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Full Length Research Paper

Screening rice (*Oryza sativa* L.*)* varieties for resistance to rice yellow mottle virus

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Rice yellow mottle virus (RYMV) is the most important virus disease of rice in Africa. It is spread all over Côte d'Ivoire and is responsible of large production losses. Until now, control measures of the disease are based on the exploitation of natural resistance sources. Thirty nine (39) rice varieties (14 irrigated and 25 rain fed) from NCAR (National Center of Agronomic Research) collection were screened for the resistance to RYMV. Using the couple symptoms/grains weight, as evaluation criteria, it appeared that different varieties groups presented different levels of sensitivity to RYMV. Thus, in lowland ecosystem, Moroberekan variety, of *japonica* type, appeared to be highly resistant whereas WITA9 and WAT316 varieties, of *indica* type, were resistant. On the other hand, IDSA46, IDSA62, IDSA74 and IDSA76 varieties of *japonica* type were tolerant in upland ecosystem. Symptoms severities were related to grains weight reduction which is varietal related. The existence of resistant/tolerant varieties to RYMV as found in this study suggests that the NCAR germplasm collection is a potential reservoir of resistance genes. It is therefore necessary to keep on exploring it in order to use them in breeding program.

Key words: Resistant/tolerant, rice varieties, rice yellow mottle virus, screening.

INTRODUCTION

Rice (*Oryza sativa*) is the most important cereal after wheat in the world. However, rice culture is threatened by climatic and pedological unfavorable conditions, weeds, ravagers and parasites (Jacquot et al., 1992; Sarra et al., 2004; Gnissa et al., 2001; Kouassi et al., 2005). Among these problems, virus diseases appear to be the major plant health problems for rice in many countries. In the rice field, 16 viral diseases were reported among which, only two were described in Africa (Awoderu, 1991; Fargette et al., 1997; N'guessan, 1999). Rice Yellow Mottle Virus (RYMV) is the most important viral disease for rice in Africa where it causes important production losses (Pinto et al., 1999; Paul et al., 2003; Banwo, 2003; Konaté et al., 2006; Traoré et al., 2006). RYMV was first recorded in West Africa in Sierra Leone in 1975. By 1990, it had been recorded in all West and Central African states, except Mauritania. It had also shown up in Madagascar and Tanzania. Over the last 20 years or so, it has become a major problem in irrigated rice systems, especially in Burkina Faso, Côte d'Ivoire, Mali and Niger, and in lowlands in Burkina Faso, Côte d'Ivoire, Senegal and Sierra Leone. It will, however, attack rice in any lowland situation. RYMV action can be devastating. Large production losses of 64 to 100 % have been recorded in Mali (West Africa). This disease is present in Côte d'Ivoire and causes variable economic losses. But, no vigorous fighting action has been set to control the disease, showing the lack of solution facing the important havocs rice yellow Mottle virus causes in rice fields. Disease control based on the change of cultivation practices and utilization of transgenic rice plants is now inefficient (Kohli et al., 1998; Morino et al., 1999; Sorho et al., 2005; Kouassi et al., 2006). Disease control is now oriented towards the exploitation of the natural resistance sources. The National Center of Agronomic Research in Côte d'Ivoire, (NCAR) which possesses a collection of 2868 genotypes of rice has initiated a screening program

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Table 1. List of 15 rice irrigated variety tested.

N° Name of variety	Pedigree	Origin
1 Kogoni 91-1		Mali
2 Niono 1		Mali
3 Niono 2		Mali
4 Niono 3 (SK 89)		Mali
5 Super Bouaké 189	B189 B-52-8-3-1	Philipines
6 TOX3052-46-E2-2-2-4-3	IR 46 (ITA 123)	ADRAO /IITA
7 WAT311 (WAS-B-B-23-7-1)	IR 13240-108-2-2-3 / ITA 306	ADRAO
8 WAT316 (WAS-B-B-51-3-1)	IR 317885-58-1-2-3 / JAVA	ADRAO
9 WAT317 (WAS-B-B-55-4-3)	IR 317885-58-1-2-3-3 / ITA 306	ADRAO
10 WAT350 (WAS-B-B-2)	TOX 3091-36-23-1/ IRAT 144 /Cisadane	ADRAO
11 WITA8 (TOX 3440-176-12-1)	TOX891-212-1-201-1-105 /TOX3056-51	ADRAO
12 WITA9 (TOX 3058-28-1-1-1)	IR 2042-178-1/ CT 19	ADRAO /IITA
13 Moroberekan		Côte d'Ivoire
14 Bouaké 189		Côte d'Ivoire

of varieties for the resistance to RYMV, to feel the gap left by the few works done on the subject. The present study is part of this program and reports the screening of some rice varieties of NRCA collection to test their resistance to RYMV. The aim of the study was to identify some resistance rice genotypes in NCAR collection, on the basis of the reaction profile of rice varieties artificially inoculated with the virus.

MATERIEL AND METHODS

Plant material

14 varieties of irrigated rice (Table 1) and 25 varieties of rain rice (Table 2) were used in this study. The rice seeds come from the NCAR collections (National Center for Agronomic Research, Côte d'Ivoire).

Irrigated rice varieties

One week before transplantation, the soil was cleaned, ploughed, planed and treated with Ronstar (4 l/ha) and supplied with NPK 10-18-18 fertilizer (150 kg/ha). The 14-day old seedlings were transplanted (2 seedlings/ hole) according an experimental design in Fischer block with 4 replicates. A treatment with Furadan (20 kg/ha) and Decis (1 l/ha), an urea supply (50 kg/ha) and a manual weeding were carried out.

Rain rice varieties

The lot crushed, ploughed and pulverized was supplied with NPK 10-18-18 fertilizer (150 kg/ha) before sowing (3 seeds/ hole). After one week, one seedling is transfer per hole according an experimental design in Fischer block with 4 replicates. A treatment with Furadan (20 kg/ha) and Decis (1l/ha), a urea supply (50 kg/ha) and a manual weeding were carried out.

Inoculum preparation and inoculation

Inoculations were performed by using leaves infested with virus disease collected from rice seedlings in lowland field. The inoculum is a viral suspension prepared by crushing of the rice leaves in boiled water (60 g/l). Inoculations were achieved 14 days after transplantation in irrigated conditions and 28 days after sowing in rain conditions consists in rubbing the whole seedling from the base to the top with the fingers soaked before hand in the viral solution.

Severity of symptoms

For each rice variety, seedlings inoculated presenting symptoms of the RYMV were recorded at 14 and 60 DAI (Days After Implantation) and disease severity the severity of the symptoms according to the evaluation scale of the varietals resistance of rice to RYMV from International Institute of Tropical Agriculture (IITA) currently used by many researchers (WARDA, 1994). The rating scale varied from 1 (weak symptoms corresponding to a resistance) to 7 (severe symptoms corresponding to a sensitivity) (Mamadou, 1999). In order to make sure that the varieties did not develop visible symptoms after the inoculation remain the same or not from virus, an indexing is carried out on leaves derived seedlings chosen randomly. Samples that didn't express positive results are later tested by ELISA (Enzyme Linkage Immuno Sorbant Assay). The antibody anti- RYMV against a complex of isolates were used.

Components of the yield

The impact of the disease on inoculated and non-inoculated mature seedlings of each variety was assessed considering the height of seedlings and the weight of seeds. In each case, mean values are calculated and the impact of the disease (Im) is assessed according the following the formula:

$$Im\ (\%) = (Ni - I) \times 100 / Ni$$

Ni = mean values on the seedlings not inoculated; I = mean values on the seedlings inoculated.

Table 2. List of 24 rice rain variety tested.

N° Name of variety	Pedigree	Origin
1 IDSA6 (IRAT 216) (ROK 18)	IRAT 144 / IRAT 13	Côte d'Ivoire
2 IDSA10 (IRAT 262)	IRAT 112 / IGUAPE CATETO	Côte d'Ivoire
3 IDSA11	IRAT 112 / IGUAPE CATETO	Côte d'Ivoire
4 IDSA17	IRAT 112 / IRAT 13	Côte d'Ivoire
5 IDSA27 (IRAT 306)	IRAT 112 / IRAT 144	Côte d'Ivoire
6 IDSA46		Côte d'ivoire
7 IDSA62		Côte d'Ivoire
8 IDSA64		Côte d'Ivoire
9 IDSA69		Côte d'Ivoire
10 IDSA74	Cuttack 4 /IRAT13 (168-5-1-2-2)	Côte d'Ivoire
11 IDSA75	E425 / IRAT 257	Côte d'Ivoire
12 IDSA76	Khao Youak / IRAT 257	Côte d'Ivoire
13 IDSA77		Côte d'Ivoire
14 IDSA78		Côte d'Ivoire
15 IDSA85		Côte d'Ivoire
16 IDSA91	IDSA 6 / IRAT 177	Côte d'Ivoire
17 IDSA92	Tox 1785 / IAC 164	Côte d'Ivoire
18 IDSA106		Côte d'Ivoire
19 IDSA109		Côte d'Ivoire
20 IDSA110		Côte d'Ivoire
21 IDSA111		Côte d'Ivoire
22 IDSA112		Côte d'Ivoire
23 IDSA113		Côte d'Ivoire
24 IDSA114		Côte d'Ivoire
25 Moroberekan		Côte d'Ivoire

Statistical analysis

Experimental data were analysed using Statistica software (release 7.5). These data were subjected to analysis of variance (ANOVA), with mean comparisons by Newman-Keuls test at 5%. Data are the mean of three replicates.

RESULTS

Irrigated rice varieties reactions

Symptoms severity

All the varieties tested, except Moroberekan, have shown symptoms of Yellow Mottle, after inoculation. A significant observation was made among the varieties that, what ever the marking date of symptoms (Table 3). Some varieties are characterized by relative sever symptoms but in others they are weak, fair or non-existent. In order to classify the varieties due to the average severity of the symptoms, a scale has been defined and includes the severity interval corresponding to the evaluation marking of varietals resistance. So any value of average severity ranging between 1-1.5 corresponds to 1, 1.6-3.5 corresponds to 3, 3.6-5.5 corresponds to 5, 5.6-7.5 corresponds to 7 and 7.6-9 corresponds to 9. The observations at 14 DAI show that the behavior of the varieties is not homogeneous (Table 4). Three varieties (Moroberekan, WITA8 and WITA9) have shown no visible symptoms. Only one (Tox 3052-46-E2-2-2-4-3) presented symptoms of severity 3 and ten was scored 5. These non-existent or relatively low symptoms at 14 DAI underwent an evolution with time to reach a stronger severity at 60 DAI, for certain varieties. For other varieties at the contrary, severity attenuated with time or remained stationary. Thus, it passed from 1 to 5, from 1 to 3 and from 5 to 3 respectively for WITA8, WITA9 and WIT350 varieties. Anyway, at 60 DAI, four groups of varieties emerge (Table 4). They are sensitive groups (severity 7), fairly resistant groups (severity 5), resistant groups (severity 3) and highly resistant groups (severity 1). The highly resistant group consisted by Moroberekan has shown no visible symptoms. However, the ELISA test detected the presence of viral particles at in this variety, which shows that Moroberekan is not immunized against RYMV but it is merely tolerant (Table 3).

Disease impact on yield components

There was a significant difference between varieties (Ta-

Table 3. Average symptoms severity expressed by the varieties of irrigated rice and results of ELISA test, after inoculation.

Irrigated rice varieties	Severity at 14 DAI	Severity at 60 DAI	ELISA test (A405 nm)
Bouaké189	4.90 a	4.95 a	nt
Moroberekan	1.00 c	1.00 c	+
Kogoni91-1	4.52 a	5.00 a	nt
Niono1	4.80 a	5.80 d	nt
Niono2	4.83 a	4.71 a	nt
Niono3	4.80 a	3.72 b	nt
Super Bouaké189	4.95 a	5.21 d	nt
Tox 3052-46-E2-2-2-4-3	3.35 b	2.83 e	nt
WAT311	4.85 a	4.66 a	nt
WAT316	5.00 a	4.94 a	nt
WAT317	5.05 a	5.00 a	nt
WAT350	4.65 a	2.59 e	nt
WATA8	1.25 c	3.25 b	nt
WITA9	1.00 c	4.11 ab	nt

Values for each parameter followed by a different letter are significantly different.
Test of Newman-Keuls at 5%
Each value represents the mean of three replicates.
+ = presence of viral particles; nt = no necessary test; A405 nm = absorbance at 405 nm; DAI= days after implantation.

ble 5). Varieties infection resulted in a reduction of seedling height and seeds weight for several varieties whereas for others, seeds production was promoted. When considering all varieties, it appears an average reduction of seedling height varying from 2 to 45% and from 0 to 100% for seeds weight. For the highly resistant variety, Moroberekan, the impact of the disease on the seedling height and the seeds weight was very low even null. On the other hand, this variety shows an increase in production when the seedling was infected (negative % of reduction). The sensitive variety (S), Niono 1, displayed an important reduction of height (45%) and seeds weight (99.01%), following the infection. For the group of varieties resistant to the RYMV, one notes that the impact of the disease depends on the variety and the parameter selected. The disease resulted in a low reduction of height for WITA9 variety (9.44%), whereas for Tox 3052-46-E2-2-2-4-3 and WAT350 varieties, it was relatively significant (respectively 27 and 19%). As for the weight of grains, the infection affected the production of grains, fairly impacting WITA9 variety (reduction negative %) while causing a reduction of 88.4 and 28% for Tox 3052-46-E2-2-2-4-3 and WAT350 varieties, respectively. The impact of the disease variety depends on the moderately resistant varieties (MR). It was observed a reduction of height and weight of the grains for WAT316 variety, whereas for Niono2 and WAT317 varieties, it was relatively significant. In this group, the reduction of height is proportional to the weight of grains.

To summarize, by having the weight of grains, a significant agronomic character as objective, and the severity of symptoms as indicator of the infection, 4 groups of varieties have been identified (Table 6). The highly resistant group (HR) includes the Moroberekan variety, whereas the varieties WAT317, Niono1, Niono2, Niono3, Bouaké189, Super Bouaké189, 55/55, WITA8, Kogoni 91-1 and Tox 3052-46-E2-2-2-4-3 form the highly sensitive group (HS). Varieties WITA9 and WAT316 showed resistance (R) to the RYMV and varieties WAT311 and WAT350 showed sensitivity (S).

Rain rice varieties reactions

Symptoms severity

A significant difference was observed between the varieties indifferently to the marketing date (Table 6). All the varieties tested developed symptoms characteristic of the RYMV. These symptoms are relative for certain varieties and weak at others. The classification of the varieties is due to the average severity of symptoms is made according to previously defined scale.

At 14 DAI, four varieties presented disease symptoms (severity 5), thirteen fairly developed the disease (severity 3) and eight did not show any symptom (severity 1) (Table 4). The severity of the symptoms evolved in time and reaches relatively more significant values on the notation scale. Thus at 60 DAI (Table 4), all the varieties tested, including Moroberekan, developed yellowing symptom characteristic of the yellow mottle. Indeed, the symptoms severity, passed from 1 to 5 for IDSA11, IDSA46, IDSA78, IDSA106, IDSA110 and IDSA112 va-

Table 4. Distribution of irrigated and rain rice varieties according to symptoms severity developed at 14 and 60 DAI.

14 DAI	Symptom intensity	Severity score
Irrigated rice varieties		
Moroberekan; WITA8; WITA9	Null	1
Tox 3052-46-E2-2-2-4-3	Low	3
Bouaké189; Super Bouaké189; Kogoni91-1; Niono1; Niono2; Niono3; WAT311; WAT316; WAT317; WAT350	Average	5
Rain rice varieties		
IDSA11; IDSA17; IDSA46; IDSA78; IDSA85; IDSA106 IDSA110; IDSA112	Null	1
IDSA6; IDSA10; IDSA27;IDSA74; IDSA75; IDSA76 IDSA91; IDSA92; IDSA77;IDSA62; IDSA109; IDSA111 Moroberekan	Low	3
IDSA64; IDSA69; IDSA113; IDSA114	Average	5
60 DAI	**Symptoms severity**	**Behavior**
Irrigated rice varieties		
Moroberekan	1	HR
Tox 3052-46-E2-2-2-4-3, WITA9, WAT350	3	R
Bouaké189, Super Bouaké189, Kogoni91-1, Niono2, Niono3, WAT316, WAT317, WATA8, WAT311	5	MR
Niono1	7	S
Rain rice varieties		
IDSA85, IDSA17	3	R
IDSA6; IDSA10; IDSA11; IDSA27; IDSA114; IDSA113, IDSA46; IDSA62; IDSA64; IDSA69; IDSA74; IDSA75, IDSA76; IDSA77; IDSA78; IDSA91; IDSA92; IDSA106; IDSA109; IDSA110; IDSA111;IDSA112; Moroberekan	5	MR

HR = highly resistant, R = Resistant, MR = moderately resistant, S = Sensitive; DAI= days after implantation.

varieties and from 1 to 3 for IDSA17 and IDSA85 varieties. For IDSA10, IDSA109, IDSA111, IDSA27, IDSA6, IDSA62, IDSA75, 1DSA77, IDSA91, IDSA92, IDSA74 and Moroberekan varieties, severity evolved by passing from 3 to 5. On the contrary, severity remained stationary (around 5) for IDSA113, IBSA114, IDSA64 and IDSA69 varieties.

Finally, two groups of varieties are apparent at 60 DAI. The resistant varieties group (R) characterized by severity 3, includes 1DSA85 and IDSA17 varieties and the moderately resistant varieties group (MR) showing the disease severity 5, and is made up by the 23 other varieties.

Disease impact on yield components

Disease impact is significant on yield components and as a result in the whole, reduction of grains height varied from 14.17 to 46.65% whereas grains weight varied from 11.95 to 100%. This reduction is related to the symptoms severity for some varieties while for the others, it varies according to the variety and the parameter selected (Table 5). This reduction is related to the symptoms severity for some varieties while for other, it varies according to the variety and the parameter selected. Among the moderately resistant varieties (MR) IDSA64 underwent the most significant losses concerning grains height (46.65%) as well as grains weight (100%). The other varieties of this group showed grains height and weight reduction varying from 16.30 to 38.17% and from 11.95 to 85.22%, respectively. For the moderately resistant varieties (MR), there is not any link between the symptoms severity and the impact of the disease on the grains height and weight (Table 5). For the same severity score of 5, with IDSA46, the disease causes about 16.30 and 11.95% reduction of grains height and weight. In contrary with IDSA62, IDSA76 and 1DSA74, disease impact varies from 22.13 to 23.66 and from 15.34 to 27.76%, reduction of grains height and weight, respectively.

With the resistant varieties (R), the impact of the infection on the components of the yield varies according to the variety and the parameter considered. Thus, IDSA17 variety underwent a low reduction of its height (27.89%), whereas the loss of the weight of grains is average (52.03%). For IDSA85 variety, a reduction of 14.17% of the height and of 35.53% of the weight of grains was

Table 5. Impact of the contamination on the components of the yield for irrigated and rain rice varieties.

Varieties	Resistance group	Height reduction (%)	Weight reduction (%)
Irrigated rice			
Moroberekan	HR	1.64 a	- 18 k
Tox 3052-46-E2-2-2-4-3	R	27 b	88.4 g
WITA9	R	9.44 c	-8.4 h
WAT350	R	19 d	28 b
Kogoni91-1	MR	27 b	81.31g
Niono2	MR	38 e	97 h
Niono3	MR	31 b	95.32 gh
Super Bouaké189	MR	31 b	89 g
WAT311	MR	29 b	59 i
WAT317	MR	37.2 e	100 h
WATA8	MR	31.2 b	78 g
WAT316	MR	20 d	11 c
Bouaké189	MR	21 d	77 g
Niono1	S	45 f	99.01 h
Rain rice varieties			
IDSA85	R	14.17 c	35.53 e
IDSA17	R	27.89 b	52.03 i
IDSA6	MR	37.01 e	75.58 g
IDSA11	MR	22.71 d	59.05 i
IDSA10	MR	22.75 d	30.50 b
IDSA27	MR	27.62 b	57.45 i
IDSA46	MR	16.30 d	11.95 c
IDSA62	MR	22.13 b	27.76 b
IDSA64	MR	46.65 f	100 h
IDSA69	MR	31.86 b	85.22 g
IDSA74	MR	23.66 d	15.34 d
IDSA75	MR	20.07 d	41.67 f
IDSA76	MR	23.25 d	26.12 b
IDSA77	MR	26.24 b	46.26 f
IDSA78	MR	30.95 b	50.72 fi
IDSA91	MR	38.17 e	66.01 i
IDSA92	MR	28.61 b	62.83 i
IDSA106	MR	25.86 b	41.55 f
IDSA109	MR	20 d	31.56 b
IDSA110	MR	21.13 d	33.45 be
IDSA111	MR	22.61 d	39.05 ef
IDSA112	MR	25.15 d	63.57 i
IDSA113	MR	25.36 d	63.38 i
IDSA114	MR	36.79 e	82.69 g
Moroberekan	MR	24.24 d	58.86 i

Values followed by a same letter are not statistically different at 5%.
Values are means of three replicates.
HS = highly significant; HR = Highly resistant; R = Resistant; MR = Moderately resistant; S = Sensitive.

observed (Table 5). Considering the significant agronomical character, grains weight and indicator of the infection, symptoms severity, and varieties can be classified into 3 groups.

Table 6. Distribution of irrigated rice varieties and rain rice varieties according to the impact of the disease on the weight of grains and symptoms severity.

Varieties	Severity score	Weight reduction (%)	Behavior
Irrigated rice			
Moroberekan	1	0	HR
WITA9; WAT316	3-5	0-11	R
WAT311; WAT350	3-5	28-59	S
Bouaké189; Super Bouaké189; Kogoni91-1; Niono1; Niono2; Niono3; WAT317; WITA8; TOX 3052-46-E2-2-2-4-3	5-7	77-100	HS
Rain rice			
IDSA10; IDSA75; IDSA78; IDSA77; IDSA85; IDSA106; IDSA109;IDSA111	3-5	30-51	S
IDSA6; IDSA11; IDSA17; IDSA27; IDSA64; IDSA69; IDSA91; IDSA92; IDSA110; IDSA112; IDSA113; IDSA114; Moroberekan	5	52-100	HS
IDSA46, IDSA74,IDSA76, IDSA62,	5	12-28	T

HR = Highly resistant; R = Resistant; S = Sensitive; HS = Highly sensitive; T = Tolerant.

Eight varieties showed symptoms varying between 3 and 5 and underwent grains weight reduction from 30 to 51%. These varieties are known as sensitive (S) to the RYMV. Thirteen varieties are highly sensitive (HS) to the disease and developed symptoms severity of 5, which brought about a reduction of grains weight varying from 52 to 100%. Four varieties underwent grains weight reduction varying from 12 to 28% with 5 as score severity. These varieties are tolerant (T) to the RYMV.

DISCUSSION

Following the inoculation, none of the varieties tested is immune. They either developed the symptoms characteristic of rice yellow mottle, or tested positive (presence of viral particles) with ELISA technique. These results are in agreement with those of other authors (Rossel and Thottappilly, 1993; Albar, 1998; N'guessan, 1999; Mamadou, 1999; Konaté et al., 2006) and show that *Oryza sativa indica* and *O. sativa japonica* species are sensitive susceptible to the RYMV. In this case, the lack of visible symptoms for Moroberekan variety in the lowland ecosystem could suggest that for this variety, the development of symptoms depends on the environment.

Disease development is early in lowland, but late on upland suggesting that the isolate used is more aggressive on the lowland varieties than on upland ones. The greatest aggressiveness of this isolate on the irrigated cultivars could be explained by the fact that it was collected in lowland and was inoculated during this work in this ecosystem. A comparative study with an isolate collected on upland could enable us to better understand this phenomenon.

Nearly all rain varieties developed disease symptoms at 60 DAI. That suggests a low rate of multiplication of viral particles. In this case the appearance of symptoms would be due to a rather long incubation period for these varieties.

The test having been led in the field, it is possible that an external isolate, more aggressive can involve and consequently cause more severe symptoms. However, the negative reaction with the leaves samples of grasses belonging to Gramineae family collected inside around and about the tests, suggests that the chances of a natural infection are rare.

The behavior of the tested varieties in relation to the disease is not homogeneous. It varies according to the variety and the parameter selected. On the basis of the symptoms developed, one distinguishes groups of varieties with different levels of sensitivity to RYMV. In lowland, the behavior of WITA8, Tox 3052-46-E2-2-2-4-3 and Moroberekan varieties is similar to that reported under the same conditions (Rossel and Thottappilly, 1993; Konaté et al., 1997; 2006). Our results showed that rain varieties IDSA6, IDSA10, IDSA77, IDSA78 and DSA91 are sensitive to the virus (N'guessan, 1999; N'guessan et al., 2001). On the other hand, IDSA74, IDSA75, IDSA76, IDSA92 and Moroberekan varieties, identified as resistant in rain conditions (CNRA, 1999) developed average symptoms under our experimental conditions. The work having been carried out in savanna area with isolates from this area in the case of NCAR, this contradictory result could be explained by differences in aggressiveness between the isolates used. Indeed, RYMV is characterized by a variability which is able to break the varietal resistance in time and space (Fargette et al., 1997; Konaté et al., 2006; Traoré et al., 2006). In the same way, the shift between the dates of notation of symptoms (28 DAI for NCAR and 60 DAI in our case), added to a larger aggressiveness of the isolate used in

our experiment, could be responsible for this behavior. The impact of the disease on yield components is related to the severity of symptoms for some varieties, whereas for the others, it varies according to the variety and the selected parameter. Considering the development of symptoms alone, one would confuse a sensitive variety with a tolerant variety and vice versa. What indicates that a good selection of resistant/tolerant varieties in relation to the RYMV cannot be limited to the evaluation of the resistance of cultivars on the basis of foliar reaction. This criterion remains certainly an invaluable tool for diagnosis of the disease, but it is not always reliable.

Between both agromorphological characters studied, grains weight, therefore the yield, is the most significant character for rice growers. Thus, any selection of varieties based on this character will meet incontestably their approval. However, it is necessary to associate to this parameter, the evaluation of disease symptoms. This alternative made it possible to identify only one highly resistant variety of *japonica* type, 2 resistant, 2 sensitive and 10 highly sensitive of *indica* type, for the irrigated varieties. As for the rain *japonica* types, 4 are tolerant, 8 are sensitive and 13 are highly sensitive. This result shows on the one hand that RYMV is an economically significant disease in Africa, and on the other hand that by retaining the couple symptoms/weight of grains, it would be possible to identify resistant/tolerant sources within the rice collection of NCAR. By using this couple of criteria, we could show that nearly all the varieties tested of *indica* type as well as of *japonica* are sensitive to RYMV. However, it is noted that the sensitivity is higher for the *indica* type and lower for the *japonica* type (Warda, 1994; N'guessan et al., 2001; Sorho et al., 2005). It is this behavior of the varieties of the *japonica* type which certainly led to qualify these varieties as par-tially resistant (Albar, 1988; Fomba, 1988; Fargette et al., 1997; Pinto et al., 1999; Ndjiondjop et al., 2001; Sorho et al., 2005; Traoré et al., 2006). The Moroberekan variety, highly resistant in lowland ecosystem did not present any visible symptom of the disease. In the same way no reduction of grains weight was recorded. On upland, with an average severity of the symptoms, the same variety underwent very significant losses. This result suggests that the resistance of this variety, in lowland ecosystem, is an acquired character from the first stages of development and that it varies according to the environment. With tolerant varieties such as IDSA46, IDSA62, IDSA74 and IDSA76, the reduction of grains weight is low in spite of average severity symptoms. What indicates that these varieties bear quite well the presence of the RMYV? For resistant varieties and sensitive varieties, some exceptions are observed, low symptoms correspond to low losses of grains weight and severe symptoms correspond also to more significant losses. For the sensitive variety WAT350 and the resistant varieties IDSA17 and IDSA85, no relation can be established between the severity level of the symptoms and the significant losses of grains weight. So, low symptoms can generate significant losses of the weight of grains.

Conclusion

The 39 varieties of rice artificially inoculated by RYMV were not homogeneous in term of sensivity to RYMV. Considering the couple symptom/weight of grains as evaluation criterion, we were able to identify 6 resistant cultivars (Moroberekan, WAT316, IDSA46, IDSA62, IDSA74 and IDSA76). This result indicates that the rice collection of NCAR is a potential reservoir of resistance gene to RYMV.

However, for a better comprehension of the relationships between the symptoms severity and the losses of weight of the grains, it is advisable to associate to the screening program, the ELISA test. In the same way, the variable performance according to the ecosystem recorded for Moroberekan variety must be elucidated. The cultivars identified as resistant/tolerant will be useful as donors of resistance genes in cross breeding, in order to obtain some lines provided with a good resistance level to RYMV.

Finally, this sorting work was related to only one isolate of RYMV. Because of the biological diversity of this virus isolates, it proves to be necessary to test the retained varieties in relation to a wide range of isolates through tests in various localities, before conclusion.

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