works reported by Ugwu[7], Law-Ogbomo[16], Nwosu and Okoli[15], as well as NRCRI[17] Annual Report on white ware-yam in different agro-ecological zones across Nigeria. Nematode incidence on the ware yam cultivars was significant ($p<0.05$) in 2014 cropping season (Table 2). Nwopoko ware yam cultivar had the highest incidence of nematode infestation within the cropping season compared to the other cultivars.

Inter-relationships between fresh tuber yield and other variables: Combined Pearson's correlation analysis across the two cropping seasons (Table 3) indicated that fresh tuber yield showed positive and highly significant ($p\leq0.01$) correlation with number of ware-yam tubers/plot, weight of yam tubers/plot and bulking rate but exhibited negative and non-significant correlation with nematode incidence. All the other variables exhibited mainly non-significant correlation amongst themselves. Across 2014 and 2015 cropping seasons, combined Spearman's ranked correlation analysis, indicated that except number of seed-yam tubers/plot and nematode incidence, positive and highly significant ($p\leq0.01$) correlation was recorded between fresh tuber yield and the other plant attributes (number of ware-yams tubers/plot, weight of yam tubers/plot and bulking rate). The results of the correlation evaluation of the yam cultivars corroborate previous reports by Quin[18], Balogun *et al.*[19] and Kabeya *et al.*[20] in studies on mini-tuberization of white-yam as well as Kabeya *et al.*[20] on the use of vine cuttings in the production of yam tubers.

The relationship between number of ware-yam tubers/plot and fresh tuber yield was poly-linear, positive with coefficient of determination $R^2 = 0.7306$ and showed a significant increase in tuber yield as number of ware-yam tubers increased (Fig. 1a). Also, the relationship between nematode incidence and fresh tuber yield was poly-linear and positive with $R^2 = 0.5644$ (Fig. 1b) but indicated a decline in fresh tuber yield ha^{-1} as incidence of nematode infestation increased before a slight plateau and then a slight upward increment in yield with increased incidence of nematode indicating minor degree of resistance by the yam cultivars to the pest. Furthermore, this indicated that increase in nematode incidence does not automatically relate to linear decline in tuber yield amongst the ware yam cultivars.

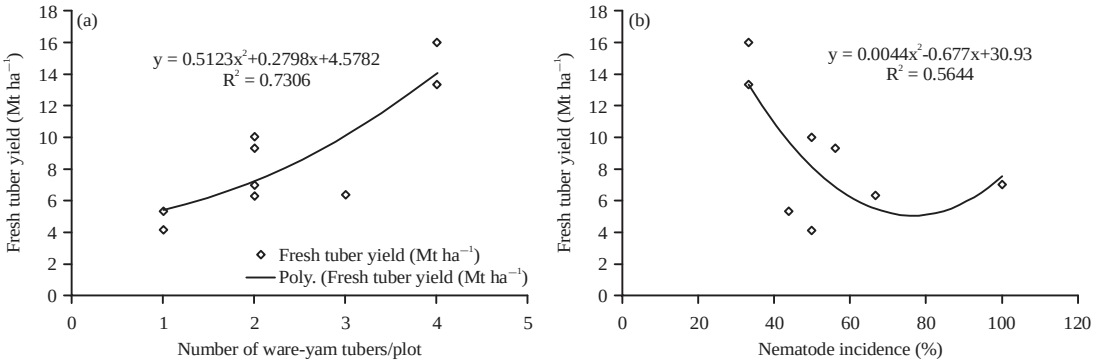

Fig. 1(a-b): Relationship between nematode incidence and fresh tuber yield (Mt ha^{-1}) in 2014 and 2015 cropping seasons with quadratic regression lines

Table 2: Yield and yield components of three ware-yam cultivars in 2014 and 2015 cropping seasons

Treatments	No. of seed-yams/plot	No. ware-yams/plot	Fresh tuber weight/plot (kg)	Bulking rate (kg month^{-1} ha^{-1})	Nematode incidence/plot (%)	Nematode yield (Mt ha^{-1})
Combined						
Nwopoko	5.00	1.33	3.33	15.2	51.8	5.56
Hebamkwase	6.50	2.33	5.33	24.4	69.8	8.89
Alumaco	8.33	3.33	7.60	34.7	42.7	12.67
$LSD_{(0.05)}$	2.826	0.823	1.689	7.71	25.64	2.815
S.E.D	1.308	0.381	0.782	3.57	11.87	1.303
Mean square	16.722	6.000	27.342	570.05	1138.0	75.939
F Pr.	0.071	<0.001	<0.001	<0.001	0.105	<0.001
2014						
Nwopoko	6.67	1.33	3.23	14.8	66.7	5.39
Hebamkwase	8.33	2.33	4.60	21.0	68.9	7.67
Alumaco	9.33	3.00	7.33	33.5	50.0	12.22
$LSD_{(0.05)}$	ns	1.49	2.694	12.30	35.10	4.491
S.E.D	1.70	0.609	1.101	5.03	14.34	1.835
Mean square	5.444	2.1111	13.074	272.61	1142.0	36.318
F Pr.	0.350^{ns}	0.086*	0.026*	0.026*	0.090*	0.026*
2015						
Nwopoko	3.33	1.33	3.43	15.7	22.2	3.43
Hebamkwase	4.67	2.33	6.07	27.7	0.00	6.07
Alumaco	7.33	3.67	7.87	35.9	16.7	7.87
$LSD_{(0.05)}$	1.153	1.153	2.535	11.57	ns	2.535
S.E.D	0.471	0.471	1.036	4.73	12.00	1.036
Mean square	12.4444	4.1111	14.914	310.92	401.20	14.914
F Pr.	<0.001***	0.007**	0.015*	0.015**	0.236^{ns}	0.015**

S.E.D: Standard error of difference between two means

Table 3: Combined Pearson's linear correlation matrix (above diagonal) and Spearman's ranked correlation matrix (below diagonal) across two cropping seasons (2014 and 2015) between different agronomic attributes and fresh tuber yield of yam cultivars

Plant characters	Fresh tuber yield (Mt ha^{-1})	No. seed-yams plot^{-1}	No. ware-yams plot^{-1}	Fresh tuber weight plot^{-1} (kg)	Bulking rate (kg month^{-1} ha^{-1})	Nematode incidence plot^{-1} (%)
Fresh tuber yield (Mt ha^{-1})	1.00	0.41^{ns}	0.70**	1.00**	1.00**	-0.36^{ns}
No. of seed yam tubers/plot	0.41^{ns}	1.00	0.33^{ns}	0.41	0.41^{ns}	0.26^{ns}
No. of ware-yam tubers/plot	0.70**	0.34^{ns}	1.00	0.70**	0.70**	-0.24^{ns}
Fresh tuber weight/plot (kg)	1.00**	0.41^{ns}	0.70**	1.00	1.00**	-0.36^{ns}
Bulking rate (kg month^{-1} ha^{-1})	1.00**	0.41^{ns}	0.70**	1.00**	1.00	-0.36^{ns}
Nematode incidence (%)	-0.40^{ns}	0.21^{ns}	-0.20^{ns}	-0.40^{ns}	-0.40^{ns}	1.00

**Correlation is significant at the 0.01 level (2-tailed), ns: Correlation is non-significant

CONCLUSION

In both years, tuber yields of the tested cultivars were significant. Alumaco had the highest tuber yield relative to Nwopoko and Hebamkwase cultivars and exhibited the least percentage of nematode incidence in the two cropping seasons. The mean sequence of tuber yield was in the order: Alumaco>Nwopoko>Hebamkwase in 2014 and 2015 as well

as in the combined analysis. Fresh tuber yield (t ha^{-1}) indicated highly significant ($p \leq 0.01$) and positive correlation with all the yield attributes while the relationships between fresh tuber yield and number of tubers/plot as well as nematode incidence were poly-linear and positive. Alumaco cultivar was the highest yielder, hence can be recommended to farmers within the agro-ecological zone of the study area.

SIGNIFICANCE STATEMENT

The three ware-yam cultivars exhibited genotypic variations across both cropping seasons. Alumaco ware-yam cultivar proved superior in fresh tuber yield compared with the other cultivars, hence adjudged to have better adaptation to the local environment. Therefore, the cultivar (Alumaco) can be recommended to farmers interested in the production of white ware-yam within the agro-ecological zone of the study area (Umudike, south-east, Nigeria).

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