

## The reaction of different cacao types to infection with swollen-shoot virus

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### SUMMARY

Graft tests were used to investigate the reaction of different cacao types to infection with swollen-shoot virus. Budlings of all the clones in Nigeria were infected with virulent isolates so that the sequence of symptom expression could be followed.

All the Amelonado and Morona clones and most of the Trinitarios were affected severely. They showed extensive, conspicuous leaf symptoms and large stem swellings. The Upper Amazon cacaos reacted less uniformly. The Scavina clones developed conspicuous symptoms, whereas those produced in the Nanay and Iquitos types were often slight and sometimes transient. Many Parinari clones and hybrids of Parinari parentage showed an extreme reaction: a veinal necrosis which often caused complete collapse of affected leaves and sometimes extended to the stem and growing point. Tests on progenies derived from crosses of sensitive with tolerant parents suggested that the sensitive reaction was dominant.

These results are discussed in relation to the present plant breeding programme and to the possibility of releasing high-yielding hybrid progenies for replanting the extensive and heavily infected areas of Nigeria, within which control measures have been stopped.

### INTRODUCTION

The viruses causing swollen-shoot disease of cacao in Nigeria have been found in all the major producing areas of the Western Region, where they are an important factor influencing productivity. Eradication of infected trees is the only control measure which can be practised on a large scale to check the spread of infection and it has been attempted by the government since 1947. However, efforts to eradicate swollen-shoot disease from the Region failed and have been abandoned in two large areas involving a total of over 1000 square miles. Within these areas virus has spread unchecked and the cycle of infection is maintained by continuous replanting on many small holdings (Lister & Thresh, 1957; Thresh, 1959).

There are no immediate prospects of obtaining cacaos immune or highly resistant to infection and the alternative of using tolerant types has been considered in Ghana and rejected (Posnette & Todd, 1951). This was because attempts were then being made to eradicate the disease and the presence of tolerant trees would have increased the difficulty in identifying infected trees. These considerations do not apply in the

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### Parinari Amazons



series is intended to obtain information on the performance of different Amazons under contrasted climatic conditions. The second series compares the growth of Amazon  $\times$  Amelonado and Amazon  $\times$  Trinitario hybrids with Amazon and Amelonado standards (Glendinning, 1962).

#### RESULTS

##### *Amelonado clones*

The Amelonado clones developed conspicuous symptoms when infected with the Egbeda virus. When they were budded on to infected root-stocks, the first formed leaves became discoloured and crinkled and many fell before reaching maturity. The surviving leaves showed extensive interveinal chlorosis (Pl., fig. 1) large stem swellings appeared and growth was stunted. Budlings on healthy stocks which were infected later showed a similar but less severe reaction and most plants passed eventually into a relatively mild chronic phase in which the leaf symptoms tended to be restricted to the areas alongside the main veins.

Some clones sometimes showed chlorotic flecks as a preliminary symptom, limited to the third- and fourth-order veins, which sometimes became necrotic. This necrotic reaction rarely affected the main veins and did not spread into the shoot.

Because of the very limited variation within the Amelonado type of cacao in West Africa it is not surprising that most of the clones reacted similarly. Indeed, the few that showed relatively inconspicuous symptoms reacted more severely when retested. Our experience is consistent with previous observations on the apparent sensitivity of Amelonado cacao to other swollen-shoot isolates (Posnette & Todd, 1951). This is an unfortunate feature, because the large, uniform bean size and flavour of Amelonado cacao are desirable attributes and several clones have been used as parents in the production of hybrid seed.

##### *Trinitario clones*

Most of the available Trinitario clones were hybrids with local Amelonados and they behaved very like the Amelonados in their reaction to the Egbeda virus. Crinkling and abscission of the leaves, severe chlorosis and large swellings were noted in the most sensitive types. These included a Nigerian selection T(N)38, Criollo cacaos and T39 seedlings obtained by the natural pollination of I.C.S.6, a clone which tolerates virus infection in Trinidad (Baker & Dale, 1947). Other Trinitarios produced less conspicuous leaf symptoms, but these were often accompanied by very large swellings. Clones C23 and C26 showed very slight leaf symptoms and the swellings were slow to appear. Symptoms were even slighter in seedlings of T9 derived from an outstanding Costa Rican clone introduced to Trinidad as Costa Rica Red. These limited tests suggest that the variable Trinitario cacaos may include very tolerant individuals also suitable in other ways for use as parents of hybrid seed.

##### *Parinari Amazons*

The cacao of the Parinari tributary of the Upper Amazon is represented in West Africa by some pure-bred types and others derived from natural and controlled pollinations with other cacaos, notably the Nanay group. The effect of the Egbeda



isolate was not the same in all clones and the most sensitive types gave a striking necrotic reaction which has not been reported previously (Pl., fig. 2). Symptoms appeared first as chlorotic flecks along the third- and fourth-order veins, which later became necrotic. Usually the necrosis then spread along the main veins and petioles, so that whole leaves wilted, and abscised. The necrosis sometimes spread along the stem to the growing point and stopped growth. The axillary shoots which developed subsequently often showed a similar sequence of necrotic symptoms. The most severely affected plants died, and survivors passed into a chronic phase of infection with inconspicuous clearing and banding of the veins. The Parinari reaction was noted in the parent clone Pa7, and in all its hybrids with Pa35, Nanay and Iquitos trees. The Trinidad clone Pa35 showed conspicuous symptoms without the necrosis, which occurred in some Pa35  $\times$  Nanay hybrids.

When seedlings of the W.A.C.R.I. Series II progenies, derived from crosses between Amazon (Parinari  $\times$  Nanay) hybrids and selected Amelonado or Trinitario trees, were infected, a proportion showed the Parinari necrosis whenever T79 (Na32  $\times$  Pa7) trees were parents. A similar segregation occurred in progenies derived from intercrossing T63 (Na32  $\times$  Pa35) trees which gave a necrotic reaction. Additional tests involved five groups of seedlings resulting from intercrossing Parinari  $\times$  Nanay hybrids. Each group showed an apparent segregation of the Parinari necrosis and the less conspicuous Nanay reaction. The ratios involved are being investigated and a larger sample of the valuable Parinari population is being studied to select less sensitive types for further breeding.

#### *Morona Amazons*

Cacao from the Rio Mara  n is poorly represented in West Africa and tests were limited to the open-pollinated progeny of two trees in Trinidad. Infected clones grew badly, produced very large swellings, and developed vein-clearing and chlorosis of the leaves.

#### *Scavina Amazons*

The Scavina Amazons were collected from Ecuador and are believed to have originated from the Napo tributary of the Upper Amazon. They have distinctive features, including great vigour and resistance to witches' broom disease in Trinidad (Holliday, 1955). The few clones in West Africa were derived from a single open-pollinated pod (T12) collected from one of the few original introductions to Trinidad. Not surprisingly, the different clones reacted to infection differently and our results differed from those obtained with Scavina material in Ghana (Blencowe, 1961). None of the five clones tested showed any evidence of tolerating the Egbeda isolate. Leaf symptoms and stem swellings were conspicuous and some clones reacted necrotically like the Parinari material. The young leaves of several clones showed large red patches and became mottled as the leaves hardened and developed chlorotic or translucent areas.

Progeny A of the Series I field trials is a hybrid between two of the Scavina clones and some seedlings became necrotic, whereas others produced only a conspicuous chlorosis.

#### *Nanay and Iquitos*

Similar cacaos were collected nearby from an island in West Africa by some pure open-pollinations with other clones. The Egbeda isolate caused large swellings. In most clones the third- and fourth-order veins showed whole leaf (Pl., fig. 2) or veinal chlorosis and necrosis between.

The chlorotic vein-banding in infection was often inconspicuous and differed from those of the Parinari. The vein-banding is most conspicuous in the veins.

Seedlings produced by the pure Nanay type and Trinitarios. Open-pollinated trees respond uniformly to infection. As in Ghana (Dale, 1961), the infection is accompanied by slight clearing between two T17 trees. The Series II progeny D also showed seedlings of this pattern.

The most tolerant hybrid derived from the pure Nanay clone grew vigorously and showed no banding and chlorotic symptoms were very inconspicuous. Egbeda in sensitive parentage to C77 was very sensitive to symptoms. This evidence of sensitivity is dominant in the seedlings obtained with an Amelonado.

#### *The reaction of representatives*

Many symptomatic clones of swollen-shoot disease were collected in Nigeria. Some isolates were antagonistic in protection (Thresh & Tinsley, 1961).



*Nanay and Iquitos Amazons*

Similar cacaos were collected from the Nanay tributary of the Upper Amazon and nearby from an island off Iquitos. They are represented in Trinidad and in West Africa by some pure-bred types and hybrids derived from natural and controlled pollinations with other cacaos. Most clones at least partially tolerated infection with the Egbeda isolate and leaf symptoms were inconspicuous and limited, with few large swellings. In most clones early red-banding was followed by fine clearings of the third- and fourth-order veins, merging in some to form a faint reticulum over the whole leaf (Pl., fig. 3). A few produced more conspicuous symptoms with inter-veinal chlorosis and crinkling from the unequal growth of the veins and the tissues between.

The chlorotic vein-banding produced in the secondary or chronic phase of infection was often indistinct and confined to the third-order veins. These symptoms differed from those produced at a comparable stage in Amelonado cacao, where the vein-banding is much more obvious and often conspicuous along the main veins.

Seedlings produced by natural pollination of Nanay trees were less tolerant than the pure Nanay types and most produced symptoms typical of the Amelonados or Trinitarios. Open-pollinated Iquitos trees of the T16 and T17 progenies did not respond uniformly to infection, although most reacted less severely than the Nanays. As in Ghana (Dale, 1957), some produced only limited leaf symptoms sometimes accompanied by slight swellings. The Series I progeny F is derived from a cross between two T17 trees selected by Dale and some seedlings produced extensive speckled leaf clearings and large swellings, whereas others were more tolerant. The Series II progeny D is a hybrid between a T16 tree and a tolerant Trinitario. Vigorous seedlings of this parentage have shown only slight symptoms in field trials.

The most tolerant clone in the whole series of tests was C77, a T85 Nanay  $\times$  Iquitos hybrid derived from a cross between the Trinidad trees Na34 and I.M.C.60. This clone grew vigorously when infected and produced slight often transient red vein-banding and chlorotic specks in the leaves (Pl., fig. 4), without swellings. These symptoms were very similar to those caused by a particularly avirulent isolate from Egbeda in sensitive Amelonado cacao (Thresh, 1961). Other clones of similar parentage to C77 were much less tolerant and the infected parents showed obvious symptoms. This evidence and the results of the Nanay  $\times$  Parinari crosses suggest that sensitivity is dominant, a conclusion supported by the sensitive reaction of two groups of seedlings obtained by crossing C77 with a sensitive Nanay  $\times$  Parinari hybrid and with an Amelonado.

*The reaction of representative clones to infection with other Nigerian isolates*

Many symptomatically distinct isolates of virus have been obtained from outbreaks of swollen-shoot disease in and around the abandoned areas of mass infection in Nigeria. Some isolates are considered to be closely related strains because they are antagonistic in protection tests, but others show no such evidence of close relationship (Thresh & Tinsley, 1960; Thresh, 1961). There is a similar situation in Ghana and



the development of tolerant varieties would be complicated if the numerous strains differ in their effects on the various types of cacao.

Budlings of representative Nanay, Scavina, Nanay  $\times$  Parinari, Trinitario and Amelonado clones were inoculated with virulent isolates of virus from five different locations in Nigeria. The Amelonado and Trinitario clones reacted severely on infection with the Egbeda virus and with each of the other isolates, including those which are thought not to be closely related. The Amazon clones were less severely affected by each virus and least of all by that from Olanla, which affected the Amazons slightly but caused swellings and conspicuous vein-banding in the Trinitarios.

The Scavina and Nanay  $\times$  Parinari clones showed an initially severe necrotic reaction to infection with the Egbeda isolate and an unrelated one from Offa-Igbo. Thus the ability to cause necrosis is not confined to a particular group of viruses and it is likely to be an indication of extreme host sensitivity.

Nanay clone C64 was obviously affected by each isolate. The virus from Offa-Igbo caused a fine banding of tissues alongside the tertiary and quaternary veins. The Ondo virus caused more severe symptoms, a chlorosis of the leaf resulting from localized speckled clearings in the mesophyll. The isolate from Abaku is the only one that never caused swellings in any clone tested.

The Nanay  $\times$  Iquitos hybrid C77 showed very slight and sometimes transient leaf symptoms and no swellings on infection with the isolates from Egbeda and Olanla. The Offa-Igbo virus caused slight leaf symptoms usually accompanied by swellings.

The results of these preliminary experiments suggest that clones tend to react in a similar way to infection with different virulent isolates, even though these seem to be unrelated and were collected from widely separated localities. If this is confirmed and clones which tolerate infection with one isolate also tolerate others, it would greatly simplify the breeding programme.

#### DISCUSSION

Most of the cacao in West Africa has been grown from seed of the Amelonado type derived from a few introductions made at the end of the 19th century from the islands of San Thomé and Fernando Po. The uniform population which has since developed with little conscious selection is characteristically small-yielding. Consequently, many farmers in Ghana and Nigeria recently have been planting the Amazon material selected by W.A.C.R.I. from the extensive introductions made from Trinidad in 1945. It is W.A.C.R.I. policy to continue the present practice of issuing seed rather than clones and the next development will be the introduction of hybrid progenies derived by crossing selected Amazons with Amelonado or Trinitario trees. Such hybrids have shown outstanding vigour, producing large crops of beans acceptable to the manufacturers.

Our tests were limited to the small proportion of the W.A.C.R.I. breeding material established in Nigeria. Nevertheless, they emphasize the extreme vulnerability of the present Amelonado population and suggest that the introduction of Amazon and hybrid material will lead to a much less uniform response to infection. This is because virus effects have been largely ignored in selection, which has been based primarily on

agronomic features. Parinari, Scavina and some of the Amazon clones are likely to be overlo-

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A series of other- virus isolates are be- readily acquire viru- then virus is likely- investigations will- varieties where sw-

Acknowledgement  
W.A.C.R.I. staff wh-

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agronomic features and flavour assessments. Hence the prevalence of the vigorous Parinari, Scavina and Nanay types in the Amazon selections, despite the sensitivity of some to infection.

Attempts to eradicate swollen-shoot disease will be complicated by the planting of many seedlings derived from mixed stands of Upper Amazon trees. Some of these are growing in the neighbourhood of Amelonados and the varied reaction to infection will make it impossible to see symptoms in some trees. Those which tolerate infection are likely to be overlooked by the survey parties and will remain as potential sources of infection. Similar problems will be encountered on the release of the present series of hybrids, which our tests suggest will have a varied but generally severe reaction to infection.

The particular situation in the large areas of Nigeria where control measures have been abandoned presents an opportunity of using the tolerant reaction to advantage. However, our results suggest that extensive reselection, recombination and perhaps new introductions will be necessary before a consistently tolerant behaviour can be obtained in vigorous hybrids producing beans of acceptable size and flavour. If the apparent dominance of the sensitive reaction is confirmed, then it is unlikely that Amelonados can be used as at present to contribute bean size and flavour. Perhaps the most promising approach would be to cross outstandingly tolerant Nanay or Iquitos types with the best Trinitarios. The Series II progeny D is the only one of this type yet produced and tested. Significantly, it has grown well despite infection and it has been much more tolerant than crosses involving an Amelonado parent.

A series of other similar hybrids has been produced and their reactions to different virus isolates are being investigated. The evidence indicating that mealybugs do not readily acquire virus from tolerant trees is being reinvestigated. If this is confirmed, then virus is likely to spread slowly in a tolerant population. The results of these investigations will facilitate a full appraisal of the possibilities of using tolerant varieties where swollen-shoot is prevalent.

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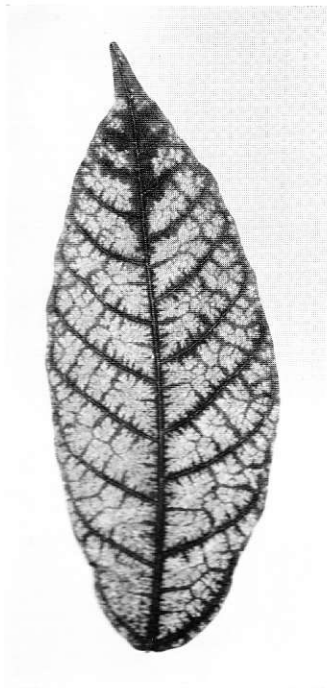
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## EXPLANATION OF PLATE

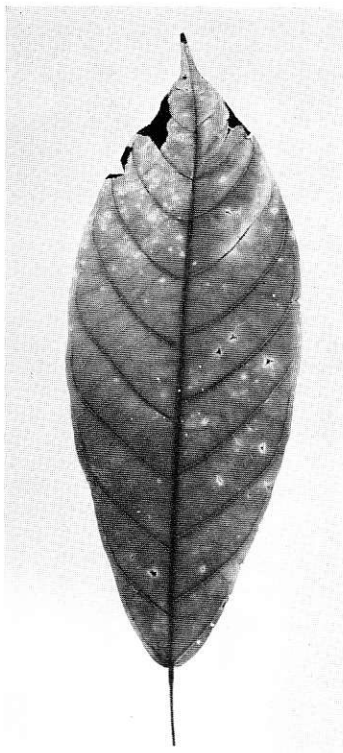
- Fig. 1. Severe interveinal chlorosis in Amelonado cacao, caused by the virulent Egbeda isolate.
- Fig. 2. Chlorotic flecks and necrosis in Parinari cacao caused by the virulent Egbeda isolate.
- Fig. 3. Clearings of the third- and fourth-order veins in Nanay cacao, caused by the virulent Egbeda isolate.
- Fig. 4. Slight clearing of the minor veins in Nanay-Iquitos clone 77, caused by the virulent Egbeda isolate.



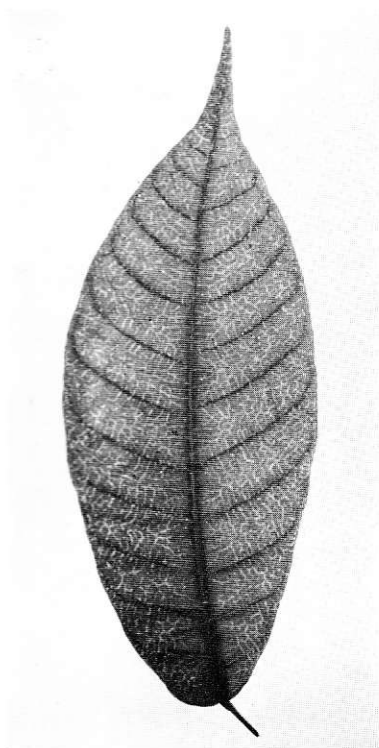




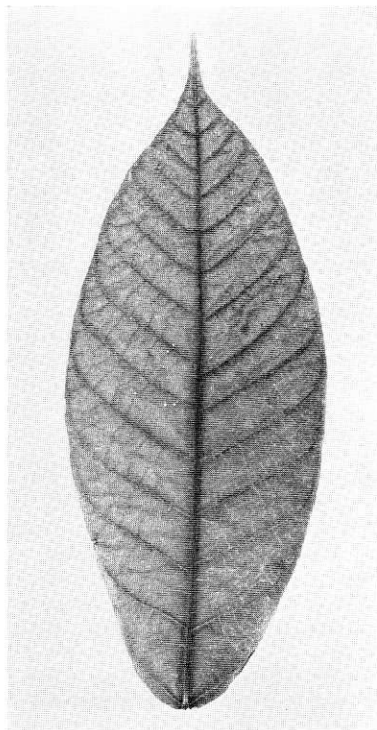
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J. F. LONGWORTH AND J. M. THRESH

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