YIELD EVALUATION AND MORPHOLOGICAL VARIABILITY OF TUBERS OF INTRA-SPECIFIC HYBRIDS OF *DIOSCOREA ROTUNDATA*

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ABSTRACT

The study was conducted to evaluate fifteen hybrid yam genotypes at the last stage of Uniform Yield trial (UYT) developed through intra-specific crosses with three landraces of Dioscorea rotundata. The objectives were to determine the variability in tuber dry matter yield of the genotypes, good tuber shape, tuber surface skin texture and tuber morphological variations. The experimental design was a two factorial arrangement in a Randomized Complete Block Design. The results showed high significant ($P<0.01$) genotype variation in fresh tuber yield, Tuber dry matter yield and number of tubers indicating substantial variation among the yam genotypes except for tuber shape index and days to physiological maturity of the tubers. Insignificant ($P>0.05$) year effect was observed for number of tubers, tuber dry matter yield, fresh tuber yield and tuber shape index indicating non- differential performances of the genotypes at different years. The morphological characterization of the yam tubers using yam manual descriptor code character and mathematics of information theory which allows simultaneous analysis of both quantitative and qualitative data indicated that the yam tubers produced by the yam genotypes were distinctively differentiated from each other showing evidence of varietal variation resulting from segregation during cross pollination. Also, the result indicated strong significant ($P<0.01$) variation on the effect of year x genotype interaction. This implied differential performances of varieties at different years. Based on this study, the following yam genotypes were selected using 5% selection pressure as superior in tuber dry matter yield potential in both years: UYT/05/085, UYT/05/070, UYT/05/001, UYT/05/048, UYT/05/044 and UYT/05/052. These genotypes had good shape and three of the genotypes had tuber skin surface texture that appeals to the eye. These could be selected for commercial yam production and should be included in the germplasm for further breeding purposes.

INTRODUCTION

Genetic diversity still exists among economically important yam species. As a result, genetic erosion in yam has not until recently been acute (Ngeve, 1999). The two indigenous African yam species *Dioscorea rotundata* and *Dioscorea cayenensis* are still very diverse, as a result of local adaptation to ecological niches and, perhaps more important, because of consumer preferences for different types, and the wide spread association of yams with cultural and ritual practices (Eastwood and Steele, 1978). However, this variation and the likelihood of maintaining genetic diversity is now threatened by certain factors, such as ; the use of preferred cultivars, increased cultivation of less labour requiring crops such as cassava, maize and rice, and cultivation and adoption of other yam species like *Dioscorea alata* which are more tolerant to diseases and pests (Ngeve,1999).

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The yam plant is a monocotyledonous and annual herbaceous plant. It has long climbing stems which wind themselves around supports. A single plant produces between one and five tubers of varying shapes, each may weigh up to 5.0kg. Certain species produce dioscorine, a toxic alkaloid that is destroyed by cooking. Rich in starch and protein, yam is a very popular tropical food. It grows in light, well drained soils and often the most fertile land is set aside for yam cultivation.

Future increases in yam output will have to rely on higher yield and necessitate that constraints to production be tackled (Manyong *et al*, 2001). Since tubers could be eaten boiled, roasted, fried, mashed or pounded to provide important energy, variability in *D. rotundata* is almost the only avenue through which local farmers and consumers can obtain yams of their desired traits. With the improved knowledge of the floral biology of yam, controlled hybridization of the yam crop, either through intra-specific (crosses within a species) or inter-specific (crosses between species) pollination can be carried out. This could lead to creation of variability from which selection can be made of yam varieties for various commercial and research purposes.

Dioscorea rotundata is among the 600 species in the family *Dioscoreaceae* (Daisy, 2000). This indicates the existence of great diversity of this crop which can be utilized for needed improvement (Okoli, 1984). With the progress so far made in the understanding of the reproductive biology of *Dioscorea rotundata,* the rich varietal diversity within this species can be utilized through intra-and inter-specific hybridization for effective genetic improvement of the *Dioscorea* species for higher yields, and improved morphological characters, will contribute to high yielding genotypes of *Dioscorea rotundata* for commercial purposes. Therefore the objective of this study is to determine the variability in tuber yield and Tuber morphological variations of Intra-specific hybrids of *Dioscorea rotundata* with the following specific objectives which include; to select for high tuber dry matter yielding genotypes for local consumption and mass production for export, to select for genotypes with good tuber shape, and surface skin texture that appeals to the eye for commercial purposes and for export and to determine the implication of the tuber morphological variability of the genotypes to yam breeding objectives

MATERIALS AND METHODS

The trial was conducted at the Western experimental farm of National Root Crops Research Institute (NRCRI) Umudike from 2009 to 2010. The land used for this study had been under fallow for two years. With predominantly *Panicum maximum, Mimosa pudica* and *chromolaena odoratum* cover. Umudike is in the tropical rainforest zone of Nigeria lying between longitude 7^{o}32” E and latitude 5^{o}28”N of the equator on an elevation of 122 metres above sea level (Agrometerological station at NRCRI, Umudike 2009 to 2010).

Umudike has an annual rainfall of 1800mm to 2200mm. The rainy season which commences from March to late October is bi-modal in pattern and dry spell in August. A part of the dry season is characterized by a cool dry north eastern wind. The air temperature varies from 22 to 32^{o}C while the relative humidity varies from 51% to 57%. A sunshine hour varies from 2.69 to 7.8% per day. The dominant soil is acid sandy loam in the utisol group (FDALR, 1985).

The hybrid yam for this experiment were the best selected Intra-specific hybrid yam genotypes (*Dioscorea rotundata*) at the last stage of uniform yield trial (UYT) supplied by the yam breeding Division of National Root Crops Research Institute- Umudike, Abia State. Three landraces were included giving a total of 15 yam varieties.

The experiment was laid out in a two; factor factorial in a randomized complete Block Design (RCBD) with 6 replications. Each block contained 15 plots making a total of 90 plots. Ten yam setts from each genotype with a mean weight of 40g were planted on the 2 ridges in each plot. The plot size was 4.5m^2 Spacing on the ridges was 45cm within the row and 100cm between the ridges giving a total of 10 yam plants per plot, 150 yam plants per block and 900 yam plants for the 6 blocks.

The following data were collected at harvest:

(a) Stand count at harvest, taken during harvesting.

(b) Tuber dry matter yield: 100g of fresh tuber from each plot were dried in a ventilated oven at 80^{0}C until a constant weight was obtained to determine the dry matter yield.

(c) Tuber shape: The length and diameter of each tuber were used to calculate the shape of the tuber according to Orkwor, *et al* (2000).

(d) Tuber surface skin texture: This was used to measure the eye appeal of the tuber.

(e) Tuber morphological characteristics using Descriptor for yam (IBPGRI,1997), and analyzed based on the mathematics of information theory developed by Feinstein (1958).

Data were collected on competitive yam plants from each genotype in a plot and averaged on single plant basis for statistical analysis using Analysis of variance, and Mean separation was done using Standard Error of Difference for most of the characters. Five percent (5%) selection pressure was used to select genotypes that were superior in terms of tuber dry matter yield. Tuber shape was scored after determining the tuber shape index (Orkwor *et al* 2000). $TSI = \frac{L}{W}$

Less than 1.0 =fair shape, 1.0 = very good shape, 2.0 = good shape, 3.0 moderately good shape, 4.0 = poor shape, 5.0 = very poor shape.

Tuber surface Texture (TST). It was visually scored. 1.0= smooth surface (skin) tuber, 2.0= rough surface (skin) tube

RESULTS AND DISCUSSION

The mean squares from analysis of variance of tuber yield and tuber yield related characters obtained and combined over the seasons are presented in Tables 1.

Tuber dry matter yield per plant:

Remarkable significant differences were observed among the tuber dry matter yield of the hybrid yam genotypes indicating substantial variation among the tuber dry matter yield per plant of the hybrid yam genotypes. Mean square analysis of variance indicated strong significant ($P<0.01$) genotypic variation in tuber dry matter yield of the genotypes in each of the years 2009 and 2010. The significant genotype variance indicated substantial tuber dry matter differences among the genotypes in each year.

The mean tuber dry matter yield varied from 0.18kg (Abbi) per plant in 2009 season to 0.34kg (UYT/05/052) per plant with mean of 0.28kg per plant. In 2010 season, tuber dry matter yield variation ranged from 0.18kg (Abbi) to 0.35kg (UYT/05/052) per plant, with mean of 0.28kg per plant (Table 2).
Combined mean analysis of variance for both seasons indicated high significant ($P<0.01$) genotype variation of tuber dry matter yield among the hybrid yam plants for the two years (Table 1). The significant genotype variance suggested remarkable variability in tuber dry matter yield among the hybrid yam genotypes. The variability in tuber dry matter yield across the seasons ranged from 0.18kg (Abbi) per plant equivalent to 0.08t per plant per hectare, to 0.35kg (UYT/05/052) per plant equivalent to 0.16t per plant per hectare, with mean of 0.28kg per plant equivalent to 0.12t per plant per hectare (Table 2).

The significant ($P<0.05$) year variance indicated significant differences in the tuber dry matter yield produced by the yam genotypes in the two years. The mean tuber dry matter yield in 2009 and 2010 was 0.28kg respectively per plant. The insignificant ($P>0.05$) year by genotype interaction variance indicated that the year had no remarkable influence on the tuber dry matter yield of the hybrid yam genotypes in the two years (Table 1).

Tuber Shape Index:

Tuber shape index (TSI) is the ratio of the length to the diameter of the tuber. It measures the shape of the yam tuber. The mean square of the analysis of variance indicated that there were insignificant ($P>0.05$) variation in the tuber shape of the yam genotypes in each of the seasons 2009 and 2010. The insignificant variation implies that there were no discernible differences in the shape of the yam tubers produced among the hybrid yam genotypes in 2009 and 2010. For the yam tubers produced per plant in 2009 season, none had shape index of less than 1.0 or above 5.0 which are bad shapes. The least tuber shape index was 2.71 (UYT/05/194), while the highest tuber shape was 3.80 (UYT/05/053) with a mean of 3.08 TSI (Table 2).

Also in 2010, the least tuber shape index was 1.99 9 (UYT/05/048) while the highest tuber shape index was 3.61 (Obiaoturugo), with mean of 3.05 TSI.

The combined analysis of variance for the two years (2009 and 2010) indicated that there were significant ($P<0.05$) year variance in the shape of the tubers in 2009 and in 2010. This indicated that there were differences in the shape of the tuber of the yam plant produced with in the two years. There were insignificant ($P>0.5$) genotypic tuber shape index variance among the hybrid yam genotypes (Table 1). This implies that there was no variation in the tuber shape of the genotypes in the two years. The tuber shape index across the seasons indicated that the mean tuber shape index was 3.07 TSI. The least tuber shape index was 2.43 obtained from UYT/05/048, while the highest across season was 3.56 TSI obtained from Obiaoturugo. (Table 2). The result of the analysis of variance also indicated insignificant ($P>0.05$) year by genotype interaction variance. This insignificant variation showed that there was no remarkable year influence on the tuber shape of the hybrid yam genotypes.

Tuber surface texture

This evaluates the eye appeal of the tuber skin surface texture. There were variations in the visual score of the skin surface texture of the hybrid yam tubers. Five of the genotypes (UYT/05/001, UYT/05/006, UYT/O5/048, UYT/05/070 and UYT/05/094) scored 2 indicating that they had spiny/rough surface visual texture/feel. The rest of the yam genotypes had tubers with smooth surface skin texture (Table 3). Other remarkable genetic variability of the tubers is observed in the tuber morphology.

Morphological Characterization of the Tubers

This method simultaneously group tubers that have corresponding biological similarity together in ranks. Any character or state that is not in alliance with the column character is discriminatory. At a glance in the table duplicate genotypes can easily be detected out (Table 3). The result of the ten principal characteristics namely flesh colour, number of tubers per plant, relationship of tubers, corm size, tuber length, texture of skin, hairiness of surface tuber, tuber spines, maturity of tuber and tuber habit were analyzed using the mathematics of information theory.

The result indicated that all the yam genotypes under the relationship of tubers, had all their tubers completely separate and distant indicating that the tubers were not fused (Table 3). Under tuber length, the fifteen yam genotypes were uniform in that character. Their tuber lengths were between 6 to 20cm. As regard their tuber maturity and tuber habit, all the yam genotypes indicated that they were early maturing (7 months or less) and annual plants (that is can be harvested the same year). Other characters in the other six columns are discriminatory. Each column is a character while each row is a state (or genotype).

All the 15 yam genotypes have the same four characteristics namely relationship of tubers, tuber length, maturity of tubers and tuber habit but there were remarkable variation in flesh colour, number of tubers per stand, corm size, texture of tuber skin, hairiness of surface tuber, and spines. Each genotype differs from the other as they appear in their rows. The result indicates that none of the tubers produced by the yam genotypes were the same. This implied that segregation took place during cross pollination which resulted in variations in the tubers. The yam varieties evolved can be used for further breeding purposes since they were distinctively different from one another.

The high remarkable differences observed among the tubers developed through intra-specific hybridization and quantitative characters measured suggested that there were variability among the yam genotypes. These variability indicated sufficient evidence for effective selection. Discernible variation existed among tuber dry matter content produced per plant, and tuber surface texture. These characters indicated variations among the hybrid yam genotypes. Genetic variability is fundamental to successful breeding programme in vegetative propagated crops such as yam. This variation in plant characters occurred during pollen crosses by way of hybridization which can be intra-specific or inter-specific. According to Rangaswarmy (2010), crop yield depends on the plant character, the climatic factors, soil factors and so on. These factors also cause variation in crop yield.

The highly significant genotype by year interaction observed for most of the yam genotypes evaluated indicated that most of the different yam genotypes behaved differently under varied environmental conditions. It was observed that the three local checks competed favourably with some of the improved genotypes for tuber dry matter. This implies that the check varieties which are landraces had evolved unique characteristics in their environments over the years and may be incorporated into the yam germplasm for breeding purposes. The significant genotype by year effect for this character indicated that the environment/year/season had strong influence on the genotypes. This showed the need to screen crop genotypes for adaptation to different environment for stability of performance (Ariyo 1992). Chopra (2001) reported that it is important to combine stability in performance with specific adaptation to ensure high productivity at the farm level.

Also, the variation in tuber dry matter between the years indicated the contribution of environmental factors to tuber dry matter yield. Studies conducted by IITA (1996) indicated that genotype by environmental interaction is an important issue in crop improvement. Higher tuber dry matter is an index of high starch content in the tuber of the genotypes. Ayenor (1985) noted that starch is the chief determinant factor in determining the physio-chemical properties of the yam food products. Based on this study, the following yam genotypes produced high dry matter content more than the three check varieties and were selected based on 5% selection pressure as having superior dry matter content: UYT/05/052 (1.53t/ha), UYT/05/085 (1.50t/ha), UYT/05/001 (1.48t/ha), UYT/05/070 (1.44t/ha), UYT/05/044 (1.36t/ha) and UYT/05/048 (1.35t/ha). In this study, none of the yam genotypes including the check varieties scored less than 1.0 for tuber shape index. The highest tuber shape index of 2.80 was recorded for UYT/05/001 while the lowest value of 2.30 was recorded for UYT/05/048, UYT/05/044, UYT/05/094 and Abbi.(Table 2). Although, no significant differences were observed for tuber shape index, the mean differences could provide the guideposts for selection of the yam genotypes for the environment. Tuber shape index is an important factor in mechanical harvesting of tubers. According to Posthumus (1973), most ware yam tubers are cylindrical in shape and this adds value to the marketability of the tubers.

The tuber surface texture was 1.0 for most of the yam genotypes in 2009 and 2010 (table 2) and 2.0 for UYT/05/001, UYT/05/006, UYT/05/048 and UYT/05/094. For the tubers with smooth tuber surface texture, it could be considered as a variation that was a good characteristics that appeals to the eye. Onwueme (1978) reported that yam tubers with roughness and thorniness may affect the marketability of the products. The tuber surface texture and tuber shape index may be controlled by genetic and environmental conditions. Plant breeders must therefore direct breeding strategies to the production of yam genotypes with both desirable tuber surface texture and tuber shape index to meet local and international quality and market demand.

The result of the ten principal characteristics namely: tuber flesh colour, number of tubers per plant, relationship of tubers, corm size, tuber length, texture of tuber skin, hairiness of surface tuber, tuber spiness, maturity of tuber, and tuber habit (Table 3) showed variability in tuber characteristics and this indicated that variations exists among the tubers of the yam genotypes. Results obtained from the tuber morphological studies could be useful to plant breeders in the selection of parents to be constituted in the hybridization block which has the objective for yield improvement (Bhatt,1970). Yam plants by it's nature of being vegetatively propagated would be highly heterogeneous. As such, segregants are observed even among the F_1 plants. Making crosses between yam genotypes belonging to different and distant related groups should result in superior segregants. It was also observed that dry matter content of the tubers was fairly high, implying that they should be good source of parents when breeding for varieties with high amount of starch, the main carbohydrate in tuber of yam plant.

Yam tubers with flesh yellow colour (UYT/05/092 and Abbi) are the choice of some consumers. The development of high yielding and stable varieties should aim at incorporating this colour into yam varieties. The yellow fleshed colour should be due to the presence of some pigment (anthocyanin). This pigment is known to be a precursor for vitamin A which is desirable in the diet of humans. White fleshed tubers are preferred to by some for pounding as fufu, a prestigious carbohydrate food. Yam food prepared in this way is a delicious staple food at the yam belt area of Nigeria. It should be possible through selection to further increase the size of the tubers beyond the level attained for now.

The morphological characterization of the yam tubers and analyzes indicated that none of the yam tubers characterized were the same. This implied that variation existed in the tuber morphology of the hybrid yam genotypes. Morphological characterization of the tubers is necessary for distinctive selection of genotypes for further improvement. According to Sharma (1980), cross pollination and hybridization leads to natural variations. This enables Plant breeders to search for useful traits.

CONCLUSION

Based on the result of this work, the following yam varieties have been selected for high tuber dry matter yield using 5% selection pressure as superior genotypes. They were considered as good tuber yielders in respect of environmental conditions prevailing during the years specified and recommended to farmers engaging in commercial yam production. They were: UYT/05/001, UYT/052, UYT/05/085, UYT/05/044, UYT/05/048, and UYT/05/070. The tubers have good shape and smooth surface skin texture that appeal to the eyes except UYT/05/048 and UYT/05/070 which their spine surface skin texture could act as a protection against foraging animals. The distinctiveness of the tuber morphology indicated variability that resulted during hybridization. These variations could be utilized for further breeding objectives.

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Table 1: Mean squares from combined analysis of variances of tuber yield and related characters obtained in two years for 15 yam genotypes

Sources of variation	d.f	Establish count	Fresh tuber yield	No. of tubers	Tuber dry matter	Tuber shap index	No of days maturity
Replications	5	48.89	0.1254	0.06422	0.010708	0.8833	9.258
Year	1	108.89*	0.00601**	0.01089NS	0.005336*	1.0278*	0.417NS
Genotypes	14	98.17*	0.06605**	0.12177**	0.027660**	0.2995NS	3.060NS
Year x genotyp	14	7.98*	0.000NS	0.02315NS	0.000134NS	0.4252NS	4.035*
Pooled error	140	46.22	0.01352	0.03303	0.002074	0.7859	4.932
Total	**179**						

NS = not significant
***= significant at 5% probability level**
**** = significant at 1% probability level**

Table 2: Variability In The Mean Performance Of Tuber Yield And Tuber Yield Traits In 2009 And 2010 and Across Seasons

Genotypes	Fresh tu yield/… 2009	Fresh tuber yield 2010	Fresh yield across season plant	Fresh yield pe plant in tons/ha	Tuber matter yield 20 (kg)	Tuber dry matter/yield 2010 (kg)	Tuber Dry matter yield per pla across season	Tuber dry matter yield i tons per hectare/plant	No of tubers plant 2	No of tubers plant 20	No of Tubers Per plan across season	No of tubers pe plant/hectare (1000)
UYT/05/053	0.55	0.56	0.56	0.25	0.29	0.30	0.30	0.13	0.43	1.38	0.91	0.91
UYT/05/194	0.46	0.48	0.47	0.21	0.20	0.21	0.21	0.21	0.40	1.28	0.84	0.84
UYT/05/001	0.45	0.46	0.46	0.20	0.32	0.33	0.33	0.15	0.37	1.37	0.87	0.87
U/05/095	0.44	0.45	0.45	0.20	0.27	0.28	0.28	0.12	1.20	1.17	1.19	1.19
UYT/05/006	0.53	0.54	0.54	0.24	0.23	0.24	0.24	0.11	1.28	1.28	1.19	1.28
UYT/05/092	0.57	0.58	0.58	0.26	0.28	0.29	0.29	0.13	1.40	1.18	1.28	1.29
UYT/05/048	0.46	0.47	0.47	0.21	0.29	0.32	0.31	0.14	1.38	1.25	1.29	1.32
UYT/05/070	0.48	0.49	0.49	0.22	0.31	0.33	0.32	0.14	1.23	1.27	1.32	1.25
UYT/05/052	0.46	0.47	0.47	0.21	0.34	0.35	0.35	0.16	1.28	1.33	1.25	1.31
UYT/05/044	0.51	0.52	0.52	0.23	0.30	0.31	0.31	0.14	1.17	1.17	1.31	1.17
UYT/05/094	0.55	0.57	0.56	0.25	0.28	0.29	0.29	0.13	1.53	1.53	1.17	1.53
UYT/05/085	0.52	0.53	0.53	0.24	0.33	0.34	0.34	0.15	1.35	1.40	1.53	1.38
Obiaoturugo	0.26	0.27	0.27	0.12	0.24	0.25	0.25	0.11	1.18	1.18	1.38	1.18
Abbi	0.33	0.34	0.34	0.15	0.18	0.18	0.18	0.08	1.23	1.27	1.18	1.25
Abioppolio	0.41	0.42	0.42	0.34	0.24	0.25	0.25	0.11	1.35	1.30	1.25	1.43
Mean	0.47	0.48	0.48	0.21	0.27	0.28	0.28	0.12	1.32	1.30	1.43	1.31
SED	0.05	0.05			0.02	0.02			0.07	0.08	1.31	

P<0.01 P<0.01 P<0.01 P<0.01 P<0.01 P<0.01

Table 2 Contd: Variability In The Mean Performance Of Tuber Yield And Tuber Yield Traits In 2009 And 2010 And Across Seasons

Genotypes	Tuber sha index 200	Tuber sha index 201	Tuber shap index acros seasons	Tuber surface texture 20(	Tuber surface texture 201	Tuber surface texture acr season	No of days to physiological maturity 2009	No of days to physiology maturity 2010	No of days to physiological maturity across season
UYT/05/053	3.80	3.27	3.54	1	1	1	151.33	151.74	151.54
UYT/05/194	2.71	3.44	3.08	1	1	1	150.96	151.97	151.45
UYT/05/001	3.24	3.12	3.18	2	2	2	151.94	152.22	151.08
UYT/05/095	3.32	3.67	3.50	1	1	1	151.87	152.32	152.10
UYT/05/006	3.77	3.04	3.41	2	2	2	151.63	152.28	152.00
UYT/05/092	2.81	2.76	2.79	1	1	1	152.19	152.89	152.54
UYT/05/048	2.87	1.99	2.43	2	2	2	152.57	148.69	150.63
UYT/05/070	2.92	3.00	2.96	2	2	2	152.58	152.53	152.56
UYT/05/052	2.49	3.74	3.12	1	1	1	151.56	152.57	152.07
UYT/05/044	3.0	2.38	2.72	1	1	1	152.08	152.25	152.17
UYT/05/094	2.72	3.49	3.11	2	2	2	152.28	152.22	152.25
UYT/05/085	3.50	2.71	3.11	1	1	1	152.26	152.54	152.4
Obiaoturugo	3.51	3.61	3.56	1	1	1	151.63	152.53	152.08
Abbi	2.73	2.81	2.77	1	1	1	151.80	152.13	151.97
Nwopoko	2.81	2.79	2.80	1	1	1	151.77	152.45	151.11
Mean	3.08	3.05	3.07	1.3	1.3	1.3	152.96	148.69	150.83
SED	0.02	0.26	-	-	-	-	0.42	1.24	
P. level	0.05	0.05					0.05	NS	

Table 3: Morphological Variations In Tubers Of 15 Yam Genotypes

Genotypes	Tuber flesh colour	No. of tuber per stand	Relationshi tubers	Corm size	Tuber lengt	Texture of t skin	Hairiness surface tube	Tuber spine	Maturity of tuber	Tuber habit
UYT/05/053	1	1	1	1	2	1	2	1	1	1
UYT/05/194	1	1	1	1	2	1	2	3	1	1
UYT/05/001	1	1	1	1	2	2	2	1	1	1
UYT/05/095	1	1	1	1	2	1	1	1	1	1
UYT/05/006	1	1	1	1	2	2	1	3	1	1
UYT/05/092	3	1	1	1	2	1	1	1	1	1
UYT/05/048	1	1	1	1	2	2	2	2	1	1
UYT/05/070	1	1	1	1	2	2	2	3	1	1
UYT/05/052	2	1	1	1	2	1	2	1	1	1
UYT/05/044	1	1	1	2	2	1	2	1	1	1
UYT/05/094	1	1	1	1	2	2	1	3	1	1
UYT/05/085	2	1	1	1	2	1	1	1	1	1
Obiaoturugo	1	1	1	1	2	1	1	1	1	1
Abbi	3	1	1	1	2	1	2	1	1	1
Nwopoko	1	2	1	1	2	1	1	1	1	1

Note: Each column is a character and the rows respective state or genotype

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CODED LIST OF GENOTYPES

(A). Flesh colour
- 1 = white
- 2 = cream
- 3 = yellow

(B). Number of tubers per stand
- 1 = normal one
- 2 = few (2-5)
- 3 = several (>5)

(C). Relationship of tubers
- 1 = completely separate and Distant
- 2 = completely separate in close cluster
- 3 = fused

(D). Corm size in relation to Tuber size
- 1 = small
- 2 = medium
- 3 = large

(E) Tuber length
- 1 = 1-5cm
- 2 = 6-20cm
- 3 = 21-100cm
- 4 = >100cm

(F) Texture of tuber skin
- 1= smooth
- 2= rough

(G) Hairiness of surface
- 1 absent
- 2 few
- 3 profuse

(H) Spineness
- 1 None
- 2 some
- 3 profuse

(I) maturity of tuber
- 1 Early maturing (7 months or less)
- 2 medium maturity more than 7 les than 10m
- 3 late maturity (more than 10 months)

(J) Tuber habit
- 1 Annual
- 2 perennial