AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 64

1. SUBJECT CLASSIFICATION

A. PRIMARY
Food production and nutrition — AF30-1500-GG50

B. SECONDARY
Plant breeding--Root vegetables--Tropics

2. TITLE AND SUBTITLE
Tropical food crops; yams,cassava,root crops,arrowroots

3. AUTHOR(S)
Martin,F.W.; Ruberte,R.M.; Rodriguez-Arias,Jaime; Cabanillas,E.; Jones,Alfred

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	46p.	ARC 631.5.M379

7. REFERENCE ORGANIZATION NAME AND ADDRESS
USDA/ARS

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In Tropical food crops,July-Dec.1971,p.109-152)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAE-037

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Arrowroots
Cassava
Data
Root crops
Varieties
Yams
Yield

13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA (AJ)-2-69 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

THIS DOCUMENT HAS BEEN EVALUATED AS SUBSTANDARD COPY FOR ROUTINE REPRODUCTION. EFFORTS IN AID/W TO OBTAIN A MORE ACCEPTABLE COPY OF THE DOCUMENT HAVE NOT BEEN SUCCESSFUL. DESPITE THIS DISADVANTAGE, WE HAVE CHOSEN TO REPRODUCE THE DOCUMENT BECAUSE OF THE SUBJECT TREATED AND TO MAKE THE DISCERNIBLE INFORMATION AVAILABLE.

631.5
M379

PASA (AID)-2-69 G75 USDA/ARS
PN-AAE-037

TROPICAL FOOD CROPS

Identification of varieties of *Dioscorea alata* from characteristics of the foliage

F. W. Martin

Our collection of yams now includes 51 accessions of the species *Dioscorea alata*, which belong to 30 to 35 varieties. Casual observations reveal considerable variation not only in characteristics of the tuber, but also in those of the foliage. We suspect this variation represents only part of that of the species as a whole. We need to characterize and classify varieties of *Dioscorea alata* not only to identify them, but also to document their interrelationships.

A series of vegetative characteristics in which varietal differences were observed is given in table 1. This list does not include late-season characteristics, such as disease susceptibilities, characteristics of the aerial tuber, and time of dormancy (to be reported later). Except where noted we have rated these characteristics on the basis of mature foliage. Not all traits were equally easy to rate because differences occurred even on the same plant. But we have not yet tried to compare the relative value of the different kinds of observations.

Table 1. Vegetative characteristics of *Dioscorea alata* accessions measured or rated

Number	Characteristics	Method of rating
1-11	Anthocyanin intensity of new stem, old stem, new wings, old wings, petiole wings, lower petiole, upper petiole, vein junction, veins of leaf, margin of leaves, new leaves	All rated on a scale of 0-3
12	Mean anthocyanin content	Sum of all anthocyanin ratings/11
13	Angle of basal veins	Angles estimated at 15°
14	Bluntness of lobes	Scale 1-3
15	Development of tail at tip of leaf	Scale 1-3
16	Widest region of leaf	1 = between tip and petiole junction 2 = through petiole junction 3 = between petiole junction and lobes

A.I.D.
Reference Center
Room 1656 NS

Table 1 (continued)

Number	Characteristic	Method of rating
1-17	Green color intensity of leaf	Scale 1-3
18	Rugosity of leaf	Scale 1-3
19	Leathery feel of leaf	Scale 1-3
20	Damage due to leaf spot	Scale 1-3
21	Damage due to virus	Scale 1-3
22	Development of spines	Scale 0-3
23	Development of wings	Scale 1-3
24	Average stems from tuber	Scale 1-3
25	Tendency for young stem to branch	Scale 0-3
26	Size of stomata	Measured
27	Internode length	Measured
28	Petiole length	Measured
29	Leaf blade length	Measured
30	Leaf blade width	Measured
31	Leaf lobe length	Measured
32	Internode index	Internode length/blade length
33	Petiole index	Petiole length/blade length
34	Width index	Blade width/blade length
35	Lobe index	Lobe length/blade length

Differences that were rated, usually on a scale of 0 (absence) to 3, were often distributed in an approximately normal curve (table 2). However, other differences were distributed hyberbolically.

Measurements of leaf and stem characteristics were used to calculate relative lengths and widths by dividing the measurement in question by the leaf length. Such relative measurements are usually more reliable than direct measurements. The measurements and indices were distributed in an apparently normal fashion (table 3).

Table 2. Distribution of varieties by ratings of vegetative characteristics

Characteristic	Ratings* 0	1	2	3
Color characteristics:				
Anthocyanin intensity in:				
New stem	34.5	15.5	1	0
Old stem	14.5	31.5	4.5	.5
New wing	34.5	15.5	1	0
Old wing	4.5	26.5	18.5	1.5
Petiole wing	18.5	24.5	9	0
Lower petiole	16	9	7.5	18.5
Upper petiole	25	15	6	5
Vein source	33.5	10.5	4	3
Leaf veins	49	3	0	0
Leaf margins	49	2	0	0
Young leaves	25	6	5	15
Mean anthocyanin content	13	16.5	14	2.5
Leaf characteristics:				
Bluntness of lobes		13.5	32	5.5
Development of tail		6.5	27.5	17
Widest region		40	6	5
Green color intensity		1	31.5	18.5
Roughness of surface		19.5	29.5	0
Leatheryness		1.5	26.5	23
Leaf spot incidence (first observation)	6	27	13	5
Virus incidence (first observation)	20	20	8	3
Stem characteristics:				
Spine development	46	2	15	1.5
Wing development		7	17	27
Emergence of stems		13	15	23
Branching of stems	13	14	17	7

* Intermediate ratings were divided among higher and lower categories.

When we complete observations with late season data, and from measurements and ratings of tubers, we expect to work out the interrelationships of the accessions by computer techniques. In this respect Dr. A. E. Rhodes of Illinois will be cooperating with us.

Meanwhile, we have used the data to classify accessions on the basis of their outstanding characteristics. The technique used was to find from the distribution data the characteristic, for which each accession represented an extreme. From these characteristics a key was constructed to identify accessions in the field. However, not all accessions can be distinguished from each other by foliage characteristics alone. The key is included in this report.

One set of characteristics was found to hang together and to divide the species into 2 more or less recognizable groups, as follows:

Group I - Common	Group II - Variant
1. Wings normal	1. Wings subdued
2. Stems not normally thorny	2. Stems somewhat thorny
3. Bulk of anthocyanins not in stem	3. Bulk of anthocyanins in stem
4. Widest part of leaves usually not through lobes	4. Widest part of leaves usually through lobes
5. Stem relatively thick	5. Stem relatively thin

Provisional key to the cultivars of *Dioscorea alata* using characteristics of the foliage

1. Wings of stem reduced in size, inconspicuous, not ruffled. Lower stem usually thorny.

   A. Leaves broad, sinus broad, angle of basal veins 100° or more, lower stem anthocyanin noticed.

      1. Vein source pink, lower petiole red, anthocyanin coloration high.

         a. Leaves large, dark green, thorns common.

            15205 Unnamed (India)

         b. Leaves small, light green, thorns rare.

            15211 Unnamed (India)

      2. Vein source green, lower petiole tinged pink, anthocyanin coloration low.

         a. Lower stem very spiny, upper stem often spiny, bulbils form early. 15210 Unnamed (India)

Table 7. Distribution of measurements and indices of vegetative characteristics

Size of Sporate (g)	Distribution	23-249 5	25-269 21	27-289 7	29-309 7	31-329 2	33-349 7	35-369 3
Length of internode (mm)	Classes Distribution	70-99 4	100-129 1[illegible]	130-159 13	160-189 12	190-219 8	220-249 4	
Length of petiole (mm)	Classes Distribution	40-59 2	60-79 1	80-99 8	100-119 11	120-139 9	140-159 13	160-179 8
Length of blade (mm)	Classes Distribution	80-99 2	100-119 2	120-139 7	140-159 9	160-179 18	180-199 12	200-219 1
Length of lobe (mm)	Classes Distribution	20-29 2	30-39 3	40-49 12	50-59 17	60-69 [illegible]	70-79 4	80-89 4
Width of blade (mm)	Classes Distribution	60-79 1	80-99 4	100-119 12	120-139 18	140-159 7	160-179 7	180-199 2
Angle of basal veins (terminated, degrees)	Classes Distribution	45 4	60 2	75 15	90 17	105 0	120 2	135 11
Internode length/blade length	Classes Distribution	.50-.69 6	.70-.79 4	.80-.89 6	.90-.99 13	1.00-1.09 9	1.10-1.19 3	1.20-1.49 10
Petiole length/blade length	Classes Distribution	.50-.59 5	.60-.69 6	.70-.79 18	.80-.89 11	.90-.99 8	1.00-1.09 2	1.10-1.19 1
Lobe length/blade length	Classes Distribution	.20-.24 5	.25-.29 10	.30-.34 11	.35-.39 14	.40-.44 6	.45-.49 3	.50-.54 2
Blade width/blade length	Classes Distribution	.50-.59 2	.60-.69 10	.70-.79 10	.80-.89 13	.90-.99 12	1.00-1.09 3	1.10-1.19 1

b. Lower stem not very spiny. Upper stem usually not spiny, bulbils form late. 15200 Feo

B. Leaves clearly longer than broad, sinus intermediate, angle of basal veins 90° or less, lower stem not strongly mottled, no thorns. 15218 [illegible]

II. Wings of stem prominent, often ruffled. Lower stem thorny only in very large plants.

A. Foliage chiefly green with very little anthocyanin coloration. Wings of lower stem pink. Wings of upper stem and petiole often tinged, lower extreme of petiole sometimes tinged with red.

1. Large-leafed, very vigorous varieties.

a. Sinus wide, angle of basal veins more than 100° overall shape of leaf not usually oval.

(1) Leaves often wider through lobes than through blade, hastate, very dark green. 15[illegible], 15324, 15327, Florida

(2) Leaves usually wider through blade than through lobes. Leaves dark to medium. Not hastate. Rugose at vein junction.

(a) Lobes strongly right angled. 15340 Forastero

(b) Lobes not strongly right angled, not rugose at vein junction, lobes short. 15394 Hunte

b. Sinus not as wide, usually angle of basal veins 90° or less, overall shape of leaves oval.

(1) Sinus narrow, angle of basal veins about 45°. Leaves light green, lobes overlapping, lower part of petiole yellowish. 15325 Hawaii

(2) Sinus medium, angle of basal veins about 90°.

(a) Leaves very large, sometimes narrow lobes strongly pointed (60°), do not overlap. 15205 Unnamed (India)

When we complete observations with late season data, and from measurements and ratings of tubers, we expect to work out the inter-relationships of the accessions by computer technique. In this respect Dr. A. E. Rhodes of Illinois will be cooperating with us.

Meanwhile, we have used the data to classify accessions on the basis of their outstanding characteristics. The technique was to find from the distribution data the characteristics for which each accession represented an extreme. From these characteristics a key was constructed to identify accessions in the field. However, not all accessions could be distinguished from each other by foliage characteristics alone. The key is included in this report.

One set of characteristics was found to hang together and to divide the species into 2 more or less recognizable groups, as follows:

Group I - Common	Group II - Variant
1. Wings normal	1. Wings reduced
2. Stems not normally thorny	2. Stems somewhat thorny
3. Bulk of anthocyanins not in stem	3. Bulk of anthocyanins in stem
4. Widest part of leaves usually not through lobes	4. Widest part of leaves usually through lobes
5. Stem relatively thick	5. Stem relatively thin

Provisional key to the cultivars of *Dioscorea alata* using characteristics of the foliage

1. Wings of stem reduced in size, inconspicuous, not ruffled. Lower stem usually thorny.

   A. Leaves broad, sinus broad, angle of basal veins 100° or more, lower stem anthocyanin mottled.

      1. Vein source pink, lower petiole red, anthocyanin coloration high.

         a. Leaves large, dark green, thorns common.

            15206 Unnamed (India)

         b. Leaves small, light green, thorns rare.

            15211 Unnamed (India)

      2. Vein source green, lower petiole tinged pink, anthocyanin coloration low.

         a. Lower stem very spiny, upper stem often spiny, bulbils form early. 15210 Unnamed (India)

(b) Leaves, large, not narrow, lobes blunt, often overlapping. 15[illegible] [illegible] Yellow

2. Vigor and leaf size intermediate. Leaves [illegible] medium green to yellowish. Sinus [illegible], angle of basal lobes about 90°, lobes somewhat [illegible], angle of sides [illegible].

a. Varieties with similar foliage, lower part of petiole green.

15[illegible] [illegible]
15130 Seal Top White
15131 Smooth [illegible]
15135 Seal Top Yellow
15343 Barbados
15393 Boro

b. Varieties with similar foliage, lower part of petiole irregularly tinged with pink.

15127 Bottleneck Lisbon
14866 Unidentified, Lisbon type
15126 Harper
15134 Farm Lisbon
15344 [illegible] Lisbon

B. Anthocyanin content high, lower extreme of petiole red.

1. Extremely red varieties. Vein source pink or red, veins and leaf margins often tinted. Upper portion of petiole always red.

a. Sinus narrow, angle of basal veins about 45°.

(1) Lobes wide angled, 75°. Large, vigorous varieties, veins usually pink.

15083 Macorfa
15201 Rojo Silvestre

(a) Lobes narrow, angled, 45-50°. Variable vigor, veins usually only tinged.

14860 Morado
14863 Vino A
14864 Vino B
14865 Vino C
15082 Lisbon Purple

b. Sinus wide, angled basal veins about 135°.

15345 Stout

2. Red varieties. Vein source usually green, veins and leaf margins seldom tinged. Upper extreme of petiole not red, but sometimes pink.

a. Upper extreme of petiole pink.

(1) Wings poorly developed, wide sinus, angle of basal veins [illegible] or more, [illegible] small. 15128 [illegible]

(2) Wings well developed. Leaves [illegible]

(a) Thick, dark green leaves. Wide sinus.
15202 Unnamed (India)
15207 Unnamed (India)
15209 Unnamed (India)

(b) Normal leaves. 15345 Sweet

b. Upper extreme of petiole either green or only tinged with anthocyanin. Wings well developed, large, vigorous native varieties.

14857 [illegible]
14852 [illegible]
15199 Del Monte
15140 Wild
15332 Wild
15334 Wild
15335 Wild
15336 Wild
15337 Wild
15339 Wild

The esterases and peroxidases of shoot tips of yams.

F. W. Martin and Ruth Ruberté

Among the problems we face with the edible yams is learning to recognize them from their above ground characteristics (see discussion above). Because isozymes tend to vary among varieties we have considered the possibility of demonstrating varietal differences by differences in their isozyme contents. The most useful and simplest enzyme systems to study, peroxidases and esterases, were studied in these tests.

Preliminary trials revealed that peroxidases were weak in the first half-inch of the growing tip of the vine. They were stronger in the regions from 1/2 to 1 inch and from 1 to 2 inches from the tip. However, young leaves of from 1/2 to 1 1/2 inches in length were the best sources of peroxidases. Such leaves contained not only enzyme bands of the stem, but also bands unique to the leaf. Esterase bands were somewhat different

in shoot tips and leaves. Young leaves were selected for the tests of peroxidase. Both leaves and shoot tips were used for the [illegible] tests. Although these were used fresh, tests showed that they could be frozen 1 or 2 days without loss of enzyme activity.

A total of 2 accessions of D. trifida, 4 of D. bulbifera, 4 of D. esculenta, 5 of D. rotundata and [illegible] of D. alata were compared [illegible] cases 2 staples were tested at different [illegible] to calculate Rf, and were judged on a scale of 1-3 for intensity [illegible] cases a shadow (darkened but not properly stained) [illegible] where bands were expected. This was [illegible].

Species showed characteristic reportable differences in peroxidases that were sufficiently marked to distinguish them (table 1). Varieties within species showed only minor differences, chiefly due to variations in intensity of particular bands.

Table 1. Principle peroxidase bands, their typical Rf's, and intensities (scale of 0, ?, 1, 2, and 3) in zymograms of young leaves of Dioscorea species

Species	Rf's of Band							
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D. trifida	0	0	0	1	0	0-1	0	0
D. bulbifera	0	0	0	0-1	0-1	0	0-1	0
D. esculenta	0-1	0	0	1-2	1	0	0	1-2
D. rotundata	?	0	3	0	1	0-1	0	0
D. alata	0-2	0-3	0	1-3	0	0	0-3	0

* A negative sign indicates movement of band toward negative pole.

Esterase bands of shoot tips were fairly strong except in D. trifida and D. alata (table 2). D. esculenta and D. bulbifera showed similar isozyme patterns. This reinforced our opinion of their close relationship. The other species showed distinctive patterns but nevertheless individual bands were identical in various cases. Dioscorea alata varieties showed weak but definite banding differences. These were not strong enough to characterize or distinguish varieties.

Table 2. Principal esterase bands, their typical Rf's and intensities (scale of 0, ?, 1, 2 and 3) in zymograms of shoot tips of *Dioscorea* species

Species	Rf of bands				
	-12	16	48	80	92
D. trifida	0	0	0	0-?	0
D. bulbifera	0	2-3	1-2	?	0
D. esculenta	0	3	2	?	0
D. rotundata	1-2	0	0	0	0
D. alata	1	0	0	?	1

The young leaves of the species showed esterase enzyme patterns distinct from those of the shoot tips (table 3). Again, esterase bands of *D. alata* were rather weak, but varietal differences were sometimes suggested. The species were quite different except for *D. bulbifera* and *D. esculenta*, which again showed similar patterns.

Table 3. Principal esterase bands, their typical Rf's and intensities (scale of 0, ?, 1, 2, and 3) in zymograms of young leaves of *Dioscorea* species

Species	Rf of Bands				
	-16	-12	8	55*	93
D. trifida	0	0	0	0	0
D. bulbifera	0	0	0-1	1-2	0
D. esculenta	0	0	0-1	1-2	0
D. rotundata	1	0	0	0	0
D. alata	0	0-2	0	0-2	0-1

* Sometimes multiple bands.

Anthocyanins of the foliage of yams.

Jaime Rodríguez-Arias, Ruth Ruberté and Franklin W. Martin

Varieties of the water yam, *Dioscorea alata*, can sometimes be distinguished by the characteristics of their foliage, including size, shape and rugosity of the leaf. In addition, the quantity and distribution of anthocyanins in the foliage is sometimes of diagnostic value. Our observations have suggested variations in the kind of red coloration itself, which appear to be due to differences in anthocyanin pigmentation. We have extracted and

partially identified these pigments to see if they help us in the problem of classifying and identifying varieties.

Anthocyanins are frequently found in the cortex or flesh of the tuber, where they impart red or purple colors. In the case of [illegible] investigated, the pigment was identified as cyanidin-3,5 diglucoside (Harper and Conway, 1957, Experientia 23:511). Other pigments were present in lesser quantities.

All Dioscorea alata varieties maintained in the collection of the Federal Experiment Station were selected for study (table 1). The [illegible] tissue was ground in methanol containing 0.1% concentrated HCl, and was then partially evaporated for chromatographing on Whatman #4 paper with three solvent systems (1, 2, and 3, table 2). After screening of varieties, 2 were selected that contained different pigments. The RF's of these pigments were determined in 5 solvent systems by replicated trials. The pigments were eluted from paper chromatograms with methanol containing 0.1% HCl, and light absorption was measured with a spectrophotometer in both visible and U.V. regions.

Table 1. Varieties of Dioscorea alata screened for anthocyanin pigment

	Pigments present		
None	A	B	A and B
Barbados	Macorís	15202 (India)	Moredo
Forastero	Florido	15206 (India)	Ashmore White
Smooth Statia White	Harpers	15208 (India)	Vino A
Smooth Statia Yellow	Ashmore Yellow	15209 (India)	Vino B
Hawaii	Oriental	15210 (India)	Vino C
Seal Top Yellow	Farm Lisbon		De Agua
Seal Top White	Sweet		Lisbon Purple
	Horn		Del Monte
	Hunt		Feo
	Wild #15334		Wild Red
			15207 (India)
			15211 (India)
			15212 (India)
			De Palo
			7 wild yams

Table 2. Rf values of anthocyanins removed from yar foliage.

Number		Compound A	Compound B	Anthocyanidin
1	N-butanol:acetic acid:water (4:1:5)	.149	.226	.715
2	N-butanol:2N HCl (1:1)	.055	.063	.693
3	Water:concentrated HCl (37:3)	.226	.[illegible]	--
4	Acetic acid:conc. HCl:water ([illegible]:1:5)	.[illegible]	.829	.346
5	Ethyl acetate:formic acid:water (14:3:3)*	.182	.211	--
6	Acetic acid:conc. HCl:water (30:3:10)	--	--	.516
7	Formic acid:conc. HCl:water (5:2:3)	--	--	.228

* Separation on silica gel thin layers.

Other eluants were hydrolyzed in N HCl for one hour in a boiling water bath. The hydrolysis mixture was extracted with amyl alcohol. The amyl fraction was rechromatographed in 5 solvent systems, and the anthocyanidin was eluted for spectral measurements. Meanwhile, the aqueous fraction was concentrated and used to determine sugar present. The sugars were determined by comparison to colors and Rfs of standards separated on boron-impregnated plates by one solvent system.

The compounds were provisionally identified by comparison to published data.

Two anthocyanin pigments, called A and B, were found. Their presence varied with variety (table 1). The Rf values of the two anthocyanins, A and B, were sufficiently similar that the pigments could be completely separated only by two of the solvent systems, and partially separated by the others (table 2). The pigments, when eluted from paper chromatograms, absorbed visible light at about 530-533 mμ, and UV at about 328-330 and 288-289 mμ. The absorption of light at 328-330 mu indicates the presence of an acyl group attached to the sugar, which is either caffeic or ferulic acid.

The eluted pigments in N HCl solution resisted hydrolysis. Generally, two hours were required for a complete reaction.

The amyl fraction from both pigments contained a single magenta anthocyanidin. This pigment absorbed light at 535-540 mμ, depending on the amount of amyl alcohol retained in the final solvent preparation. When excess acid was carefully removed to give a pH of 2 or more, then the peak absorption was changed to about 558 after a few drops of ethanolic $AlCl_3$

were added to the solution. The color of the solution was changed to a purplish blue. The Rf values of the anthocyanidin (table 2) closely approximate published Rf values for cyanidin.

On the basis of color, absorption of light and Rf values the evidence overwhelmingly suggests that the anthocyanidin of [illegible] is cyanidin.

Tests for the sugars split from the anthocyanins released by hydrolysis are summarized in table 3. The Rf's for the sugars from the two compounds are similar. The values which most closely [illegible] those of [illegible] but are not far removed from those of glucose and fructose. The [illegible] reagent used, aniline phthalate, does not distinguish between these particular sugars by giving a differential color response.

Table 3. Rf values of reference sugars and sugars released from anthocyanins by hydrolysis*

Sugar or source of sugar	Rf
Ribose	.75
Fructose	.65
Arabinose	.77
Galactose	.69
Glucose	.72
Rhamnose	.78
Xylose	.76
A (hydrolysis mixture)	.67
B (hydrolysis mixture)	.68

* Separated on boron-impregnated silica gel G by methyl ethyl ketone:acetic acid:ethanol (3:1:1).

Up to this time it has not been possible to make a final identification of the two anthocyanins. Twenty-two glycosides of cyanidin have been described. Comparison of the Rf's with those of our compounds does not permit even a tentative identification. Our compounds are different from those described in the tuber by Pepper and Cooney. Acylated glycosides of cyanidin have only been described in a few plants. Our compounds are not identical to those described. It appears, therefore, that the anthocyanins of the foliage of yams are new and as yet undescribed compounds.

To complete the identification of the anthocyanins is a somewhat sophisticated task requiring very carefully controlled and replicated experiments. If we can obtain the use of a recording spectrophotometer we should be able to accomplish this task. We need also to obtain other sugars for reference purposes, and make a more thorough identification of sugars. Finally, both the kind and number of phenolic acid attached to the sugars (acyl group) needs to be determined.

Propagation of yams from stem cuttings.

A. Cabanillas and F. W. Martin

Generally, the edible yams, *Dioscorea alata*, *esculenta*, and *rotundata*, are propagated by pieces of the upper portion (head pieces) of the tubers, but when seed is scarce or an increased planting [illegible] whole tubers are cut in big pieces and used as propagating material. This reduces marketable yield. A satisfactory method of propagation from stem cuttings would therefore be useful. We have made some tests, [illegible] reported general observations (this report, p.2, 4). More detailed information is shown here.

Vines were cut in the field, covered with wet burlap bags to prevent excessive drying, and brought to the greenhouse. The stems were cut about 2-3 inches in length with the node in the middle. The cuttings were immediately placed in the gravel beds under the mist sprayer.

The following observations of a general nature were made in this preliminary trial: Callus tissue appears in the axle of the leaf. This forms one or two very small tubers. Roots develop from this tissue at about 20 to 25 days and are ready to be removed from the gravel bed 5 or 10 days later. Shoots usually grow later. Stem cuttings can be made from the whole length of the vine except from the last 18 to 20 inches of the tender growing tips (table 1). Cuttings from base, middle and top were made in the usual way. The last portion or tender tip of about 8-10 inches was planted whole.

Table 1. Comparative rooting ability of cutting from different portions of the stem, and of shoot tips

Portion of stem	Cuttings	Rooted	Rooted with tubers	No roots	Dead	Percent rooting
Base	46	20	16	8	2	78.2
Middle	47	15	26	4	2	87.2
Tops	60	23	18	17	2	68.3
Tips (12-15 inches)	47	10	-	-	37	11.2

Leaves should be whole and without insect damage. Broken or badly bruised leaves will rot very rapidly. Not all cuttings that develop roots also develop shoots. Often after rooting the original leaf of the cutting dies back leaving a small, rooted tuber that appears to be dormant. We have not yet found a way to stimulate these dormant tubers to produce shoots.

Species and varieties differ in response to this propagating method (Table 2). [illegible] D. [illegible] responded very well, with only notable exceptions (Florido, Smooth Stalk, Oahan types). [illegible] vigorous, bulbil-producing varieties responded more favorably than the more compact, [illegible] D. [illegible]. [illegible] frequently do not respond to these treatments. Some progenies of ray variety also varied in difference to the response. We have not yet identified all of the inputs for variable rooting ability of cuttings to propagate. [illegible] for [illegible] varieties the technique has indeed very successful.

Table 2. Rooting ability of edible yam species and varieties

Accession Number	Species and Variety	Cuttings Planted	Rooted (%)
	D. alata		
14230	Lorado	51	74.5
14262	Johnson White	45	54.3
14533	Vino A	66	62.1
14564	Vino B	53	56.0
14235	Bonifacio Ibaloy	67	58.2
14[illegible]7	De Agua	44	99.0
15[illegible]	Purple Ibaloy	64	56.[illegible]
15083	Macoffe	100	100.0
15088	Florido	100	65.0
15126	Lisperas	53	69.8
15127	Yellow Johnson	67	77.6
15128	Oahan A	75	84.0
15130	Seal Top White	60	83.3
15131	Smooth Stalk White	94	36.[illegible]
15132	Smooth Stalk Yellow	69	30.4
15134	Foam Ibaloy	67	83.5
15140	Del Pedro	18	100.0
15199	De Palo	70	77.3
15200	Feo	76	99.0
15202	Wild Red	85	81.4
15205	P.I. 349691	55	89.0
15206	P.I. 349692	70	74.2
15208	P.I. 349694	68	83.6
15209	P.I. 349695	52	32.3
15210	P.I. 349696	70	91.4
15211	P.I. 349697	120	73.3
15212	P.I. 349698	73	100.0
15324	Florido	606	56.1
15325	Hawaii	50	35.0
15332	Wild yam species	56	96.4
15339	Feo-Wild "	100	100.0

(Continued)

Table 2 (cont.)

Accession Number	[illegible]	[illegible]	[illegible] (%)
15331	[illegible]	72	97.[illegible]
15[illegible]	" " "	[illegible]	[illegible]
15331	" " "	100	84.4
15[illegible]	" " "	105	60.0
15340	Forestero	40	47.5
	D. rotundata		
15085	Guinea Blanco	355	57.4
15085	Habanero	346	57.1
15126	Keith 46	90	7[illegible].8
15326	Guinea Blanco	222	57.[illegible]
15331	Guinea [illegible]	77	38.[illegible]
	D. [illegible]		
15081	Potato yam	242	7.5
15090	Pana yam	275	8.0
15213	Di 67-27	225	9.6
15214	Assam	327	42.7
15215	D. [illegible]	193	56.2

Effects of season on rooting and shooting of Dioscorea stem cuttings.

F. Cabanillas and F. W. Martin

The successful techniques used to produce new yam plants from stem cuttings were originally developed for use with the sapogenin-bearing species. A continued problem experienced with the technique was its lack of reliability. Not only did some species and selections respond better than others, but also seasonal variations were observed. Yams were much easier to propagate early than late in the season. This response was not entirely due to the age of the cutting itself, for efforts were made to always use physiologically "young" cuttings. Nevertheless, tests showed that physiologically "old" or mature leaves were not as suitable for cuttings as were fully expanded but immature leaves.

To test for seasonal differences in rooting, we made a series of tests with the commercial variety Florido, a variety that does not respond very well to propagation from stem cuttings. The test was not formally

arranged but consisted only of making a series of trials with what appeared to be comparable material during the season. The results of these trials in terms of rooting and shooting are summarized in table 1.

Table 1. [illegible] of cuttings of [illegible] [illegible]

Date of preparation of cuttings	Number of cuttings	[illegible]	[illegible]
May 20	100	65.0	49.0
June 15	150	43.3	8.6
July 10	360	50.2	3.8
July 22	96	50.1	11.3
" "	150	75.0	1.4
" "	164	62.0	1.8
July 24	135	62.0	0.0
September 4	200	62.5	0.0
November 6	50	83.0	0.0

* Rooted cuttings were transplanted to [illegible] about 30 days later.

The table clearly shows that adequate shoot production occurred only during the first trial. In later trials root production was usually excellent while shoot production was too low. This problem was not associated with condition of the beds, as cuttings of other varieties rooted very well during the tests. Cuttings with roots but no [illegible] produced small tubers which continued to grow while the leaves of the cuttings lasted. When the leaves of the original cuttings died back, the small tubers stayed intact in the soil without germination. We are trying now to find ways of germinating these small tubers.

These results point clearly to the need of propagating [illegible] from stem cuttings very early in the season. This is especially true with respect to the difficult-to-root varieties.

[illegible]

[illegible] of yams for small tuber pieces.

[illegible]

Improved techniques are needed for propagating yams for [illegible] reasons. [illegible], the multiplication of [illegible] [illegible] [illegible] being [illegible] [illegible] small tuber [illegible].

The [illegible] cut [illegible] into [illegible] inch [illegible]. [illegible] then cut into pie shaped wedges about one inch wide. The narrow end of the wedge is then cut off and discarded.

The [illegible] or [illegible] blocks are then covered with a slurry of a fungicide. They are planted on wire screen in a moist chamber. The humidity is maintained in the chamber by daily sprays, and by [illegible] permit rapid evaporation from a pan below the chamber.

When pieces begin to germinate, they are removed from the [illegible] chamber and planted either in a [illegible] bed or directly in the field.

These techniques have been tried in a preliminary fashion with yams of Dioscorea alata. The yams were of different varieties and different states at the time of the trials. The cubes from different portions of the yam were separated for independent measurements of their capacity to germinate. In addition, some variations of techniques were also tried. Results are summarized in table 1.

Preliminary trials showed that cubes without epidermis could not germinate. Such data are not included here.

The cubes of yam germinated very well considering the difference in condition of the mother yams and the many variations in the trials. In comparison of two groups of the variety Peo, cubes not treated with fungicidal slurry germinated better than cubes so treated. One group of yams covered with sphagnum moss germinated very well. However, sphagnum moss does not seem to be essential for adequate germination. Two yams (Horn and Hunt) received from Barbados in poor condition did not germinate well. Horn, which germinated very poorly in these trials also germinated poorly in the field when conventional pieces were planted. Although some differences were encountered between head, middle and tail pieces, we could see no consistent trend in this respect.

Table 1. Germination of small cubes of *Dioscorea* tuber in moist chambers

Variety of mother tuber	State of mother tuber	Head pieces		Middle pieces		Tail pieces	
		Number tested	Percent success	Number tested	Percent success	Number tested	Percent success
Florido	Dormant	33	[illegible]	[illegible]	33	[illegible]	[illegible]
Forastero	Dormant	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Feo.	Ready to sprout	34	[illegible]	50	[illegible]	[illegible]	[illegible]
Feo[1]	Ready to sprout	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
De Palo[2]	Ready to sprout	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Horn	Stored, deteriorated	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hunt	Stored, deteriorated	12	92	47	17	[illegible]	[illegible]

1/ Without fungicidal slurry.
2/ In sphagnum moss.

[illegible] planted in [illegible] beds [illegible] were conducted [illegible] widely [illegible] a small [illegible]. [illegible] showing an sprouted [illegible] of [illegible] very [illegible], [illegible] of the Palo Alto. [illegible] attribute [illegible] to the [illegible] of [illegible]. [illegible] of La Palo [illegible] [illegible] [illegible]

2. Measure pH. Calculate necessary lime to adjust pH to 6.5 (depth of 6 inches), and distribute lime over the field.

3. Spread cashes over the soil at the rate of 2[illegible] yards per acre (this practice to be discontinued when [illegible] [illegible] [illegible] [illegible] [illegible] practice [illegible] to be unnecessary).

4. [illegible], [illegible] the soil into ridges [illegible] high, 2 feet wide, and 5 feet apart.

Preparing seed material.

1. At harvest time select seed material only from healthy plants. Seed that is damaged mechanically can be used, but it must be free of rot.

2. Permit the seed to cure under a few days of warm, humid conditions, but not exposed to the sun.

3. Store the seed in flats in a cool, well-ventilated space.

4. A few days before planting cut the seed yams into about 4-5 ounce pieces. Treat these pieces with a slurry of fungicide, and allow them to dry.

Making the planting.

1. Time planting to coincide with sprouting of seed pieces.

2. Lay out field in 100 foot rows.

3. Before planting place mineral fertilizer (10-5-20) in the rows, 8 inches deep, at the rate of 800-1000 lbs. per acre.

4. Plant pieces by hand or machine near the surface of the soil, 2 feet apart.

5. Treat soil with aerazine at the rate of 3 lbs per acre.

Staking the field (the system below not yet used).

1. After planting but before sprouting occurs construct staking system.

2. With tractor, dig 3-foot holes the size of principal support stakes at 100 foot intervals.

3. Place in these holes pressure-treated rot-resistant poles 9-10 feet in length. Brace these poles with shorter poles or by constructing "deadman".

4. [illegible] possible, and [illegible] the soil [illegible]

5. Place [illegible] stake [illegible] support [illegible]

6. When [illegible] to [illegible]

Maintaining the planting.

1. Control [illegible] by [illegible] applied with a [illegible] wand.

2. Watch for the occurrence of vines, and rogue strongly infested plants.

3. Watch for leaf spot disease, and spray entire planting with zineb when necessary.

4. Irrigate during prolonged dry periods.

Harvest.

1. Delay harvest until foliage dies back.

2. Cut vines at base.

3. Pull out support wires for storage.

4. Remove principal poles.

5. Clear field of vines, strings, and intermediate poles.

6. Lift yams with a deep moldboard plow.

7. Sort yams from soil and place in boxes.

8. Remove boxes from sun as quickly as possible, and take them to a hot, damp, area where curing can occur.

9. Sort and grade.

Jul. [illegible] 31, [illegible]

Cassava yield evaluation and preliminary selections.

L. C[illegible] and F. W. [illegible]

[illegible] cassava [illegible] from the [illegible] [illegible] [illegible] 250 [illegible] plants were [illegible] [illegible] included for [illegible]

[illegible] 12 months the [illegible] harvested. Yields are given in table 1 for the [illegible]. Large differences in yield were found. For the named varieties [illegible] the second, and results of the two [illegible] were compared. [illegible] comparisons were made with [illegible] from the [illegible]. Consistently high yielding varieties were selected for replicated yield trials.

Seedlings varied tremendously in vigor, tendency to flower and yield. The largest plants and those with a tendency to seed set were selected for yield trials with the varietal collection. The yields of these selected plants of only 7 months of age are expended on the trials. It is evident from our observations that the seedlings yield very well the first year. We wish to [illegible] if high yields are maintained in future trials.

Propagating sticks of all varieties were given to Dr. [illegible] Patiño for evaluation in the [illegible] collection, at Palmira, Colombia.

Table 1. Yields of cassava varieties at Las Mesas, Mayagüez

Second Test

Accession Number	Variety or Number	No. of plants	Average yield per plant (Kg)
14642	[illegible]	5	2.26
14643	Trinidad [illegible] 56	2	0.[illegible]
14644	Biña	5	1.76
14645	Pana Monasillo	2	3.01
14646	Pana Coronal	5	0.75
14647	Trinidad 14-56	2	0.45
14648	Seda	5	1.91
14650	Inglesa	2	0.74
14651	Amarilla	2	All rotted
14652	Trinidad 12-56	2	4.99
14653	Ceiba	2	5.05
14654	Venezolana	2	3.[illegible]
14655	Pata Palma	2	1.[illegible]
14656	Brazil	5	1.[illegible]
14657	Mameya	5	2.10

(Continued)

Table 1 (cont.)

Accession Number	Variety or Number	No. of plants	Average yield per plant (Kg)
[illegible]	[illegible]	5	1.48
[illegible]	[illegible]	2	1.48
1430[illegible]	#11 ([illegible])	2	2.41
1432[illegible]	#22 ([illegible])	2	1.19
14[illegible]	#4[illegible] ([illegible])	2	2.27
14[illegible]	#54 ([illegible])	2	2.21
14[illegible]	#70 ([illegible])	1	6.67
14342	#72 ([illegible])	2	4.31
14345	#10 ([illegible])	2	1.92
14348	#40 ([illegible])	2	1.05
14352	Black Stick	2	0.45
14353	Pana	2	5.05
14355	Tremancina	2	2.38

First Test

14763	9182	2	1.76
14764	9589	2	1.99
14765	9595	2	4.65
14766	9596	2	7.89
14767	9597	2	6.81
14768	9598	2	2.30
14769	9599	2	3.35
14770	9600	2	3.74
14771	9602	2	5.67
14772	9603	2	3.40
14773	9608	2	2.27
14774	9609	2	1.59
14775	9610	2	2.44
14776	9569	2	3.97
14777	9570	2	4.11
14778	9572	2	1.62
14779	9573	2	5.05
14780	9576	2	5.42
14781	9580	2	4.71
14782	9581	1	3.20
14783	9584	2	4.48
14784	9586	2	0.94
14785	9587	2	1.19
14786	9177	2	2.38
14787	9588	2	0.74
14789	9181	2	4.48
14790	95[illegible]	2	all rotted
14791	95[illegible]	2	3.39
14792	9583	2	4.82
14793	9176	2	1.62

(Continued)

Table 1 (con.)

Yield data on [illegible]

	Method [illegible]	[illegible]
Y-1	[illegible]	[illegible]
Y-2	[illegible]	[illegible]
Y-4	[illegible]	[illegible]
Y-6	[illegible]	[illegible]
Y-[illegible]	[illegible]	[illegible]
Y-[illegible]	[illegible]	[illegible]
Y-12	[illegible]	[illegible]

The cassava variety Blanera.

F. W. Martin

Although cassava is a generous source of calories, its protein content is generally a very low 1-2 percent. Therefore, wherever cassava is [illegible] upon as a staple food, nutritional diseases are common. To avoid such side effects, heavy diets of cassava should be supplemented by protein [illegible].

Recently a large number of varieties of cassava [illegible] protein content in Colombia. One of these, the variety [illegible] have a protein content of 6.7 percent or more (dry weight [illegible]). The yields of this variety have been high, as much as 72 [illegible] The roots mature 8 to 12 months after planting. To my knowledge, the relative amounts of the various amino acids have not yet been measured. The variety is low in hydrocyanic glucosides.

We have obtained the variety Blanera and find that it performs very well here in Puerto Rico. We anticipate tests of protein content and amino acid spectrum when roots are mature. Meanwhile, we are multiplying [illegible] cassava for further tests and for distribution.

Techniques adapted for measuring hydrocyanic glucoside content of cassava roots.

F. W. Martin and Ruth Roberts

The amount of hydrocyanic glucoside in cassava roots determines their edibility. If the amount is high, roots must be carefully processed before they are safe to eat. As part of the evaluation of our cassava collection we have adapted techniques from several sources, utilizing the existing equipment of the station to measure the hydrocyanic glucoside of roots. The technique depends on releasing the hydrocyanic acid from its sugars by autolysis, distilling the HCN into a base, and measuring the amount by a starch-iodine titration method. For future use of the technique, the details of the test are given below:

1. Use fresh tuberous root, or if frozen, thaw before use.

2. Remove the outer cortex (peel).
3. Weigh 12.5 grams of tuber, and cut the weighed portion into small pieces.
4. Grind the sample in a blender for 1-2 minutes with 50 ml. distilled water.
5. Pour the mixture into a 200 ml round bottom flask.
6. Wash out the blender with about 50 ml [illegible] water, and [illegible] into the flask.
7. Add to the flask 3 [illegible] and a [illegible] spray to suppress foam.
8. Place the flask in a heating jacket.
9. Attach to the flask a coil with a [illegible] tube extending [illegible] collection flask.
10. The collection flask is a long (10") test tube containing 15 ml 2.5% sodium hydroxide. The flexible tube from the sample attaches to a glass tube which reaches to the bottom of the test tube.
11. Wait 1 hour for autolysis to occur.
12. Adjust the rheostat controls of the heating jacket to the predetermined voltage level which leads to slow boiling. With our rheostat the adjustment is to 5%.
13. Permit about 15 ml of water to boil away from the sample [illegible], into the collecting tube.
14. Turn off the rheostat and immediately remove the tubing [illegible].
15. Allow the sample to cool.
16. Pour the collecting solution into a 125 ml flask.
17. Add a drop of phenophthalein.
18. Add 2N HCl until the red color disappears.
19. Add about 2-3 grams sodium bicarbonate to the flask until no further reaction (bubbling) occurs.
20. Add about 1 gram soluble starch to the flask.
21. Titrate with .01N iodine in N potassium iodide until a [illegible] blue color results.
22. Calculate HCN concentration:

HCN (mg/100 g cassava) = 4.32 x ml. of iodine solution used.

Hydrocyanic acid content of cassava varieties.

F. W. Martin and Ruth Ruberté

The majority of the cassava clones available in our present collection have now been tested for hydrocyanic acid content (table 1). It is well known that such content varies with area where plants are grown, and with region of the tuberous root tested. Thus, the measurements taken so far can only be regarded as preliminary. If hydrocyanic acid content of root is over 100 mg per 100 g, the root should be considered poisonous. Levels of 50 to 100 mg per 100 g suggest slightly poisonous roots. Lesser amounts of hydrocyanic acid are not considered dangerous if the cassava roots are properly cooked.

[illegible] December 31, 1950

Table 1. Hydrocyanic acid content (mg. per [illegible] of [illegible] of [illegible] varieties [illegible] [illegible] collection

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

One tenth of a gram of starch [illegible] sodium hydroxide, and boiled [illegible] of solution. [illegible] of the solution [illegible] To this is added [illegible] of a solution of [illegible] hydrogen [illegible] is added as a buffer. [illegible] tenths of [illegible] of a [illegible] 10 g KI in 500 ml H_2O) is also added. [illegible] the addition of water.

After [illegible] minutes color equilibrium [illegible] the color is measured against a [illegible] [illegible] at [illegible] mμ in the spectrophotometer. [illegible]

The percentages of amylose [illegible] yams, yautiaz, and [illegible] are given [illegible] percentages, running [illegible] 26 [illegible] starches themselves, which would affect digestibility. [illegible] these differences [illegible] starchy food crops. Unfortunately [illegible] characterized as a high amylose type.

With respect to the yams, the species D. [illegible], D. [illegible], and D. bulbifera all contained fair amounts of amylose. The amounts in D. esculenta (Pana, Papa) and D. trifida (Mapuey) were alarmingly low and suggest poor digestibility.

These preliminary, unreplicated observations suggest to us the importance of full characterizations of the starches of these [illegible]. We intend to evaluate in considerable detail [illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

1. [illegible]
2. [illegible]
3. [illegible]
4. Two buds were removed [illegible] plant, and were [illegible] pollinated the following morning in the laboratory. After 3 hours or more the stigmas were processed and pollen tubes per stigma were counted, as an index of self-fertility.
5. A single bud was removed from each plant. The following morning the flowers from a given plot were cross-pollinated in a random fashion, and pollen tubes per stigma were counted.

[illegible]

[illegible]

With [illegible] of [illegible]

[illegible] partially or fully [illegible] completely freely.

[illegible] as strong in the last [illegible] individual plant measurements were [illegible], it [illegible] pollen germination per stigma represented [illegible] increase of fertility of the partially fertile plants rather than the occurrence of self-fertility in plants that had previously been [illegible] incompatible.

Over 50 percent of [illegible] generation failed. In about 30 percent of the [illegible] only 1 or 2 pollen grains germinated. [illegible] than 20 [illegible] in the 6th and [illegible] the 3 sets of measurements [illegible] fertility increases somewhat with [illegible].

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* In this and [illegible] 3.0 [illegible] .6%.

[illegible] pollen [illegible] needle [illegible] 2 or 4 [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
III	.57	.38	.30	.74	.75	.83	1.42	1.36	3.46
IV	1.03	.33	.22	.5[illegible]	.72	.50	.36	[illegible]	2.34
IV	.19	.32	.35	.53	.54	2.50	1.20	[illegible]	[illegible]
V	.03	.78	.32	.34	.55	[illegible]	2.88	[illegible]	2.74
VI	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VII	.5[illegible]	.20	.27	2.2[illegible]	[illegible]	[illegible]	1.73	[illegible]	4.[illegible]
Mean	.50	.29	.25	.86	.45	3.39	1.34	7.31	3.85

* Only 3 [illegible] of measurements made.

Pod and seed production. Apparent differences among sets of measurements and among percentages of pods per flower were not significant (table 3). [illegible] flowers, rate of [illegible] decrease of [illegible] pollination produced more seed per open pollinated [illegible] in March [illegible].

Table 3. Pods per [illegible] and [illegible] fertilization of [illegible] of sweetpotato

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible] fertility [illegible] pod per plant [illegible] both [illegible] the seed set per [illegible], one [illegible] fertility, [illegible] to obtain an index of [illegible] fertility. Thus, [illegible] 6 [illegible] measures [illegible] obtained (Table [illegible]) .41, .34, .45, .[illegible], .[illegible], 1.32. These calculations [illegible] to indicate the [illegible] pollination, the total fertility [illegible].

[illegible] pollination [illegible] six generations [illegible] increase [illegible] fertility, indicating compatibility [illegible] fertility. The fact that [illegible] did not provide a [illegible] to evaluate the sterility and [illegible] compatibility [illegible] to expect the [illegible] to [illegible] fertility, measured [illegible] may be the cause for the rapid development of more fertile sweetpotato populations.

The results of this study have been prepared for publication.

[illegible]

[illegible]

[illegible]

[illegible]

Recently Dr. S. F. Chest of the University of London, England, has reported [illegible]

While our experiments [illegible] ready for [illegible] from asymptomatic plants which originated from seeds kept in an [illegible] greenhouse. Six [illegible] of these plants contained virus particles. It is possible that the virus present, [illegible] to be detected by the dip method [illegible], or the virus may be spherical and therefore not easily observed by this technique. It is however of note that [illegible] able to observe elongated particles in leaves from plants [illegible] which contained a low concentration of the virus (and no symptoms). We found this [illegible] morphologically related to known [illegible] viruses of cassava, and usually elongated viruses lend themselves to observation in the electron microscope by the dip method. Further work is in progress.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Table 3. Virus-free [illegible] of chrysanthemum which [illegible] the NPT collection, [illegible]

Acc. No.	Ratio[1/]	Acc. No.	Ratio[1/]	Acc. No.	Ratio[1/]
15[illegible]	5/5	15085	0/5	[illegible]	0/7
15[illegible]	2/2	15[illegible]	0/2	[illegible]	0/[illegible]
15[illegible]	0/3	8	2/4	[illegible]	[illegible]
15211	0/2	15080	16/[illegible]	15[illegible]	0/[illegible]
15[illegible]	0/5	15086	0/10	15146	[illegible]
15[illegible]	3/3	3	1/7	15109	2/5
[illegible]	[illegible]	[illegible]	42/42	[illegible]	[illegible]
15[illegible]7	[illegible]	[illegible]	2/11	[illegible]	1/3
15[illegible]08	2/2	15[illegible]	0/10	[illegible]	[illegible]
15207	1/1	15134	2/13	[illegible]	1/9
15216	1/2	1	0/13	[illegible]	0/[illegible]
15234	0/2	15[illegible]	0/9	[illegible]	[illegible]
[illegible]	0/5	15125	3/2	[illegible]	0/[illegible]
[illegible]	0/[illegible]	[illegible]	[illegible]	[illegible]	1/[illegible]
15	0/13	15[illegible]	0/2	7	1/6
016	0/5	15135	1/1	15190	11/48
15	2/3	15127	0/6		
14	0/4	14[illegible]	0/[illegible]		
[illegible]	1/4	15087	6/6		
5	11/11	15135	4/4		
9	0/3	15131	7/7		
10	0/10	2	0/22		
11	4/10	15200	0/4		
12	1/3	15082	0/7		
4	0/7	[illegible]	7/[illegible]		
15130	2/2	[illegible]	1/7		

1/ Ratio of diseased/total plants.

[illegible]

[illegible] Subgrafting (UgB) [illegible]

[illegible]

1.	[illegible] (D. [illegible])	0/15,5/[illegible],10/[illegible] 1/	[illegible] 2/	[illegible]	[illegible]
2.	Morado (D. [illegible])	8/1[illegible],23/[illegible],0/12,[illegible] 10/2[illegible]	+,[illegible],++,+	"	[illegible]
3.	Coconut [illegible] (D. [illegible])	0/1[illegible],5/23,2/[illegible]	+,[illegible]	"	[illegible]
4.	Oriental (D. [illegible])	4/11,1/[illegible],0/[illegible]	+,[illegible]	"	[illegible]
5.	Barbados (D. [illegible])	16/21,[illegible],10/[illegible],1[illegible] 6/7	[illegible]	"	"
6.	Smooth [illegible] (D. [illegible])	15/[illegible],9/12,6/6,[illegible]	+,[illegible],+,+	"	[illegible]
7.	[illegible] (D. [illegible])	5/5,10/[illegible],5[illegible],3/[illegible] 12/[illegible]	0,[illegible],+,0,[illegible]	Very slight	Very slight
8.	Florida (D. [illegible])	9/[illegible],0/[illegible],6/[illegible],0/[illegible]	+,[illegible],+,6	Slight	[illegible]
9.	Farm Lisbon (D. [illegible])	0/23,0/25,0/23	+,+,++	Very slight	Slight
[illegible]	Napuey (D. [illegible])	14/[illegible] (not [illegible])	+	Slight	[illegible]

1/ 0/15 = no plants with symptoms, of a total of 15 inspected.
2/ + = very light infection, ++ = light infection.

[illegible]

[illegible]

[illegible]

July 1 [illegible]

[illegible] the plantings [illegible] healthy [illegible] plants [illegible]

[illegible]

[illegible] Florida.

Table 1. [illegible]

Inoculation 1/	[illegible]
1. [illegible] Amarillo [illegible] Acc. No. 147	5/14 2/ stunt slight, [illegible] veinal chlorosis
2. [illegible] Inglaza Acc. No. [illegible]	8/14 stunt slight, systemic, leaf [illegible] veinal chlorosis
3. [illegible] Cayman Acc. No. [illegible]	[illegible] stunt slight, systemic, [illegible] veinal chlorosis
4. [illegible] Base Acc. No. [illegible]	5/[illegible] stunt slight, systemic, leaf [illegible] veinal chlorosis

1/ Symptoms: 1 = whole leaf wrinkled, 2 = whole leaf wrinkled, 3 = chlorotic stripes on leaves, 4 = no symptoms.

2/ 9/14 = 9 infected plants of a total of 14 plants inoculated. All 25 plants not inoculated were without symptoms.

Continued

Table 2 (con.)

Accession	Observations: Virus 1	Virus 2	Fungus 1	Fungus 2	Accession	Observations: Virus 1	Virus 2	Fungus 1	Fungus 2
14885	-	-	-	+	14810	-	+	+	++
14916	-(?)	-	-	-	14811	+	+	+	+
L68-144	-	dead	+	dead	14812	++	++	++	++
L68-142	-	-	+	-	14813	+	+	++	++
14794	-	+	+	+	22	-	+	+	+
14795	?	+	+++	+++	V. violaceum	-	-	-	+
14796	-	+	+++	+++	Barenta	-	-	-	+
14797	-	+	+	++	Canea	-	-	++	++
14801	-	+	+	+	Luz blanca	-	+	++	++
14800	-	-	+++	+	Las Mesas	+	++	+	+++
14799	-	+	++	++	LM59-66	+	+	+	++
14798	+	+	+	+					
14802	-	++	+++	++					
14803	+	++	+++	+++					
14804	+	++	+++	+++					

Readings are of observations made 5 and 7 months after planting.
- = negative + = mild ++ = moderate +++ = severe.

As can be seen in table 2, in some readings of virus symptoms lines seemed to be affected less strongly or not at all in the last field observations. Other lines expressed symptoms of virus infection in the latter part of the season. The classification of virus and fungus infection refers to the total group of plants for each introduction. There was usually large variations in symptom expression among the plants of each introduction.

Time of tuberization and normal season of growth of leren.

P. W. Martin and E. Cabanillas

Leren (Calathea allonia) is planted near the beginning of the rainy season and harvested after the foliage dies during the dry season. Therefore, the tuberous roots are normally harvested from December to March and are not available for the rest of the year. This year, in order to observe time of tuber formation we dug plants once a month beginning in September and continuing until the following June. From these observations we can make some generalizations about the normal growth cycle and time of tuberization. After digging the plants, we divided them into offshoots and replanted them in plastic bags near the greenhouse, where they were watered regularly. In so doing we stimulated development of offshoots and produced lerens out of season.

Normal [illegible] during the dry season [illegible] [illegible] left in the ground until time [illegible], or can be harvested and stored in a cool area. [illegible] their [illegible] quality if left in the ground. However, with [illegible] of [illegible] plants begin to germinate. [illegible] divided [illegible] [illegible]

[illegible] the rainy [illegible] of [illegible] [illegible] in competition [illegible]. Tuberization [illegible] be seen as an enlargement of the [illegible] of the [illegible] from the offset or corm. Tuberization proceeds rapidly, so that [illegible] edible tubers are ready in [illegible]. [illegible] the plants, tuberization, including the production of new [illegible], continues through [illegible]. We do not [illegible] continuously [illegible] become [illegible], but [illegible] the dry [illegible] willing, yellowing and [illegible] of the plants. [illegible] to be a normal [illegible]. Once the plants are dormant [illegible] tuberization occurs.

During the 1969-70 season the plants went dormant in December [illegible] to a very early drought. Yields were therefore only about 150 grams of tuber per plant, compared to about 750 grams the year before. We [illegible] these yields are not acceptable from a crop plant, even when it is a specialty crop such as loren. Yields of plants grown in partial shade were about the same as those of plants grown in the sun.

Abnormal seasons of growth. All of the plants [illegible] from offshoots after harvest began to grow again. However, each group [illegible] different dormancy and tuberization behavior. Observations of the [illegible] are summarized in table 1. From these observations [illegible] generalization can be made.

Plants normally pass through a period of [illegible] dormancy. The time and length of the dormancy can be modified by digging and dividing the plants at an appropriate time. If dug just before natural dormancy begins, the offsets germinate without passing through dormancy. Normal time to germinate of the corm is about 4 weeks.

Upon replanting of corms, the new plants may tuberize. The actual amount of tuberization per offset may be far higher than that of the undisturbed plants. We consider mid-November the most appropriate time for division of the clump. After dormancy has begun the offshoots will germinate but will not tuberize. Once replanted, loren requires frequent watering. The tuberous roots produced by offshoots tend to develop later than those of normal plants. Thus, excellent tubers may be obtained at least until mid-June.

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 64

1. SUBJECT CLASSIFICATION

A. PRIMARY
Food production and nutrition — AF30-1500-GG50

B. SECONDARY
Plant breeding--Root vegetables--Tropics

2. TITLE AND SUBTITLE
Tropical food crops; yams,cassava,root crops,arrowroots

3. AUTHOR(S)
Martin,F.W.; Ruberte,R.M.; Rodriguez-Arias,Jaime; Cabanillas,E.; Jones,Alfred

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	46p.	ARC 631.5.M379

7. REFERENCE ORGANIZATION NAME AND ADDRESS
USDA/ARS

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In Tropical food crops,July-Dec.1971,p.109-152)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAE-037

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Arrowroots
Cassava
Data
Root crops
Varieties
Yams
Yield

13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA (AJ)-2-69 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

THIS DOCUMENT HAS BEEN EVALUATED AS SUBSTANDARD COPY FOR ROUTINE REPRODUCTION. EFFORTS IN AID/W TO OBTAIN A MORE ACCEPTABLE COPY OF THE DOCUMENT HAVE NOT BEEN SUCCESSFUL. DESPITE THIS DISADVANTAGE, WE HAVE CHOSEN TO REPRODUCE THE DOCUMENT BECAUSE OF THE SUBJECT TREATED AND TO MAKE THE DISCERNIBLE INFORMATION AVAILABLE.

631.5
M379

PASA (AID)-2-69 G75 USDA/ARS
PN-AAE-037

TROPICAL FOOD CROPS

Identification of varieties of *Dioscorea alata* from characteristics of the foliage

F. W. Martin

Our collection of yams now includes 51 accessions of the species *Dioscorea alata*, which belong to 30 to 35 varieties. Casual observations reveal considerable variation not only in characteristics of the tuber, but also in those of the foliage. We suspect this variation represents only part of that of the species as a whole. We need to characterize and classify varieties of *Dioscorea alata* not only to identify them, but also to document their interrelationships.

A series of vegetative characteristics in which varietal differences were observed is given in table 1. This list does not include late-season characteristics, such as disease susceptibilities, characteristics of the aerial tuber, and time of dormancy (to be reported later). Except where noted we have rated these characteristics on the basis of mature foliage. Not all traits were equally easy to rate because differences occurred even on the same plant. But we have not yet tried to compare the relative value of the different kinds of observations.

Table 1. Vegetative characteristics of *Dioscorea alata* accessions measured or rated

Number	Characteristics	Method of rating
1-11	Anthocyanin intensity of new stem, old stem, new wings, old wings, petiole wings, lower petiole, upper petiole, vein junction, veins of leaf, margin of leaves, new leaves	All rated on a scale of 0-3
12	Mean anthocyanin content	Sum of all anthocyanin ratings/11
13	Angle of basal veins	Angles estimated at 15°
14	Bluntness of lobes	Scale 1-3
15	Development of tail at tip of leaf	Scale 1-3
16	Widest region of leaf	1 = between tip and petiole junction 2 = through petiole junction 3 = between petiole junction and lobes

A.I.D.
Reference Center
Room 1656 NS

Table 1 (continued)

Number	Characteristic	Method of rating
1-17	Green color intensity of leaf	Scale 1-3
18	Rugosity of leaf	Scale 1-3
19	Leathery feel of leaf	Scale 1-3
20	Damage due to leaf spot	Scale 1-3
21	Damage due to virus	Scale 1-3
22	Development of spines	Scale 0-3
23	Development of wings	Scale 1-3
24	Average stems from tuber	Scale 1-3
25	Tendency for young stem to branch	Scale 0-3
26	Size of stomata	Measured
27	Internode length	Measured
28	Petiole length	Measured
29	Leaf blade length	Measured
30	Leaf blade width	Measured
31	Leaf lobe length	Measured
32	Internode index	Internode length/blade length
33	Petiole index	Petiole length/blade length
34	Width index	Blade width/blade length
35	Lobe index	Lobe length/blade length

Differences that were rated, usually on a scale of 0 (absence) to 3, were often distributed in an approximately normal curve (table 2). However, other differences were distributed hyberbolically.

Measurements of leaf and stem characteristics were used to calculate relative lengths and widths by dividing the measurement in question by the leaf length. Such relative measurements are usually more reliable than direct measurements. The measurements and indices were distributed in an apparently normal fashion (table 3).

Table 2. Distribution of varieties by ratings of vegetative characteristics

Characteristic	Ratings* 0	1	2	3
Color characteristics:				
Anthocyanin intensity in:				
New stem	34.5	15.5	1	0
Old stem	14.5	31.5	4.5	.5
New wing	34.5	15.5	1	0
Old wing	4.5	26.5	18.5	1.5
Petiole wing	18.5	24.5	9	0
Lower petiole	16	9	7.5	18.5
Upper petiole	25	15	6	5
Vein source	33.5	10.5	4	3
Leaf veins	49	3	0	0
Leaf margins	49	2	0	0
Young leaves	25	6	5	15
Mean anthocyanin content	13	16.5	14	2.5
Leaf characteristics:				
Bluntness of lobes		13.5	32	5.5
Development of tail		6.5	27.5	17
Widest region		40	6	5
Green color intensity		1	31.5	18.5
Roughness of surface		19.5	29.5	0
Leatheryness		1.5	26.5	23
Leaf spot incidence (first observation)	6	27	13	5
Virus incidence (first observation)	20	20	8	3
Stem characteristics:				
Spine development	46	2	15	1.5
Wing development		7	17	27
Emergence of stems		13	15	23
Branching of stems	13	14	17	7

* Intermediate ratings were divided among higher and lower categories.

When we complete observations with late season data, and from measurements and ratings of tubers, we expect to work out the interrelationships of the accessions by computer techniques. In this respect Dr. A. E. Rhodes of Illinois will be cooperating with us.

Meanwhile, we have used the data to classify accessions on the basis of their outstanding characteristics. The technique used was to find from the distribution data the characteristic, for which each accession represented an extreme. From these characteristics a key was constructed to identify accessions in the field. However, not all accessions can be distinguished from each other by foliage characteristics alone. The key is included in this report.

One set of characteristics was found to hang together and to divide the species into 2 more or less recognizable groups, as follows:

Group I - Common	Group II - Variant
1. Wings normal	1. Wings subdued
2. Stems not normally thorny	2. Stems somewhat thorny
3. Bulk of anthocyanins not in stem	3. Bulk of anthocyanins in stem
4. Widest part of leaves usually not through lobes	4. Widest part of leaves usually through lobes
5. Stem relatively thick	5. Stem relatively thin

Provisional key to the cultivars of *Dioscorea alata* using characteristics of the foliage

1. Wings of stem reduced in size, inconspicuous, not ruffled. Lower stem usually thorny.

   A. Leaves broad, sinus broad, angle of basal veins 100° or more, lower stem anthocyanin noticed.

      1. Vein source pink, lower petiole red, anthocyanin coloration high.

         a. Leaves large, dark green, thorns common.

            15205 Unnamed (India)

         b. Leaves small, light green, thorns rare.

            15211 Unnamed (India)

      2. Vein source green, lower petiole tinged pink, anthocyanin coloration low.

         a. Lower stem very spiny, upper stem often spiny, bulbils form early. 15210 Unnamed (India)

Table 7. Distribution of measurements and indices of vegetative characteristics

Size of Sporate (g)	Distribution	23-249 5	25-269 21	27-289 7	29-309 7	31-329 2	33-349 7	35-369 3
Length of internode (mm)	Classes Distribution	70-99 4	100-129 1[illegible]	130-159 13	160-189 12	190-219 8	220-249 4	
Length of petiole (mm)	Classes Distribution	40-59 2	60-79 1	80-99 8	100-119 11	120-139 9	140-159 13	160-179 8
Length of blade (mm)	Classes Distribution	80-99 2	100-119 2	120-139 7	140-159 9	160-179 18	180-199 12	200-219 1
Length of lobe (mm)	Classes Distribution	20-29 2	30-39 3	40-49 12	50-59 17	60-69 [illegible]	70-79 4	80-89 4
Width of blade (mm)	Classes Distribution	60-79 1	80-99 4	100-119 12	120-139 18	140-159 7	160-179 7	180-199 2
Angle of basal veins (terminated, degrees)	Classes Distribution	45 4	60 2	75 15	90 17	105 0	120 2	135 11
Internode length/blade length	Classes Distribution	.50-.69 6	.70-.79 4	.80-.89 6	.90-.99 13	1.00-1.09 9	1.10-1.19 3	1.20-1.49 10
Petiole length/blade length	Classes Distribution	.50-.59 5	.60-.69 6	.70-.79 18	.80-.89 11	.90-.99 8	1.00-1.09 2	1.10-1.19 1
Lobe length/blade length	Classes Distribution	.20-.24 5	.25-.29 10	.30-.34 11	.35-.39 14	.40-.44 6	.45-.49 3	.50-.54 2
Blade width/blade length	Classes Distribution	.50-.59 2	.60-.69 10	.70-.79 10	.80-.89 13	.90-.99 12	1.00-1.09 3	1.10-1.19 1

b. Lower stem not very spiny. Upper stem usually not spiny, bulbils form late. 15200 Feo

B. Leaves clearly longer than broad, sinus intermediate, angle of basal veins 90° or less, lower stem not strongly mottled, no thorns. 15218 [illegible]

II. Wings of stem prominent, often ruffled. Lower stem thorny only in very large plants.

A. Foliage chiefly green with very little anthocyanin coloration. Wings of lower stem pink. Wings of upper stem and petiole often tinged, lower extreme of petiole sometimes tinged with red.

1. Large-leafed, very vigorous varieties.

a. Sinus wide, angle of basal veins more than 100° overall shape of leaf not usually oval.

(1) Leaves often wider through lobes than through blade, hastate, very dark green. 15[illegible], 15324, 15327, Florida

(2) Leaves usually wider through blade than through lobes. Leaves dark to medium. Not hastate. Rugose at vein junction.

(a) Lobes strongly right angled. 15340 Forastero

(b) Lobes not strongly right angled, not rugose at vein junction, lobes short. 15394 Hunte

b. Sinus not as wide, usually angle of basal veins 90° or less, overall shape of leaves oval.

(1) Sinus narrow, angle of basal veins about 45°. Leaves light green, lobes overlapping, lower part of petiole yellowish. 15325 Hawaii

(2) Sinus medium, angle of basal veins about 90°.

(a) Leaves very large, sometimes narrow lobes strongly pointed (60°), do not overlap. 15205 Unnamed (India)

When we complete observations with late season data, and from measurements and ratings of tubers, we expect to work out the inter-relationships of the accessions by computer technique. In this respect Dr. A. E. Rhodes of Illinois will be cooperating with us.

Meanwhile, we have used the data to classify accessions on the basis of their outstanding characteristics. The technique was to find from the distribution data the characteristics for which each accession represented an extreme. From these characteristics a key was constructed to identify accessions in the field. However, not all accessions could be distinguished from each other by foliage characteristics alone. The key is included in this report.

One set of characteristics was found to hang together and to divide the species into 2 more or less recognizable groups, as follows:

Group I - Common	Group II - Variant
1. Wings normal	1. Wings reduced
2. Stems not normally thorny	2. Stems somewhat thorny
3. Bulk of anthocyanins not in stem	3. Bulk of anthocyanins in stem
4. Widest part of leaves usually not through lobes	4. Widest part of leaves usually through lobes
5. Stem relatively thick	5. Stem relatively thin

Provisional key to the cultivars of *Dioscorea alata* using characteristics of the foliage

1. Wings of stem reduced in size, inconspicuous, not ruffled. Lower stem usually thorny.

   A. Leaves broad, sinus broad, angle of basal veins 100° or more, lower stem anthocyanin mottled.

      1. Vein source pink, lower petiole red, anthocyanin coloration high.

         a. Leaves large, dark green, thorns common.

            15206 Unnamed (India)

         b. Leaves small, light green, thorns rare.

            15211 Unnamed (India)

      2. Vein source green, lower petiole tinged pink, anthocyanin coloration low.

         a. Lower stem very spiny, upper stem often spiny, bulbils form early. 15210 Unnamed (India)

(b) Leaves, large, not narrow, lobes blunt, often overlapping. 15[illegible] [illegible] Yellow

2. Vigor and leaf size intermediate. Leaves [illegible] medium green to yellowish. Sinus [illegible] of basal lobes about 90°, lobes somewhat [illegible], angle of sides [illegible].

a. Varieties with similar foliage, lower part of petiole green.

15[illegible] [illegible]
15130 Seal Top White
15131 Smooth [illegible]
15135 Seal Top Yellow
15343 Barbados
15393 Boro

b. Varieties with similar foliage, lower part of petiole irregularly tinged with pink.

15127 Bottleneck Lisbon
14866 Unidentified, Lisbon type
15126 Harper
15134 Farm Lisbon
15344 [illegible] Lisbon

B. Anthocyanin content high, lower extreme of petiole red.

1. Extremely red varieties. Vein source pink or red, veins and leaf margins often tinted. Upper portion of petiole always red.

a. Sinus narrow, angle of basal veins about 45°.

(1) Lobes wide angled, 75°. Large, vigorous varieties, veins usually pink.

15083 Macorfa
15201 Rojo Silvestre

(a) Lobes narrow, angled, 45-50°. Variable vigor, veins usually only tinged.

14860 Morado
14863 Vino A
14864 Vino B
14865 Vino C
15082 Lisbon Purple

b. Sinus wide, angled basal veins about 135°.

15345 Stout

2. Red varieties. Vein source usually green, veins and leaf margins seldom tinged. Upper extreme of petiole not red, but sometimes pink.

a. Upper extreme of petiole pink.

(1) Wings poorly developed, wide sinus, angle of basal veins [illegible] or more, [illegible] small. 15128 [illegible]

(2) Wings well developed. Leaves [illegible]

(a) Thick, dark green leaves. Wide sinus.
15202 Unnamed (India)
15207 Unnamed (India)
15209 Unnamed (India)

(b) Normal leaves. 15345 Sweet

b. Upper extreme of petiole either green or only tinged with anthocyanin. Wings well developed, large, vigorous native varieties.

14857 [illegible]
14852 [illegible]
15199 Del Monte
15140 Wild
15332 Wild
15334 Wild
15335 Wild
15336 Wild
15337 Wild
15339 Wild

The esterases and peroxidases of shoot tips of yams.

F. W. Martin and Ruth Ruberté

Among the problems we face with the edible yams is learning to recognize them from their above ground characteristics (see discussion above). Because isozymes tend to vary among varieties we have considered the possibility of demonstrating varietal differences by differences in their isozyme contents. The most useful and simplest enzyme systems to study, peroxidases and esterases, were studied in these tests.

Preliminary trials revealed that peroxidases were weak in the first half-inch of the growing tip of the vine. They were stronger in the regions from 1/2 to 1 inch and from 1 to 2 inches from the tip. However, young leaves of from 1/2 to 1 1/2 inches in length were the best sources of peroxidases. Such leaves contained not only enzyme bands of the stem, but also bands unique to the leaf. Esterase bands were somewhat different

in shoot tips and leaves. Young leaves were selected for the tests of peroxidase. Both leaves and shoot tips were used for the [illegible] tests. Although these were used fresh, tests showed that they could be frozen 1 or 2 days without loss of enzyme activity.

A total of 2 accessions of D. trifida, 4 of D. bulbifera, 4 of D. esculenta, 5 of D. rotundata and [illegible] of D. alata were compared [illegible] cases 2 staples were tested at different [illegible] to calculate Rf, and were judged on a scale of 1-3 for intensity [illegible] cases a shadow (darkened but not properly stained) [illegible] where bands were expected. This was [illegible].

Species showed characteristic reportable differences in peroxidases that were sufficiently marked to distinguish them (table 1). Varieties within species showed only minor differences, chiefly due to variations in intensity of particular bands.

Table 1. Principle peroxidase bands, their typical Rf's, and intensities (scale of 0, ?, 1, 2, and 3) in zymograms of young leaves of Dioscorea species

Species	Rf's of Band							
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D. trifida	0	0	0	1	0	0-1	0	0
D. bulbifera	0	0	0	0-1	0-1	0	0-1	0
D. esculenta	0-1	0	0	1-2	1	0	0	1-2
D. rotundata	?	0	3	0	1	0-1	0	0
D. alata	0-2	0-3	0	1-3	0	0	0-3	0

* A negative sign indicates movement of band toward negative pole.

Esterase bands of shoot tips were fairly strong except in D. trifida and D. alata (table 2). D. esculenta and D. bulbifera showed similar isozyme patterns. This reinforced our opinion of their close relationship. The other species showed distinctive patterns but nevertheless individual bands were identical in various cases. Dioscorea alata varieties showed weak but definite banding differences. These were not strong enough to characterize or distinguish varieties.

Table 2. Principal esterase bands, their typical Rf's and intensities (scale of 0, ?, 1, 2 and 3) in zymograms of shoot tips of *Dioscorea* species

Species	Rf of bands				
	-12	12	48	80	92
D. trifida	0	0	0	0-?	0
D. bulbifera	0	2-3	1-2	?	0
D. esculenta	0	3	2	?	0
D. rotundata	1-2	0	0	0	0
D. alata	1	0	0	?	1

The young leaves of the species showed esterase enzyme patterns distinct from those of the shoot tips (table 3). Again, esterase bands of *D. alata* were rather weak, but varietal differences were sometimes suggested. The species were quite different except for *D. bulbifera* and *D. esculenta*, which again showed similar patterns.

Table 3. Principal esterase bands, their typical Rf's and intensities (scale of 0, ?, 1, 2, and 3) in zymograms of young leaves of *Dioscorea* species

Species	Rf of Bands				
	-16	-12	8	55*	93
D. trifida	0	0	0	0	0
D. bulbifera	0	0	0-1	1-2	0
D. esculenta	0	0	0-1	1-2	0
D. rotundata	1	0	0	0	0
D. alata	0	0-2	0	0-2	0-1

* Sometimes multiple bands.

Anthocyanins of the foliage of yams.

Jaime Rodríguez-Arias, Ruth Ruberté and Franklin W. Martin

Varieties of the water yam, *Dioscorea alata*, can sometimes be distinguished by the characteristics of their foliage, including size, shape and rugosity of the leaf. In addition, the quantity and distribution of anthocyanins in the foliage is sometimes of diagnostic value. Our observations have suggested variations in the kind of red coloration itself, which appear to be due to differences in anthocyanin pigmentation. We have extracted and

partially identified these pigments to see if they help us in the problem of classifying and identifying varieties.

Anthocyanins are frequently found in the cortex or flesh of the tuber, where they impart red or purple colors. In the case of [illegible] investigated, the pigment was identified as cyanidin-3,5 diglucoside (Harper and Conway, 1957, Experientia 23:511). Other pigments were present in lesser quantities.

All Dioscorea alata varieties maintained in the collection of the Federal Experiment Station were selected for study (table 1). The [illegible] tissue was ground in methanol containing 0.1% concentrated HCl, and was then partially evaporated for chromatographing on Whatman #4 paper with three solvent systems (1, 2, and 3, table 2). After screening of varieties, 2 were selected that contained different pigments. The RF's of these pigments were determined in 5 solvent systems by replicated trials. The pigments were eluted from paper chromatograms with methanol containing 0.1% HCl, and light absorption was measured with a spectrophotometer in both visible and U.V. regions.

Table 1. Varieties of Dioscorea alata screened for anthocyanin pigment

	Pigments present		
None	A	B	A and B
Barbados	Macorís	15202 (India)	Moredo
Forastero	Florido	15206 (India)	Ashmore White
Smooth Statia White	Harpers	15208 (India)	Vino A
Smooth Statia Yellow	Ashmore Yellow	15209 (India)	Vino B
Hawaii	Oriental	15210 (India)	Vino C
Seal Top Yellow	Farm Lisbon		De Agua
Seal Top White	Sweet		Lisbon Purple
	Horn		Del Monte
	Hunt		Feo
	Wild #15334		Wild Red
			15207 (India)
			15211 (India)
			15212 (India)
			De Palo
			7 wild yams

Table 2. Rf values of anthocyanins removed from yar foliage.

Number		Compound A	Compound B	Anthocyanidin
1	N-butanol:acetic acid:water (4:1:5)	.149	.226	.715
2	N-butanol:2N HCl (1:1)	.055	.063	.693
3	Water:concentrated HCl (37:3)	.226	.[illegible]	--
4	Acetic acid:conc. HCl:water ([illegible]:1:5)	.[illegible]	.829	.346
5	Ethyl acetate:formic acid:water (14:3:3)*	.182	.211	--
6	Acetic acid:conc. HCl:water (30:3:10)	--	--	.516
7	Formic acid:conc. HCl:water (5:2:3)	--	--	.228

* Separation on silica gel thin layers.

Other eluants were hydrolyzed in N HCl for one hour in a boiling water bath. The hydrolysis mixture was extracted with amyl alcohol. The amyl fraction was rechromatographed in 5 solvent systems, and the anthocyanidin was eluted for spectral measurements. Meanwhile, the aqueous fraction was concentrated and used to determine sugar present. The sugars were determined by comparison to colors and Rfs of standards separated on boron-impregnated plates by one solvent system.

The compounds were provisionally identified by comparison to published data.

Two anthocyanin pigments, called A and B, were found. Their presence varied with variety (table 1). The Rf values of the two anthocyanins, A and B, were sufficiently similar that the pigments could be completely separated only by two of the solvent systems, and partially separated by the others (table 2). The pigments, when eluted from paper chromatograms, absorbed visible light at about 530-533 mμ, and UV at about 328-330 and 288-289 mμ. The absorption of light at 328-330 mu indicates the presence of an acyl group attached to the sugar, which is either caffeic or ferulic acid.

The eluted pigments in N HCl solution resisted hydrolysis. Generally, two hours were required for a complete reaction.

The amyl fraction from both pigments contained a single magenta anthocyanidin. This pigment absorbed light at 535-540 mμ, depending on the amount of amyl alcohol retained in the final solvent preparation. When excess acid was carefully removed to give a pH of 2 or more, then the peak absorption was changed to about 558 after a few drops of ethanolic $AlCl_3$

were added to the solution. The color of the solution was changed to a purplish blue. The Rf values of the anthocyanidin (table 2) closely approximate published Rf values for cyanidin.

On the basis of color, absorption of light and Rf values the evidence overwhelmingly suggests that the anthocyanidin of [illegible] is cyanidin.

Tests for the sugars split from the anthocyanins released by hydrolysis are summarized in table 3. The Rf's for the sugars from the two compounds are similar. The values which most closely [illegible] those of [illegible] but are not far removed from those of glucose and fructose. The [illegible] reagent used, aniline phthalate, does not distinguish between these particular sugars by giving a differential color response.

Table 3. Rf values of reference sugars and sugars released from anthocyanins by hydrolysis*

Sugar or source of sugar	Rf
Ribose	.75
Fructose	.65
Arabinose	.77
Galactose	.69
Glucose	.72
Rhamnose	.78
Xylose	.76
A (hydrolysis mixture)	.67
B (hydrolysis mixture)	.68

* Separated on boron-impregnated silica gel G by methyl ethyl ketone:acetic acid:ethanol (3:1:1).

Up to this time it has not been possible to make a final identification of the two anthocyanins. Twenty-two glycosides of cyanidin have been described. Comparison of the Rf's with those of our compounds does not permit even a tentative identification. Our compounds are different from those described in the tuber by Pepper and Cooney. Acylated glycosides of cyanidin have only been described in a few plants. Our compounds are not identical to those described. It appears, therefore, that the anthocyanins of the foliage of yams are new and as yet undescribed compounds.

To complete the identification of the anthocyanins is a somewhat sophisticated task requiring very carefully controlled and replicated experiments. If we can obtain the use of a recording spectrophotometer we should be able to accomplish this task. We need also to obtain other sugars for reference purposes, and make a more thorough identification of sugars. Finally, both the kind and number of phenolic acid attached to the sugars (acyl group) needs to be determined.

Propagation of yams from stem cuttings.

A. Cabanillas and F. W. Martin

Generally, the edible yams, *Dioscorea alata*, *escolanta*, and *rotundata*, are propagated by pieces of the upper portion (head pieces) of the tubers, but when seed is scarce or an increased planting [illegible] whole tubers are cut in big pieces and used as propagating material. This reduces marketable yield. A satisfactory method of propagation from stem cuttings would therefore be useful. We have made some tests, [illegible] reported general observations (this report, p.2, 4). More detailed information is shown here.

Vines were cut in the field, covered with wet burlap bags to prevent excessive drying, and brought to the greenhouse. The stems were cut about 2-3 inches in length with the node in the middle. The cuttings were immediately placed in the gravel beds under the mist sprayer.

The following observations of a general nature were made in this preliminary trial: Callus tissue appears in the axle of the leaf. This forms one or two very small tubers. Roots develop from this tissue at about 20 to 25 days and are ready to be removed from the gravel bed 5 or 10 days later. Shoots usually grow later. Stem cuttings can be made from the whole length of the vine except from the last 18 to 20 inches of the tender growing tips (table 1). Cuttings from base, middle and top were made in the usual way. The last portion or tender tip of about 8-10 inches was planted whole.

Table 1. Comparative rooting ability of cutting from different portions of the stem, and of shoot tips

Portion of stem	Cuttings	Rooted	Rooted with tubers	No roots	Dead	Percent rooting
Base	46	20	16	8	2	78.2
Middle	47	15	26	4	2	87.2
Tops	60	23	18	17	2	68.3
Tips (12-15 inches)	47	10	-	-	37	11.2

Leaves should be whole and without insect damage. Broken or badly bruised leaves will rot very rapidly. Not all cuttings that develop roots also develop shoots. Often after rooting the original leaf of the cutting dies back leaving a small, rooted tuber that appears to be dormant. We have not yet found a way to stimulate these dormant tubers to produce shoots.

Species and varieties differ in response to this propagating method (Table 2). [illegible] D. [illegible] responded very well, with only notable exceptions (Florido, Smooth Stalk, Oahan types). [illegible] vigorous, bulbil-producing varieties responded more favorably than the more compact, [illegible] D. [illegible]. [illegible] frequently do not respond to these treatments. Some progenies of ray variety also varied in difference to the response. We have not yet identified all of the inputs for variable rooting ability of cuttings to propagate. [illegible] for [illegible] varieties the technique has indeed very successful.

Table 2. Rooting ability of edible yam species and varieties

Accession Number	Species and Variety	Cuttings Planted	Rooted (%)
	D. alata		
14230	Lorado	51	74.5
14262	Johnson White	45	54.3
14533	Vino A	66	62.1
14564	Vino B	53	56.0
14235	Bonifacio Ibaloy	67	58.2
14[illegible]7	De Agua	44	99.0
15[illegible]	Purple Ibaloy	64	56.[illegible]
15083	Macoffe	100	100.0
15088	Florido	100	65.0
15126	Lisperas	53	69.8
15127	Yellow Johnson	67	77.6
15128	Oahan A	75	84.0
15130	Seal Top White	60	83.3
15131	Smooth Stalk White	94	36.[illegible]
15132	Smooth Stalk Yellow	69	30.4
15134	Foam Ibaloy	67	83.5
15140	Del Pedro	18	100.0
15199	De Palo	70	77.3
15200	Feo	76	99.0
15202	Wild Red	85	81.4
15205	P.I. 349691	55	89.0
15206	P.I. 349692	70	74.2
15208	P.I. 349694	68	83.6
15209	P.I. 349695	52	32.3
15210	P.I. 349696	70	91.4
15211	P.I. 349697	120	73.3
15212	P.I. 349698	73	100.0
15324	Florido	606	56.1
15325	Hawaii	50	35.0
15332	Wild yam species	56	96.4
15339	Feo-Wild "	100	100.0

(Continued)

Table 2 (cont.)

Accession Number	[illegible]	[illegible]	[illegible] (%)
15331	[illegible]	72	97.[illegible]
15[illegible]	" " "	[illegible]	[illegible]
15331	" " "	100	84.4
15[illegible]	" " "	105	60.0
15340	Forestero	40	47.5
	D. rotundata		
15085	Guinea Blanco	355	57.4
15085	Habanero	346	57.1
15126	Keith 46	90	7[illegible].8
15326	Guinea Blanco	222	57.[illegible]
15331	Guinea [illegible]	77	38.[illegible]
	D. [illegible]		
15081	Potato yam	242	7.5
15090	Pana yam	275	8.0
15213	Di 67-27	225	9.6
15214	Assam	327	42.7
15215	D. [illegible]	193	56.2

Effects of season on rooting and shooting of Dioscorea stem cuttings.

F. Cabanillas and F. W. Martin

The successful techniques used to produce new yam plants from stem cuttings were originally developed for use with the sapogenin-bearing species. A continued problem experienced with the technique was its lack of reliability. Not only did some species and selections respond better than others, but also seasonal variations were observed. Yams were much easier to propagate early than late in the season. This response was not entirely due to the age of the cutting itself, for efforts were made to always use physiologically "young" cuttings. Nevertheless, tests showed that physiologically "old" or mature leaves were not as suitable for cuttings as were fully expanded but immature leaves.

To test for seasonal differences in rooting, we made a series of tests with the commercial variety Florido, a variety that does not respond very well to propagation from stem cuttings. The test was not formally

arranged but consisted only of making a series of trials with what appeared to be comparable material during the season. The results of these trials in terms of rooting and shooting are summarized in table 1.

Table 1. [illegible] of cuttings of [illegible] [illegible]

Date of preparation of cuttings	Number of cuttings	[illegible]	[illegible]
May 20	100	65.0	49.0
June 15	150	43.3	8.6
July 10	360	50.2	3.8
July 22	96	50.1	11.3
" "	150	75.0	1.4
" "	164	62.0	1.8
July 24	135	62.0	0.0
September 4	200	62.5	0.0
November 6	50	83.0	0.0

* Rooted cuttings were transplanted to [illegible] about 30 days later.

The table clearly shows that adequate shoot production occurred only during the first trial. In later trials root production was usually excellent while shoot production was too low. This problem was not associated with condition of the beds, as cuttings of other varieties rooted very well during the tests. Cuttings with roots but no [illegible] produced small tubers which continued to grow while the leaves of the cuttings lasted. When the leaves of the original cuttings died back, the small tubers stayed intact in the soil without germination. We are trying now to find ways of germinating these small tubers.

These results point clearly to the need of propagating [illegible] from stem cuttings very early in the season. This is especially true with respect to the difficult-to-root varieties.

[illegible] July 1-[illegible]

Propagation of yams from small tuber pieces.

[illegible] and E. [illegible]

Improved techniques are needed for propagating yams for [illegible] reasons. Thus, the multiplication of [illegible] [illegible] being [illegible] [illegible] of small tuber [illegible].

The [illegible] cut [illegible] into [illegible] inch [illegible]. [illegible] then cut into pie shaped wedges about one inch wide. The narrow end of the wedge is then cut off and discarded.

The [illegible] or [illegible] blocks are then covered with a [illegible] of a fungicide. They are planted on wire screen in a moist chamber. The humidity is maintained in the chamber by daily sprays, and by [illegible] permit rapid evaporation from a pan below the chamber.

When pieces begin to germinate, they are removed from the [illegible] chamber and planted either in a nut [illegible] bed or directly in the field.

These techniques have been tried in a preliminary fashion with yams of Dioscorea [illegible]. The yams were of different varieties and different states at the time of the trials. The cubes from different portions of the yam were separated for independent measurements of their capacity to germinate. In addition, some variations of techniques were also tried. Results are summarized in table 1.

Preliminary trials showed that cubes without epidermis could not germinate. Such data are not included here.

The cubes of yam germinated very well considering the difference in condition of the mother yams and the many variations in the trials. In comparison of two groups of the variety Eco, cubes not treated with fungicidal slurry germinated better than cubes so treated. One group of yams covered with sphagnum moss germinated very well. However, sphagnum moss does not seem to be essential for adequate germination. Two yams (Horn and Hunt) received from Barbados in poor condition did not germinate well. Horn, which germinated very poorly in these trials also germinated poorly in the field when conventional pieces were planted. Although some differences were encountered between head, middle and tail pieces, we could see no consistent trend in this respect.

Table 1. Germination of small cubes of *Dioscorea* tuber in moist chambers

Variety of mother tuber	State of mother tuber	Head pieces		Middle pieces		Tail pieces	
		Number tested	Percent success	Number tested	Percent success	Number tested	Percent success
Florido	Dormant	33	[illegible]	[illegible]	33	[illegible]	[illegible]
Forastero	Dormant	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Feo.	Ready to sprout	34	[illegible]	50	[illegible]	[illegible]	[illegible]
Feo[1]	Ready to sprout	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
De Palo[2]	Ready to sprout	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Horn	Stored, deteriorated	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hunt	Stored, deteriorated	12	92	47	17	[illegible]	[illegible]

1/ Without fungicidal slurry.
2/ In sphagnum moss.

[illegible] planted in [illegible] beds [illegible] were conducted [illegible] widely [illegible] a small [illegible]. [illegible] showing an sprouted [illegible] of [illegible] very [illegible], [illegible] of the Palo Alto. [illegible] attribute [illegible] to the [illegible] of [illegible]. [illegible] of La Palo [illegible] [illegible] [illegible]

2. Measure pH. Calculate necessary lime to adjust pH to 6.5 (depth of 6 inches), and distribute lime over the field.

3. Spread cashes over the soil at the rate of 2[illegible] yards per acre (this practice to be discontinued when [illegible] [illegible] [illegible] [illegible] [illegible] practice [illegible] to be unnecessary).

4. [illegible], [illegible] the soil into ridges [illegible] high, 2 feet wide, and 5 feet apart.

Preparing seed material.

1. At harvest time select seed material only from healthy plants. Seed that is damaged mechanically can be used, but it must be free of rot.

2. Permit the seed to cure under a few days of warm, humid conditions, but not exposed to the sun.

3. Store the seed in flats in a cool, well-ventilated space.

4. A few days before planting cut the seed yams into about 4-5 ounce pieces. Treat these pieces with a slurry of fungicide, and allow them to dry.

Making the planting.

1. Time planting to coincide with sprouting of seed pieces.

2. Lay out field in 100 foot rows.

3. Before planting place mineral fertilizer (10-5-20) in the rows, 8 inches deep, at the rate of 800-1000 lbs. per acre.

4. Plant pieces by hand or machine near the surface of the soil, 2 feet apart.

5. Treat soil with aerazine at the rate of 3 lbs per acre.

Staking the field (the system below not yet used).

1. After planting but before sprouting occurs construct staking system.

2. With tractor, dig 3-foot holes the size of principal support stakes at 100 foot intervals.

3. Place in these holes pressure-treated rot-resistant poles 9-10 feet in length. Brace these poles with shorter poles or by constructing "deadman".

4. [illegible] possible, and [illegible] the soil [illegible]

5. Place [illegible] stake [illegible] support [illegible]

6. When [illegible] to [illegible]

Maintaining the planting.

1. Control [illegible] by [illegible] applied with a [illegible] wand.

2. Watch for the occurrence of vines, and rogue strongly infested plants.

3. Watch for leaf spot disease, and spray entire planting with zineb when necessary.

4. Irrigate during prolonged dry periods.

Harvest.

1. Delay harvest until foliage dies back.

2. Cut vines at base.

3. Pull out support wires for storage.

4. Remove principal poles.

5. Clear field of vines, strings, and intermediate poles.

6. Lift yams with a deep moldboard plow.

7. Sort yams from soil and place in boxes.

8. Remove boxes from sun as quickly as possible, and take them to a hot, damp, area where curing can occur.

9. Sort and grade.

[illegible] 31, [illegible]

Cassava yield evaluation and preliminary selections.

[illegible]

[illegible] from the [illegible] [illegible] 250 [illegible] plants were [illegible] included for [illegible]

[illegible] 12 [illegible] harvested. Yields are given in table 1 [illegible] differences in yield were found. For the [illegible] and results of the two [illegible] were compared. [illegible] comparisons were made with [illegible] from the [illegible]. Consistently high yielding varieties were selected for [illegible] yield trials.

Seedlings varied tremendously in vigor, tendency to flower and yield. The largest plants and those with a tendency to seed set were selected for yield trials with the varietal collection. The yields of these selected plants of only 7 months [illegible] are [illegible] the [illegible]. It is evident from our observations that the seedlings yield very well the first year. We wish to [illegible] if high yields are maintained in future trials.

Propagating sticks of all varieties were given to Dr. [illegible] Patiño for evaluation in the CIAT collection, at Palmira, Colombia.

Table 1. Yields of cassava varieties at Las Mesas, Mayagüez

Second Trial

Accession Number	Variety or Parent	No. of plants	Average yield per plant (Kg)
14642	[illegible]	5	2.26
14643	Trinidad [illegible] 56	2	0.85
14644	Biña	5	1.76
14645	Pana Monastillo	2	3.01
14646	Pana Coroal	5	0.75
14647	Trinidad 14-56	2	0.45
14648	Seda	5	1.91
14650	Inglesa	2	0.74
14651	Amarilla	2	All rotted
14652	Trinidad 12-56	2	4.99
14653	Ceiba	2	5.05
14654	Venezolana	2	3.40
14655	Pata Palosa	2	1.42
14656	Brazil	5	1.[illegible]
14657	Mameya	5	2.10

(Continued)

Table 1 (cont.)

Accession Number	Variety or Number	No. of plants	Average yield per plant (Kg)
[illegible]	[illegible]	5	1.48
[illegible]	[illegible]	2	1.48
1430[illegible]	#11 ([illegible])	2	2.41
1432[illegible]	#22 ([illegible])	2	1.19
14[illegible]	#4[illegible] ([illegible])	2	2.27
14[illegible]	#54 ([illegible])	2	2.21
14[illegible]	#70 ([illegible])	1	6.67
14342	#72 ([illegible])	2	4.31
14345	#10 ([illegible])	2	1.92
14348	#40 ([illegible])	2	1.05
14352	Black Stick	2	0.45
14353	Pana	2	5.05
14355	Tremancina	2	2.38

First Test

14763	9182	2	1.76
14764	9589	2	1.99
14765	9595	2	4.65
14766	9596	2	7.89
14767	9597	2	6.81
14768	9598	2	2.30
14769	9599	2	3.35
14770	9600	2	3.74
14771	9602	2	5.67
14772	9603	2	3.40
14773	9608	2	2.27
14774	9609	2	1.59
14775	9610	2	2.44
14776	9569	2	3.97
14777	9570	2	4.11
14778	9572	2	1.62
14779	9573	2	5.05
14780	9576	2	5.42
14781	9580	2	4.71
14782	9581	1	3.20
14783	9584	2	4.48
14784	9586	2	0.94
14785	9587	2	1.19
14786	9177	2	2.38
14787	9588	2	0.74
14789	9181	2	4.48
14790	95[illegible]	2	all rotted
14791	95[illegible]	2	3.39
14792	9583	2	4.82
14793	9176	2	1.62

(Continued)

Table 1 (con.)

Yield data on [illegible]

	Method [illegible]	[illegible]
Y-1	[illegible]	[illegible]
Y-2	[illegible]	[illegible]
Y-4	[illegible]	[illegible]
Y-6	[illegible]	[illegible]
Y-[illegible]	[illegible]	[illegible]
Y-[illegible]	[illegible]	[illegible]
Y-12	[illegible]	[illegible]

The cassava variety Blanera.

F. W. Martin

Although cassava is a generous source of calories, its protein content is generally a very low 1-2 percent. Therefore, wherever cassava is [illegible] upon as a staple food, nutritional diseases are common. To avoid such side effects, heavy diets of cassava should be supplemented by protein [illegible].

Recently a large number of varieties of cassava [illegible] protein content in Colombia. One of these, the variety [illegible] have a protein content of 6.7 percent or more (dry weight [illegible]). The yields of this variety have been high, as much as 72 [illegible] The roots mature 8 to 12 months after planting. To my knowledge, the relative amounts of the various amino acids have not yet been measured. The variety is low in hydrocyanic glucosides.

We have obtained the variety Blanera and find that it performs very well here in Puerto Rico. We anticipate tests of protein content and amino acid spectrum when roots are mature. Meanwhile, we are multiplying [illegible] cassava for further tests and for distribution.

Techniques adapted for measuring hydrocyanic glucoside content of cassava roots.

F. W. Martin and Ruth Roberts

The amount of hydrocyanic glucoside in cassava roots determines their edibility. If the amount is high, roots must be carefully processed before they are safe to eat. As part of the evaluation of our cassava collection we have adapted techniques from several sources, utilizing the existing equipment of the station to measure the hydrocyanic glucoside of roots. The technique depends on releasing the hydrocyanic acid from its sugars by autolysis, distilling the HCN into a base, and measuring the amount by a starch-iodine titration method. For future use of the technique, the details of the test are given below:

1. Use fresh tuberous root, or if frozen, thaw before use.

2. Remove the outer cortex (peel).
3. Weigh 12.5 grams of tuber, and cut the weighed portion into small pieces.
4. Grind the sample in a blender for 1-2 minutes with 50 ml. distilled water.
5. Pour the mixture into a 200 ml round bottom flask.
6. Wash out the blender with about 50 ml [illegible] water, and [illegible] into the flask.
7. Add to the flask 3 [illegible] and a [illegible] spray to suppress foam.
8. Place the flask in a heating jacket.
9. Attach to the flask a coil with a [illegible] tube extending [illegible] collection flask.
10. The collection flask is a long (10") test tube containing 15 ml 2.5% sodium hydroxide. The flexible tube from the sample attaches to a glass tube which reaches to the bottom of the test tube.
11. Wait 1 hour for autolysis to occur.
12. Adjust the rheostat controls of the heating jacket to the predetermined voltage level which leads to slow boiling. With our rheostat the adjustment is to 5%.
13. Permit about 15 ml of water to boil away from the sample [illegible], into the collecting tube.
14. Turn off the rheostat and immediately remove the tubing [illegible].
15. Allow the sample to cool.
16. Pour the collecting solution into a 125 ml flask.
17. Add a drop of phenophthalein.
18. Add 2N HCl until the red color disappears.
19. Add about 2-3 grams sodium bicarbonate to the flask until no further reaction (bubbling) occurs.
20. Add about 1 gram soluble starch to the flask.
21. Titrate with .01N iodine in N potassium iodide until a [illegible] blue color results.
22. Calculate HCN concentration:

HCN (mg/100 g cassava) = 4.32 x ml. of iodine solution used.

Hydrocyanic acid content of cassava varieties.

F. W. Martin and Ruth Ruberté

The majority of the cassava clones available in our present collection have now been tested for hydrocyanic acid content (table 1). It is well known that such content varies with area where plants are grown, and with region of the tuberous root tested. Thus, the measurements taken so far can only be regarded as preliminary. If hydrocyanic acid content of root is over 100 mg per 100 g, the root should be considered poisonous. Levels of 50 to 100 mg per 100 g suggest slightly poisonous roots. Lesser amounts of hydrocyanic acid are not considered dangerous if the cassava roots are properly cooked.

[illegible] December 31, 1950

Table 1. Hydrocyanic acid content (mg. per [illegible] of [illegible] of [illegible] varieties [illegible] [illegible] collection

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

One tenth of a gram of starch [illegible] sodium hydroxide, and boiled [illegible] of solution. [illegible] of the solution [illegible] To this is added [illegible] of a solution of [illegible] hydrogen [illegible] is added as a buffer. [illegible] tenths of [illegible] of a [illegible] 10 g KI in 500 ml H_2O) is also added. [illegible] the addition of water.

After [illegible] minutes color equilibrium [illegible] the color is measured against a [illegible] [illegible] at [illegible] mμ in the spectrophotometer. [illegible]

The percentages of amylose [illegible] yams, yautiaz, and [illegible] are given [illegible] percentages, running [illegible] 26 [illegible] starches themselves, which would affect digestibility. [illegible] these differences [illegible] starchy food crops. Unfortunately [illegible] characterized as a high amylose type.

With respect to the yams, the species D. [illegible], D. [illegible], and D. bulbifera all contained fair amounts of amylose. The amounts in D. esculenta (Pana, Papa) and D. trifida (Mapuey) were alarmingly low and suggest poor digestibility.

These preliminary, unreplicated observations suggest to us the importance of full characterizations of the starches of these [illegible]. We intend to evaluate in considerable detail [illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

1. [illegible]
2. [illegible]
3. [illegible]
4. Two buds were removed [illegible], and were [illegible] pollinated the following morning in the laboratory. After 3 hours or more the stigmas were processed and pollen tubes per stigma were counted, as an index of self-fertility.
5. A single bud was removed from each plant. The following morning the flowers from a given plot were cross-pollinated in a random fashion, and pollen tubes per stigma were counted.

[illegible]

[illegible]

With [illegible] of [illegible]

[illegible] partially or fully [illegible] completely freely.

[illegible] as strong in the last [illegible] individual plant measurements were [illegible], it [illegible] pollen germination per stigma represented [illegible] increase of fertility of the partially fertile plants rather than the occurrence of self-fertility in plants that had previously been [illegible] incompatible.

Over 50 percent of [illegible] generation failed. In about 30 percent of the [illegible] only 1 or 2 pollen grains germinated. [illegible] than 20 [illegible] in the 6th and [illegible] the 3 sets of measurements [illegible] fertility increases somewhat with [illegible].

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* In this and [illegible] 3.0 [illegible] .6%.

[illegible] pollen [illegible] needle [illegible] 2 or 4 [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
III	.57	.38	.30	.74	.75	.83	1.42	1.36	3.46
IV	1.03	.33	.22	.5[illegible]	.72	.50	.36	[illegible]	2.34
IV	.19	.32	.35	.53	.54	2.50	1.20	[illegible]	[illegible]
V	.03	.78	.32	.34	.55	[illegible]	2.88	[illegible]	2.74
VI	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VII	.5[illegible]	.20	.27	2.2[illegible]	[illegible]	[illegible]	1.73	[illegible]	4.[illegible]
Mean	.50	.29	.25	.86	.45	3.39	1.34	7.31	3.85

* Only 3 [illegible] of measurements made.

Pod and seed production. Apparent differences among sets of measurements and among percentages of pods per flower were not significant (table 3). [illegible] flowers, rate of [illegible] decrease of [illegible] pollination produced more seed per open pollinated [illegible] in March [illegible].

Table 3. Pods per [illegible] and [illegible] fertilization of [illegible] of sweetpotato

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible] fertility [illegible] pod per plant [illegible] both [illegible] the seed set per [illegible], one [illegible] fertility, [illegible] to obtain an index of [illegible] fertility. Thus, [illegible] 6 [illegible] measures [illegible] obtained (Table [illegible]) .41, .34, .45, .[illegible], .[illegible], 1.32. These calculations [illegible] to indicate the [illegible] pollination, the total fertility [illegible].

[illegible] pollination [illegible] six generations [illegible] increase [illegible] fertility, indicating compatibility [illegible] fertility. The fact that [illegible] did not provide a [illegible] to evaluate the sterility and [illegible] compatibility [illegible] to expect the [illegible] to [illegible] fertility, measured [illegible] may be the cause for the rapid development of more fertile sweetpotato populations.

The results of this study have been prepared for publication.

[illegible]

[illegible]

[illegible]

[illegible]

Recently Dr. S. F. Chest of the University of London, England, has reported [illegible]

While our experiments [illegible] ready for [illegible] from asymptomatic plants which originated from seeds kept in an [illegible] greenhouse. Six [illegible] of these plants contained virus particles. It is possible that the virus present, [illegible] to be detected by the dip method [illegible], or the virus may be spherical and therefore not easily observed by this technique. It is however of note that [illegible] able to observe elongated particles in leaves from plants [illegible] which contained a low concentration of the virus (and no symptoms). We found this [illegible] morphologically related to known [illegible] viruses of cassava, and usually elongated viruses lend themselves to observation in the electron microscope by the dip method. Further work is in progress.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Table 3. Virus-free [illegible] of chrysanthemum which [illegible] the NPT collection, [illegible]

Acc. No.	Ratio[1/]	Acc. No.	Ratio[1/]	Acc. No.	Ratio[1/]
15[illegible]	5/5	15085	0/5	[illegible]	0/7
15[illegible]	2/2	15[illegible]	0/2	[illegible]	0/[illegible]
15[illegible]	0/3	8	2/4	[illegible]	[illegible]
15211	0/2	15080	16/[illegible]	15[illegible]	0/[illegible]
15[illegible]	0/5	15086	0/10	15146	[illegible]
15[illegible]	3/3	3	1/7	15109	2/5
[illegible]	[illegible]	[illegible]	42/42	[illegible]	[illegible]
15[illegible]7	[illegible]	[illegible]	2/11	[illegible]	1/3
15[illegible]08	2/2	15[illegible]	0/10	[illegible]	[illegible]
15207	1/1	15134	2/13	[illegible]	1/9
15216	1/2	1	0/13	[illegible]	0/[illegible]
15234	0/2	15[illegible]	0/9	[illegible]	[illegible]
[illegible]	0/5	15125	3/2	[illegible]	0/[illegible]
[illegible]	0/[illegible]	[illegible]	[illegible]	[illegible]	1/[illegible]
15	0/13	15[illegible]	0/2	7	1/6
016	0/5	15135	1/1	15190	11/48
15	2/3	15127	0/6		
14	0/4	14[illegible]	0/[illegible]		
[illegible]	1/4	15087	6/6		
5	11/11	15135	4/4		
9	0/3	15131	7/7		
10	0/10	2	0/22		
11	4/10	15200	0/4		
12	1/3	15082	0/7		
4	0/7	[illegible]	7/[illegible]		
15130	2/2	[illegible]	1/7		

1/ Ratio of diseased/total plants.

[illegible]

[illegible] Subgrafting (UgB) [illegible]

[illegible]

1.	[illegible] (D. [illegible])	0/15,5/[illegible],10/[illegible] 1/	[illegible] 2/	[illegible]	[illegible]
2.	Morado (D. [illegible])	8/1[illegible],23/[illegible],0/12,[illegible] 10/2[illegible]	+,[illegible],++,+	"	[illegible]
3.	Coconut [illegible] (D. [illegible])	0/1[illegible],5/23,2/[illegible]	+,[illegible]	"	[illegible]
4.	Oriental (D. [illegible])	4/11,1/[illegible],0/[illegible]	+,[illegible]	"	[illegible]
5.	Barbados (D. [illegible])	16/21,[illegible],10/[illegible],1[illegible] 6/7	[illegible]	"	"
6.	Smooth [illegible] (D. [illegible])	15/[illegible],9/12,6/6,[illegible]	+,[illegible],+,+	"	[illegible]
7.	[illegible] (D. [illegible])	5/5,10/[illegible],5[illegible] 12/[illegible]	0,[illegible],+,0,[illegible]	Very slight	Very slight
8.	Florida (D. [illegible])	9/[illegible],0/[illegible],6/[illegible],0/[illegible]	+,[illegible],+,6	Slight	[illegible]
9.	Farm Lisbon (D. [illegible])	0/23,0/25,0/23	+,+,++	Very slight	Slight
10.	Napuey (D. [illegible])	14/[illegible] (not [illegible])	+	Slight	[illegible]

1/ 0/15 = no plants with symptoms, of a total of 15 inspected.
2/ + = very light infection, ++ = light infection.

[illegible]

[illegible]

[illegible]

July 1 [illegible]

[illegible] the plantings [illegible] health [illegible] plants [illegible]

[illegible]

[illegible] Florida.

Table 1. [illegible]

Inoculation 1/	[illegible]
1. [illegible] Amarillo [illegible] Acc. No. 147	9/14 2/ stunt slight, [illegible] veinal chlorosis
2. [illegible] Inglaterra Acc. No. [illegible]	8/14 stunt slight, systemic, leaf [illegible] veinal chlorosis
3. [illegible] Cayman Acc. No. [illegible]	[illegible] stunt slight, systemic, [illegible] veinal chlorosis
4. [illegible] Rose Acc. No. [illegible]	5/[illegible] stunt slight, systemic, leaf [illegible] veinal chlorosis

1/ Symptoms: 1 = whole leaf wrinkled, 2 = whole leaf wrinkled, 3 = chlorotic stripes on leaves, 4 = no symptoms.

2/ 9/14 = 9 infected plants of a total of 14 plants inoculated. All 25 plants not inoculated were without symptoms.

Continued

Table 2 (con.)

Accession	Observations: Virus 1	Virus 2	Fungus 1	Fungus 2	Accession	Observations: Virus 1	Virus 2	Fungus 1	Fungus 2
14885	-	-	-	+	14810	-	+	+	++
14916	-(?)	-	-	-	14811	+	+	+	+
L68-144	-	dead	+	dead	14812	++	++	++	++
L68-142	-	-	+	-	14813	+	+	++	++
14794	-	+	+	+	22	-	+	+	+
14795	?	+	+++	+++	V. violaceum	-	-	-	+
14796	-	+	+++	+++	Barenta	-	-	-	+
14797	-	+	+	++	Canea	-	-	++	++
14801	-	+	+	+	Luz blanca	-	+	++	++
14800	-	-	+++	+	Las Mesas	+	++	+	+++
14799	-	+	++	++	LM59-66	+	+	+	++
14798	+	+	+	+					
14802	-	++	+++	++					
14803	+	++	+++	+++					
14804	+	++	+++	+++					

Readings are of observations made 5 and 7 months after planting.
- = negative + = mild ++ = moderate +++ = severe.

As can be seen in table 2, in some readings of virus symptoms lines seemed to be affected less strongly or not at all in the last field observations. Other lines expressed symptoms of virus infection in the latter part of the season. The classification of virus and fungus infection refers to the total group of plants for each introduction. There was usually large variations in symptom expression among the plants of each introduction.

Time of tuberization and normal season of growth of leren.

P. W. Martin and E. Cabanillas

Leren (Calathea allonia) is planted near the beginning of the rainy season and harvested after the foliage dies during the dry season. Therefore, the tuberous roots are normally harvested from December to March and are not available for the rest of the year. This year, in order to observe time of tuber formation we dug plants once a month beginning in September and continuing until the following June. From these observations we can make some generalizations about the normal growth cycle and time of tuberization. After digging the plants, we divided them into offshoots and replanted them in plastic bags near the greenhouse, where they were watered regularly. In so doing we stimulated development of offshoots and produced lerens out of season.

Normal [illegible] during the dry season [illegible] [illegible] left in the ground until time [illegible], or can be harvested and stored in a cool area. [illegible] their [illegible] quality if left in the ground. However, with [illegible] of [illegible] plants begin to germinate. [illegible] divided [illegible] [illegible]

[illegible] the rainy [illegible] of [illegible] [illegible] in competition [illegible]. Tuberization [illegible] be seen as an enlargement of the [illegible] of the [illegible] from the offset or corm. Tuberization proceeds rapidly, so that [illegible] edible tubers are ready in [illegible]. [illegible] the plants, tuberization, including the production of new [illegible], continues through [illegible]. We do not [illegible] continuously [illegible] become [illegible], but [illegible] the dry [illegible] willing, yellowing and [illegible] of the plants. [illegible] to be a normal [illegible]. Once the plants are dormant [illegible] tuberization occurs.

During the 1969-70 season the plants went dormant in December [illegible] to a very early drought. Yields were therefore only about 150 grams of tuber per plant, compared to about 750 grams the year before. We [illegible] these yields are not acceptable from a crop plant, even when it is a specialty crop such as loren. Yields of plants grown in partial shade were about the same as those of plants grown in the sun.

Abnormal seasons of growth. All of the plants [illegible] from offshoots after harvest began to grow again. However, each group [illegible] different dormancy and tuberization behavior. Observations of the [illegible] are summarized in table 1. From these observations [illegible] generalization can be made.

Plants normally pass through a period of [illegible] dormancy. The time and length of the dormancy can be modified by digging and dividing the plants at an appropriate time. If dug just before natural dormancy begins, the offsets germinate without passing through dormancy. Normal time to germinate of the corm is about 4 weeks.

Upon replanting of corms, the new plants may tuberize. The actual amount of tuberization per offset may be far higher than that of the undisturbed plants. We consider mid-November the most appropriate time for division of the clump. After dormancy has begun the offshoots will germinate but will not tuberize. Once replanted, loren requires frequent watering. The tuberous roots produced by offshoots tend to develop later than those of normal plants. Thus, excellent tubers may be obtained at least until mid-June.