FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

INTERNATIONAL BOARD FOR
PLANT GENETIC RESOURCES

FAO/IBPGR TECHNICAL GUIDELINES
FOR THE
SAFE MOVEMENT OF YAM GERMPLASM

Edited by
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In collaboration with

RESEARCH INSTITUTE FOR PLANT PROTECTION

INTRODUCTION

Collecting, conservation and utilization of plant genetic resources and their global distribution are essential components of international crop improvement programmes.

Inevitably, the movement of germplasm involves a risk of accidentally introducing plant quarantine pests along with the host plant material; in particular, cryptic pathogens such as viruses pose a special risk. In order to minimize this risk, effective testing (indexing) procedures are required to ensure that distributed material is free of pests that are of quarantine concern.

The ever increasing volume of germplasm exchanged internationally, coupled with recent rapid advances in biotechnology, has created a pressing need for crop specific overviews of the existing knowledge in all disciplines relating to the phytosanitary safety of germplasm transfer. This has prompted FAO and IBPGR to launch a collaborative programme for the safe and expeditious movement of germplasm reflecting the complementarity of their mandates with regard to the safe movement of germplasm. FAO has a long-standing mandate to assist its member governments to strengthen their Plant Quarantine Services, while IBPGR's mandate - *inter alia* - is to further the collecting, conservation and use of the genetic diversity of useful plants for the benefit of people throughout the world.

The aim of the joint FAO/IBPGR programme is to generate a series of crop-specific technical guidelines that provide relevant information on disease indexing and other procedures that will help to ensure phytosanitary safety when germplasm is moved internationally.

The technical guidelines are produced by meetings of panels of experts on the crop concerned, who have been selected in consultation with the relevant specialized institutions and research centres. The experts contribute to the elaboration of the guidelines in their private capacities and do not represent the organizations to whom they belong. FAO, IBPGR and the contributing experts cannot be held responsible for any failures resulting from the application of the present guidelines. By their nature they reflect the consensus of the crop specialists who attended the meeting, based on the best scientific knowledge available at the time of the meeting.

The technical guidelines are written in a short, direct, sometimes 'telegraphic' style, in order to keep the volume of the document to a minimum and to facilitate

updating. The guidelines are divided into two parts: The first part makes general recommendations on how best to move germplasm of the crop concerned and mentions available intermediate quarantine facilities when relevant. The second part covers the important pests and diseases of quarantine concern. The information given on a particular pest or disease does not pretend to be exhaustive but concentrates on those aspects that are most relevant to quarantine. In general, references are only given on the geographical distribution of the diseases and pests.

The present guidelines were developed at a meeting held in Wageningen, the Netherlands from 14 to 18 November 1988. The meeting was hosted by the Research Institute for Plant Protection and sponsored by the Directorate General for International Cooperation (DGIS) of the Netherlands Ministry for Development Cooperation.

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GENERAL RECOMMENDATIONS

The guidelines set out below should be followed when transferring yam germplasm:

Seed

- For species that do produce seed and if it is not essential to move particular genotypes, seeds should be preferred for the movement of yam germplasm.

- Unblemished seeds should be selected from plants which appear healthy. Seeds should be fumigated and treated with fungicide.

- On arrival in the recipient country, the seed should be germinated and the seedlings grown in post-entry quarantine for one crop cycle.

Vegetative propagating material

- Germplasm in vegetative form should be transferred as sterile, pathogen-tested plantlets growing on tissue-culture medium for those species where the techniques are available. (Until now, transfer of such material has only been used for *Dioscorea rotundata-cayenensis* from West Africa and *D. alata* from the Caribbean.)

- Meristem-tips should be cultured either in the country of origin or at an intermediate quarantine centre. Prior thermotherapy may be beneficial (Mantell, 1980).

- For the movement of *in vitro* cultures, neither antibiotics nor charcoal should be added to the medium.

- Each meristem accession should be given a code number for future reference.

- Plantlets should be tested for viruses (see **Indexing** below) in the country of origin, in an intermediate quarantine station or in post-entry quarantine. Only material tested and found free of viruses of concern should be released.

- For species for which techniques to produce pathogen-tested plantlets are not available, plant material should be moved from one country to another only as nodal cuttings (node plus 1-1.5 cm of stem) cultured *in vitro* in a standard tissue-culture medium (Mantell, Haque and Whitehall, 1978). No other form of vegetative propagating material should be moved.

- Plantlets derived from nodal cuttings should be grown out under glasshouse post-entry quarantine conditions upon receipt, for a period equivalent to one crop cycle. Only material tested and found free of viruses of concern should be released.

References

Mantell, S.H. 1980. Apical meristem-tip culture for eradication of flexuous rod viruses in yams *(Dioscorea alata). Trop. Pest Management* **26**(2):170-179.

Mantell, S.H., Haque, S.Q. and Whitehall, A.P. 1978. Clonal multiplication of *Dioscorea alata* L. and *Dioscorea rotundata* Poir. yams by tissue culture. *J. Hortic. Sci.* **53**:95-98.

Intermediate quarantine stations available for yam*

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*This list is not exclusive but was elaborated by the meeting based on information given by the participants.

PESTS OF QUARANTINE IMPORTANCE

Virus diseases

1. Chinese yam necrotic mosaic virus (CYNMV)

Symptoms
Conspicuous chlorotic and/or necrotic spots and severe interveinal chlorosis and necrosis.

Geographical distribution
Reported only from Japan (Fukumoto and Tochihara, 1978).

Transmission
The virus is transmitted efficiently in the non-persistent manner by aphids (especially *Aphis gossypii* and *Myzus persicae).*

Particle morphology
Filamentous particles of about 12-13 x 660 nm.

Indexing
The virus can be rapidly detected and identified by electro-blot immonassay.

References
Fukumoto, F. and Tochihara, H. 1978. Chinese yam necrotic mosaic virus. *Ann. Phytopath. Soc. Japan* **44**:1-5.

Shirako, Y. and Ehara, Y. 1986. Rapid diagnosis of Chinese yam necrotic mosaic virus infection by electro-blot immunoassay. *Ann. Phytopath. Soc. Japan* **52**:453-459.

2. Cucumber mosaic virus (CMV)

(cucumovirus group)

Symptoms
Severe leaf chlorosis.

Geographical distribution
Worldwide in a wide range of plant species, but reported in *D. alata* only in West Africa (Fauquet and Thouvenel, 1987).

Transmission
Efficiently transmitted in the non-persistent manner by a wide range of aphid species.

Particle morphology
Isometric, about 30 nm in diameter.

Indexing
The virus is mechanically transmissible to a wide range of test species of which cucumber *(Cucumis sativa), Nicotiana glutinosa, N. benthamiana* and *Chenopodium quinoa* are most useful. It is readily identified by standard serological procedures (ELISA and ISEM).

References
Fauquet, C. and Thouvenel, J.-C. 1987. Cucumber mosaic on sweet potato and yam. p. 29. In: *Plant Viral Diseases in the Ivory Coast*, Documentations Techniques no. 46. Editions de l'ORSTOM, Paris.

3. *Dioscorea alata* virus (= Yam virus I)

(Possible potyvirus group)

Symptoms
Infected plants have leaves which are symptomless or have inconspicuous mottling (Fig. 1).

Geographical distribution
Probably coincident with the culture of *D. alata* (Hughes, 1986).

Transmission
Vector unknown.

Particle morphology
Flexuous filamentous particles, about 12 x 750 nm.

Indexing
By detection of potyvirus-like particles in sap which are not 'decorated' by antibodies to yam mosaic virus (YMV) using ISEM. Not transmissible to herbaceous indicator species (unlike YMV).

Reference
Hughes, J. d'A. 1986. Viruses of the Araceae and *Dioscorea* species: their isolation, characterization and detection. Ph.D Thesis, University of Reading.

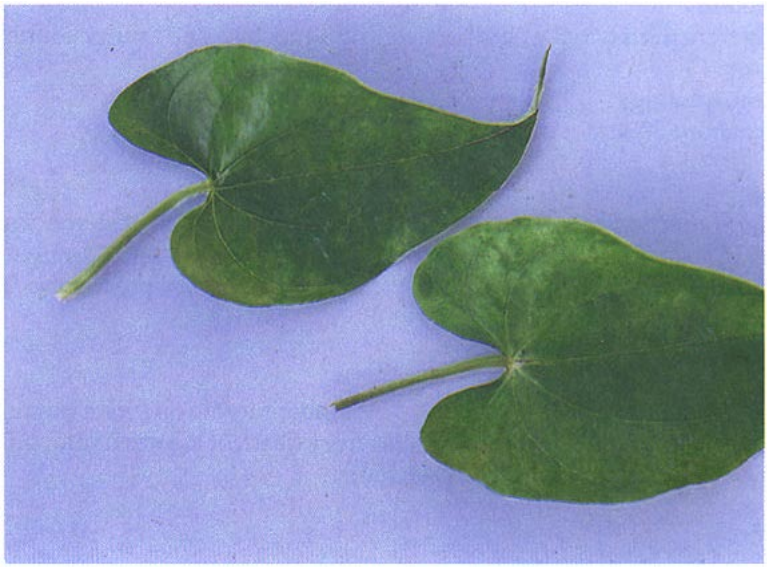

Fig. 1. Symptoms of *Dioscorea alata* virus. (Dr. H.W. Rossel, IITA, Ibadan)

4. *Dioscorea* bacilliform virus

Symptoms
Severe interveinal leaf chlorosis in *D. bulbifera* and associated with internal brown spotting of tubers in *D. alata* cv. White Lisbon.

Geographical distribution
Widespread in *D. bulbifera* in the Caribbean area, and occurs in *D. alata* cv. White Lisbon in Barbados (Harrison and Roberts, 1973).

Transmission
Vector unknown.

Particle morphology
Bacilliform, about 28 x 130 nm.

Indexing
The virus is sap transmissible to seedlings of *D. bulbifera* (but not other common herbaceous indicator plant species) in which it induces conspicuous interveinal leaf chlorosis. It is readily identified by standard serological procedures (ELISA and ISEM).

Reference
Harrison, B.D. and Roberts, I.M. 1973. Association of virus-like particles with internal brown spot of yam *(Dioscorea alata). Trop. Agric.* (Trinidad) **50**:335-340.

5. *Dioscorea* latent virus

(potexvirus group)

Symptoms
Absent.

Geographical distribution
Common in *D. floribunda* and *D. composita* in Puerto Rico (Phillips and Brunt, 1988).

Transmission
No known vector; through planting material, probably by mechanical means.

Particle morphology
Slightly flexuous filaments, about 11 x 485 run.

Indexing
The virus is readily sap transmissible to several species of *Nicotiana,* but induces a symptomless systemic infection in *N. megalosiphon.* The virus is readily detected and identified by standard serological procedures (ELISA and ISEM) (Waterworth, Lawson and Kahn, 1974; Hearon *et al.,* 1978) .

References
Hearon, S.S., Corbett, M.K., Lawson, R.H., Gillespie, A.G. and Waterworth, H.E. 1978. Two flexuous-rod viruses in *Dioscorea floribunda:* symptoms, identification and ultrastructure. *Phytopathology* **68**:1137-1146.

Phillips, S. and Brunt, A.A. 1988. *Dioscorea* latent virus. AAB Descriptions of Plant Viruses, No. 335. Association of Applied Biologists, Wellesbourne.

Waterworth, H.E., Lawson, R.H. and Kahn, R.P. 1974. Purification, electron microscopy, and serology of *Dioscorea* latent virus. *J. Agric. Univ. Puerto Rico* **58**:351-357.

Fig. 2. Yellowing tapered leaves, characteristic of infection by yam mosaic virus on near mature plants of *Dioscorea alata.* (Dr. G.V.H. Jackson South Pacific Commission, Nouméa)

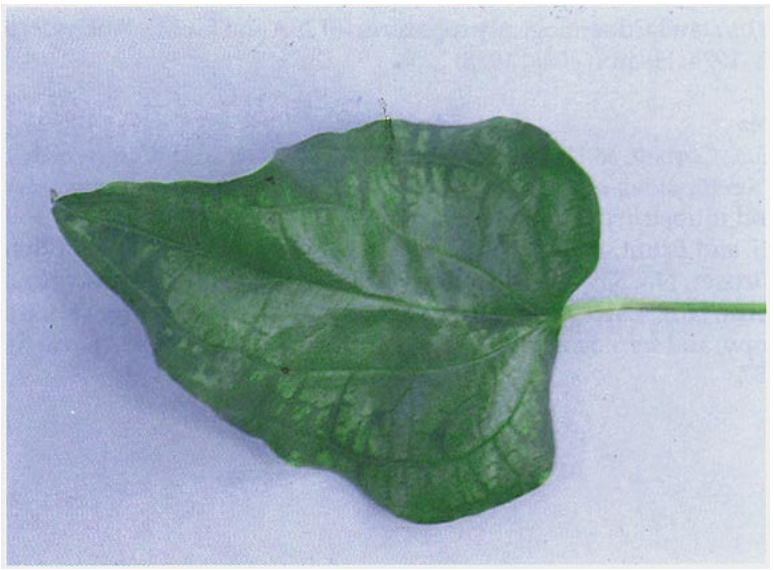

Fig. 3. Symptoms yam mosaic virus of *Dioscorea rotundata.* (Dr. H.W. Rossel, IITA, Ibadan)

6. Yam mosaic virus (YMV)

(potyvirus group)

Symptoms

Severe leaf chlorosis and leaf distortion (Figs. 2 and 3).

Geographical distribution

In *D. rotundata-cayenensis* and *D. esculenta*, the virus is widespread in West Africa and detected occasionally in *D. alata* from the South Pacific (Thouvenel and Fauquet, 1979; 1986; Porth, Lesemann and Vetten, 1987).

Transmission

Non-persistently transmitted by aphids (especially *Aphis gossypii).*

Particle morphology

Flexuous filaments, about 12 x 750 nm.

Indexing

The virus is mechanically transmissible to indicator plant species (e.g. *Nicotiana benthamiana)* and is readily identified by standard serological assays (ELISA and immunosorbent electron microscopy).

References

Porth, A., Lesemann, D.-E. and Vetten, H.J. 1987. Characterization of potyvirus isolates from West Africa yams *(Dioscorea* spp.). *J. Phytopathol.* **120**:166-183.

Thouvenel, J.-C. and Fauquet, C. 1979. Yam mosaic virus, a new potyvirus infecting *Dioscorea cayenensis* in the Ivory Coast. *Ann. app. Biol.* **93**:279-283.

Thouvenel, J.-C. and Fauquet, C. 1986. Yam mosaic virus. AAB Descriptions of Plant Viruses, No. 314. Association of Applied Biologists, Wellesbourne.

Fungal diseases

Anthracnose (dieback or scorch)

Cause
Glomerella cingulata, conidial state: *Colletotrichum gloeosporioides.*

Symptoms
On young leaves, brown spots occur which enlarge, and sometimes coalesce, as leaves approach maturity. Spots may have pale yellow margins. Epidemics occur during prolonged rains: young growth is infected and destroyed by rapidly expanding black lesions, and mature leaves of anthracnose-susceptible varieties rapidly blacken in response to sunlight and the presence of numerous *Colletotrichum* spores which germinate but rarely penetrate the leaf surface. Stems also blacken. Repeated regrowth of vines between epidemics leads to multi-stemmed plants and production of several small tubers (Figs. 4 and 5) (Jackson, Newhook and Winch, 1980; Winch *et. al.,* 1984).

Geographical distribution
Widespread throughout the tropical countries (Mordue, 1971).

Biology
C. gloeosporioides attacks many crops, and spores from these sources may infect yams. The fungus is also commonly isolated from soil and is tuberborne (Adebanjo and Onesirosan, 1986). Spores are formed in large numbers on the leaf spots and splashed in rain and dew to adjacent leaves and stems (Jackson, Newhook and Winch, 1980).

Alternative hosts
Many cultivated and wild hosts.

Quarantine measures
- The unrestricted movement of tubers between countries should not be permitted. If it is essential to import tubers they should be washed free of soil, fumigated or dipped in insecticide (carbaryl/malathion, white oil mixture) and treated with fungicide.
- Preference should be given to importations as sterile, pathogen-tested plantlets growing in a tissue culture medium.

References
Adebanjo, A. and Onesirosan, P.J. 1986. Surface-borne infection of *Dioscorea alata* tubers by *Colletotrichum gloeosporioides. J. Plant Protect. Trop.* **3**:132-137.

Fig. 4. Leaf spots and dieback on vines: symptoms of yam anthracnose by Colletotrichum gloeosporioides. (Dr. G.V.H. Jackson, South Pacific Commission, Nouméa)

Fig. 5. Leaf blackening, a symptom of yam anthracnose on mature leaves caused by *Colletotrichum gloeosporioides* (Dr. G.V.H. Jackson, South Pacific Commission, Nouméa)

Jackson, G.V.H., Newhook, F.J. and Winch, J. 1980. Yam dieback. Advisory Leaflet 12. South Pacific Commission, Nouméa.

Mordue, J.E.M. 1971. *Glomerella cingulata*. Commonwealth Mycological Institute Descriptions of Pathogenic Fungi and Bacteria No. 315. Commonwealth Agricultural Bureaux, Slough.

Winch, J.E.,Newhook, F.J., Jackson, G.V.H. and Cole, J.S. 1984. Studies of *Colletotrichum gloeosporioides* of yam, *Dioscorea alata* in Solomon Islands. *Plant Pathol.* **33**:467-477.

Insects

1. Greater yam beetle, *Heteroligus meles*

Damage

Adult beetles eat the planting setts and plants may wilt and die. Tubers are attacked; the holes reduce market value and predispose them to decay (Coursey, 1967; Anonymous, 1978).

Geographical distribution

Heteroligus meles is widespread in tropical Africa (Coursey, 1967; Anonymous, 1978).

Biology

Adult beetles are 23-33 mm long, dark brown to black, with two prominent knobs on the head. The beetles lay eggs in the soil close to river banks and these hatch to produce creamy-white to grey larvae, which feed on grass roots and other organic matter. From egg to adult takes 22-24 weeks and emergence coincides with the beginning of the rains and the planting of yams. Further attack occurs just before harvest when the beetles again feed voraciously and then migrate to the breeding sites (Anonymous, 1978).

Other yam beetles

The lesser yam beetle, *H. appius,* occurs in southern Nigeria. The beetle is smaller than *H. meles*, but the damage is similar. The adults migrate from wetter areas, where they hibernate during the dry period, into yam gardens to breed. The larvae of the yam beetle *Prionoryctes caniculus* also bore into tubers and are a major pest.

Quarantine measures

- The unrestricted movement of tubers between countries should be avoided. If it is essential to import tubers they should be fumigated or dipped in insecticide (carbaryl/malathion, white oil mixture) and treated with fungicide.

- Preference should be given to importing sterile plantlets (ideally pathogen-tested), growing in tissue culture medium.

References

Anonymous. 1978. *Pest Control in Tropical* Root *Crops.* Pans Manual No. 4. Centre for Overseas Pest Research, Ministry of Overseas Development, London.

Coursey, D.G. 1967. *Yams.* Longman, London.

2. Yam scale, *Aspidiella hartii*

Damage

Infestations of tubers and sometimes foliage cause poor growth. Stored tubers are particularly susceptible to attack and large numbers cause shrivelling (Anonymous, 1978).

Geographical distribution

Widespread in Africa, Asia, Central America, Pacific Islands and West Indies (Anonymous, 1966).

Biology

Adult female scales are pinkish-brown, roughly oyster-shaped, conical, with a white patch at the tip of the cone. Younger scales with relatively more white. Crawlers are yellow (Swaine, 1971).

Alternative hosts

Ginger, turmeric and taro.

Quarantine measures

- The unrestricted movement of tubers between countries should be avoided. If it is essential to import tubers they should be fumigated or dipped in insecticide (carbaryl/malathion, white oil mixture) and treated with fungicide.
- Preference should be given to importing sterile plantlets (ideally pathogen-tested), growing in tissue culture medium.

References

Anonymous. 1966. *Aspidiella hartii* (Ckll.). Commonwealth Institute of Entomology Distribution Maps of Pests. Series A (Agriculture), No. 217. Commonwealth Agricultural Bureaux, Slough.

Anonymous. 1978. *Pest Control in Tropical Root Crops.* Pans Manual No. 4. Centre for Overseas Pest Research, Ministry of Overseas Development, London.

Swaine, G. 1971. *Agricultural Zoology in Fiji.* Overseas Research Publication No. 18. Foreign and Commonwealth Office, Overseas Development Administration, London.

Nematodes

Yam nematode, *Scutellunema bradys*

Symptoms

Lesions beneath the tuber skin are yellow at first, developing into dark brown dry rots (Fig. 6), l-2 cm deep, which may cover the tuber surface in heavily infested tubers. Externally, the skin may crack and flake, showing the brown rot beneath. Secondary rots, often caused by fungi, may completely destroy the tuber. Infection often starts before harvest and continues in storage leading to a loss of food and planting material for the next season's crop (Anonymous, 1978; Bridge, 1972, 1973).

Geographical distribution

S. bradys is a major pathogen in West Africa: Côte d'Ivoire, Nigeria, Senegal and Togo, and is also recorded from Brazil, India, Jamaica and Puerto Rico (Bridge, 1972; Siddiqi, 1972b).

Fig. 6. Dry rot beneath skin on tuber of *Dioscorea rotundata* caused by Scutel-*lonema bradys* (the tuber on the left is healthy). (Dr. J. Bridge, South Pacific Commission, Nouméa)

Biology

Entry to tubers is through the growing point at the head of the developing tuber and through roots and cracks in the skin. Eggs are mainly laid in plant tissues or soil where they hatch and develop into adults. All stages appear to be infective (Anonymous, 1978; Siddiqi, 1972b).

Alternate hosts

In Nigeria the nematode is found in association with corn, pawpaw, cowpea, chillies, oil palm, cassava, rubber trees, banana and cotton (Siddiqi, 1972b).

Other nematodes

Pratylenchus coffeae gives similar symptoms in yam and is also a major pest of many other crops worldwide. It has been recorded on yams in Puerto Rico and in several countries of the South Pacific (Anonymous, 1978; Siddiqi, 1972a).

Quarantine measures

- The unrestricted movement of tubers between countries should be avoided. If it is essential to import tubers they should be fumigated or dipped in insecticide (carbaryl/malathion, white oil mixture). Note that hot-water treatment will reduce populations but cannot be used to guarantee that yams are free of all nematodes.
- Preference should be given to importing sterile plantlets (ideally pathogen-tested), growing in a tissue culture medium.

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Anonymous. 1978. *Pest Control in Tropical Root Crops.* Pans Manual No. 4. Centre for Overseas Pest Research, Ministry of Overseas Development, London.

Bridge, J. 1972. Nematode problems with yams *(Dioscorea* spp.) in Nigeria. *PANS* **18**:89-91.

Bridge, J. 1973. Nematodes as pests of yams in Nigeria. *Mededelingen Faculteit Landbouwwetenschappen, Rijks Universiteit, Gent* **38**:841-852.

Siddiqi, M.R. 1972a. *Pratylenchus coffeae.* Commonwealth Institute of Helminthology Descriptions of Plant Parasitic Nematodes. Set 1, No. 6. Commonwealth Agricultural Bureaux, Slough.

Siddiqi, M.R. 1972b. *Scutellonema bradys.* Commonwealth Institute of Helminthology Descriptions of Plant Parasitic Nematodes. Set 1, No. 12. Commonwealth Agricultural Bureaux, Slough.

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