GROWTH AND STORAGE IN TROPICAL ROOT CROPS

— *by* —

L. M. Degras

Yam (*Dioscorea*), Sweet Potatoes (*Ipomoea*) Tannia and Eddoes (*Aroids*) are three staple food crops in the West Indies as well as in some other tropical countries. Our knowledge of their biology does not permit a rational basis for varietal improvement.

The well-known research of the Trinidadian School (Brown 1931, Oyebog 1955, Gooding 1960, Chapman 1964, Cowling 1965, Haynes & Williams 1965, Spence & Haynes 1966), the Mayaguez staff (Martin et al 1963, 1966), the Japanese research workers (Tsunoda 1959, Tsuno and Fujise 1964, Yuan 1966), the American geneticists (Poole 1955, Hernandez, Miller 1964, 1966) and, also, less known publications of some West African agronomists, have thrown an interesting insight into many aspects of their biology. We are not still able to set up an integrated presentation of their biological facts which might lead to a sound breeding policy. Though empirical selection could produce valuable varieties, it is evident that some combined and speculative approach will ensure maximum progress in this field.

Calorific value of root crops is linked with dry matter production. So yield is directly dependent on synthesis, transport and accumulation of dry matter. The appraisal of these processes for breeding bears on the morphological and physiological determinants of yield. The concepts of Gregory, Watson and others (see V. Stoy 1964 and Spence & Haynes 1966) led to the use of growth analysis in terms of leaf area and the relation of this area with duration and density of the crop. Through Milthorpe and Ivins (1963) and other works revised by Moule (1960) and Jonard (1964), it appears that the specific physiology of the storage sites plays a dominant role at least in some phase of dry matter accumulation. It is on these lines, morphological and physiological, associated with leaf and root storing processes that the following observations have been undertaken.

Limitation in the set of results expected has been introduced from a hurricane in September 1966. No attempt will be made here to conceal the lack of extensive support of some tentative conclusions.

I. Yield and Dry Matter Storage in Sweet Potatoes, Yam, Tannia.

1. *Yielding Capacity*

Table I shows three orders of yield obtained with these root crops. The final order of yield obtained (column 5) has been taken as indicating yield potential or productivity of the crop. Nothing is truly new in these facts. But speculating on the factors on which rational selection should be based with a view to ensuring productivity is an interesting prospect here. Crop duration as determined by a number of economic and technical reason should be shortened through selection, at least the control of environment permits to extend it. Shortening of crop duration generally is subject to certain limitations unless there is a modification in the storing processes. The well-known empirical method of selection for fresh weight yield has already been questioned because of its complex nature being dependent on morphological and physiological components. If we examine the average of each factor at each level of yield we observe that the variation of percentage of dry matter is the only one agreeing with that of dry matter yield per day of crop duration. Thus, percentage of dry matter remains the basic way by which crop duration and fresh weight yield should be measured.

2. *Yielding efficiency*

Capacity of storing dry matter is primarily dependent on progressive redistribution of the photosynthates between structures for future synthesis and sites of accumulation. Figure 1 brings together interesting features of this distribution in the crops observed:

(1) General participation of exponential curves in these growth relations,

(2) Dependence of yielding efficiency on either,

(a) ecological situations (Sweet Potatoes No. XI for two years)

(b) varietal behaviour (Tahiti and Couleuvre Yams)

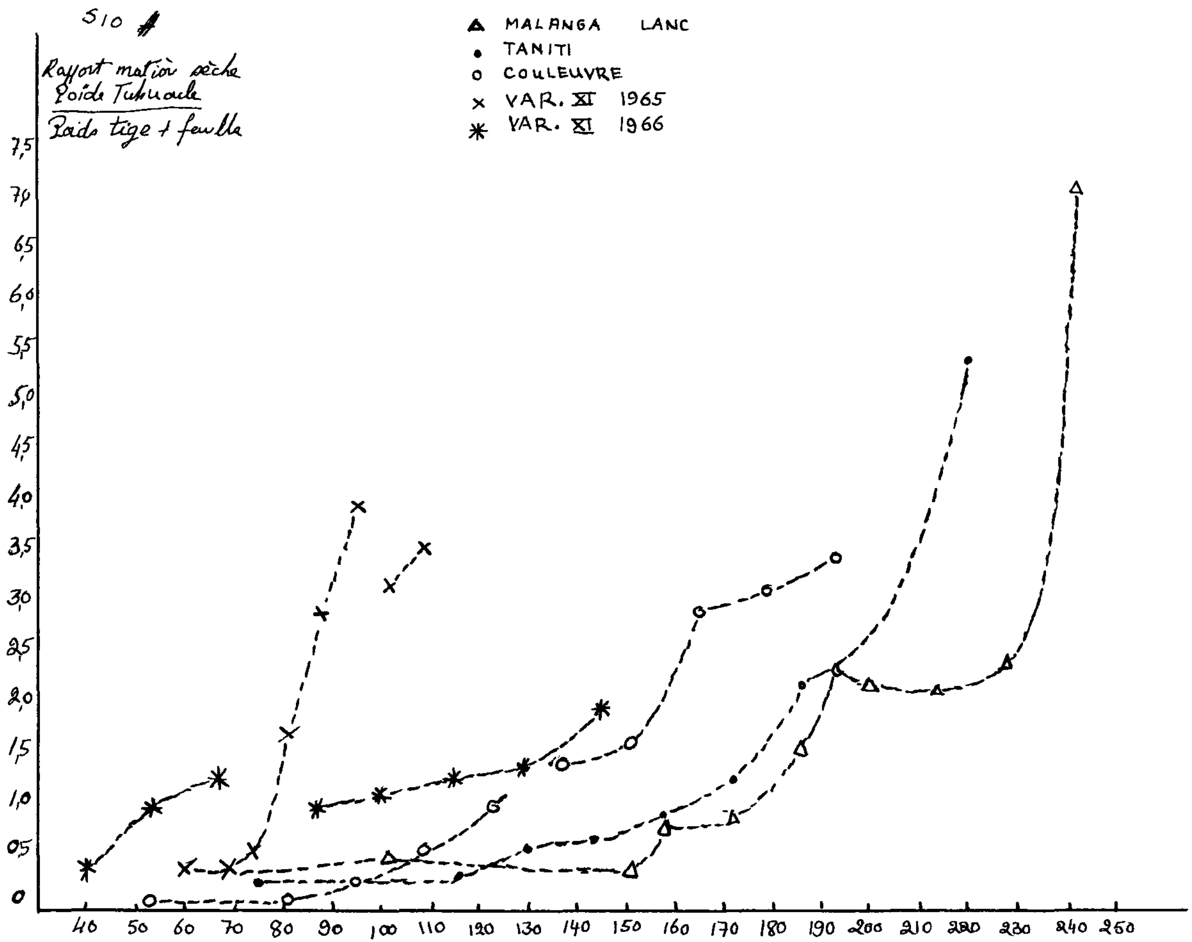
(c) stage of growth (no linearity of the ascending curves).

The occurence of exponential curves here, though not published in our knowledge elsewhere, for these root plants, needs not too much explanation since Gregory and Blackman's classical presentation of growth rate. Yet, the modalities we see suggest definite stages of growth regarding shoot-root relations. The departure from true exponential curves in Sweet Potato can be accounted for by the limitation of material for sampling.

Table I. Relevant factors of yielding capacity

Varieties	Crop Duration (Day)	Fresh Weight (T/ha)	D.M. (%)	D.M. Yield (Kilo/ha/day)
Tahiti	220	32.0	31.0	
	(157)	(21.8)	(34.1)	45 (High)
Sweet Potato No. XI	95	11.7	37.1	
Couleuvre Yam	193	22.5	34.0	
	(196)	(24.0)	(32.3)	39 (Medium)
Tahiti Yam	200	25.6	30.7	
Sweet Potato No. XI	129	5.0	34.2	
	(185)	(9.0)	(29.0)	13 (Low)
White Tannia	242	13.1	23.9	

(See the text ch. I, 1. Number in bracket is the average).


Rapport matière sèche
Poids Tubercule
Poids tige + feuilles
MALANGA LANC
TANITI
COULEUVRE
VAR. XI 1965
VAR. XI 1966
7,5
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0
40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250

II. *Storing Process in Couleuvre Yam* (*D. alata*)

The fact that Couleuvre Yam possesses a certain number of intermediate characteristics leads one to envisage a possible scheme for the storing process in this variety. Figure 2 permits comparison of six curves, the meaning of which we stress here:

A. Net assimilation rate (E) in grams per square decimeter per two weeks (between two samplings) for the whole plant.

B. Relative growth rate of root in percentage of dry weight of existing tuber.

C. Growth rate of root relative to the leaf area (same unit asA).

D. Relative growth rate of leaf area in percentage of existing lamina surface.

E. Leaf area per plant.

F. An index of light interception intended to take account of the part of the leaf canopy reaching compensation point (Tsunoda 1959, Saeki 1963, for instance). This index has been tentatively calculated through leaf area divided by fresh weight of vine.

Let us compare the curve A (E) and B (percentage tuber growth). The major discrepancy rises from 81 to 123 days after shooting, another less important one being placed at the end. There can be no doubt that this discrepancy from the proper course of tuberisation is due at the beginning to its initiation, and at the end, to dormancy. In other instances E goes on a line sufficiently close to that of tuber growth.

Now let us compare E (A) with the curve C relating tuber growths to leaf area. Around the 123rd day the two curves reverse their positions. Clearly, this signifies a change in the immediate source of dry matter entering the tuber, the amount of dry matter actually photosynthesized being insufficient for its enlargement. From this time, dry matter consumption of stem storage is necessarily beginning. But, one can notice that curve C variations remain in relation with those of E. This may be understood as E being a limiting factor of tuber growth.

The reversal of curves A and C would be surprising when considering the concurrent ascending curve of leaf area, if the correlative elevation of the index of light interception did not suggest a possible contribution of lamina ageing at the same time. Climatic circumstances could also support this interpretation.

Summarizing the main facts, it can be said that the storing process in Couleuvre Yam is the joint effect of tuberisation (initiation and dormancy) and lamina dry matter synthesis (and loss).

III. *Structure of the Leaf Canopy and Yielding Ability in Sweet Potatoes.*

As may be seen from Figure 3, each crop offers a definite relation between lamina dry weight and stem dry weight, the general ranking being Yam, Tannia (petiole instead of stem) and Sweet Potato.

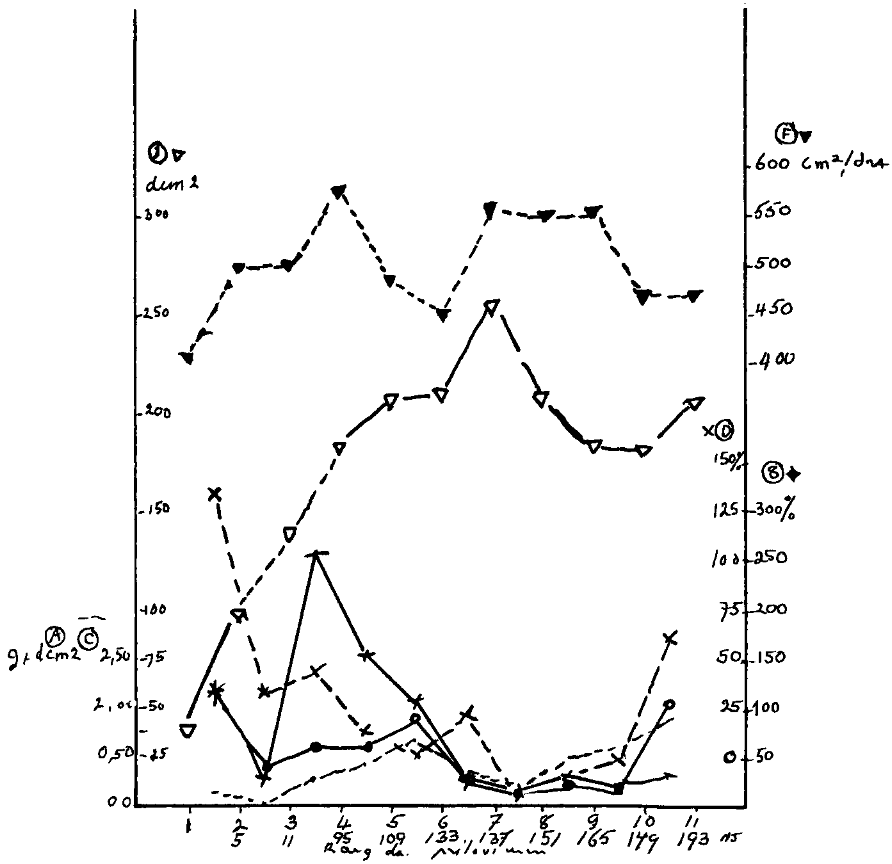
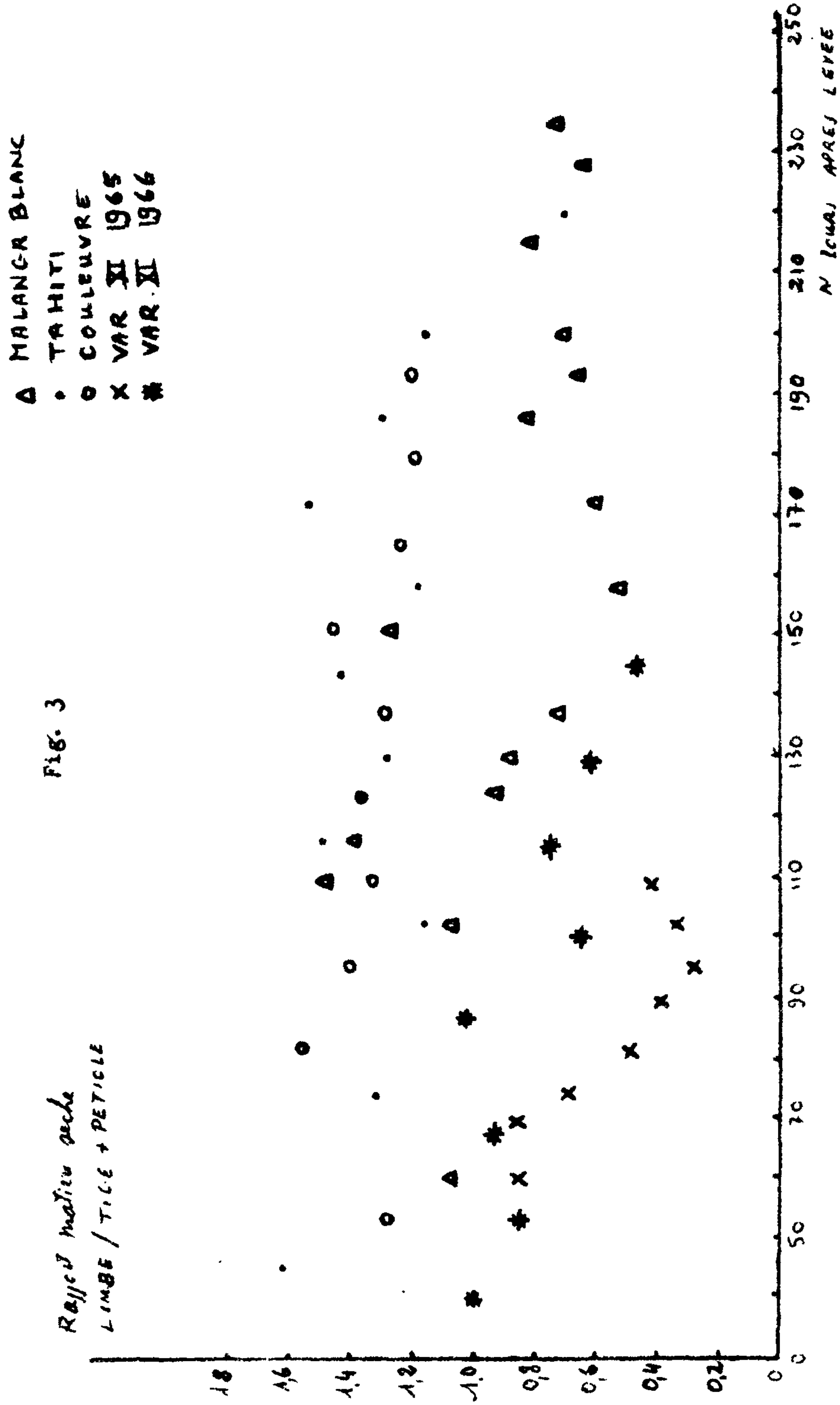


Fig. 2

EVOLATION DU SYSTEME FOLIAIRE
ET ACCUMULATION DES RESERVES
CHEZ L'IGNAME COULEUVRE



MALANGA BLANC
TAHITI
COULEUVRE
VAR XI 1965
VAR XI 1966
LIMBE / TIGE + PETIOLE
0
50
70
90
110
130
150
170
190
210
230
250
0,2
0,4
0,6
0,8
1,0
1,2
1,4
1,6
1,8

Fig. 3

For this last crop a deeper investigation must be reported. Assuming the well-known importance (Tsunoda 1959, Brougham 1958, Saeki 1960, and others) of lamina surface (S), lamina and petiole relation, in weight (Lw, Pw) and length (L1, P1), density of leaf along the stem (Ld), we observed their combined value among five Sweet Potato varieties which had been cultivated in trials for two years:

Parameters	*Assumed intervention in yielding ability*
S	Positive
Lw/Pw	Positive
L1/P1	Negative
Ld	Positive
S x Ld	Positive

The ranking of the five varieties for each parameter is shown in Table II, and also the conventional summation of these ranks against the average yield obtained from the two years. The adequacy of this comparison at least, encouraging. It would be even better if we have had dry matter estimation: see the number in brackets calculated on the basis of one year dry matter percentage. It stresses both the interpretative value of the physiological assumptions and the possibility of a selective approach of a sufficient wide range of yielding ability through morphological examination.

Indications not considered here give additional outstanding interest to these parameters for morphological seriation among ten studied varieties.

Table II. Leaf canopy structure and yield in sweet potato

	Rank for Parameters						Average Plot Yield
Varieties	S	Ld	S x Ld	L1/P1	Lw/Pw	Total	(Kilos) Total
XI	3	1	3	1	1	9	91 (33)
IX	4	1	1	3	3	12	60 (22)
VII	2	3	4	5	1	15	52 (18)
III	1	4	5	1	5	16	38 (13)
X	5	5	2	4	4	20	51 (14)

(see text Ch. II, 2.)

IV. *Tuberisation and Yielding Ability in Sweet Potatoes*

Periodic sampling of ten varieties of Sweet Potato over a nine month trial culture set forth the determining value for yield of early tuber bulking in a given environment.

Planting was carried out at the end of September 1965. Shoot-root/fresh weight ratio has been considered from the 75th to the 171st day. Harvesting was carried out in relation to tuber development and, in the different varieties, extended from the 171st to the 285th day.

The range of relative tuber development is maximized at the 154th day. If one relates yield capacity (total yield divided by duration of the crop) to total tuberisation, a double line of correlation between them seems possible. (Figure 4).

V. *Conclusions*

Rather than outstanding results in the field concerned, it is hoped that a useful methodology may come out of these observations. It lies in two general views relating growth investigations with breeding for yield in our wet tropical countries.

1. From the growth curves of the three root crops presented as well as from the first analysis of yield factors in a set of varieties, it appears that common principles can be found, brought out by a study of the particular factors responsible for the distinct but homologous series.

Thus, we notice the general intervention of sequences of exponential curves. The question arises of the nature of the phases concerned which can be analysed through their limiting factors and level of their intervention. Seemingly, in our *Dioscorea* culture modification of the immediate source of root dry matter may account for a distinct phase of growth. However, it remains that within each phase primary and somewhat common factors to be determined will explain the curve evolution.

On the other hand, the possible existence of two series in the relationship between yield and earliness of tuberisation in our Sweet Potato varieties denotes common determining factors with the exception of a given transposition factor, not yet identified, but thought to lie in morphological structures.

2. All these observations lie in the direction of physiology and morphology of growth. There is also as has been already discussed genetical implication of growth in breeding for yield. But we must now emphasize basic biological knowledge lacking in the current appraisal of tropical root crops. Every one is convinced that in wet tropical countries speciation has led to proliferation of many forms more adapted to vegetative reproduction than to seed setting. On the sexual side, apomixy is a typical field of tropical grass research for instance. Deeper investigation is necessary in the asexual reproduction of plants than in the case of temperate plants. On the vegetative side, dry matter accumulation of which authors (Zalensky 1954, Thomas 1965) have said that tropical countries are the fittest in many respects must be a favourite objective in our breeding policy.

- 6 bis -

4

TUBERISATION ET RENDEMENT CHEZ DIX VARIETES DE PATATE