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The Effect of *Rice yellow mottle virus* Infection on the Performance of Rice (*Oryza sativa* L.) Relative to Time of Infection under Screenhouse Condition

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Abstract: The study on the resistance of Gigante, Moroberekan and Bouake 189 rice varieties was investigated against the *Rice yellow mottle virus* (RYMV) infection relative to time of infection under screenhouse controlled condition. Rice varieties, Moroberekan, Gigante and Bouake 189, were inoculated with RYMV isolate at seedling, tillering, booting and flowering growth stages. Gigante, Moroberekan and Bouake 189 gave mean yield losses of 12.68, 78.06 and 94.4%, respectively at booting and seedling infection stages. The No. of grains plant^{-1} is mostly affected at booting infection stage in Bouake 189 and at seedling infection stage in Moroberekan. No significant difference in No. of empty spikelets plant^{-1} due to infection at different growth stages among the three varieties. Plant height was significantly affected by virus infection at seedling stage of the three varieties and other growth stages of Bouake 189. The highest yield loss of 94.4% obtained in Bouake 189 at seedling and booting infection stages establishes the fact that yield losses to RYMV are strongly influenced by host cultivars as well as time of virus infection. The study revealed that the period from seedling and booting represents the most vulnerable phase to RYMV infection in rice growth stages. This information would strongly assist breeding programmes in the development of durable resistant rice cultivars to RYMV disease.

Key words: *Rice yellow mottle virus*, rice variety, Indica, Japonica, growth stages, resistance

INTRODUCTION

Rice yellow mottle virus (RYMV), belongs to the sobemovirus group, is very stable and highly infectious to rice (Abo *et al*., 2005). It infects rice in most rice growing countries in Africa and its surrounding islands (Abo *et al*., 1998). The disease is characterized by mottle and yellowing symptoms of varying intensities depending on genotypes and this could be mistaken with iron or nitrogen deficiency (Onasanya *et al*., 2006). Gnanamanickam (2009) stated that RYMV infected rice plants usually have pale yellow mottle leaves, stunted, reduced tillering, non-synchronous flowering, poor panicle exertion and spikelet discoloration of grains. But in mechanically inoculated plants, the first symptoms are few yellow-green spots on the youngest leaves, although more resistant cultivars may show no distinctive symptoms (Gnanamanickam, 2009). Symptom expression may depend among other factors on rice genotype and time of infection.

Previous study on yield reductions from inoculated and naturally infected rice plants revealed a yield reduction rate of 84% for Bouake 189, 67% for BG 90-2 and 4% for Moroberekan (Heinrichs *et al*., 1997). Yield losses depend on date and time of infections as well as the genotype (Rossel *et al*., 1982). RYMV is transmitted through mechanical contact and inoculations as well as by insect-vectors such as beetles and long-horned grasshoppers (Abo *et al*., 1998). It has been established that cows, donkeys and grass rats transit the virus in irrigated rice fields (Sarra and Peters, 2003), however, the disease is not transmitted through seed or nematode (Abo *et al*., 2004). Some insect attacks on rice fields have been reported in other continents outside Africa but no RYMV infestation (Lanjar *et al*., 2002; Rustamani *et al*., 2002). Besides, no issue or problem identified by farmers caused by RYMV disease in other continents outside Africa regarding rice technology adoption (Mirani *et al*., 2001).

RYMV has now become a major limiting factor to rice production for lowland and irrigated ecosystem in Africa (Banwo *et al*., 2004). Although, some works have been carried out on this economically important disease of rice, yet none has related the effect of the virus to growth stages or established the stage of plant growth at which virus infection is most detrimental to growth and yield

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attributes. The present study is therefore aimed to investigate the resistance in Gigante and as well as other Japonica types with known RYMV resistance to ascertain whether resistance expression is subject to the growth stage of the plant at which virus infection occurred and to determine if resistance conferred by some rice varieties can be overcome at certain growth stages of the plant due to virus infection.

MATERIALS AND METHODS

Research location: The study was conducted under an artificial environment inside a screen house at the National Cereals Research Institute (NCRI) Badeggi, Niger State, Nigeria from August 2008 to February 2009.

Rice varieties: Moroberekan, Gigante and Bouake 189 with known levels of reaction to *Rice yellow mottle virus* (RYMV) (Onasanya *et al*., 2004, 2006) were used for the study.

RYMV isolate: Leaves of RYMV infected rice plants were collected from farmers' fields at Wushishi, Niger state, Nigeria. The collected RYMV infected leaf sample was propagated on the highly susceptible Bouake 189 following mechanical inoculation of 21 old plants in the screenhouse (Onasanya *et al*., 2006). Three weeks after inoculation, leaves bearing typical yellow mottle symptoms were harvested and used for inoculating the rice varieties.

Experimental design, treatments and treatment allocation: The experiment was a 2 by 4 factorial Complete Randomized Design (CRD). The RYMV inoculated (V_1) and non-inoculated (V_0) and growth stages (seedling, tillering, booting and flowering) represent the two factors studied at 2 and 4 levels, respectively. The eight treatment combinations were replicated three times. Three seeds each of the test varieties were seeded directly in the plastic buckets (16 cm diameter) earlier filled with 2.5 kg fadama soil and later thinned to a seedling pot^{-1}. Pots were constantly supplied with fresh tap water morning and evening until maturity. Then 2 g of NPK was applied to the plants at 28 days after planting (DAP), followed by application of 2 g urea at 45 DAP and at early flowering stage of the plants.

Inoculation of rice varieties: The virus mechanical inoculation method was according to Onasanya *et al.* (2006). Infected leaf samples of the RYMV isolate was ground with 0.01 M phosphate buffer pH 7.0 at the ratio of 1:10 (w/v) and the resulting homogenate filtered through cheesecloth. Carborundum powder (600 mesh) was added to the inoculum to aid the penetration of the virus into leaf tissues. The virus was introduced at seedling, tillering, booting and 50% flowering stages of Moroberekan (a resistant *Japonica* type), Bouake 189 (a susceptible *Indica* type) and Gigante (a resistant *Indica* type). For each test variety, three entries were inoculated with the virus and three were left un-inoculated to serve as control.

Data collection: The parameters such as grain yield to estimate percentage yield loss, plant height (cm), No. of leaf plant^{-1}, No. of grain plant^{-1} and No. of empty spikeletes plant^{-1} were collected from both control and test varieties (Onasanya *et al*., 2006; Nwilene *et al*., 2009).

Data analysis: Using the yield data from both test and control varieties, percentage yield loss due to RYMV disease was determined for each variety. All the data were subjected to statistical analysis using IRRISTAT software (Xiaoping and Ognjen, 2005).

RESULTS

The study on the resistance of Gigante and Moroberekan rice varieties against the *Rice yellow mottle virus* (RYMV) infection relative to time of infection under screenhouse controlled condition was investigated. In this study, the highest yield losses of 12.68, 78.06 and 94.4% for Gigante, Moroberekan and Bouake 189, respectively were obtained at booting and seedling stages (Fig. 1). The No. of grains plant^{-1} is mostly affected at booting infection stage in Bouake 189 and at seedling infection stage in Moroberekan (Table 2). Moreover, there is no significant difference observed in the No. of

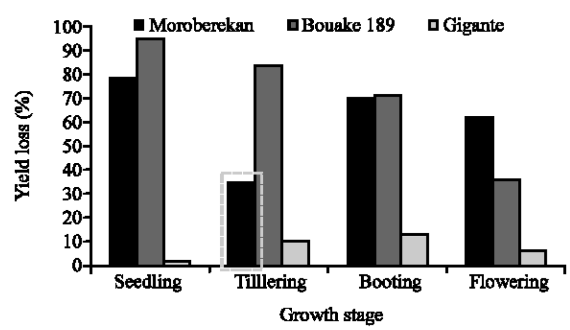

Fig. 1: The contribution of RYMV infection to percentage yield loss in relation to time of infection on Gigante, Moroberekan and Bouake 189 under screenhouse condition

Table 1: Effect of RYMV infection on plant height (cm) and No. of leaves plant^{-1} for gigante, moroberekan and bouake 189 in relation to time of infection (growth stages)

		Time of infection (growth stages)									
		Seedling		Tillering		Booting		Flowering			
Parameters	Rice variety	V_1	V_0	V_1	V_0	V_1	V_0	V_1	V_0	CV (%)	LSD (p = 0.05)
Plant	Gigante	96.67	101.00	98.67	107.33	97.67	101.67	98.33	104.00	2.6	4.455
height	Bouake 189	60.00	88.33	59.33	88.33	80.33	91.00	85.33	88.33	6.6	9.118
(cm)	Moroberekan	93.00	97.67	104.33	98.00	99.00	101.33	100.00	102.67	5.5	9.507
No. of	Gigante	113.67	116.00	109.33	102.67	111.00	111.67	109.33	104.67	7.3	13.955
leaves	Bouake 189	147.33	126.67	227.00	133.00	128.00	131.67	139.00	129.00	23.2	58.379
plant^{-1}	Moroberekan	31.67	32.00	28.67	28.00	34.33	27.33	36.00	31.33	15.4	8.316

V_1: RYMV inoculated entries; V_0: Entries not inoculated (control); CV: Coefficient of variation; LSD: Least significant difference; p: Probability

Table 2: Effect of RYMV infection on No. of grains plant^{-1} and No. of empty spikelets plant^{-1} for gigante, moroberekan and bouake 189 in relation to time of infection (growth stages)

		Time of infection (growth stages)									
		Seedling		Tillering		Booting		Flowering			
Parameters	Rice variety	V_1	V_0	V_1	V_0	V_1	V_0	V_1	V_0	CV (%)	LSD (p = 0.05)
No. of	Gigante	76.00	81.00	69.67	76.00	67.67	79.00	72.67	74.00	7.9	10.240
grains	Bouake 189	6.33	115.00	19.11	115.00	3.00	112.00	73.33	115.33	11.2	14.313
plant^{-1}	Moroberekan	2.67	13.00	8.00	7.67	3.68	14.33	4.67	13.67	38.5	5.642
N.o of empty	Gigante	27.67	32.33	27.33	29.33	25.67	30.00	27.00	28.00	15.4	7.561
spikelets	Bouake 189	79.33	219.33	80.33	27.00	93.33	35.67	37.00	34.33	33.6	30.241
plant^{-1}	Moroberekan	74.33	60.67	68.00	68.00	64.67	65.00	54.00	56.67	13.0	14.369

V_1: RYMV inoculated entries; V_0: Entries not inoculated (control); CV: Coefficient of variation; LSD: Least significant difference; p: Probability

empty spikelets plant^{-1} at different infection growth stages among the three varieties (Table 2). Besides, plant height was significantly affected by RYMV infection at various growth stages of Gigante and Bouake 189 (Table 1). However, it is evident that the virus mostly affected the seedling stage of inoculated Gigante plants as well as Moroberekan (Table 1, 2, Fig. 1). The highly susceptible Bouake 189 was affected most at active tillering inoculation stage, which produced mean height value that was significantly (p = 0.05) lower than those produced by other rice varieties (Table 1). The No. of leaves plant^{-1} increased for virus infected varieties, although, the mean differences at various growth stages were significantly the same (Table 1). Bouake 189 produced a significantly (p = 0.05) higher No. of virus-infected leaves plant^{-1} with mean value of 227 leaves plant^{-1} at active tillering inoculation stage (Table 1).

DISCUSSION

Yield losses usually depend on many variables including virus strain or isolate, host cultivars and growth stage of the plant when infected (Onasanya *et al*., 2004, 2006; Bailiss and Senananyke, 1984). In the current study, the highest yield losses of 94.4% obtained in Bouake 189 at booting and seedling stages establishes the fact that yield losses to RYMV are strongly influenced by host cultivars as well as time of virus infection (Bailiss and Senananyke, 1984). Apart from different rice varieties, country where the study was carried out and origin of RYMV isolate used in the present study which makes it different from past studies, previous studies have revealed similar results in rice varieties inoculated at active tillering stage in a screen house experiment (Onasanya *et al*., 2004, 2006). However, similar results could be obtained under natural viral infestation under field condition (Heinrichs *et al*., 1997; Rossel *et al*., 1982). The No. of grains plant^{-1} is mostly affected at booting infection stage in Bouake 189 as obtained in this study, this is simply because Bouake 189 is highly susceptible to RYMV and at booting stage over 94% of the total leaves usually carried 94% RYMV disease incidence leading to significant decrease in yields and No. of grains plant^{-1} (Onasanya *et al*., 2004, 2006). Similarly, since Moroberekan is known to be highly resistant to RYMV the No. of grains plant^{-1} affected at seedling infection stage in Moroberekan as noticed in this study might be that Moroberekan could develop susceptibility to the virus at seedling infection stage but later overcome this viral infection as the plant gets older (Onasanya *et al*., 2006; Ndjiondjop *et al*., 2001).

Plant height estimate is one of the essential components used in the evaluation of RYMV disease in rice varieties (Nwilene *et al*., 2009; Banwo, 2003). In the present study plant height was significantly affected by virus infection at various growth stages of Bouake 189 and at the seedling stage of inoculated Gigante and

Moroberekan. It is likely that the effect of the virus on growth parameters was less at booting stage while increasing significantly after this stage for yield parameters. Similarly, previous findings revealed that the period from panicle differentiation to heading represents the most vulnerable phase in the life and growth of rice plant (Onasanya *et al*., 2006; Nwilene *et al*., 2009; Banwo, 2003). This probably explains why the impact of the virus on Gigante (RYMV resistant variety) and of course the susceptible Bouake 189 in terms of yield loss was highest at booting stages.

CONCLUSION

The resistance of Gigante and Moroberekan rice varieties was investigated against the *Rice yellow mottle virus* (RYMV) infection relative to time of infection under screenhouse controlled condition revealed that the period from seedling and booting represents the most vulnerable phase in the growth of rice plant. This information would strongly assist breeding programmes in the development of durable resistant rice cultivars to RYMV disease.

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