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Cassava Yield, Garrification Traits and Economic Returns as Influenced by Different Genotypes in an Ultisol

Nyaudoh Ndaeyo[1*], Justina U. Okon[1], Chiedozie N. Egesi[2], Okechukwu N. Eke-Okoro[2], Francis O. Ogbe[2]

[1]Department of Crop Science, University of Uyo, Uyo, Nigeria
[2]National Root Crops Research Institute, Umudike, Nigeria
Email: *nyaudoh.ndaeyo@gmail.com, nyaudohndaeyo@uniuyo.edu.ng

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Abstract

Field trials were conducted at the University of Uyo Teaching and Research Farm in 2009/2010 and 2010/2011 to evaluate cassava yield, garrification traits, and economic returns as influenced by genotypes grown in an ultisol. Uyo is located between latitudes 4˚30' and 5˚27'N and longitudes 7˚50'E and 80˚20'E. The area, which lies within the humid tropical rainforest zone of southeastern Nigeria, has an annual mean rainfall of 2500 mm with a bimodal rainfall pattern, monthly sunshine of 3.14 hours, and a mean annual temperature of 28˚C. The experimental site was previously put into cultivation of some arable crops such as fluted pumpkin, okra, and waterleaf before it was fallowed for two years. A randomized complete block design, replicated three times was used. Treatments were 16 cassava genotypes (AR1-82, NR02/0028, NR03/0174, CR12-45, NR03/0211, TMS98/2132, TMS01/1206, TMS01/1368, TMS01/1371, CR36-5, NR02/0007, NR03/0155, AR37-108, TMS01/1412, TMS30572 and local best variety "*Obubit okpo*"). Results obtained via combined (pooled) analysis of the two seasons indicated that cassava yield differed significantly among the genotypes. NR02/0018 (42.50 t/ha) out-yielded others by 17% - 52% followed by NR 02/0007 (35.42 t/ha), and NR 03/0155 (32.08 t/ha). TMS 98/2132 had the most preferred garrification attributes followed by NR 02/0018, NR 02/0007, and NR03/01155. NR 02/0018 genotype gave the highest economic returns followed by NR 02/0007 and NR03/0155. NR02/0018 superseded others in yield, garrification traits, and economic returns, which is therefore recommended.

Keywords

Cassava, Genotypes, Yield, Garrification Traits, Economic Returns

1. Introduction

Cassava (*Manihot esculenta* Crantz), a member of the *Euphorbiaceae* family, is one of the most important food crops in the tropics. It is a staple food for over 50 million Nigerians, and is cultivated on small and large scales, especially in the southern parts of the country. The crop is amendable to agronomic as well as genetic improvement and has a high yield potential under good conditions and performs better than other crops under sub-optimal conditions. Cassava grows over a wide range of ecological conditions and is more tolerant to low soil fertility, drought, pests, and diseases, and can be grown all year round [1] [2]. It tolerates altitudes of up to 2000 m above sea level [1], requires annual rainfall above 750 mm [3], and can survive 4 - 6 months of dry weather. Cassava appears to be generally photoperiodic neutral for commercial cultivation purposes and the suitable temperature requirement range is 24˚C - 30˚C. It derives its importance from its starchy, thickened, storage roots which are valuable sources of cheap calories, especially in developing countries where calories deficiency and malnutrition are widespread [1] [4]. Over two-thirds of the total production of cassava is consumed in various forms by humans. Cassava storage roots can be processed into garri, fufu, chips, starch, tapioca, and flour among others [5] [6].

Over the years, the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, and National Root Crop Research Institute, Umudike, Nigeria have developed improved and new high-yielding cassava varieties under the Tropical Manihot Selection (TMS) and National Root (NR) Series [7] [8]. These improved varieties are said to yield between 25 and 40 tonnes per hectare, are resistant to pests and diseases, and have acceptable sensory/ culinary and industrial qualities [9] [10] compared to local varieties with yields between 5 and 10 t/ha and even those earlier released. Efforts are still continuing in the areas of breeding for specific ecologies, low cyanide content, specific industrial requirements, and early bulking. The desired attributes of a good cassava variety are basically early bulking, high dry matter and starch contents, resistance to pests and diseases, low cyanide content, weed-suppressing ability, good in-ground storability and good processing, and cooking qualities [11].

Garri, a fermented gelatinous granular flour is a major source of dietary energy for low-income consumers in many parts of Tropical Africa, including major urban [12] [13]. It is eaten in Nigeria and other parts of West Africa. However, acceptability relies on the conformity with the major quality attributes demanded in garri as affected by the cassava cultivars or varieties [14]. Garri colour, texture, and overall garri qualities acceptability such as swelling index, suitability for Sipping and making into "eba" (a native bolus) were reported to be controlled by the duration of fermentation and methods of processing and not on cultivars [15].

Although Nigeria is currently the world-leading producer of cassava, low yields are still being recorded by cassava farmers, particularly at the peasant level. This has been attributed to several factors such as the inability of farmers to select and/or cultivate improved variety, pest and disease attacks, availability of adaptable and appropriate varieties, as well as low soil fertility status. Besides these factors, there is also the challenge of having cassava varieties that can meet the desired qualities of the various end-users. Against these backgrounds, a study was conducted to evaluate the yield and yield components, garrification attributes, cost of production, and economic returns (profit) of some newly bred cassava genotypes under ultisol in a rainforest ecology.

2. Materials and Methods

2.1. Experimental Site and Cropping History

This study was conducted at the University of Uyo Teaching and Research Farm located at Use Offot, Uyo, during the 2009/2010 and 2010/2011 planting seasons. Uyo is located between latitudes 4˚30' and 5˚27'N and longitudes 7˚50'E and 80˚20'E [16]. The area, which lies within the humid tropical rainforest zone of southeastern Nigeria, has an annual mean rainfall of 2500 mm with a bimodal rainfall pattern. The rain usually starts in March and ends in November with a short period of relative moisture stress in August, traditionally referred to as "August Break" [17]. The average monthly sunshine is 3.14 hours and annual temperature is 28˚C. The temperature is generally high in the months of February through April [18]. Uyo has an annual average relative humidity of 79% and evaporation rate of 2.6 cm^2. The soil is an ultisol which is moist, highly weathered and acidic but good enough to support cassava production. The experimental site was previously put into cultivation of some arable crops such as fluted pumpkin (*Telfairia occidentalis* Hook. F.), okra (*Abelmoschus esculentus* L. Moench), and waterleaf (*Talinum triangulare* (L.) Juss) before it was fallowed for two years.

2.2. Experimental Design, Treatment, and Cultural Details

The experiment site was laid out in a randomized complete block design with three replicates. The entire experimental size measured 45 m × 25 m. Each replicate measured 45 m × 4 m and was demarcated from each other by 1 m path. Each plot measured 4 m × 4 m and demarcated from the other by a 1 m path. The treatments were 15 cassava genotypes (AR 1-82, NR 02/0018, NR 03/0174, CR 12-45, NR 03/0211, TMS 98/2132, TMS 01/1368, TMS 01/1371, CR 36-5, NR 03/0155, NR 02/0007, AR 37-108, TMS 01/1206, TMS 01/1412, and TMS 30572) obtained from National Root Crops Research Institute, Umudike, Abia State, Nigeria and 1 local best (*Obubit okpo*) obtained from Use Offot, Uyo, Nigeria.

The experimental site was mechanically ploughed, harrowed and ridged with tractor mounted implements (plough, harrower, ridger, respectively), before it was marked out using measuring tape, rope and pegs. Planting was done on 12th June in both seasons using cassava stem cuttings measuring 25 cm and inserted on the crest of the ridge in a vertical position at a spacing of 1 m × 1 m (10,000 stands per hectare). Weeding was done three times using native weeding hoe at 3, 6 and 9 months after planting (MAP). NPK (15:15:15) fertilizer was manually applied to all plots using ring method at the rate of 400 $kg \cdot ha^{-1}$. The cassava roots were harvested manually at 12 MAP in line with local farmers' practice. Yield and yield components determined were: number of stands per hectare (counted at harvest), number of rotten tubers (counted per plot at harvest), number of fresh tubers per plant (counted at harvest), tuber length (measured in cm from proximal to distal end) and circumference (measured in cm at the middle of each tuber), tuber yield per hectare (determined using a top-load weighing balance) and dry matter accumulation in the tubers (drying with oven and weighing with a top-load weighing balance). Cassava stems were harvested at soil surface level at harvest and 50 good stems, each at least of 1 m length constituted a bundle.

2.3. Cassava Processing and Garrification

The tubers (20 kg from each genotype) were manually peeled after harvesting using kitchen knife. The peeled tubers were washed with water and grated using mechanical grater. The grated cassava mash was packed into a white porous sack bags and pressed using hydraulic press (5 hp diesel powered engine) for two days to dewater the pulp. The dewatered lump of the pulp was manually pulverized/crushed and sieved. The resulting semi-dry fine pulp was fried in a shallow iron cast fryer using farmer's method. During the frying process, a piece of calabash was used in toasting the particles within the fryer. The dried garri particles were cooled and arranged on genotype basis by spreading them on different clean polythene sheets. They were then packed into different polythene bags, weighed and labeled for easy identification [19]. Sensory evaluation of the garri from the genotypes by consumers was done in Department of Crop Science laboratory. A taste panel comprising ten persons inspected and ranked garri from the sixteen genotypes based on preference for texture, sipping, making of "eba" (a local bolus) and swelling index. Garri (1 kg) from each genotype was poured into sixteen separate plates of the same size for the taste panel members to examine by sighting of the garri followed by feeling the texture of the samples with their hands. Garri samples were ranked on a scale of 1 - 6, where 1 = very fine, 2 = fine, 3 = fairly fine, 4 = fairly rough, 5 = rough and 6 = very rough [11] for the traits. The same scale was also used in ranking preference based on texture, and sipping. Sipping of garri was done after 60 cl of cold water was added to 30 g of garri from each of the genotypes. Preference based on making 40 g of garri into"eba" from each of the genotypes was done by pouring 70 cl of hot water to it and rated using the same scale [11]. Swelling index was obtained by measuring 100 g of garri from each of the genotypes into a well calibrated glass cylinder. Cold water was poured into each cylinder to a level of 1000 ml. The swelling index was observed at 5, 10, 15, 20, 25, 30 and 60 minutes [20] which was later converted and expressed in percent.

2.4. Data Analysis

All yield data collected from the two seasons were combined (pooled) for analysis and subjected to analysis of variance procedure and treatments means that indicated significant difference were compared using Duncans Multiple Range Test (DMRT) at 5 percent level of probability [21].

2.5. Cost-Benefit Analysis

Cost-benefit of producing fresh cassava tubers, stem cuttings and garri as affected by the different genotypes were analysed using partial budgeting to determine economic returns [22].

3. Results

3.1. Yield and Yield Components of Cassava as Influenced by Different Genotypes

Table 1 shows yield and yield components of cassava as influenced by different genotypes. The number of stands per hectare at harvest as influenced by different genotypes was not significantly different among the genotypes. However, the highest number of stands per hectare on the average in both seasons was from TMS98/2132 (9792) and the CR36-5 (9792) genotypes while the least was from AR1-82 (8542). The TMS98/2132 and CR36-5 had 2% - 11% more number of stands per hectare than other genotypes. There were significant differences ($P \le 0.05$) in the number of cassava fresh tubers per plant among the genotypes in both seasons (**Table 1**). The CR36-5 and NR03/0155 had the highest number of fresh tubers per plant (7.17) whereas AR37-108 recorded the least number (4.17). The CR37-5 and NR03/0155 genotypes had 13% - 33% more fresh tubers than other genotypes in both seasons.

There was no significant difference in the length of fresh tubers (cm) as influenced by different genotypes (**Table 1**) but CR12-45 genotype had the longest fresh tubers (47.67 cm) on the average while the shortest fresh tubers were from AR1-82 (37.78 cm). There was significant difference ($P \le 0.05$) in circumference of fresh tubers as influenced by the different genotypes (**Table 1**). The TMS 01/1368 has the widest fresh tubers (18.33 cm) whereas the least fresh tubers circumference was from CR12-45 (12.22 cm). The TMS01/1368 had 2% - 32% wider fresh tuber circumference than other cassava genotypes.

Table 1 indicates that there were significant differences ($P \le 0.05$) in the number of rotten tubers per plot as influenced by different genotypes. TMS98/2132, NR02/0007 and AR37-108 genotypes had the least number of rotten tubers (0.33), whereas the highest was from TMS01/1371 (3.00). There were significant differences ($P \le 0.05$) in tuber yield as influenced by different genotypes. The NR02/0018 had the highest fresh tuber yield (42.50 t/ha) whereas the local best variety "*Obubit okpo*" had the least yield (17.00 t/ha). The NR02/0018 genotype out-yielded other cassava genotypes by 16% - 52%.

Similarly, **Table 1** shows that the NR02/0018 had the highest garri yield (15.96

t/ha) while the least garri was from the local variety "*Obubit okpo*" (3.71 t/ha). The NR02/0018 had 24% - 70% more garri yield than others. Table 1 and Table 2 also show that cassava dry matter accumulation as influenced by different genotypes was significantly different ($P \leq 0.05$). Dry matter accumulated most in the local variety "*Obubit okpo*" (350.67 g/kg) while TMS 01/1412 had the least (210.00 g/kg). The local variety, "*Obubit okpo*", had 3% - 38% higher dry matter accumulation than other cassava genotypes.

3.2. Garrification Attributes of Cassava as Influenced by Different Genotypes

Table 2 shows garri swelling characteristics of cassava as influenced by different genotypes after soaking in water for 5, 10, 15, 20, 25, 30 and 60 minutes. The NR02/0018 genotype had the highest swelling index of 190, 340, 360, 390, 400 and 410 ml at, 10, 15, 20, 25, 30 and 60 minutes, respectively (which was later converted and expressed in percent) whereas the least swelling was from TMS01/1368. The NR02/0018 and NR03/0174 genotypes had the highest swelling index (293.3%). The swelling index of NR02/0018 and NR03/0174 was 1% - 35% more than those of other cassava genotypes.

Table 1. Yield and yield components of cassava as influenced by different genotypes (means of two seasons).

Genotype	No. of Stands ha^{-1} at harvest	No. of tubers per plant	Length of fresh tubers (cm)	Circumference of fresh tubers (cm)	No. of rotten tubers per plot	Tuber yield (tha^{-1})	Garri (tha^{-1})	Dry matter accumulation (g/kg)
AR1-82	8542a	5.67b	37.78a	17.11a	1.67c	29.16b	9.33c	290.00d
NR02/0018	9375a	5.33b	47.55a	15.67b	1.67c	42.50a	15.96a	290.33d
NR03/0174	9375a	5.92b	41.55a	14.78c	1.33d	27.50c	6.97d	210.33f
CR12-45	8750a	4.50c	47.67a	12.22c	0.67e	19.58d	5.06d	320.33c
NR03/0211	9167a	6.08b	41.45a	16.00a	0.67e	31.68b	9.22c	310.00c
TMS98/2132	9792a	6.08b	43.11a	16.67a	0.33f	23.76c	8.92c	260.67e
TMS01/1368	9167a	5.17b	38.00a	18.33a	2.00b	25.22c	8.16c	290.67d
TMS01/1371	8750a	5.17b	45.00a	12.33c	3.00a	18.34d	3.76e	220.00f
CR36-5	9792a	7.17a	46.44a	13.33c	1.00d	27.50c	9.45c	340.33a
NR03/0155	9167a	7.17a	42.78a	16.56a	1.67c	32.08b	11.52b	320.33c
NR02/0007	8958a	6.00b	45.55a	15.11b	0.33f	35.42b	12.16b	280.00b
AR 37-108	8758a	4.17c	38.33a	17.89a	0.33f	23.32c	7.09d	310.00b
TMS01/1206	9375a	5.42b	45.33a	15.00b	1.00d	20.84d	5.60d	310.00b
TMS01/1412	9583a	4.50c	41.22a	1533b	1.67c	29.16b	6.81d	210.00f
TMS30572	8958a	6.25b	42.11a	14.78c	1.33d	21.86d	6.97d	310.00c
Obubit okpo	9167a	5.00c	41.89a	13.00c	0.67e	17.00e	3.71e	350.67a

a, b, c mean the same superscript in each column is not significantly different ($P < 0.05$) according to DMRT.

Table 2. Garri swelling characteristics (ml) of cassava as influenced by different genotypes (means of two seasons).

Genotype	Minutes							Swelling (%)	Overall acceptability Ranking
	5	**10**	**15**	**20**	**25**	**30**	**60**		
AR1-82	250	300	320	340	350	360	370	270.0	4th
NR02/0018	310	340	360	390	400	410	420	293.3	1st
NR03/0174	300	330	350	370	380	390	420	293.3	1st
CR12-45	280	290	300	310	320	320	330	230.0	9th
NR03/0211	210	250	270	290	300	310	320	220.0	10th
TMS98/2132	260	300	330	340	350	360	365	265.0	5th
TMS01/1368	220	250	260	270	280	280	290	190.0	11th
TMS01/1371	250	300	330	340	350	360	370	270.0	4th
CR36-5	270	310	320	340	350	360	365	265.0	5th
NR03/0155	220	290	310	330	340	350	380	280.0	3rd
NR02/0007	240	300	340	350	360	380	390	290.0	2nd
AR 37-108	250	290	300	310	310	320	330	230.0	9th
TMS01/1206	270	300	310	320	320	330	340	240.0	8th
TMS01/1412	260	300	310	320	330	340	345	245.0	7th
TMS30572	260	300	320	330	340	350	360	260.0	6th
Obubit okpo	250	300	330	340	350	360	365	265.0	5th

Table 3 shows other sensory evaluation attributes of the genotypes. The TMS98/2132 genotype was the most preferred by sight (1.4 score—very fine) and NR03/0174 was the least preferred. On preference based on texture, TMS98/2132 had the finest texture (1.4 score—very fine) while CR12-45 had the worst texture (6.0—very rough).

The TMS98/2132 genotype was the most preferred in sipping (1.6—very fine) while the local best variety "*Obubit okpo*" was the least preferred (6.0—very rough). **Table 3** further shows that TMS98/2132 was the most preferred when made into "eba" and moulded into garri balls with a score of 1.2 (very fine) while TMS01/1412 was the least preferred (6.0—very rough). On the basis of overall acceptability, TMS98/2132 had the most preferred garrification attributes followed by NR02/0018 and NR03/0155 whereas TMS01/1368 genotype had the least acceptance.

3.3. Cost of Production and Economic Return of Management (₦ /Ha) as Influenced by Different Genotypes

Table 4 indicates that the total cost of production per hectare for fresh tuber production for the cassava genotypes was ₦153,000, while for the production of garri an extra ₦31,250 was required for transportation of the fresh tubers to processing points and final processing of the fresh tubers to garri, all totaling ₦184,250. The returns to management or net profit showed that NR02/0018 genotype had the highest economic returns (₦4,977,000) while the least was from the local best variety (*Obubit okpo*) on the basis of fresh cassava tubers and stems. When the cassava genotypes are considered on the basis of fresh tuber yield alone, NR02/0018 produced the highest net profit (₦4,947,000) and the least was from the local variety (₦l,887,000).

Table 3. Some garrification attributes of cassava as influenced by different genotypes (means of two seasons).

Genotype	Sensory evaluation							
	Sight	Rank	Texture	Rank	Sipping	Rank	Making Eba	Rank
AR1-82	5.4	14th	2.6	3rd	4.6	12th	3.6	6th
NR02/0018	1.5	2nd	1.6	2nd	2.0	2nd	1.8	2nd
NR03/0174	6.0	16th	5.5	14th	3.6	8th	5.2	11th
CR12-45	4.4	9th	6.0	16th	5.0	13th	5.6	14th
NR03/0211	3.7	7th	4.4	9th	4.0	10th	4.7	9th
TMS98/2132	1.4	1st	1.4	1st	1.6	1st	1.2	1st
TMS01/1368	1.7	3rd	5.0	12th	5.2	14th	5.4	12th
TMS01/1371	4.2	8th	3.6	6th	3.4	7th	4.9	10th
CR36-5	1.9	4th	4.8	11th	4.4	11th	3.8	7th
NR03/0155	5.7	15th	2.8	4th	3.2	6th	2.8	4th
NR02/0007	4.8	11th	3.8	7th	3.8	9th	2.4	3rd
AR 37-108	2.2	5th	5.2	13th	5.4	15th	5.5	13th
TMS01/1206	5.2	13th	5.8	15th	2.5	4th	5.8	15th
TMS01/1412	5.0	12th	4.6	10th	2.3	3rd	6.0	16th
TMS30572	2.4	6th	3.4	5th	3.0	5th	4.2	8th
Obubit okpo	4.6	10th	3.9	8th	6.0	16th	3.2	5th

Scale: 1 = Very fine, 2 = Fine, 3 = Fairly fine, 4 = Fairly rough, 5 = Rough, 6 = Very rough.

Table 4. Cost of production and economic return of management (₦/ha) as influenced by different genotypes (means of two season.

Operation details	AR1-82	NR02/ 0018	NR03/ 0174	CR12-45	NR03/ 0211	TMS98/ 2132	TMS01/ 1368	TMS01/ 1371	CR36-5	NR03/ 0155	NR02/ 0007	AR 37-108	TMS01/ 1206	TMS01/ 1412	TMS30572	*Obubit okpo*
Bush clearing	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000
Tillage analysis	32,000	32000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000
Cost of planting material	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Cost of planting and supply	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200
Cost of data collection	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Cost of fertilizer & application	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800

Continued

Cost of weeding	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000
Cost of harvesting	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000
Total cost of production of fresh tubers	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000	153,000
Cost of processing fresh tubers to garri & transportation	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250	31,250
Total cost of production of garri	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250	184,250
Stem yield (bundle/ha)	216	300	204	120	216	228	112	204	216	112	240	252	228	216	264	288
Tuber yield (t/ha)	29.16	42.50	27.50	19.58	31.68	23.76	25.22	18.34	27.50	32.08	35.42	23.32	20.84	29.16	21.86	17.00
Garri (t/ha)	9.33	15.96	9.33	15.96	6.97	5.03	9.22	8.92	8.16	3.76	9.45	11.52	12.16	7.09	5.60	6.81
6.97G3.71ross revenue tubers (₦)	3,499,200	5,100,000	3,300,000	2,349,600	3.801600	2,851,200	3,026,400	2,202,000	3,300,000	3,849,600	4,250,400	2,798,400	2,500,800	3,499,200	2,623,200	2,040,000
Gross revenue stem (₦)	21,600	30,000	20,400	12,000	21,600	22,800	11,200	20,400	21,600	11,200	24,000	25,200	22,800	21,600	26,400	28,800
Gross revenue garri (₦)	3,358,800	5,745,600	2,509,200	1,821,600	3,319,200	3,211,200	2,937,600	1,353,600	3,402,000	4,147,200	4,377,600	2,552,400	2,016,000	2,451,600	2,509,200	1,335,600
Gross revenue garri and stem	3,520,800	5,130,000														
Returns tuber	3,380,400	5,775,600	2,529,600	1,833,600	3,340,800	3,234,000	2,948,800	1,374,000	3,423,600	4,158,400	4,401,600	2,577,600	2,038,800	2,473,200	2,535,600	1,364,400
Returns garri	3,346,200	494,700	3,147,000	2,196,600	3,648,600	2,698,200	2,873,400	2,049,000	3,147,000	3,696,600	4,097,400	2,645,400	2,347,800	3,346,200	2,470,200	1,887,000
Returns stem	3,174,550	5,561,350	2,324,950	1,637,350	3,134,950	3,026,950	2,753,350	1,169,350	3,217,750	3,962,950	4,193,350	2,368,150	1,831,750	2,267,350	23,244,950	1,151,350
Returns tubers and stem	−131,400	−123,000	−123,600	−141,000	−131,400	−130,200	−142,000	−132,600	−131,400	−141,800	−129,000	−127,800	−130,200	−131,400	−126,600	−124,200
Returns tubers and stem	3,367,800	4,977,000	3,167,400	2,208,600	3,670,200	2,721,000	2,884,600	2,069,400	3,168,600	3,707,800	4,121,400	2,670,600	2,370,600	3,367,800	2,496,600	1,915,800
Returns garri and stem	3,196,150	5,591,350	2,345,350	1,649,350	3,156,550	3,049,750	2,764,550	1,189,750	32,393,350	3,974,150	4,217,350	2,393,350	1,854,550	2,288,950	2,351,350	1,180,150
Benefit cost ratio tubers and stem	22.01	32.53	20.70	14.44	23.99	17.78	18.85	13.53	20.71	24.24	26.94	17.445	15.49	22.01	16.32	12.52
Benefit cost ratio garri and stem	17.35	30.35	12.73	8.95	17.13	16.55	15.00	6.46	17.58	21.54	22.89	12.99	10.07	12.42	12.76	6.41
Cost benefit ration stem	−0.86	−0.80	−0.87	−0.92	−0.86	−0.85	−0.93	−0.87	−0.86	−0.93	−0.84	−0.84	−0.85	−0.86	−0.83	−0.81
Cost benefit ratio garri	17.23	30.18	12.62	8.89	17.01	16.42	14.94	6.35	17.46	21.51	22.76	12.85	9.94	12.31	12.62	6.25
Cost benefit ratio tubers	21.87	32.33	20.57	14.36	23.85	17.64	18.78	13.39	20.57	24.16	26.78	17.29	15.35	21.87	16.15	12.33

A yield × mean unit price of ₦120000.00 per tonne of fresh cassava tuber, ₦1100.00 per bundle of cassava stem cuttings sand ₦360000.00 per tonne of garri based on the prevailing market price at the time of harvest.

On the basis of garri and stem production, NR 02/0018 had the highest returns (₦5,591,350) whereas the least was from the local variety (₦I,180,150). When the genotypes were considered on the basis of garri alone, NR02/0018 equally had the highest economic returns (₦5,561,350) whereas the local variety had the least returns (₦I,151,350). On the basis of stem yield alone, there was no profit, though NR02/0018 produced the highest stem yield (300 bundle/ha), while the least bundle per hectare was from CR12-45 (120 bundle/ha).

4. Discussion

The results of the swelling index (percentage) of the garri samples showed that swelling capacity is apparently a function of genetic makeup of the different genotypes which perhaps varied in such traits as the starch content and the degree of gelatinization. This reflected in the swelling properties of the garri and was expressed during sipping and making into eba. Sanni *et al.* (2005) [23] reported that the swelling index of granules reflect the extent of associative forces within the granules, therefore the higher the swelling index, the lower the associative forces.

It has been reported that a good quality garri should have swelling capacity value above three times its original volume [24] [25] [26]. This does not however suggest that those whose swelling index is below three times its original volume may not be cherished for other attributes.

Cost of production and economic returns to management show promising returns to investment on the basis of tuber and garri yields. This is because all the improved varieties had high tuber yielding capacity than the local variety. This is apparently because the improved cassava genotypes are bred to withstand adverse conditions and yet perform considerably well including resistance and tolerance to pests and diseases [2]. However, in terms of stem cutting yield, returns to management were poor, probably because of the prevailing market price of cassava stem cuttings at the time of harvest, which was a period of low demand. However, processing cassava into garri produced the highest returns to investment, with NR02/0018 giving the highest returns, followed by NR02/0007 and NR03/0155 while the local variety produced the least return to management. Eke-Okoro *et al.* (2005) [27] had reported a very high-profit margin from cassava production and the findings from this study are in tandem with the findings of Ikeh [28].

5. Conclusion

Based on the findings of this study, it is concluded that planting NR02/0018 genotype would produce higher total tuber yield and economic returns and thus be more beneficial to the farmers. On the hand, if the interest of the farmer is on garrification, the TMS 98/2132 ranked highest in garrification overall attributes and as such is preferred followed by NR02/0018, NR02/0007, and NR03/0155. Therefore, the two genotypes (NR02/0018 and TMS 98/2132) which showed superiority in tuber yield, garrification attributes, and economic returns are recommended to the farmers in Uyo, Southeastern Nigeria.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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