

# Selected Varieties of *Dioscorea alata* L., the Asian Greater Yam<sup>1</sup>

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## ABSTRACT

Each of more than 300 varieties of *D. alata* collected throughout the tropics have been evaluated for 100 observable characteristics in the field, at harvest, and in the laboratory and kitchen. Concepts of quality were developed from these observations and these have been used to select better varieties. Six excellent commercial-type varieties (Florido, Smooth Statia, Forastero, Veeven, Gemelos and Leone Globe) are the results of these selections which now are available for distribution throughout the tropics.

## INTRODUCTION

Improved varieties of *Dioscorea alata* L. (also known commonly as the Asian greater yam, the 10-months yam, or the water yam) apparently cannot be produced by typical plant-breeding techniques. No systematic breeding has been reported. Seedlings have not been described. Existing varieties seldom flower. When they do, the flowers usually are sterile, perhaps partly because of their polyploid status. The sources of current varieties are unknown, but presumably they are very old; perhaps ancient. The traditional method of planting from tuber pieces or from small tubers continues to be the principal mode of propagation. Because several related varieties are often grown in a given geographical area, it appears that some variation has occurred through mutation.

Because of the limitations to conventional breeding, better varieties can be obtained only through selection. Because *D. alata* came into cultivation first, possibly in Burma or New Guinea, its varieties have been widely distributed by man, so that given areas are often characterized by a few well-known varieties that often have no particular advantage over others available in nearby regions. To obtain good adapted varieties, yams must be collected from many regions, and then compared and selected where their use is intended.

A collection of more than 300 varieties of *D. alata* has been assembled, grown, and evaluated at the Mayagüez Institute of Tropical Agriculture,

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Puerto Rico. A duplicate collection was also maintained at Isabela, Puerto Rico, under conditions of contrasting climate and soils. From studies of these collections, very definite ideas have been obtained as to what constitutes a good variety of this species of yam, and exceptional selections are now available.

A good variety of *D. alata* is resistant to leaf spot diseases and viruses, and is not affected adversely by excessive moisture. The tubers are borne in pairs or in threes, are spherical or cylindrical in shape, are not often branched, and have smooth but thickened skin that resists abrasion. Their surface may have some fine roots, but the principal roots should be concentrated in the fibrous upper extreme of the tuber. Resistance to insects, diseases and nematodes is desirable. Yields must be high and dependable, even when the crop is produced without support for the climbing vines.

Some special characteristics related to cooking are desirable in addition to these varietal characteristics. The parenchyma storage flesh should be white or cream colored, and free of anthocyanin pigments. The "grain" of the tuber caused by starch accumulation around the vascular bundles should be fine, giving a compact and uniform appearance. After being cut, the flesh should not discolor readily by oxidation, and preferably the tuber should be somewhat resistant to oxidation and discoloration associated with injury and storage. The boiling time necessary to reach an acceptable softness may vary, but the better varieties generally reach this stage rapidly. The cooking water should remain free of grey or pink pigments. The flesh of the boiled tuber may be white, cream, or light yellow, appetizing in appearance, and free from grey color. It should appear to be smooth and that appearance verified when tasted. The cooked tuber should be moist in the mouth; not dry and difficult to swallow. The taste should be rich and distinctive, neither too bitter nor too sweet.

In addition, the variety should produce good yields (20 tons/hectare or more), the tubers should store well and resist fungi, and the seed pieces should germinate readily when planted.

No variety the authors have seen combines all desirable characteristics. Selection of new varieties thus becomes a matter of compromise.

#### METHODS AND MATERIALS

Cultivars of yams were obtained by purchase or exploration in the Caribbean, West Africa, and by exchange and correspondence with persons throughout the tropics. A large collection of these cultivars from Southeast Asia will require evaluation over several years. Some duplications have been found among the accessions and other duplications may exist. An exact accounting thus is not possible, but about 300 varieties were involved in these studies.

Each accession in the collection was evaluated for 100 characteristics observed in the field, at harvest, or in the laboratory both before and after cooking. These characteristics were studied by correlation techniques<sup>3</sup> which made possible the prediction of cooking quality through observation of foliar and tuber characteristics. From the evaluation process, clear concepts of quality of cultivars were established.

Using concepts of quality, inferior cultivars were eliminated until only 19 remained. These remaining cultivars were subjected to close examination during one to three additional seasons, in at least two contrasting soil types (heavy clay, light loam). Most of the cultivars were included in replicated yield trials.

From the more detailed observations, six varieties were selected as superior for commercial-type purposes. Seven varieties were selected as suitable for home production. Three varieties were selected for possible use as animal feeds. Three varieties were discarded.

## RESULTS

Inspection of many cultivars showed that the species *D. alata* covers a vast range of local types, many of which are completely unsuitable for home or commercial use when better varieties are available. All varieties tested, however, were judged edible, even if not appetizing or agronomically suitable.

The following defects were encountered in many varieties: tubers too long or irregular in shape to permit easy harvest or preparation in the kitchen, flesh inferior before or after cooking because of polyphenolic oxidation, presence of pigments, off-flavors, or other similar disagreeable features, or inadequate yields. Nineteen varieties were selected that showed outstandingly desirable features. These selections then were further tested more systematically taking the noted defects into consideration when making the final selection.

The 19 varieties finally selected are given in table 1, together with information concerning their recent geographical origins, a few of their strengths or weaknesses, and a judgment of appropriate use of each.

A few of the many characteristics rated in the field or at harvest are given in table 2. Anthocyanin content is negatively correlated with tuber quality. Almost all of the selections had very little anthocyanin in the foliage. The selections varied in susceptibility to leaf-spot disease, the most troublesome condition limiting yam production. Complete resistance was not seen in any variety. In addition, differences were seen in expression of virus symptoms. The virus diseases of yams are not understood well

<sup>3</sup> Martin, F. W. and Rhodes, A. M., Correlations among greater yam (*Dioscorea alata* L.) cultivars, Trop. Agric. (Trinidad) 50: 183-192, 1973.

enough for evaluation of these differences. Slight differences were seen in time of maturity. The earliest varieties mature no more than a month before the latest. Varieties differed in yields, and these differences were consistent over the observation period.

After harvest, the characteristics of individual tubers were tabulated (table 3). Within any variety, considerable variation was caused by mal-

TABLE 1.—*Information on outstanding characteristics, principal defects, and recommendations for use of Dioscorea alata selections*

Common name	Recent source	Outstanding characteristic	Principal defect	Recommendation for use
Florido	Puerto Rico	Quality	Leaf spot susceptibility	Commerce
Smooth Statia	Puerto Rico	Shape, flavor	Virus susceptibility	Commerce
White Lisbon	Trinidad	Quality	Shape	Home
Prolific	India	Yield	Quality, shape	Feed
Forastero	Puerto Rico	Yield, quality	Shape	Commerce
Belep	New Caledonia	Yield	Shape	Feed
Pacala	West Africa	Quality	Leaf spot susceptibility	Home
Veeven	Nigeria	Yield, disease-tolerance	Flesh oxidation	Commerce
Beka	Fiji	Disease-tolerance	Quality	Not recommended
Murapoi	Fiji	Shape	Quality	Home
Gemelos	Puerto Rico	Yield, quality	Branching	Commerce
Suidie	Ivory Coast	Quality	Yield	Home
Puka	Ghana	Quality	Leaf spot susceptibility	Not recommended
Alowinrin	Nigeria	Disease-tolerance	Fair yield	Home
Onwala	Nigeria	Shape	Vigor, yield	Home
Nsukka	Nigeria	Disease-resistance	Yield	Home
Grandote	Nigeria	Yield	Quality	Feed
Ewura Oya	Nigeria	Disease-tolerance	Yield, quality	Not recommended
Leone Globe	Sierra Leone	Yield, quality	Irregular shape	Commerce

formation of tubers by soil conditions, but a typical shape was discernible. Shape depends on many intrinsic factors, including tendency to grow in length instead of in width, and the degree of branching and the site thereof. These characteristics, as well as smoothness of surface and quantity of roots, influence the ease of harvest by either hand or mechanical techniques, and the ease of processing the tuber in the kitchen or factory.

Finally, important characteristics contributing to quality, observed or measured in the laboratory, are given in table 4. The characteristics ob-

TABLE 2.—*Field and foliage characteristics, and yielding tendency*

Common name	Sprouting	Anthocyanin content	Virus	Susceptibility to leaf-spot ( <i>Candelilla</i> )	Time of maturity	Yield tendency
Florido	Excellent	None	Susceptible	Very susceptible	Early	Average
Smooth Statia	Good	Almost none	Average	Average	Average	Average
Farm Lisbon	Excellent	Almost none	Average	Average	Average	Good
Prolific	Good	Almost none	Resistant	Resistant	Mid-season	Excellent
Forastero	Late	None	Resistant	Sometimes susceptible	Late	Excellent
Belep	Fair	Almost none	Unknown	Tolerant	Average	Excellent
Pacala	Good	None	Unknown	Average	Average	Average
Veeven	Poor	Almost none	Unknown	Average	Average	Good
Beka	Average	Considerable	Unknown	Average	Average	Average
Murapoi	Fair	Very little	Unknown	Resistant	Average	Good
Gemelos	Excellent	Considerable	Unknown	Tolerant	Late	Excellent
Suidic	Fair	Almost none	Unknown	Susceptible	Average	Fair
Puka	Poor	Considerable	Unknown	Susceptible	Early	Poor
Alowinrin	Excellent	Almost none	Unknown	Average	Early	Fair
Onwala	Good	Almost none	Unknown	Average	Average	Fair
Nsukka	Good	Almost none	Unknown	Average	Late	Fair
Grandote	Fair	Considerable	Unknown	Resistant	Late	Excellent
Ewura Oya	Fair	Almost none	Unknown	Average	Average	Fair
Leone Globe	Poor	None	Unknown	Resistant	Late	Excellent

TABLE 3.—*Tuber characteristics*

Common name	Tubers per plant	Tuber shape	Tendency to branch	Place of branching	Smoothness of bark	Surface roots	Summary rating <sup>1</sup>
Florido	1-2	Ellipsoidal	Low	—	Very smooth	Few	5
Smooth Statia	1	Spindle	Very low	—	Very smooth	Few	1
Farm Lisbon	1-2	Deltoid	High	Low	Rough	Some	3
Prolific	1	Deltoid	High	Irregular	Smooth	Few	3
Forastero	1-2	Clavate	Low	—	Smooth	Few	4
Belep	1	Deltoid	Low	—	Slightly rough	Few	3
Pacala	1	Cylindrical	Low	—	Smooth	Some	3
Veeven	1-2	Short cylindrical	Low	—	Smooth	Some	3
Beka	1-2	Like hands	High	Middle to low	Smooth	Some	3
Murapoi	1-3	Globular	Low	—	Rough	Few	3
Gemelos	2-4	Short cylindrical	Low	Irregular	Smooth	Few	5
Suidie	1	Long spindle	Very low	—	Very smooth	Few	3
Puka	1	Rough globular	High	All over	Very rough	Some	2
Alowinrin	1-2	Spindle	Very low	—	Slightly rough	Some	2
Onwala	1	Stout cylindrical	Low	—	Slightly rough	Some	1
Nsukka	1-2	Globular	High	Mid to top	Rough	Few	1
Grandote	1	Flattened cylindrical	Low	—	Smooth	Few	2
Ewura Oya	1-2	Compact cylindrical	Medium	High	Rough	Few	1
Leone Globe	1-6	Irregular globular	High	Many sites	Rough	Few	3

<sup>1</sup> Rated from 1 (poor) to 5 (excellent).

TABLE 4.—*Kitchen and culinary characteristics*

Common name	Ease of peeling	Color of flesh	Oxidation	Texture	Appearance	Moisture	Flavor	Summary rating
Florido	Easy	Light cream	Low	Regular	Good	Average	Excellent	Good
Smooth Statia	Easy	Cream	Average	Coarse	Excellent	Average	Good	Good
White Lisbon	Difficult	Light cream	Low	Smooth	Very good	Average	Excellent	Good
Prolific	Difficult	Cream	Average	Coarse	Fair	Regular	Fair	Fair
Forastero	Average	Light cream	Low	Smooth	Excellent	Above average	Excellent	Excellent
Belep	Difficult	Light cream	Low	Smooth	Average	Regular	Regular	Average
Pacala	Regular	Light cream	Low	Smooth	Good	High	Excellent	Good
Veeven	Easy	Cream	Regular	Regular	Average	Regular	Fair	Good
Beka	Very difficult	Cream	High	Coarse	Poor	Regular	Regular	Fair
Murapoi	Average	Dark cream	High	Coarse	Poor	Average	Poor	Poor
Gemelos	Easy	Light cream	Regular	Regular	Excellent	Regular	Good	Good
Suidie	Easy	Light yellow	Low	Smooth	Excellent	High	Excellent	Excellent
Puka	Difficult	Cream	Regular	Smooth	Good	Low	Excellent	Good
Alowinrin	Easy	Cream	Regular	Coarse	Fair	High	Good	Fair
Onwala	Easy	Light cream	Low	Smooth	Good	Regular	Good	Good
Nsukka	Easy	Light cream	Regular	Regular	Good	High	Good	Good
Grandote	Average	Cream	Average	Coarse	Average	High	Average	Good
Ewura Oya	Easy	Dark cream	High	Coarse	Poor	Regular	Regular	Fair
Leone Globe	Average	Cream	High	Average	Good	Average	Good	Excellent

served before cooking, such as color, texture and oxidation tendency, are closely related to the attractive appearance, moisture, and flavor of the cooked tuber. From such observations, a summary evaluation of culinary characteristics was made.

The reanalysis of the 19 varieties revealed more clearly the weaknesses of the majority. Of the original varieties, only 6 were considered to combine



FIG. 1.—Large, solitary tuber of Florida ( $\times 0.33$ ).

a proportion of desirable characteristics high enough to recommend them as truly fine cultivars for commercial use (table 1).

#### CHARACTERISTICS OF THE EIGHT BEST VARIETIES

##### FLORIDO

Early sprouting, leaves arrowshaped and free of anthocyanin, very dark green, very susceptible to leaf spot, virus can be extreme but easily controlled by roguing, matures early. Tuber (fig. 1) yields high when foliage not damaged by leaf spot. Tubers produced singly or in 2's and 3's, short,



compact, regular cylinders, surface slightly corrugated by thick bark, almost free of roots. Insect damage to surface frequent. Flesh white to light cream, finely granulated, low flesh oxidation, frequently damaged near surface by nematodes. Excellent cooking quality, good appearance, very good for processing for flour, but too bland for the best fried products. Keeps well in storage. A standard variety in Puerto Rico.

#### FORASTERO

Late and irregular sprouting, leaves large and arrowshaped, extremely vigorous growth, free of anthocyanin, susceptible to some but apparently not to all strains of leaf spot and stem rot, apparently resistant to virus, matures late. Excellent yields when not damaged by leaf spot. Tubers (fig. 2)



FIG. 2. Somewhat irregular tuber of Forastero ( $\times 0.33$ ).

produced singly or in multiples, flattened or bent cylinders, surface smooth and bark thin, almost free of roots. Flesh cream, finely granulated, and compact, low oxidation. The best cooking qualities, excellent for fries and for flour, good appearance and taste. Keeps very well in storage. A variety sometimes seen in western Puerto Rico.

#### GEMELOS

Very early sprouting, leaves small and arrowshaped, confused with those of Florido, foliage less extensive than that of Florido, free of anthocyanin, tolerant or somewhat resistant to leaf spot, viruses not seen thus far in this variety. Matures mid-season, yields usually excellent. Tubers (fig. 3) almost always produced in 2's, 3's, or more. Compact cylinders, or with large regular branches, surface rugose due to thick bark, almost free of roots. Flesh white, granular in appearance, low tendency to oxidize. Very good cooking qualities, appearance, and taste after boiling, makes good flour. Keeps well in storage except for early sprouting. A variety

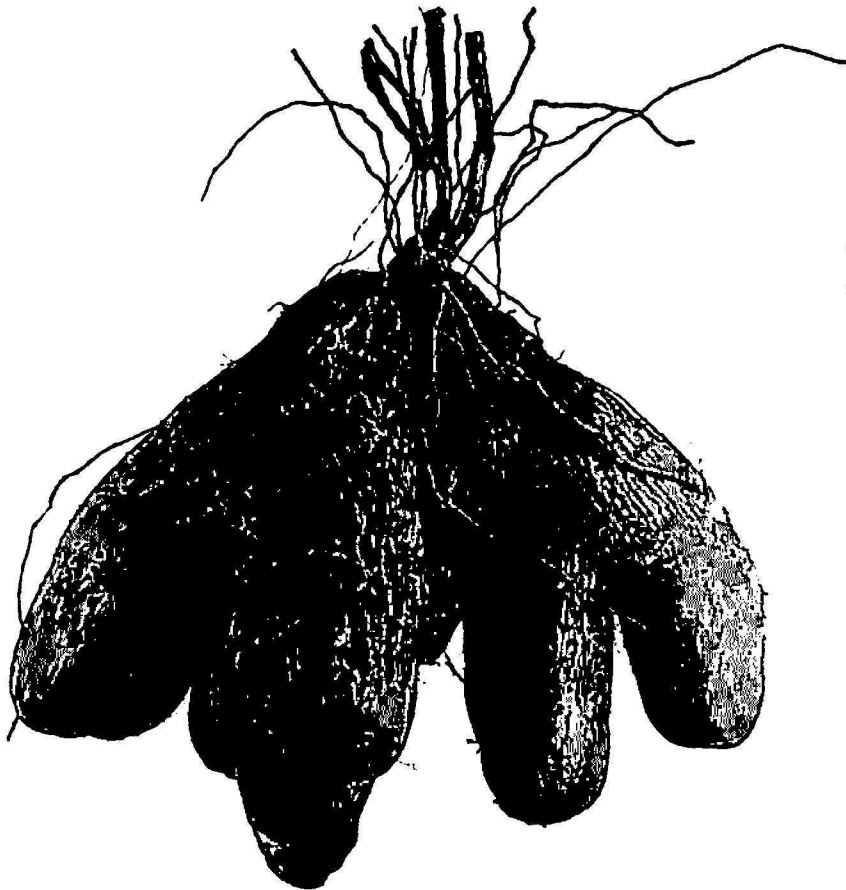


FIG. 3. Multiple branched tubers of Gemelos ( $\times 0.33$ ).

selected from unnamed types seen in Puerto Rico. Confused with Florido, but superior in many ways. The smaller plants can be planted somewhat closer than those of other varieties.

#### LEONE GLOBE

Late germination, leaves large and arrowshaped, free of anthocyanin, vigorous foliage, light green, resistant to leaf spot and virus, matures late.



FIG. 4. -Single and multiple tubers of Leone Globe ( $\times 0.33$ ).

Tubers (fig. 4) produced in groups of 2 to 6, somewhat spherical but surface irregular (peeling thus difficult), bark thick, with a few thick surface roots, yields very high, insect damage to surface frequent. Flesh white, fine textured, very little oxidation of the flesh. Excellent cooking quality, color, flavor, and texture near perfect. Because of large, spherical tubers, this is a good variety for processing. Keeps well in storage if not damaged at harvest. A variety common in Sierra Leone.

#### VEEVEN

Germinates late and sometimes poorly, leaves large, ovate, medium vigor, tolerant of leaf-spot disease, reaction to virus unknown, matures

mid-season. Tubers (fig. 5) produced singly or in 2's, large, somewhat irregular cylinders, smooth surface free from large roots, bark thick, yields medium to high. Susceptible to insects, which damage the surface. Flesh light cream, granulated texture, flesh oxidation variable. Believed to be quite susceptible to harvest injuries. Good cooking qualities, usually excellent color and good flavor, occasionally polyphenolic oxidation results

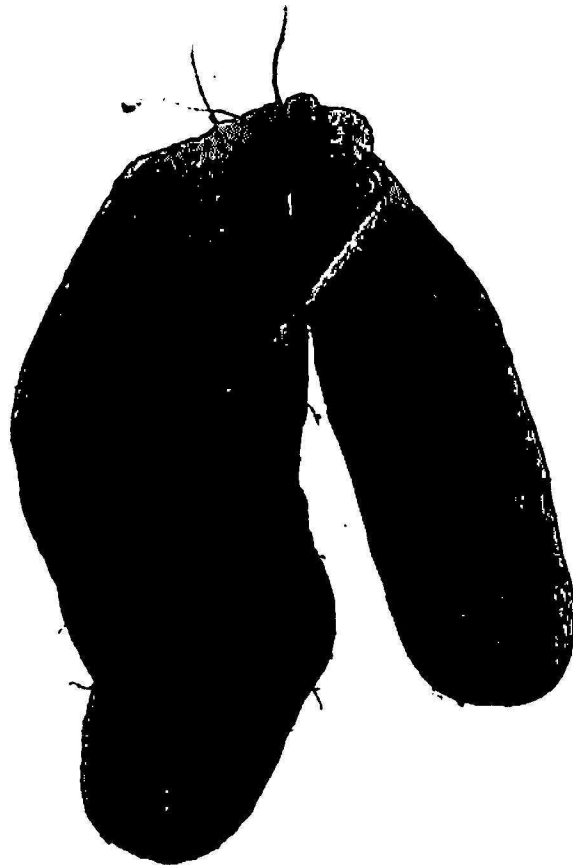


FIG. 5.- Large, cylindrical tubers of Veeven ( $\times 0.33$ ).

in gray color and poor flavor. Keeps well in storage. A variety sent from Nigeria.

#### SMOOTH STATIA

Late sprouting, leaves medium and ovate in shape, only fair vegetative growth, free of anthocyanin, somewhat tolerant of leaf spot, extremely susceptible to virus, must be kept free of virus by avoidance and roguing. Matures earlier than most varieties, yields good to very good. Tubers (fig. 6) produced singly or in 2's, large but compact cylinders, very regular in

shape, surface very smooth and free of roots. Flesh a dark cream color, very grainy in appearance. Medium oxidation, injury and exposure of cut surfaces to the air should be avoided to reduce polyphenolic oxidation. Color and taste usually very good, granular in appearance and taste on cooking. Fair keeping qualities in storage. The tuber is too large for convenient household use. A variety introduced years ago to the Caribbean, but seldom seen because of susceptibility to virus. The virus symptomatology has been reduced by heat treatment of tubers.

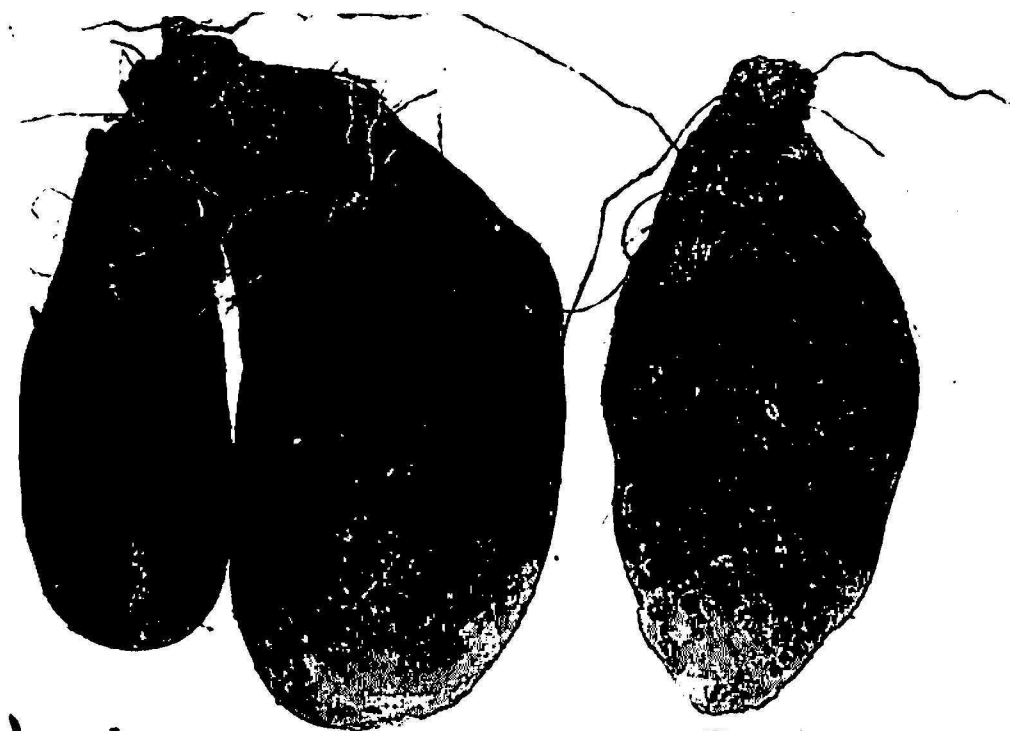


FIG. 6.—Compact, cylindrical tubers of Smooth Statia ( $\times 0.33$ ).

#### FARM LISBON

Late sprouting, leaves medium in size and ovate in shape, good vegetative growth, free of anthocyanin, tolerant of leaf spot disease, probably carries virus, but with slight symptom expression. Late maturing, yields usually good. There may be a single tuber (fig. 7) or several, each tuber rather pyramidal in shape, the lower half bluntly branched, surface irregular and often covered with fibrous roots, difficult yam to peel. Flesh white to cream, compact and finely textured, low oxidation tendency. On cooking this is an excellent yam, and very good for fries and flours. The erosion on cooking is more than normal. The flavor and appearance are excellent. Tubers store very well. This variety is a well-known favorite in Trinidad and Barbados, and would merit more attention if it were not for its difficult-to-manage shape.



FIG. 7.—The much-branched tuber of Farm Lisbon ( $\times 0.33$ ).

#### SUIDIE

Poor and irregular germination, poor to fair foliage production, leaves medium size and ovate shape, moderately susceptible to leaf-spot disease and probably carrying a virus. Matures mid-season, and yields fair to average. Tubers (fig. 8) usually produced singly, spindle-shaped to long, uniform cylinders, surface smooth with few surface roots. Flesh white, low oxidation, finely textured but not dense. Rather soft and easily eroded by cooking, excellent appearance and flavor, very good for chips and fries. Very poor storage qualities, tubers rot easily where injured. A variety collected in the Ivory Coast that would have little value were it not for its very excellent cooking qualities.



FIG. 8. —A shorter than normal tuber of Suidie ( $\times 0.33$ ).

### YIELDS

Typical yields of the better varieties are given in table 5. Yields varied according to treatments, years, and locations, as expected. No effort is made here to treat these differences statistically. Except when plants are diseased, average yields of the selected varieties reach 20 tons or more per hectare. When maximum conditions for growth are maintained (organic material added to the soil and vines supported adequately), yields of 30 tons per hectare or more can be realized. These yields must be contrasted with those of larger, coarse tuber varieties that yield 50 or 60 tons per

hectare in Puerto Rico and suitable only for consumption by animals or for processing under favorable conditions.

### DISCUSSION

Introduction of yam cultivars from worldwide sources has made it possible to obtain considerable insight into the variation and potential of *Dioscorea alata*. Findings suggest very poor distribution of the better

TABLE 5.—Yields (tons per hectare) of selected *Dioscorea alata* varieties in Puerto Rico

Variety	Site and circumstances of the planting <sup>1</sup>				
	A	B	C	D	E
Florido	29.4	20.9	17.7	—	18.4
Forastero	23.8	14.0 <sup>2</sup>	27.4	14.4 <sup>2</sup>	43.2
Gemelos	—	—	19.7	25.0, 20.2 <sup>3</sup>	21.6
Leone Globe	—	—	—	25.0	42.4
Smooth Statia	13.1 <sup>4</sup>	—	—	10.3	—
Veeven	—	—	19.9	18.0	20.0
Farm Lisbon	29.4, 38.2 <sup>3</sup>	24.7	26.9	21.4, 32.3 <sup>3</sup>	—
Suidie	—	—	15.2	16.4	—

<sup>1</sup> Site and circumstances of planting:

A Mayagüez, planted in ridges, spaced 0.6 × 1.6 meters, organic material added to soil, individual plants staked.

B Isabela, planted in ridges, spaced 0.6 × 1.6 meters, mineral fertilizer, wire and string support.

C Isabela, planted in ridges, spaced 0.4 × 1.6 meters, mineral fertilizer, no staking system.

D Isabela, planted in ridges, spaced 0.6 × 1.6 meters, mineral fertilizer, no staking system.

E Caguas, planted in hills, spaced 0.45 × 0.68 meters, mineral fertilizer, no staking system.

<sup>2</sup> Diseased, leaf spot.

<sup>3</sup> Yield of two different plots grown at the same time.

<sup>4</sup> Diseased, virus.

varieties and the consequent use of inferior types in many regions that would not be used if better varieties were known. In many yam-growing regions, rapid progress in quality improvement can be made by introduction and propagation of superior types.

A potential obstacle to introduction of yams from one geographical area to another is the presence in some varieties of virus-like symptoms. When symptoms are severe, yields of individual plants are reduced. The disease has not received much attention in this species and its potential for spread or threat to the industry is an unknown factor. However, in small plantings, rigorous roguing of infected plants, followed by regular



selection of large tubers for seed purposes hold the disease in check or reduce symptoms to almost zero. Virus-like symptoms have been found in yams from every geographical area sampled, and this suggests that the disease or diseases already are widespread. Extreme caution is thus necessary, as in the carrying out of any plant or animal introduction program.

#### RESUMEN

Una colección de 300 variedades de ñame de agua (*Dioscorea alata*) de diversas regiones del trópico fue evaluada tomando en consideración 100 características observables de campo, de laboratorio y culinarias. De estas observaciones se desarrollaron conceptos de calidad usados para seleccionar variedades superiores. Se seleccionaron seis variedades excelentes de tipo comercial (Florido, Smooth Statia, Forastero, Veeven, Gemelos y Leone (Globe)), las cuales están ahora disponibles para distribuirse a países tropicales.