RICE YELLOW MOTTLE AND AFRICAN SOYBEAN DWARF, NEWLY DISCOVERED VIRUS DISEASES OF ECONOMIC IMPORTANCE IN WEST AFRICA

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ABSTRACT

Rice yellow mottle virus (RYMV), first described in Kenya in 1970, is now known to occur widely both in East and West Africa. It represents a major threat to improved rice cultivation under irrigated conditions, particularly when the new, high-yielding varieties introduced from Southeast Asia are grown.

African soybean dwarf is a new and hitherto undescribed virus disease which until now has only been reported in Nigeria. The disease is whitefly-borne and appears to represent a major threat to soybean production of highly susceptible varieties which are newly introduced and have not been sufficiently tested.

At the International Institute of Tropical Agriculture (IITA) at Ibadan, Nigeria, breeding programs on rice and soybean have taken both diseases into account. New genotypes being developed for international adaptive testing and release as improved varieties are being selected for various desirable characters, including resistance (tolerance) to these potentially disastrous virus diseases.

The rice yellow mottle virus disease in Africa

Introduction

Traditionally, in Africa, rice is grown mostly under rainfed conditions in upland environments, although cultivation in lowlands and swamps is practised in certain areas. In regions where flooded rice is grown, e.g. in valley bottom lands, hydromorphic soils, coastal and in-land swamps, etc., the crop is mostly grown as a rainfed crop only. A long and severe dry season, ranging from 4–8 months, typical of most of the savanna regions of West Africa, made this crop largely a seasonal one in most of the areas where it was traditionally grown. Consequently, endemic virus diseases, which would have become widely disseminated under conditions of continuous cropping were unknown in Africa. However, in recent years irrigated rice production schemes have become increasingly important. These schemes have often been established in cooperative efforts with technical assistance from bilateral and international aid programs such as the International Bank for Reconstruction and Development (World Bank) or the Food and Agriculture Organization (FAO) of the United Nations. These projects are now playing an important role in various African countries which have recognized the need to meet the rapidly increasing consumer demand for rice.

New, improved varieties - mostly from Southeast Asia - were introduced because of their suitability for irrigated production systems and higher yields. These varieties were introduced, however, without extensive adaptive testing in these new environments with their particular locale-specific constraints. It was under these conditions that a virus, causing severe yellowing and stunted growth, sometimes followed by extensive necrosis, particularly in highly susceptible genotypes was first reported for rice in East Africa (Kenya) in the late 1960s (Bakker, 1970). The causal agent - a beetle-transmitted, highly infectious and readily sap-transmissible virus - was studied in detail and described as rice yellow mottle virus (RYMV) by Bakker (1974). The virus was subsequently described in Sierra Leone, where it was called pale yellow mottle virus

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(Raymundo and Buddenhagen, 1976), as well as from the Ivory Coast (Fauquet and Thouvenel, 1977) and Nigeria (Rossel *et al.,* 1982a), where it was known to occur since 1978 (IITA, 1979; Buddenhagen and Rossel, unpublished). The disease in these countries occurred under similar conditions of continuous irrigated production of this crop.

Chaetocnema pulla and various other chrysomelid beetles have been reported as vectors of this virus (Bakker, 1974). Most of these are common leaf feeders of rice in Africa. Other chrysomelid beetles have been reported from the rice-growing areas in Southeast Asia.

Earlier surveys by Buddenhagen of IITA, Ibadan, Nigeria, had shown that RYMV occurs in other countries, including Tanzania and Liberia where it had also become established under similar conditions in irrigation schemes (Rossel *et al.,* 1982b). Apparently, continuous rice culture in these irrigation schemes allows the virus to be carried over from one season to the next.

More recently outbreaks of the disease have been reported in Mali, Upper Volta and Niger (John *et al.,* 1984). RYMV thus seems to have a continent-wide distribution in Africa.

Disease outbreaks occurred mostly in new varieties, often of comparatively recent introduction, which apparently are all susceptible to this virus (Bakker, 1970; Rossel *et al.,* 1982a).

On testing numerous materials at IITA, it was found that resistance to RYMV is indeed very rare but not absent from *Oryza sativa* germplasm of Southeast Asian origin (IITA, 1979; Buddenhagen, unpublished). In contrast, traditionally-grown landraces, mostly adapted to upland growing conditions ('OS-6', 'Lac 23', 'Moroberekan' etc.), proved moderately to highly resistant to this typical African virus disease.

1 Ecology of RYMV

In spite of intensive searching in Nigeria for natural weed hosts of the virus, no evidence for the natural occurrence of RYMV - neither in indigenous *Oryza* species nor in other wild grasses - has ever been obtained; not even in the vicinity of heavily infected rice crops. This seems to contradict findings in Kenya where the natural spread of RYMV was observed from artificially infected rice to *Dinebra retroflexa, Eleusine indica, Eragrostis tennifolia* and *Oryza* sp. when interplanted with the infected rice in alternate rows (Okioma *et al.,* 1983). Neither was any evidence obtained in Nigeria for the occurrence of the virus in farmers' fields planted with traditional upland varieties under upland and hydromorphic conditions.

Oryza glaberrima was shown to be generally highly tolerant to RYMV in studies conducted at IITA (Attere and Fatokun, 1983). It is one of the most common indigenous *Oryza* species in Africa which although still found grown as a sole crop or in mixed cropping with *O. sativa* in northwestern Nigeria, is usually considered as a rice-associated weed species. Until now no (latent) infections have been encountered among numerous samples tested of this species taken from natural vegetation in rice-growing areas of Nigeria.

Similarly surveys within Nigeria have not found infected plants of *O. longistaminata,* a typically perennial wild *Oryza*-species. Neither have infected plants been found in *O. barthii,* which is endemic to the same more or less permanently wet flood-plain habitats along the Niger river.

Interestingly, an accession of *O. barthii* which was collected during one of the surveys undertaken in earlier mentioned ecologies along the Niger proved immune to RYMV. One of two similarly tested *O. longistaminata* accessions (vegetatively propagated) which was collected in the same habitat also proved immune to RYMV. In contrast the other accession of the latter species proved quite susceptible to the virus.

During a recent survey in various Sahelian countries conducted by scientists from IITA and the West African Rice Development Organization (WARDA), Monrovia, Liberia, naturally infected plants - other than *O. sativa* - were found for the first time since the discovery of the virus in Africa. Among populations of *O. longistaminata,* (commonly found growing at the edges of small ponds and permanently flooded swamps) in Niger and Mali, plants were observed which were suspected of being infected with a virus disease. Upon testing with RYMV antiserum it was confirmed that natural infections of RYMV were involved (John *et al.,* 1984).

Oryza longistaminata most likely represents a natural host of RYMV in some parts of Africa. The virus has probably spread from this species to *O. sativa* when the latter was introduced into Africa several hundred years ago.

2 Epidemiology

Until now RYMV has not been found outside of Africa and its neighboring islands. If accidentally introduced to the main rice-growing areas of the world in Southeast Asia it could ravage the crop in this region since apparently epidemic spread of this virus in *O. sativa* is primarily governed by crop factors such as (high) susceptibility and continuity of cropping, both in time and in space; not at the first instance by availability of an efficient vector. RYMV was not discovered in Africa until recently when continuous cropping with highly susceptible, exotic varieties apparently allowed the disease to progressively buildup to epidemic levels. It is an interesting, although unanswered, question whether the old landraces of *O. sativa* represent more resistant selections from several generally susceptible types, or whether - through introgression from indigenous, highly tolerant *O. glaberrima* - types have come to the foreground with similarly high levels of resistance.

Although found throughout Africa, RYMV appears to be remarkably homogeneous as far as serological relationship and reaction pattern across *O. sativa* germplasm are concerned. Various upland varieties of rice tested and demonstrated to be quite resistant to RYMV in Sierra Leone (Raymundo, 1980), were also shown at IITA to be equally resistant to an isolate of the virus obtained in Nigeria.

By comparing an isolate from Nigeria (West Africa), with an isolate from Kenya (East Africa), no obvious differences in type nor severity of reaction were observed among 5 selected rice varieties. These varieties had been selected to represent the entire range of reactions to RYMV (from highly susceptible, variety IR-5, to highly tolerant, variety OS-6) when tested with the Nigerian isolate of RYMV.

3 Control

A breeding program aimed at incorporating a high level of resistance to RYMV into new varieties being developed at IITA is well underway. Emphasis in this program is placed on incorporating such resistance into varieties being developed for irrigated and hydromorphic growing conditions in Africa. Under these conditions resistance to RYMV seems to be a prerequisite to successful cultivation as evidenced by severe outbreaks of the disease experienced in various large-scale irrigated rice production schemes in recent years.

Soybean dwarf in Nigeria, a new, whitefly-transmitted disease

Introduction

For several years severely dwarfed plants had been seen occasionally in soybean breeding plots and agronomy trials conducted by IITA in various ecological zones within Nigeria. Diseased plants were only rarely seen in local soybean (var. Malayan). At IITA, during the 1980/81 dry season (November–May) the disease reached epidemic proportions in an approximately 0.5 ha plot planted with a particular breeding line (TGx 309-021G). A number of lines in the breeding nurseries showed a high incidence of the same severe dwarfing disease at IITA during the 1981 rainfed growing season (May–November), in breeder's plots under irrigation during the 1981/82 dry season, and again during the 1982 growing season.

1 Symptoms

Symptoms are strikingly similar to those caused by soybean dwarf virus (SDV) reported from Japan (Tamada, 1975) and Indonesian soybean dwarf virus (ISDV) (Iwaki *et al.,* 1980) both of which are transmitted by aphids in a persistent manner.

2 Diagnosis

The disease was found to be non sap-transmissible. It could, however, be transmitted by grafting.

Virus purification attempts did not provide any further evidence of a spherical particle described as being necessary for SDV involvement (Rossel and Thottappilly, 1982). In fact no conclusive evidence on the type of virus particle involved has been obtained so far.

Interestingly, in serological tests with an antiserum to SDV, strong and seemingly specific reactions were initially obtained with samples taken from diseased plants from the field at IITA. In agar-gel diffusion tests, in addition to host protein-related, straight precipitation bands - observed both with healthy as well as with diseased samples - curved bands closer to the antigen wells formed with most samples taken from diseased plants (Rossel and Thottappilly, 1982). No explanation could be given for this.

3 Vector transmission

Aphid transmission was neither obtained with *Aphis craccivora, Myzus persicae* nor with an unidentified aphid species commonly found colonizing the common weed, *Eupatorium odoratum.* All these are common aphid species in Nigeria. The aphid species described as vectors of SDV and ISDV were not encountered during these studies.

In the following a series of experiments will be described detailing the characterization of the relationship of the whitefly, *Bemisia tabaci,* found to be the vector of the dwarf disease in Nigeria, with its causal agent whose nature has not yet been established (see Tables 1-4).

All transmission studies were carried out using young seedlings of the highly susceptible IITA soybean breeding line TGx 309-021G as test plants. Leaf cages were used for whitefly feeding consisting of small 0.75 cm long cut-off pieces of ultraclear centrifuge tubes which were gauze-covered on both ends. These cages were clipped onto the leaves by means of a slit along one side, through which the whiteflies also were introduced by means of a simple aspirator tube.

Table 1 Influence of various acquisition access periods on the transmission of soybean "dwarf" in Nigeria by its vector *Bemisia tabaci*

Acquisition access period	Number of plants infected out of 10
1 min	0
5 min	0
15 min	0
1 hr	0
4 hr	1
8 hr	3
24 hr	3
48 hr	7

* Inoculation access period: 72 hr.

Table 2 Persistence of transmission of soybean "dwarf" in Nigeria by its vector, *Bemisia tabaci**

	Days after acquisition*								
Series	1	2	3	4	5	6	7	8	9
1	+	+	–	–	–	+	+	–	–
2	+	+	–	–	+	–	D		
3	–	–	–	–	–	–	–	–	–
4	+	+	+	–	–	+	–	+	+
5	–	+	+	–	–	+	–	–	–
6	–	–	–	–	D				
7	+	+	+	+	+	–	–	D	
8	+	+	+	+	–	–	D		
9	+	+	+	+	+	+	+	–	–
10	+	–	–	–	–	–	–	–	–

* Acquisition access period: 48 hr, with daily transfer to new test plants.
\+ Plant developed typical symptoms.
D Whitefly died.

Table 3 Influence of number of whiteflies on infection incidence with soybean "dwarf" in Nigeria by its vector *Bemisia tabaci**

Number of whiteflies per leaf cage	Number of plants infected out of 10
1	3
2	2
3	3
4	3
5	4
6	4
7	4
8	6
9	6
10	8

* Acquisition access period: 24 hr.
Inoculation access period: 48 hr.

Table 4 Transmission studies with soybean "dwarf" in Nigeria, determining the occurrence of a period of latency in its vector, *Bemisia tabaci*

	Hours after acquisition access*								
Series	2	4	6	8	10	14	22	30	54
1**	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–	–
4	–	–	+	–	–	–	–	–	–
5	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–
8	–	–	–	+	–	+	–	–	+
9	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	+	–	–	–

* Acquisition access period: 8 hr.
** 5 whiteflies per leaf cage (series).
\+ Plants developing characteristic symptoms.

4 Host range

Once it had been established that the whitefly, *Bemisia tabaci* can transmit the disease, viruliferous whiteflies were allowed access to the following crops and test plant species: *Arachis hypogaea, Cajanus cajan, Canavalia ensiformis* 'TCe 6', *Phaseolus vulgaris* 'Bataaf', *Phaseolus lunatus* 'TP1 250B', *Psophocarpus tetragonolobus* 'TPt 2', *Vigna unguiculata* 'TVu 22' and 'TVu 1582', *Lycopersicon esculentum* 'Panase F', *Nicotiana benthamiana, N. clevelandii* and *N. tabacum* 'White Burley'. However, no symptoms were observed in any of these, neither could infection be determined through back-tests.

In conclusion it is obvious that the severe, and potentially epidemic "dwarf" disease of soybean in Nigeria is not related to any of the known whitefly-borne diseases occurring in the crops indicated. It may thus represent a new and hitherto undescribed virus disease of soybean which apparently is quite efficiently transmitted by *Bemisia tabaci.*

Various soybean germplasm accessions being used as parental materials in the soybean breeding program at IITA were screened for resistance to the "dwarf" disease by caging 10 plants each of the accessions listed with a viruliferous whitefly culture on diseased soybean (Table 5). Some accessions commonly used for hybridizations were identified as highly resistant to the disease, notably the varieties Bossier, Improved Pelican and IITA germplasm accessions, TGm 119 and TGm 662.

The local soybean variety, Malayan, appeared to be "field-resistant". Indeed, following artificial inoculation it proved to be only moderately susceptible. This may explain the rarity of the disease in farmers' fields in Nigeria where until recently this variety predominated.

The "dwarf" disease may not be restricted to Nigeria alone, but may well have a much wider distribution and possibly may occur Africa-wide as several other Africa-specific virus diseases. The name "African soybean dwarf virus" has thus been proposed; although, virus particles likely to represent the causal agent of this disease have not yet been isolated or identified.

Table 5 Important soybean germplasm introductions at IITA tested for resistance to the "dwarf" disease of soybean in Nigeria

Introduction number	Variety name (origin)	Symptoms*
TGM 7	('Improved Pelican')	1
TGm 80	('Bossier')	1
TGm 119	(unknown origin)	2
TGm 120	('S3')	5
TGm 334	('Hernon 237')	5
TGm 479	('Jupiter')	5
TGm 579	('M 351': local, improved breeding line)	3
TGm 618	('Obo')	5
TGm 623	('Indo 9')	4
TGm 636	('Indo 30A')	3
TGm 637	(unknown origin)	3
TGm 662	('Indo 100')	1
TGm 683	('Indo 125')	4
TGm 685	('Indo 131')	4
TGm 693	('Indo 153')	4
TGm 715	('Indo 195')	4
TGm 737 p.f.	('Indo 243')	4
TGm 739	('Indo 246')	3
TGm 107	('Malayan': local variety)	3
M79	('Samsoy 1': local, improved variety)	4
M90	(local, improved breeding line)	5
M216	('Samsoy 2': local, improved variety)	4

* Scoring scale: 1-5 (1: no symptoms; 5: severe stunt).

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Discussion

Honda, Y. (Japan): Is the causal agent of African soybean dwarf disease a geminivirus or cowpea mild mottle virus?

Answer: It is very difficult to determine whether it is a geminivirus as purification attempts have been inconclusive.

Honda, Y. (Japan): Don't you think that the virus you described is similar to the Thai isolate of soybean crinkle leaf virus?

Answer: It is quite possible although the symptoms are different.

Reddy, D.V.R. (ICRISAT): It may be advisable that you postpone naming this virus until you characterize it. You may also want to check serological relationships using other serological methods.

Answer: The name African soybean dwarf is only used as a result of the strong similarity in symptomatology and following the tradition of African cassava mosaic versus cassava mosaic in South America, for instance. When the virus is identified, the name for the disease will be replaced by an appropriate new name for the causal virus. The serological studies yielded unexpected typically positive reactions which however can only be of a specific nature. They are mentioned only as a point of possible interest to other colleagues who might have observed similar specific reactions.

Morinaka, T. (Japan): Several species of beetles have been reported as the vectors of rice yellow mottle virus. Which beetle species did you use for artificial inoculation in the screening tests for rice resistant varieties?

Answer: Although other species of beetles can be used, *Chaetocnema pulla* is the most efficient vector. We did not use beetles for inoculation as the virus is readily sap-transmissible (dilution end point of infectivity is above 10^{-6} and higher). Artificial inoculation is an easy and efficient process, simply performed by rubbing the plants with juice to which Carborundum is added.