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Evaluation of the resistance to BYDV of a group of important world rice genotypes

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Abstract. A serious disease named "giallume" (i.e. yellowing) has been described as occuring in Europe since 1965, mainly in Italy and Spain. It is caused by the Barley Yellow Dwarf Virus (BYDV). The non specifically aphid transmitted strain (PAV-BYDV) is the most common in Italy in rice also. BYDV is reported to occur in many other-countries of the world, besides Europe, in natural and cultivated *Gramineae*, but not in rice. It is also very well known that rice is grown in the vicinity of different *Gramineae* in areas where BYDV and related aphid vectors are present. It is therefore unlikely to exclude in this context future BYDV problems due to BYDV in rice in Mediterranean but also in non Mediterranean countries. On the basis of this statement, the University of Udine, the Italian Rice Council of Milan and the CIMMYT of Mexico City have accomplished a joint programme with the purpose of testing the resistance to BYDV of a group of important world rice genotypes. A total of 44 genotypes of the following countries were experimentally inoculated with PAV-BYDV by using *Rhopalosiphum padi* L. as chief vector: China, Columbia, Hungary, the Ivory Coast, India, Indonesia, Italy, Korea, Malaysia, Nigeria, Pakistan, IRRI-Philippines and the USA. An average number of 35 test plants/cv. were inoculated and then both observed for the symptom expression and tested by ELISA. Three genotypes of Malaysia and one from Italy revealed to be completely resistant (no symptoms, no serological reactions); nineteen were absolutely symptomless carriers; the remaining genotypes were of a different degree of susceptibility to BYDV.

The results obtained are discussed and connected with some general epidemiological involvements.

I – Introduction

Barley Yellow Dwarf Virus (BYDV) is a complex of Luteovirus which causes yellow diseases in over 100 species of *Gramineae* (Rochow and Duffus, 1981). The isolates of the virus are grouped into strains mostly according to their vector specificity (Rochow, 1970; 1979), serology (D’Arcy et al., 1992; Lister and Rochow, 1979) and nucleic acid hybridization (Fottouh et al., 1990; Martin and D’Arcy, 1990).

The main vectors of BYDV are the aphids *Rhopalosiphum padi* L., *Sitobion avenae* Fabricious, *Metopolophium dirhodum* Walker, *Schizaphis graminum* Rondani, *R. maidis* Fitch.

A severe disease of *Oryza sativa* L., named “giallume” (i. e. yellowing), has been observed in Northern Italy since 1955 (Corbetta, 1967). It is caused by a PAV strain of BYDV (Osler, 1980; 1984; Plumb, 1974; Rochow, 1969) known to be nonspecifically transmitted by various aphid vectors. The most efficient vector of the virus is the aphid *R. padi*. Although less important, *M. dirhodum* and *S. avenae* are also vectors of RGV (Rice Giallume Virus) (Osler, 1980; 1984). Several species of *Gramineae* can be the natural alternative hosts of RGV (Amici et al., 1978).

A similar disease is reported to occur naturally on rice in Spain and in Hungary (Jorda et al., 1987; Pocsai et al., 1985), but not in other countries of the world where rice is cultivated (Burnett, 1984).

On the contrary, BYDV is present with its different strains in many countries of the world in wild and cultivated *Gramineae* (Burnett, 1990). It is also a well known fact that rice is commonly grown in the proximity of various *Gramineae* in areas where BYDV and relative aphid vectors are present and epiphytotics of the disease repeatedly occur both in time and space.

Considering that rice is a host for BYDV (Belli et al., 1974; Moletti and Osler, 1979; Osler, 1980; 1984) and that different species of aphids can colonize this cereal, it is surprising that the disease on rice is limited to very few European countries. In this connection, it is widely reported that the epidemiology of BYDV is greately influenced by different factors. Of these, specificity of transmission and host reaction to infection are crucial (Lister et al., 1984). On the basis of this statement, the University of Udine, the Rice Research Centre of Castello d'Agogna and CIMMYT of Mexico City have accomplished a joint programme with the purpose of verifying the reaction of a group of important world rice genotypes when inoculated with the PAV strain of BYDV which causes "giallume" in Italy. More precisely, the aim was to ascertain if RGV could induce symptomatic or non symptomatic infections in such rice genotypes (Table 1).

II – Materials and methods

Altogether 44 rice genotypes gathered in 13 different countries (Table 1) round the world were tested for their reaction to RGV. An average number of 35 test plants/cv. (two replications) was inoculated. The Italian cvs Arborio, Cripto and Drago were also included in the experiment, the former being well known for its resistance to RGV, the latter two for their high susceptibility to the virus.

The infectivity level of the inoculative aphids was tested by exposing each of them to the *Avena byzantina* K. Koch test plant.

The RGV isolate was originally derived from naturally infected rice in northwestern Italy by using the vector *R. padi*. Sources of inoculum were symptomatic *A. byzantina* and rice cv. Balilla inoculated 15-20 days before. The test rice seedlings were grown inside a greenhouse and infested at the stage of one leaf. *R. padi*, the most efficient vector for RGV, was used in all the transmissions. The virus-free colonies of *R. padi* were started from a group of tested viviparous females and then grown on caged *A. byzantina* and rice. The two-day acquisition feeding occured in a growth chamber on detached leaves of the source of inoculum, in humid Petri dishes, at 20°C and constant light. Inoculation was performed in a greenhouse, at 25°C and lasted for three days; for each test plant two aphids were used derived from infected oat and three from infected rice. The vectors were individually transferred by using a channel hairbrush.

At the end of the inoculation period, the test plants were sprayed with an insecticide and moved outdoors where the treatment was periodically repeated. The plants were then regularly observed till harvest time for symptom expression.

One month after the inoculation, the test plants were also sampled and subjected to the DAS-Elisa test (Clark and Adams, 1977). The samples, 0.5 g of leaves collected from each plant, were grinded in 5 ml of extraction buffer (phosphate saline buffer with 2% PVP and 0.05% Tween 20, pH 7.4). The antiserum used was specific to BYDV-PAV strain (Bioreba, Switzerland). Diagnosis by Elisa was based on the "3X healthy background" criterium for a positive A_{405} value.

III – Results

The average percentage of infectivity of the aphids *R. padi*, which acquired the virus from rice and *A. byzantina* sources of inoculum, was 68 and 75 respectively.

As reported in Table 1, besides Arborio, three other rice cultivars, all coming from Malaysia, revealed to be completely resistant to RGV: MR 7, MR 77 and MR 103. In fact, no plant of these genotypes inoculated with the virus showed symptoms of the disease or reacted positively to Elisa.

Eighteen of the 44 rice genotypes were symptomless carriers. Among these, the Indonesian cv. Bakka Batjere resulted positive to Elisa in 66% of the inoculated plants; in the case of Oryzica 1 from Columbia, the percentage was 3. In average, 22% of the plants of these 18 cvs. of rice reacted positively to Elisa.

The remaining 22 cvs. showed a variable susceptibility to RGV. In average, 48% of the plants showed symptoms of the disease whereas 62% were positive to Elisa. Generally, Elisa was a more sensitive method for evaluating the positive inoculations than the observation of the symptoms.

Italian Arborio reacted as a completely resistant cultivar; Cripto and Drago were highly susceptible (high percentage of symptomatic and virus-hosting plants).

Among the tested genotypes, the Malaysian were the most resistant/tolerant to RGV; the Nigerian ones the most susceptible.

IV – Discussion

Considering the general reaction to RGV of the 44 rice genotypes, it is clear that the vast majority of them are susceptible or symptomless carriers. In fact, besides Arborio, only three cvs. revealed a complete resistance to the virus. According to the positive reaction to Elisa, it must also be stressed that an average of 21% of the rice plants belonging to the symptomless carrier cvs. and 62% of the plants of the 22 susceptible cvs. resulted infected.

Considering the reaction to RGV of the total 1427 inoculated rice plants belonging to the 44 genotypes investigated, only 337 (24%) resulted symptomatically infected; the total number of infected plants (positive to Elisa) was 571 (40%). This means that a high proportion of the plants of the 44 rice genotypes tested are at least infectable.

Therefore on the basis of these last results, the reason why BYDV is at present exceptional in rice in the world is not to be primarily attributed to the characteristics of resistance of the cultivated rice.

BYD is a complicated event also in non-rice *Gramineae* as the disease outbreaks depend on several factors, i.e. the virus, the vectors, the plant and the environmental conditions (Irwin and Thresh, 1990). In rice, the disease diffusion seems more difficult than in other *Gramineae*. In fact, rice is a poor host both for the aphids and for BYDV, particularly if compared with barley and oat.

As for the virus-strains, it must be noted that not all the BYDV isolates can cause the disease in rice (Osler et al., 1987). A trial is in progress in order to verify the infectivity level in rice of several BYDV strains isolated in different countries of the world.

Considering the resistance/susceptibility to RGV of the tested genotypes, we can conclude that the situation is very variable from country to country. Interestingly, the majority of the tested genotypes from Malaysia are resistant or symptomless carriers of RGV. Only 3 of the 280 inoculated plants became symptomatically infected. These genotypes could be utilized in future programmes as sources of resistance to BYDV.

Till now, as already mentioned, only in Italy, Spain and Hungary, BYDV is reported to infect rice. Nevertheless, particularly for the following reasons, we cannot exclude for the future BYD epiphyties also in other rice cultivated areas: i) BYDV is found spread in the countries where rice is cultivated; ii) rice is grown near *Gramineae* infected by BYDV; iii) rice, although not the favourite plant by BYDV and by aphids is anyway a proven host for both; iv) it was demonstrated here that the strain PAV-like of BYDV can infect the majority of the 44 tested world-cultivated genotypes; v) the PAV strain is found in the most important areas where rice is cultivated.

To better understand the epidemiology of the disease and to predict the real risk of BYD-epyphyties for rice, we need to better investigate on the role played by the environment, the vectors and the viruses. The reaction of rice to the most important local isolates of BYDV should be studied at least in the most important rice cultivating countries.

Table 1. Reaction to BYDV of 44 rice genotypes derived from 13 different countries

Country	Rice genotype	Symptoms +	Elisa +	Comment
CHINA	BUASAN	5/28	15/28	S
CHINA	GUICHAO	29/35	28/35	S
CHINA	ZHENGUI 59	0/36	9/36	SLC
CHINA	NONGQING	7/19	11/19	S
INDIA	RAGHUSAIL	O/32	10/32	SLC
INDIA	RANDHUINIPAGAL	3/35	28/35	S
INDONESIA	BAKKA BATJERE	0/29	19/29	SLC
KOREA	MILYANG 83	34/39	37/39	S
MALAYSIA	MR1	0/34	10/34	SLC
MALAYSIA	**MR7**	**0/37**	**0/37**	**R**
MALAYSIA	MR10	0/33	12/33	SLC
MALAYSIA	**MR77**	**0/32**	**0/32**	**R**
MALAYSIA	MR81	3/37	20/37	S
MALAYSIA	MR84	0/41	2/41	SLC
MALAYSIA	**MR103**	**0/33**	**0/33**	**R**
MALAYSIA	MR106	0/33	14/33	SLC
PAKISTAN	PK139912111	1/33	13/33	S
PAKISTAN	PK165648221	0/37	16/37	SLC
PHILIPPINES	IR36	0/35	1/35	SLC
PHILIPPINES	IR50	0/34	2/34	SLC
COLOMBIA	CICA8	9/34	24/34	S
COLOMBIA	ORYZICA 1	0/38	1/38	SLC
COLOMBIA	ORYZICA 2	1/33	11/33	S
COLOMBIA	ORYZICA 3	2/32	22/32	S
COLOMBIA	ORIZYCA LLANOS 4	0/32	2/32	SLC
COLOMBIA	ORYZICA LLANOS 5	0/34	3/34	SLC
HUNGARY	M-225	0/16	4/16	SLC
ITALY	**ARBORIO**	**0/29**	**0/29**	**R**
ITALY	CRIPTO	29/33	20/33	S
ITALY	DRAGO	29/32	25/32	S
IVORY COAST	IDSA6	23/37	19/37	S
IVORY COAST	WAB 56-104	16/37	17/37	S
NIGERIA	BG 90-2	0/30	5/30	SLC
NIGERIA	BG 400-1	0/34	8/34	SLC
NIGERIA	IRAT 104	30/32	30/32	S
NIGERIA	IRAT 144	28/29	22/29	S
NIGERIA	IRAT 170	19/19	10/19	S
NIGERIA	ITA 150	23/31	26/31	S
NIGERIA	ITA 212	4/33	13/33	S
NIGERIA	ITA 222	0/33	2/33	SLC
NIGERIA	ITA 235	11/31	11/31	S
NIGERIA	ITA 257	12/31	17/31	S
NIGERIA	ITA 315	19/29	18/29	S
USA	NEWBONNET	0/36	14/36	SLC

SLC: Genotype Symptomless Carriers; R: Genotype Resistant; S: Genotype Susceptible.

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