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Dichotomous key determining varietal groups of yam species *Dioscorea alata L.*

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ABSTRACT

Yam is an important food crop in Côte d'Ivoire. Nevertheless, its production is facing many constraints including the inability to distinguish cultivated varieties from one another. Thus, different varieties and species are designated by the same names from one region to the other and vice versa, the same varieties are called differently. The absence of major descriptors, which are easy to use is the main cause of this confusion. The objective of this study is to propose agro-morphological descriptors easy to identify, for a better determination of yam varieties of *D. alata*. A total of 91 accessions of yam of *D. alata* species were used. These accessions were observed using morphological parameter. Eight simple agro-morphological descriptors which are easy to describe were identified as major dichotomous keys for the determination of the *D. alata* species. These characters have been selected based on the discrimination they permit to operate. Using them, four varietal groups were formed: Pyramid, Douoblé, Brazo and Bêtê-Bêtê.

Keywords: Yam, *Dioscorea alata*, morphological characterization, dichotomous keys, varietal groups.

INTRODUCTION

Yams of the *Dioscorea* genus are among the most widespread tropical food crops (Coursey, 1967). The main producers of this crops are in West Africa. Nigeria is the first producer in the world with 37.11 million of tonnes of yams. It is followed in Africa by Côte d'Ivoire with a production of 5.8 million of tonnes in 2013 (FAOSTAT, 2014). There are over 600 species of yams in the world, some are wild, while others are grown. This genetic diversity is an asset for the sustainability of yam cultivation. Indeed, it offers the possibility to make selections and create new varieties responding to the ever evolving concerns of the populations. Therefore, for thousands of years, producers exploit this variability to develop their crops (Geoffrey, 2000). The desired traits of yams are: high yield, good resistance to diseases and pests and good organoleptic and nutritional qualities. However, new needs arise with the industrialization such us production of starch, flour, pharmaceutical products and admixtures.

The importance of each species depends on the country. In Ivory Coast, the species *Dioscorea alata* is the most cultivated and consumed, in contrast to other African countries where *Dioscorea rotundata* is yam species primarily found. *D. alata* represent more than 55 to 60% of the national production (Doumbia et al., 2006). However, most research on the genetics of yams in Africa and in the world have focused on the species *D. rotundata* (Hamon et al, 1986;. Zoundjihékpon 1993; Dansi et al., 1997; Mignouna, 2002). The works on the genetics of *D. alata* have essentially focused on the molecular aspects (Egesi et al., 2007, Obidiegwu et al., 2009).

Despite their socio-economic importance and the high number of yams species cultivated, several obstacles limit the integration of yam in a modern agricultural system. Among these constraints, there is the inability to distinguish cultivated varieties from one another. Thus, it is found different varieties and species designated by the same names from one region to the other and vice versa, the same varieties are called differently. The absence of major descriptors, which are easy to use by all is the main cause of this confusion.

The overall objective of this article is to propose agro-morphological descriptors easy to identify, for a better determination of yam varieties of *D. alata*. Specifically, this will involve the determination of genetic groups of *D. alata* yams, by the use of major dichotomous keys.

MATERIALS AND METHODS

Plant material

The plant material is composed of 91 accessions of yam of *D. alata* species from the CNRA yams collection in Ivory Coast.

Methods

The work was conducted at the CNRA research station of food crops located in Bouake, in the central of Côte d'Ivoire, between 7 ° 40 'N and 5 ° 2 O. The region is dominated by the Guinean savannah and a lateritic soils moderately desaturated. The average annual rainfall is between 1100 and 1200 mm.

The approach used in this study was to observe characters describing the stem and leaves for the aerial parts, roots and tubers for underground parts and reproductive organs that are bulbils and flowers. The stem, leaves and tubers were described by their shape and colour, while the absence or presence of flowers, bulbils and roots were recorded. The number and weight of products tubers were evaluated. The severity of anthracnose and viruses as well as attacks of mealybugs were recorded.

The culture was made without any fertilization. Yam plants were staked individually in order to avoid mixing between stems and leaves during observations.

Experimental design

The experimental design used is one block without repetition. The accessions were planted on mounds in strips of 10 m. Each yam accession has been represented by 10 plants spaced one meter on lines and one meter between the lines.

Observations and measurements

The observations were made on ten (10) plants per accession and averages were calculated for each character. Only accessions having a number of living plants greater than or equal to 5 were selected. Data collection focused on 27 agro-morphological characters as described in Table 1. The characters that describe the stem, leaves and leaf diseases were observed during the vegetative phase of the plant and those describing the tubers were recorded at harvest. Data were collected using the descriptors defined by IPGRI-IITA (1997).

The characters were separated according to whether they are related to:

- the stem and the leaf,
- the health status of the plant,
- reproduction (Table 2)
- Morphology of tuber and yield components (Table 3).

The description of young plants was made two months after planting, and those of the adult plants was done between five and six months after planting. The ratings of severity of anthracnose and viruses were made five months after planting by the method of Nicole *et al.*, (1990). The severity is the percentage of the leaf surface of the plant affected by the disease. The terms are:

1 = 0 to 2% of affected leaf area,
2 = 3-25% of affected leaf area,
3 = 25 to 50% of affected leaf area,
4 = more than 50% of affected leaf area,
5 = plant has died from the attack.

Regarding the attacks of mealybugs on tubers at harvest, terms are:

0: no mealybugs on the tuber,
1: presence of a small number of mealybugs on the tuber
2: presence of a large number of mealybugs on the tuber.

At harvest, tubers were weighed and separated into small and large tubers tubers. Large tubers are those whose weight is greater than or equal to 1 kg. The others are considered as small tubers. Each batch was then counted and weighed. Before frequencies calculation, the results recorded were converted into numbers of tubers classes according to the rule of Sturge (Scherrer, 1984). Similarly, the weight of tubers weights obtained after weighing, were transformed into tuber weight classes.

The class determination formula is:

Number of Classes = 1 + (3.3 log n); n being the number of samples (91 in this case).
The class intervals were obtained by applying the rule of Yule (Scherrer, 1984):
Intervals of classes = (Xmax - Xmin) / Number of classes, Xmax and Xmin respectively being the largest and the smallest value in the statistical series.

Descriptive analyses were performed with the EXCEL software to characterise the accessions at the agro-morphological level.

Table 1: agro-morphological characters observed on the collection of *D. alata*

Type of characters	described organs	characters	Code	Number of observed modalities
Characters related to the stem	Stem	Colour of the young plant at the base	CJPB	3
		Colour of the young plant at the top	CJPS	3
		Wing colour of the young plant	CAJP	4
		Presence of thorns on the stem	ET	2
		Presence or absence of on wings stem	AT	2
		Aspect of the stem section	ST	4
Characters related to the leaf	Leaf	Colour of young leaf	CJF	3
		Colour of mature leaf	CL	3
		Coloration of the petiole	CP	5
		Shape of leaves	TF	4
Characters related to the reproduction	Flower	Flowering type	FLO	4
	Bulbille	Presence or absence of bulbils	BUL	2
Characters related to disease susceptibility	Leaf	Severity of virosis	SEVIR	5
		Severity of anthracnose	SEVANTH	5
		Severity of attacks of mealybugs	COCH	3
Characters related to yield	Tuber	Number of tubers per plant	NTUB	4
		Number of large tubers per plant	GTUB	4
		Number of small tubers per plant	PTUB	4
		Weight of tubers produced per plant	PDTUB	4
Characters related to the morphology physiology of the tuber	Tuber	Presence or absence of roots on the tuber	RACTUB	2
		Oxidation of the amylaceous parenchyma of the tuber	OXY	2
		Aspect of the amylaceous Parenchyma of the tuber	ASPC	3
		Colour of the amylaceous Parenchyma of the tuber	COUCH	8
		Uniformity of the colour of the amylaceous Parenchyma of the tuber	UNCO	2
		Colour of the phelloderm	COPE	4
		Thickness of tubers phelloderm	EPE	2
		Ramification of the tuber	RAM	3
		Tuber Shape	FOTU	6

Table 2: Qualitative Characters used to describe the stem, leaf and aerial organs of reproduction of *D. alata*

Characters observed		Code	Modalities	Notation
Characters related to the stem	Colour of young plant at the base	CJPB	Green	1
			Purple	2
			Brown	3
	Colour of young plant at the top	CJPS	Green	1
			Purple	2
			Brown	3
	Colour of wings of young plant	CAJP	Absent	0
			Green	1
			Purple	2
			Brown	3
	Presence of thorns on the stem	ET	Absence	0
			Presence	1
	Presence of wings on the stem	AT	Absence	0
			Presence	1
	Aspect of the stem section	ST	Circular	1
			Square	2
			Angle in thorn	3
			Angle in wing	4
Characters related to the leaf	Colour of the young leaf	CJF	Yellowish	1
			Green	2
			Purple	3
	Colour of mature leaf	CL	Yellowish	1
			Green	2
			Purple	3
	Colour of the petiole	CP	Fully green	1
			Fully purple	2
			Fully green with purple base	3
			Fully green with purple leaf junction	5
			Fully green with the 2 ends purple	7
	Shape of adult leaves	TF	Oval	1
			Cordate	2
			Sagittate	3
			Hastate	4
Characters related to the reproduction mode	Flowering type	FLO	Absence	0
			Male	1
			Female	2
			Monoecius	3
	Presence of bulbils	BUL	Absence	0
			Presence	1

Table 3: Descriptors used for the characterization of tubers of *D. alata*

Characters observed	Modalities	Notation
Presence or absence of roots on the tuber	Absence	0
	Presence	1
Oxidation of the flesh of the tubers 5 min after cutting	No oxidation	0
	Oxidation	1
Aspect of flesh of the tubers	Smooth	1
	Grainy	2
	very grainy	3
Colour of the flesh of the tuber in transversal section	White (Florido type)	1
	Yellowish-white or off-white (Suidié type)	2
	Purple	3
	Orange (Brazo type)	4
	White with purple dots	5
	Purple with white dots	6
	Exterior Purple / Interior White	7
	Exterior white / Interior purple	8
Uniformity of the colour of the flesh of the tubers	Non uniform	0
	Uniform	1
Thickness of tubers phelloderma	<1mm	1
	>1mm	2
Colour of the phelloderma	Light brown	1
	Dark brown	2
	Greyish	3
	Yellow	4
	violet	5
	orange	6
	White	7
Tubers ramification	No branching	0
	slightly branched	1
	very branched	3
Tubers shape	Rounded	1
	Cylindrical	2
	Flattened	3
	Irregular	4
	Conical	5
	fingered	6

RESULTS

Aerial vegetative characters

Variability of characters related to the stem

The absence of thorns on the stem, the presence of wings on the stem and the quadrangular section with the angle in wings are the phenotypes mostly observed (Table 4). They are present in 98.90% of accessions representing 90 of the 91 analysed genotypes. In contrast, the presence of thorns on the stem and the absence of wings on the stem as well as the circular section of the stem are rare characters for *D. alata* and are present only on one accession in the study population; this represents 1.10%.

Regarding the colour of the young stem, green, purple and brown are the three observed characteristics. Fifty seven (57) of 91 accessions have purple colour at the base of the stem of young plants, against one brown accession and 33 accessions whose base is green. But at the top of the stem, accessions with green colour are most numerous with 78 accessions of 91, while those who had the top of the stem purple are 11. Two (2) the accessions have the top of the stem brown.

Table 4: Distribution of the accessions of the collection of *D. alata* according to aerial vegetative characters

Organs	Characters	Modalities	Population observed	Frequencies observed (%)
Stem	Thorns on stem	Absence	90	98,90
		Presence	1	1,10
	Wings on the stem	Absence	1	1,10
		Presence	90	98,90
	Section of the stem	Circular	1	1,10
		Angle in wing	90	98,90
	Colour of the young plant at the base	Green	33	32,26
		Purple	57	62,64
		Brown	1	1,10
	Colour of the young plant at the top	Green	78	85,71
		Purple	11	12,09
		Brown	2	2,20
	Wing colour of the young plant	Absent	1	1,10
		Green	66	72,52
		Purple	22	24,18
		Brown	2	2,20
Leaf	Colour of the young leaf	Green	82	90,11
		Purple	9	9,89
	Colour of mature leaf	Yellowish	19	20,88
		Green	71	78,02
		Purple	1	1,10
	Colour of the petiole of adult plant	Fully green	69	75,83
		Green with purple base	5	5,49
		Geen with the 2 ends Purple	17	18,68
	Leaf type	Cordate	52	57,14
		Sagittate	39	42,86
		Absent	1	1,10
	Colour of the wing of the petiole	Green	40	43,96
		Purple	9	9,89
		Brown	41	45,05

Variability of characters related to the leaf

The young leaves have purple or green colour. Ninety percent (90%) of young leaves are green and 10% are purple. For the adult leaves, 72 of the 91 accessions have green leaves, while leaves of the 19 another accessions are yellowish.

The adult leaves have a strung shape for 57.14% of the accessions and a sagittate shape for 42.86% of these accessions; one accession has hastate shape leaves.

Variability associated with the colour of the petiole

Three colour of petiole were observed in the population examined. They are completely green petiole or green petiole with both ends purple and green petiole with their junction on the stem purple. Accessions with entirely green petioles represented 76% of the observed accessions, against 19% of accessions which petiole were completely green with purple colour at the two ends, and 5% with green petiole having purple base.

Variability between characters related to reproduction

Only 10 of the 91 accessions observed have flourished (10.99%). Among the flowering clones, 7 male accessions were observed against 03 female accessions. Only 12% of accessions gave bulbils (Table 5).

Table 5: Distribution of accessions of *D. alata* according to the type of flowers produced and bulbil production

Characters	Phenotype observed	Populations observed	Frequencies observed (%)
flowering	Absence	81	89,01
	Male	7	7,69
	Female	3	3,30
Presence or absence of bulbils	Absence	80	87,91
	Presence	11	12,09

Table 6: Basic Statistics on yield components

Characters	Minimum	Average	Maximum
Number of small tubers per plant	0	0,95	3,4
Number of large tubers per plant	0	0,54	1,44
Total number of tubers per plant	0,55	1,5	4,2
Weight of small tubers per plant (kg)	0,16	1	4

Variability of traits related to yield components

The average number of small tubers produced per plant was 0.94 for a maximum of 3.4 small tubers per plant. Some accessions did not produce small tubers.

The average number of large tubers per plant was 0.54; the maximum for that character being 1.44. Some accessions did not produce large tubers.

As for the total number of tubers per plant, the minimum was 0.55 and the maximum 4.2; the average being 1.5 for the population studied.

The average weight of tubers per plant was 1 kg; the minimum was 0.16 kg and the maximum, 4 kg (Table 6).

For each yield components, seven classes were defined. The intervals between two classes were 0.2 for the number of large tubers per plant and 0.5 for the number of small tubers per plant, the total number of tubers per plant and the total weight of tubers per plant. For practical use of the results, these classes were grouped into large and small tubers, according to their individual weight greater than 1000 g or not.

All accessions produced at least one tuber per plant. Accessions with only produces large tubers represent 13.19%, while those who have produced only small tubers constitute 8.79% of the population (Figure 1). In the category of large caliber tubers, the following proportions were obtained (Figure 2):

- 8.79% no big tuber
- 86.81% one large tuber per plant;
- 4.40% two large tubers per plant.

Among the accessions that produces small tubers, the breakdown is as follows (Figure 3):
- 13.19% no small tuber
- 60.44% one tuber
- 20.88% two tubers
- 3.3% 3 tubers.
- 2.2% over than 3 tubers.

As for the total number of tubers produced per plant, there was 14.29% of accessions with a single tuber ; 62.64% with two (2) tubers ; 18.68 with three (3) tubers and 3 4.4% with more than 3 tubers (Figure 4).

The proportions for the weight of production is 74.73% for accessions whose tuber weight is less than one kilogram per plant ; 24.18% for those with tuber weight per plant between 1 and 2 kg, and 1.1% for accessions with a weight of tuber per plant between 2 and 3 kg (Figure 5).

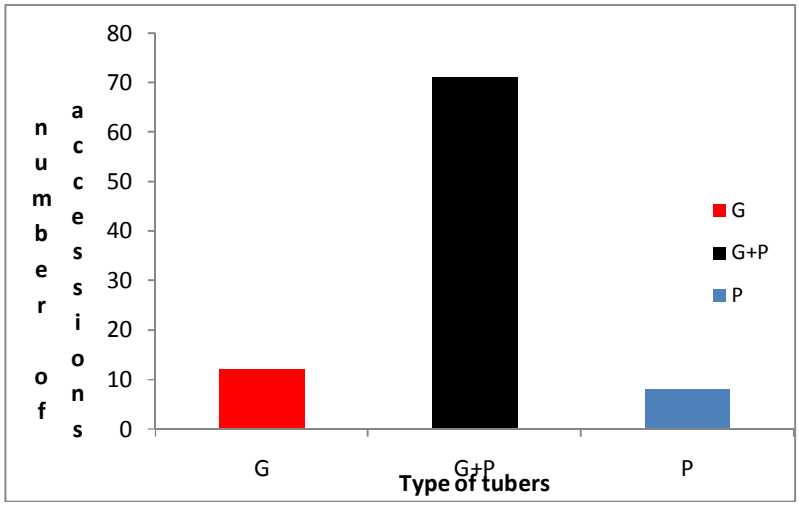

Figure 1: Distribution of accessions of *D. alata* according to the weight of tubers produced
Legend: G : Large tubers ; G + P : Large and small tubers ; P : Small tubers

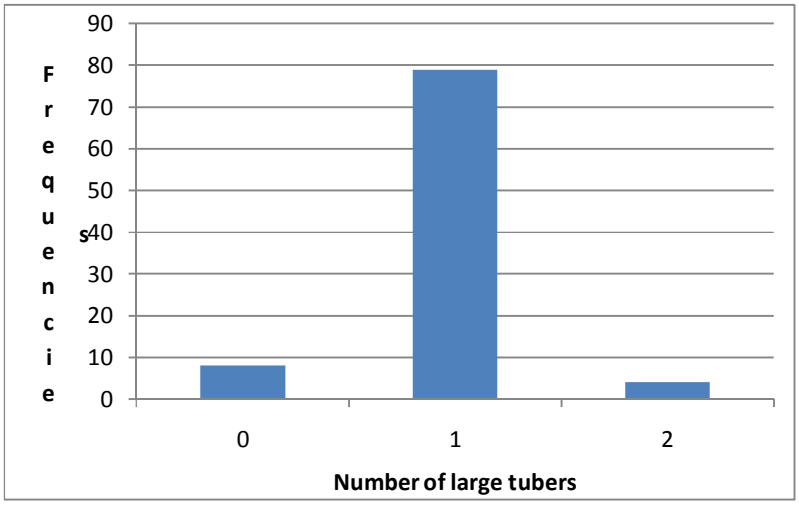

Figure 2 : Frequencies of accessions according to large tubers produced

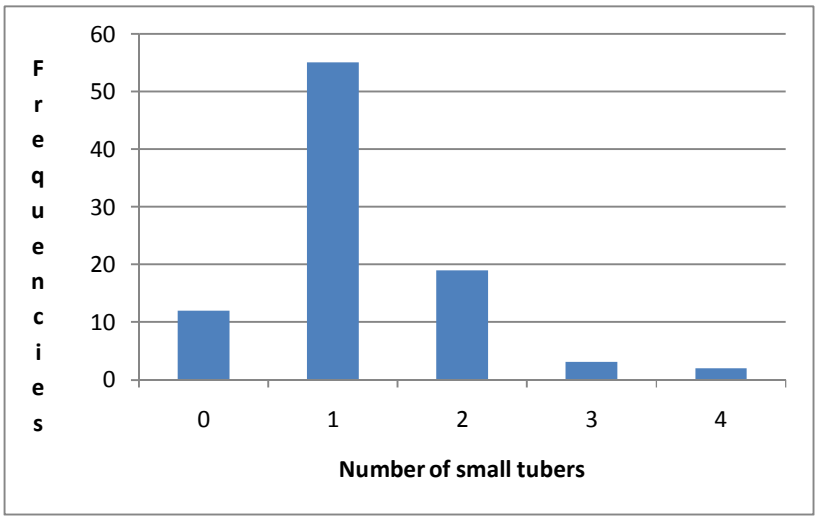

Figure 3 : Frequencies of accessions according to small tubers produced

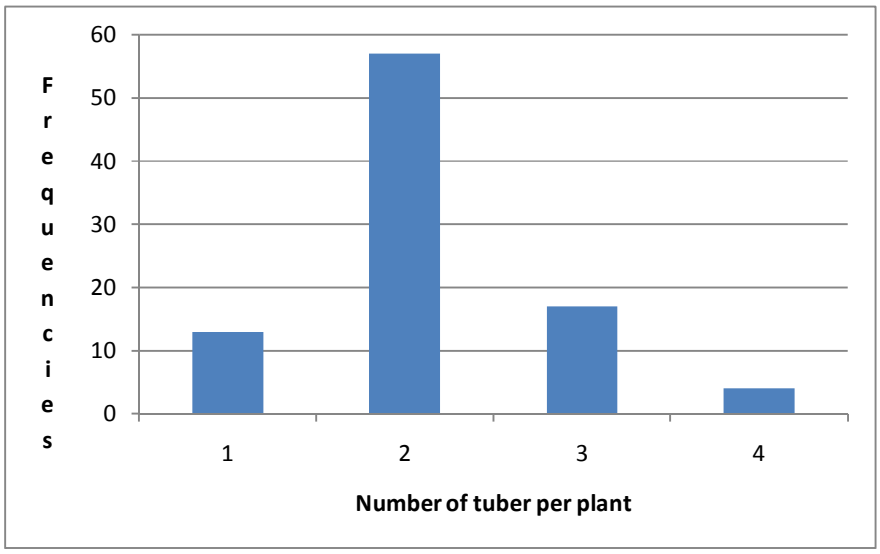

Figure 4 : Frequencies of accessions according to the number of tubers per plant

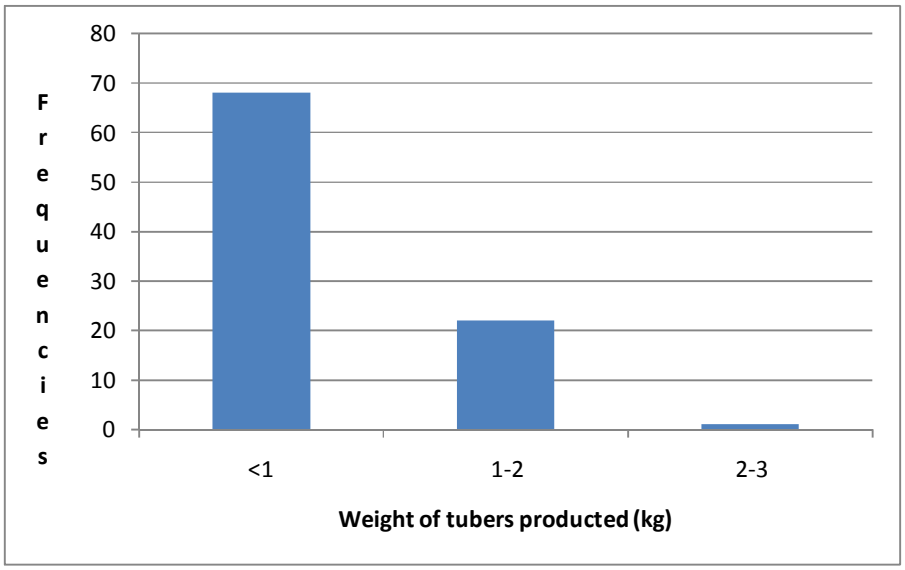

Figure 5 : Frequencies of accessions according to the weight of tubers per plant

Characters related to the external morphology of the tuber

The presence of roots on the tuber, the level of branching and tuber shape describe the external appearance of the tuber (Table 7). There is a predominance of accessions that have no roots on the tuber. They represent 70.33% of accessions, against 24.18% who have very little root on the tuber and 5.49% of accessions which tuber is covered with roots. Seventy eight (78) accessions, or 85.71% have unbranched tubers and 23 accessions or 25.87% have branched tubers. Forty (40) accessions, or 43.95% showed round-shaped tubers and 32 genotypes, or 35.16% had cylindrical tubers. These two forms are the most frequent. The collection also includes two accessions (2.2%), whose tubers are flattened; 4 (4.4%) with conical tubers and 13 (14.29%) with irregularly shaped tubers.

Table 7: Distribution of the *D. alata* accessions according to the external appearance of the tuber

Characters	Modalities	Populations observed	Frequencies observed (%)
Presence of roots on the tuber	Absence	64	70,33
	Little	22	24,18
	many	5	5,49
Level of the ramification of tubers	No branching	77	84,61
	Top third	10	10,99
	Middle	2	2,20
	Lower third	2	2,20
Tubers shape	Rounded	40	43,95
	Cylindrical	32	35,16
	Flattened	2	2,20
	Irregular	13	14,29
	Conical	4	4,40

Characters related to the internal aspect of the tuber

The oxidation of the amylaceous parenchyma, its texture and colour, as well as the uniformity of the colour and the thickness of phelloderm describe the internal aspect of the tuber in cross section. Less than 10% of accessions showed oxidation after cutting (Table 8). The texture of the amylaceous parenchyma varied from fine texture to the moderately grainy and the very grainy texture. Most of the accessions (72.5%) presented tubers with a fine texture amylaceous parenchyma and 16.5% had a moderately grainy texture. The other 11% of the accessions showed a very grainy texture.

Three (3) colours were observed for the fresh flesh of the tuber. White flesh predominated, with almost 75% of the genotypes. Pure white flesh of the tuber represented 32.97% of the accessions whereas 40.66% of them were yellowish-white. Orange flesh was noted for 16.48% of the accessions and the purple colour was shown by 7.69% of them (Figure 6).

These uniform colours of the flesh of the tuber were observed in 85.71% the cases. The other accessions have white and purple or white and orange flesh.

The thickness of the phelloderm was less than one centimetre for 81% of the accessions.

Table 8: Distribution of *D. alata* accessions according to the internal aspect of the tuber

Characters	Modalities	Populations observed	Frequencies observed (%)
Oxidation of the flesh of the tubers 5 min after cutting	No oxidation	83	91,21
	Oxidation	8	8,79
Aspect of the flesh of the tubers	Smooth	66	72,53
	Grainy	15	16,48
	Very grainy	10	10,89
Colour of the flesh of the tubers in transversal section	White (Florido type)	30	32,97
	Blanc Yellowish-white or off-white (Suidié type)	37	40,66
	Purple	7	7,69
	Orange (Brazo type)	15	16,48
	White with purple dots	1	1,10
	Purple with white dots	1	1,10
Uniformity of the colour of the flesh of the tubers	Non uniform	13	14,29
	Uniform	78	85,71
Thickness of tubers phelloderma	<1mm	74	81,32
	>1mm	17	18,68

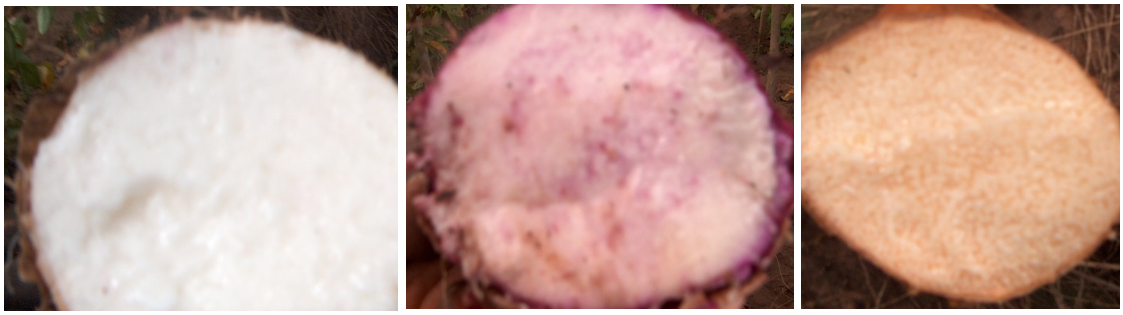

Figure 6: Colours white, purple and orange of the flesh of the tubers of *D. alata* accessions

Traits related to disease susceptibility

Few accessions of the collection were susceptible to viruses and anthracnose (Table 9).

For yam virus, 48.35% of the accessions showed any symptom; 32.97% of the accessions had 3 to 25% of their leaf area affected, while 13.19% had 25 to 50% of their leaf area with symptoms. Only 5.49% of the accessions had more than 50% of their leaf area attacked. Considering anthracnose, 64.84% of the accessions didn't show any symptom. Only one accession died after the attack of *Colletotricum gleoesporioides* while for 13.19% of the accessions, the attack has concerned between 3 and 25% of the leaf area. The proportion of accessions with 25 to 50% of leaf area attacked by anthracnose was 13.19%.

Mealybugs, were present on the tubers of 58.24% of accessions at the harvest time (Table 9).

Table 9: Distribution of *D. alalta* accessions of the collection according to their sensitivity to viral diseases, anthracnose and mealybugs

Characters	Infestation rate (%)	Populations observed	Frequencies observed (%)
Severity of viruses	0 à 2 % 3 à 25 % 25 à 50 % > 50 % ;	44 30 12 5	48,35 32,97 13,19 5,49
Severity of anthracnose	0 à 2 % 3 à 25 % 25 à 50 % > 50 % ; Plant died	59 12 12 7 1	64,84 13,19 13,19 7,69 1,10
Attacks of mealybugs	0 1	38 53	41,76 58,24

Dichotomous key for the determination of the varietal groups

In the light of the characters observed, we propose a key of determination for *D. alata* varietal groups. It consists of eight simple agro-morphological descriptors which are easy to determine. These descriptors are: the presence of thorns on the stem, the presence of wings on the stem, the shape of the cross section of the stem, the presence of the purple colour on the stem, the presence of the purple colour in leaves of the young plant, the presence of the purple colour in the tuber, the colour of the flesh of the tuber and the colour of the leaf.

These traits have been selected on the base of their facility to be used. Thus four varietal groups were formed (Figure 7). In fact, the presence of thorns on the stem, the presence of wings on the stem, the shape of the cross section of the stem permitted to separate distinctively the clone IB26 from the other *D. alata*. The presence of thorns and the absence of wings on the stem and also the circular shape of the cross section of the stem characterise the IB26 accession. This genotype forms therefore alone a varietal group to be called Pyramid group.

After this first group of characters, the presence of the purple colour in the tuber and the aerial vegetative organs are used to separate the other accessions. Accessions having purple stems, purple leaves of

purple young plants and the purple flesh tuber can be opposed to the others. These are the accessions of the group called Douoblé.

Among *D. alata,* apart from the accessions that belongs to the two groups already described some others have green petiole with purple extremities; orange flesh, green stems and grenen mature leaves. These genotypes are grouped in the Brazo group.

The accessions of the fourth group have an entirely green mature stems, green petiole, green leaves and white flesh: they form the Bêtê-Bêtê group. This Bêtê-Bêtê group can be separated into three subgroups. One is formed of accessions having dark-green leaves and piriform tubers. The second subgroup includes accessions which leaves are pale-green and have arrowhead form their tubers have oval form. The third subgroup has accessions with large and heart-shaped leaves, Their tubers are elongated. The first accessions compose the N'Za subgroup, the second subgroup is called Florido and the last is Bêtê-Bêtê

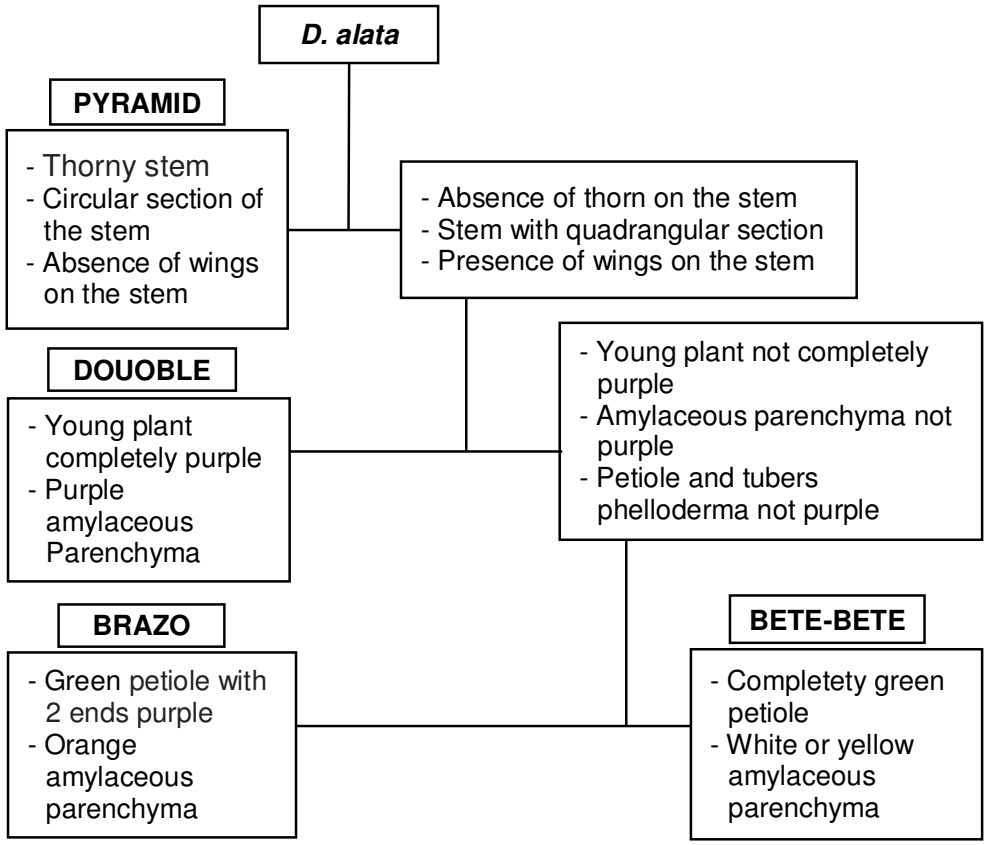

Figure 7: dichotomous key for identifying varietal groups of accessions of D. alata species

DISCUSSION

The accessions of *D. alata* of the yam collection of CNRA in Côte d'Ivoire can be separated into four varietal groups. Bêtê-Bêtê and Brazo groups contain the largest numbers of accessions. The first group is characterised by the green colour of the aerial part of the plant and a white flesh of the tuber. This group was identified by Dumont and Jeanteur in 1988 as the one including the most cultivated yams varieties in Côte d'Ivoire. In New Caledonia, Lebot and *a*l. (1998), identified a group of *D. alata* cultivars including 85 out of the 131 examined. This group of yams has very wide green leaves, and their plants are vigorous and have late maturity. These descriptions are identical to those observed in Bêtê-Bêtê, especially regarding the colour of the leaves. This group of New Caledonia can be assimilate to Bêtê-Bêtê of Côte d'Ivoire. Similarly, this group could also correspond to Pacala group of Caribbean (Degras, 1986). The genotypes composing this group have good organoleptic qualities (Degras, 1986). They also have a good postharvest storability (Girardin, 1996). However, most of the Bêtê-Bêtê are marked by the presence of Internal Brown Spot (IBS), which is a viral disease that attack the tubers and which origin is not well known (Girardin, 1996). When this spots are abundant, the tuber cannot be eaten (Nindjin et al., 2007). The Bêtê-Bêtê group is separated into three subgroups: Florido, N'Za and Suidié. Florido are characterized by fully green vegetative organs and white flesh of the tuber. These tubers have

a fine texture. The round or oval shape of their tubers and their arrowhead-shaped leaves distinguish them from the other accessions of the Bêtê-Bêtê group. This subgroup is very uniform within the Bêtê-Bêtê group like the N'Za marked by their piriform tubers and dark green leaves. Thus, Contrary to the conclusions of Rodriguez (1983), who considered that Florido belongs to N'za group, it appears that Florido and N'Za are inside the large group Bêtê-Bêtê, but they constitute two different subgroups.

The Brazo group is characterized by the genotypes with green petiole and purple tips. Their flesh has orange colour. Most of them have recently been introduced in Côte d'Ivoire from Puerto Rico (Rodriguez, 1983; Dumont and Jeanteur 1988). Some accessions like EA12 and EM10, produce large tubers that bear roots over the whole surface. They therefore, have two characters, one of which (production of large tubers) is desires by the farmers and the other (presence of roots on the tuber) greatly depreciates the market value of the variety. However, the presence of roots on the tuber is influenced by the physical quality of the soil and can therefore be reduced. The genotypes of Brazo group are less sensitive to anthracnose and viruses and have very high yields often being above 30 tonnes per hectare. Most of them produce flowers and can be used in breeding schemes for the research of high yielding varieties resistant or tolerant to viruses and anthracnose. The coarse texture of the flesh of Brazo tubers could be an indication of their poor cooking quality when they are freshly harvested.

The Douoblé group represents only seven percent of the total number of accessions of the collection. This group is very homogeneous with the purple colour of the leaves, the stem of the young plant and the flesh of the tuber. The uniformity of this group can be explained by a monoclonal origin. Indeed, Hamon and *al.* (1986) observed that the Gnan group of the species *D. rotundata* of Côte d'Ivoire is monomorphic and attributed this characteristic to its monoclonal nature. These authors also noted the poverty of the vernacular nomenclature of this group. Similarly, yams of Douoblé group are designated in all regions of Côte d'Ivoire by names which translation means the violet coloration of their organs.

The Pyramid group is numerically the least important of the collection. It is represented by a single accession of the collection on which this study focused.

The varietal groups described in this work are different from those of Rhodes and Martin (1972) who, using 100 morphological characters have regrouped 30 accessions of *D. alata* in three groups after analyses using a principal component analysis and a hierarchical clustering. At the end of their studies, they classified Brazo Fuerte cultivars and Pyramid in the same group while Florido and Farmlisbon were regrouped in another one. In this study, Farmlisbon and Brazo Fuerte landraces are in the group Brazo, while Pyramid alone constitutes another different group. Indeed, the presence of thorns and the circular section of the Pyramid stem oppose it to the other accessions of *D. alata*. Considering the diversity of the organs that contain the purple colour within the *D. alata* species, it is not proper to consider that all the accessions that have a purple organ constitute a single varietal group. Only accessions which have the purple colour in the same organ can be classified in the same group.

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