STUDIES ON THE FLOWERING ABILITY AND VARIABILITY IN TUBER YIELD CHARACTERISTICS OF TRIFOLIATE YAM (Dioscorea dumetorum)

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Abstract
Fifteen accessions of trifoliate yam were collected from farmers in Abia State, Akwa Ibom State and from the Genetic Resources Unit of the National Root Crops Research Institute (NRCRI) Umudike to study the flowering ability and variability in tuber yield characteristics of the trifoliate yam. The trial took place at the Institute's experimental field. The field was demarcated into 15 plots in a randomized complete block design replicated three times. Data collected were on above-ground breeding traits such as vigour, flower sex, time of flower initiation, flowering ability, and below-ground traits such as number of large tubers, number of small tubers, percentage of large number of tubers and fresh tuber weight. Data collected were subjected to analyses of variance. Result indicated that accessions that combine both high number of large tubers and fresh tuber yield above their grand means will be adequate as good parents for developing high yielding progenies with large tuber sizes.

Keywords: Trifoliate yam, breeding traits, progenies, flowering ability and tuber yield

Introduction

Trifoliate yam (Dioscorea dumetorum) is a crop with many names. Three leaf yam, trifoliate yam, cluster yam and bitter yam are various names given to Dioscorea dumentorum. Unlike the last name, D. dumentorum is not bitter, rather the tuber is sweet. However, most wild types are bitter. The trifoliate yam belongs to the family Dioscoreaceae (Bai and Ekanayake, 1998). According to King and Hackett (1986), it is native to West Africa. The tubers of D. dumetorum grow in clusters with its tubers fused to the head region. It grows well in most soils where it requires average of 8 to 10 months growth period for maximum maturity. Nutritionally when compared with D. rotundata, D. dumetorum has higher tuber protein content (Baquar and Oke., 1977), while the starch grains are smaller and more digestible than D. rotundata or D. cayenensis (Robin, 1976). Most varieties become hard after harvest and inedible, making the tubers good only for next season's planting. Characterization of D. dumetorum will assist to clearly distinguish the genotypes for breeding activities and to genetically improve the crop for economic utilization. Trifoliate yam is considered as one of the most important food security crops in the country especially for the people of southeastern Nigeria. This is because of the crop's high tuber yield with the tubers packed with high supply of dietary carbohydrate and higher content of beta-carotene than white yam (Dioscorea rotundata). Despite its importance, the crop has not been given adequate breeding focus as the white and water yams. Many D. dumentorium accessions exist in farmers' fields and in the wild. As genetic variability is essential for effective breeding, concerted efforts should be geared towards the collection of available accessions to enhance genetic variability for varietal development. From a germplasm collection activity carried out in 2014, some D. dumentorium accessions were collected and conserved in the NRCRI, Umudike Genetic Resources Unit. These accessions need to be characterized and evaluated to enhance their effective utilization for varietal development. Therefore the specific objectives of this study were to assess the flowering ability as well as the

variability in the tuber yield and yield components of the various accessions of the yam species so as to use them in the breeding programme.

Materials and Methods

The trial was conducted at the western farm of the National Root Crops Research Institute, Umudike (NRCRI) in 2014. Treatments comprised 15 accessions/landraces obtained from Abia State, Akwa Ibom State and NRCRI, Umudike Genetic Resources Unit. The treatments were laid out in a Randomized Complete Block Design (RCBD) with 3 replications after land preparation. The ridges were spaced 1.0m apart and the cut tuber setts were planted on the crest of the ridge. The plot size was 4 m x 5 m. Sett size of 40g was planted at a spacing of 100cm x 45cm in May 2014 and 2015 of each year. Pre-emergence herbicide (put name of herbicide here) was applied immediately after ridging, and this was complemented with manual weeding to ensure weed-free plots. Fertilizer NPK 15:15:15 was applied at the rate of 400kg per hectare using side application method.

Data collection

The following data were collected:

(1) above-ground traits - plant vigour, flower sex, time of flower initiation and flowering ability. Flower sex was scored as follow: 1 = absence of flower, 2 = presence of either male and female flower, 3 = male yam plant, 4 = female yam plant, 5 = monoecious, male flower > female flower, 6 = monoecious, female flower > male flower. Flowering ability was scored as sparse, moderate or profuse (Orkwor et al 2000). Data were also collected on the response of the accessions to foliar diseases such as yam mosaic virus, anthracnose and leaf spot. Pest damage (beetles, crickets, nematodes, mealy bugs, scale insects) and Diseases symptoms attacking the leaves were scored at 5 and 8 months after planting on a scale of 1 to 5, where 1= no symptoms, 2= mild, 3= moderate, 4= severe and 5= very severe.

(2) below-ground (harvest) traits - number of large tubers, number of small tubers, fresh tuber weight, flesh colour and tuber diseases and pests. Severity of pests infestation in the field immediately after harvest were scored as follows: Severity 1: no holes on the tubers, Severity 2: number of tubers with less than 5 holes per tuber, Severity 3: number of tubers with more than 5 holes but less than 10 holes. Severity 4: the number of tubers with more than 10 holes per tuber but less than 20 holes. Severity 5: the number of tubers with more than 20 holes per tuber and above.

Data analysis

Analysis of variance was performed on the data using (mention model used) model, while standard error (state which standard error that was used, if it was SE of mean or SE of difference) was used to separate the means of the traits measured.

Results and Discussion

Soil and climatic factors: The soil was a sandy loam, Haplic Acrisol with an isohyperthermic temperature. It is low in organic matter, and total nitrogen but high in available phosphorous with moderate to strong acidity. Total rainfall within the period of growth was 1911.4mm in 2014. Monthly average maximum air temperature and relative humidity were 31.9^0C and 77.7% respectively while the monthly average minimum air temperature and relative humidity were 22.4^0C and 63.3% respectively. In 2014 and 2015 the mean monthly average maximum air temperature and relative humidity were 32.1^0C and 80.3% respectively. The mean sunshine hours in the two years were 52.4 hours. Please also add a Table for the soil analysis.

Foliar phenotypic assessment

The foliar phenotypic assessment (such as the leaves or stem characteristics alone) of the trifoliate yam is of little taxonomic value because they are too similar to provide enough taxonomic

information to individually distinguish the trifoliate yam accessions evaluated. The only phenotypic variation is the flower sex expression and tuber morphology. The result on the phenotypic breeding trait assessment of the trifoliate yam accessions is presented in Table 1.

Plant establishment

There was high percentage plant establishment which ranged from 90.0 to 100.0% (Table 1). High percentage crop establishment was evidence of adaptability of the accessions to the environment of study. It also connotes that the field condition during the establishment period was optimum to support good sprout initiation and stand survival. High plant productivity begins with good stand establishment. The fact that the observed variability among the accessions was low signifies that there will be no need to select accessions for breeding purpose based on their ability to sprout and survive.

Plant vigour

The vigour rating for all the accessions was very high (Table 1). All the accessions exhibited good vigour during growth with the vigour rating score of 4 except Una-aro (Dd/006). Vigorous plants could lead to high tuber yield in form of number of tubers and tuber weight per plant. It is an indication of the plant's ability to effectively convert photosynthates to biomass. Highly vigorous trifoliate plants are able to subdue weeds better than less vigorous ones (Jill, 1990). According to Jill (1990), Plant vigour is related to yield as well as erosion and weed control. Clones with low vigour usually produce low yields. Clones with medium vigour usually produce medium yields. However, clones with high vigour can produce either high yields or low yields. Some clones put almost all of their energy into very vigorous leaf growth and consequently have poor corm growth. Therefore, an ideal clone must have both high vigour and high corm yield. Trifoliate yam plants with high vigour could be selected as parents for hybridization since this trait could easily be transferred to their offspring.

Days to flower initiation: The result on Table 1 indicated that the number of days taken by the trifoliate yam accessions to initiate flowering ranged from 154 – 161 with most accessions at 159 days for males, and 164 days for the only female trifoliate yam. Number of days to flower initiation enables for flower synchronization of male and female yam genotypes, and could genetically be used to distinguish the trifoliate yam plant (IBPGR 1997). Please discuss these results vis-a-vis the findings of other authors. Do this for all the traits in Table 1.

Sex: All the trifoliate yam plants evaluated were male plants except Nwonye-ukwu (Dd/005) which represented 6.67% of all the accessions evaluated, that was the only female accession among the collected germplasm (Table 1). More explorations need to be undertaken by curators for the inclusion of more female trifoliate yam genotypes for effective breeding purpose. Flower sex as a morphological descriptor could be used to separate trifoliate yam genotypes into distinct groups.

Flowering ability: The result for flowering ability of the trifoliate yam indicated that the male trifoliate accessions flowered profusely more than the only female trifoliate accession Dd/005 (Nwonye-ukwu) (Table 1). The result also showed that the accession Nwonye-ukwu (Dd/005) flowered sparsely**.** The abiliy of a yam genotype to flower profusely or intensively makes such accession suitable for hybridization. Good accessions that flower sparsely should be planted more in the hybridization block to compensate for their low flowering ability. As the male trifoliate yam accessions flowered profusely, few stands may be enough to supply all the flowers needed for crossing. Crop improvement depends on the ability of the crop to flower and produce seeds and the understanding of the flowering pattern. Few female trifoliate accessions that flowered sparsely could provide a challenge in accessing their genes through conventional breeding. Gasura et al., (2008) noted that flowering ability is an important aspect of sweetpotato breeding since it determines the potential of improving certain cultivars through breeding.

Table 1: Mean phenotypic trait assessment of trifoliate yam accessions carried out in two years

Name of accessions	Plant establishment (%)	Vigour rating	Number of days to flower initiation	Sex	Flowering habit	Capsule set	Anthracnose	Leaf spot	Virus
Dd/001 (Una Okposi)	90.0	4	158	Male	Profuse	None	1	4	3
Dd/002 (Ofu-anya)	100.0	4	158	Male	Profuse	None	1	4	3
Dd/003(Una-Nkporo)	100.0	4	158	Male	Profuse	None	1	4	3
Dd/oo4(Una-Asaga)	100.0	4	159	Male	Profuse	None	1	4	3
Dd/005(Nwonyeukwu)	100.0	4	164	Female	Sparse	Sparse	1	4	3
Dd/006 (Una-Aro)	90.0	3	158	Male	Profuse	None	1	4	3
Dd/007 (Nkporo 2)	100.0	4	156	Male	Profuse	None	1	4	3
Dd /008 (Ochulli)	90.0	4	159	Male	Profuse	None	2	4	3
Dd/009 (Eleme)	100.0	4	155	Male	Profuse	None	1	4	3
Dd/ 010 (Una-Ngwa)	100.0	4	158	Male	Profuse	None	1	4	3
Dd/011 (Ojiobi)	100.0	4	155	Male	Profuse	Nine	1	4	3
Dd/012	100.0	4	158	Male	Profuse	None	2	4	3
Dd/013 (Irok)	100.0	4	161	Male	Profuse	None	2	4	3
Dd/014 (GRU)	100.0	4	159	Male	Profuse	None	1	4	3
Dd/015 (Umudike)	100.0	4	154	Male	Profuse	None	1	4	3

Profuse flowering, 4 = (76-100%), High flowering intensity, 3 = (51-75%), Moderate flowering. 2= (26-50%)
Low/sparse flowering, 1 = (1-25%), Non-flowering yam plants (0%)

The results of fresh tuber weight (t/ha), mean total number of tubers, mean total number of small and large tubers and tuber flesh colour are presented in Table 2.

Fresh tuber weight: Wide variation existed among the trifoliate yam accessions for fresh tuber weight. This was evidenced in the fresh tuber yield variation which ranged from 3.1 t/ha for Dd/014 (GRU) to as high as 35.6 t/ha for Dd/015 (Umudike) with grand mean fresh tuber weight of 11.8t/ha. Since there was no commercial variety in existence that could be used as a control, any Trifoliate yam accession that had mean fresh tuber weight above the grand mean could be selected for breeding purposes. Such accessions will be combining such good traits as high yield potential and adaptability to the study environment, which can be used to develop new progenies with such good agronomic background.

Mean total number of tubers: Mean number of tubers significantly high ($P<0.01$) among the trifoliate yam accessions. The trait varied from 12.3 tubers per clump for Dd /008 (Ochulli) to as high as 32.7t/ha for Dd/015 (Umudike) with a general mean of 19.3 (Table 2). Number of tubers per plant is an important yield component (Nwankwo et al., 2015). The trifoliate yam accessions with high number of tubers per cluster or clump showed evidence of high yield performance and could be selected as high yielding parents for breeding purposes.

Mean total number of large tubers: Tubers of trifoliate yams grow in clumps/clusters and are usually in a mixture of large and small tubers.. From Table 2, number of large tubers ranged from 3.0 (which was 23.1% of total tubers for Dd/009 (Eleme)) to as high as 17.0 (which was 55.0% of the tubers of Dd/001 (Una Okposi)). However, accessions that combine both high number of large tubers and fresh tuber yield above their grand means will be adequate as good parents for developing high yielding progenies with large tuber sizes.

Mean total number of small tubers: The mean total number of small tubers from the clumps are significantly ($P<0.0$) high and varies from 7.0 for Dd/010 to 22.0 for Dd/004 (Una-Asaga) (Table 2). Small tubers of trifoliate yam cultivars are of no commercial value. Trifoliate yam accessions with high percentage of small tubers could be attributed to inadequate input use, low soil fertility or unadaptability to location of cultivation. The tubers of trifoliate yam are in clusters because they are fused at the head or the corm region. The implication of including accessions with small tuber size in hybridation scheme is the development of high yielding progeny population with small root size. No matter how high yielding such genotypes may be, its adoption by farmers and and household consumers will be very low.

Tuber flesh colour: The 15 trifoliate yam accessions characterized showed limited variation in the flesh colour. The flesh colour were of three classes - cream, pale yellow and yellow. The yellow flesh colour is rich in bioavailable beta-carotene which the body converts into vitamin A. Beta-carotene is useful for improved eyesight and enhanced immunity of children under five years of age (Burgos,et al., 2009). Only the accession Nwonye-ukwu (Dd/005) had yellow flesh. Four other accessions had cream flesh colour, while the rest 10 accessios had pale yellow flesh. The flesh colour of the accession Nwonye-ukwu (Dd/005) which was yellow in colour could be a good parental trait for selection for the improvement of food nutritional quality of other accessions through intra- and enter- specific hybridization (Zossimo, 1992).

Table 2: Fresh tuber weight, mean total number of tubers, mean total number of large tubers, mean total number of small tubers, percentage number of large tubers and tuber flesh colour

Name of accessions	Fresh tuber weight t/ha	Mean total number of tubers	Mean total number of large tubers from clump	Mean total number of small tubers from clump	Percent number of large tubers	Tuber flesh colour
Dd/001(Una-Okposi)	14.7	31.0	17.0	14.0	55.0	Pale yellow
Dd/002,(Ofu-anya)	14.4	16.0	6.0	10.0	38.0	Cream
Dd/003(Una-Nkporo)	11.0	16.7	5.7	11.0	34.1	Pale yellow
Dd/004(Una-Asaga)	29.1	30.0	8.0	22.0	27.0	Pale yellow
Dd/005(Nwonye-ukwu)	8.5	15.7	7.7	8.0	49.0	Yellow
Dd/006 (Una-Aro)	23.5	29.0	9.0	20.0	31.0	Pale yellow
Dd/007 (Nkporo 2)	12.6	19.7	6.7	13.0	34.0	Pale yellow
Dd /008 (Ochulli)	3.7	12.3	5.0	7.3	41.0	Pale yellow
Dd/009Eleme	4.7	13.0	3.0	10.0	23.1	Cream
Dd/ 010 (Una-Ngwa)	3.7	13.3	6.3	7.0	47.4	Pale yellow
Dd/011 (Ojiobi)	8.2	17.0	7.0	10.0	41.1	Cream
Dd/012	3.6	14.0	4.0	10.0	29.0	Pale yellow
Dd/013 (Irok)	4.0	13.7	4.4	9.3	32.1	Pale yellow
Dd/014 (GRU)	3.1	15.0	4.0	11.0	27.0	Cream
Dd/015 (Umudike)	35.6	32.7	12.0	20.7	37.0	Pale yellow
Mean	11.8	19.3	7.0	12.2	-	-
Range	3.1 - 35.6	12.3 - 32.0	3.0 - 17.0	7.0-17.0		
Standard error of mean	7.8	11.2	2.7	3.6		
Sig.level	P<0.01	P<0.01	P<0.01	P<0.01		

Pests and diseases reaction of trifoliate yam: The results of the trifoliate yams reactions to foliar diseases and tuber pests and diseases attacking trifoliate yam in the field is presented in Table 3. All the trifoliate yam accessions showed susceptibility to fungal foliar spot (severity score of 4.0) and trifoliate yam virus disease (severity score of 3.0). As such, none of them could be used as parents for developing resistant varieties to these two foliar diseases. Also, these disease reaction scores further indicate that the accessions will only be highly productive in low-disease pressure areas, and should not be cultivated in areas that are hotspot for leaf spot and virus diseases. Nwankwo (2013) had previously reported same observations.

For anthracnose disease, most of the accessions showed no symptoms at all (severity score of 1.0), while few (only three) showed very mild (severity score of 2.0) anthracnose symptoms (Table 3). The general disease reaction of the accessions showed that most of the trifoliate yam accessions were resistant to the anthracnose disease that attacked their foliage. As the screen for resistance to anthracnose was through field natural infection, it is understood that there could be false positives among the accessions. However, the presence of anthracnose symptoms on the mildly susceptible accessions showed that the pathogen was present on the field, and some that showed resistance must be truly resistant. The study has provided means for selecting anthracnose resistant parents for use in developing more productive anthracnose-resistant varieties in the future if/when the need arises.

There was no pest and disease damage on the tubers of the trifoliate yam accessions evaluated except for the mild attack of crickets. The bases for the seeming resistance of the tubers of the accessions to pests and diseases are not understood. However, trifoliate yam tubers are known to contain alkaloids which could probably be involved in the prevention of disease infections and pest damages on the tubers. Further studies need to be carried out to elucidate the mode of resistance of the roots to diseases and pests as observed in this study.

Table 3: Foliar diseases and tuber pests and diseases of Trifoliate yam

	Foliar diseases			Tuber Pests						Tuber diseases		
				Yam beetle	Crickets	Termites	Millipedes	Meal-bugs	Scale insects	Nematodes	Wet rot	Dry rot
Name of accessions	Anthracnose	Leaf spot	Virus									
Dd/001(Una-Okposi)	1	4	3	1	2	1	1	1	1	1	1	1
Dd/002,(Ofu-anya)	1	4	3	1	2	1	1	1	1	1	1	1
Dd/003(Una-Nkporo)	1	4	3	1	1	1	1	1	1	1	1	1
Dd/004(Una-Asaga)	1	4	3	1	1	1	1	1	1	1	1	1
Dd/005(Nwonye-ukwu)	1	4	3	1	2	1	1	1	1	1	1	1
Dd/006 (Una-Aro)	1	4	3	1	2	1	1	1	1	1	1	1
Dd/007 (Nkporo 2)	1	4	3	1	2	1	1	1	1	1	1	1
Dd /008 (Ochulli)	2	4	3	1	2	1	1	1	1	1	1	1
Dd/009Eleme	1	4	3	1	1	1	1	1	1	1	1	1
Dd/ 010 (Una-Ngwa)	1	4	3	1	1	1	1	1	1	1	1	1
Dd/011 (Ojiobi)	1	4	3	1	2	1	1	1	1	1	1	1
Dd/012	2	4	3	1	2	1	1	1	1	1	1	1
Dd/013 (Irok)	2	4	3	1	2	1	1	1	1	1	1	1
Dd/014 (GRU)	1	4	3	1	2	1	1	1	1	1	1	1
Dd/015 (Umudike)	1	4	3	1	1	1	1	1	1	1	1	1
Mean	1.2	4.0	3.0	1.0	1.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Note: **Disease scoring**: 1= no symptoms, 2= mild, 3= moderate, 4= severe and 5= very severe.

Pests scoring: Severity 1: no holes on the tubers, Severity 2: number of tubers with less than 5 holes per tuber, Severity 3: number of tubers with more than 5 holes but less than 10 holes. Severity 4: the number of tubers with more than 10 holes per tuber but less than 20 holes. Severity 5: the number of tubers with more than 20 holes per tuber and above

Conclusion

Trifoliate yam accessions with desirable breeding traits that could transfer their genes for high vigour, high flowering ability such as profuseness, high tuber yield and disease resistant/tolerant characteristics to their progenies have been identified for selection as parents for crop improvement purposes.

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