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SEVERITY AND INCIDENCE OF *RICE YELLOW MOTTLE SOBEMOVIRUS* ON RICE YIELD

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ABSTRACT

Screenhouse and field experiments were conducted to evaluate the severity and incidence of *Rice yellow mottle Sobemovirus* (RYMV) on paddy yield of 14 rice cultivars. The screenhouse experiment was arranged as a completely randomized design while the field experiment was laid out in a randomized complete block design. Each treatment was replicated three times. The test cultivars were inoculated with the virus at 3 weeks after sowing. Analysis of variance indicated that the virus had significant effect on all the parameters (disease severity, incidence and paddy yield) assessed. The screenhouse results showed that disease severity ranged from 54.3 to 64.4 %, RYMV incidence varied from 73.4 to 100 % and paddy yield per plant was in the range of 0.8 to 2.3 g. On the other hand, the results of the field experiment indicated that disease severity, incidence and paddy yield ranged from 44.4 to 64.3 %, 66.1 to 100 % and 1.4 to 3.2 t ha^{-1}, respectively.

Key words: *Rice yellow mottle virus;* severity; incidence; yield; rice; guinea savanna; Nigeria

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INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal crop in Nigeria (Anon, 2004). It is grown on over 2 million hectares of land with annual production of about 3 million metric tonnes (FAO, 2002). Rice production in Nigeria is seriously threatened by RYMV (Abo *et al.*, 2002). For example, RYMV incidence has shown to range from 5 to 100 % and paddy yield losses from 25 to 100 % (Rossel *et al.*, 1982). The virus induces mottling and yellowing symptoms on the leaves of susceptible rice plants, reduces tiller production and plant height, delays flowering, discolours spikelets and grains, sterilizes infected plants and in severe infection kills young seedlings (Bakker, 1970). Abo *et al.* (2002) reported that the virus is vectored by the insects *Chaetocnema pulla* Chapius (Coleoptera: Chrysomelidae), *Chnootriba similis* Thunberg (Coleoptera : Coccinelidae), *Conocephalus longipennis* de Haan (Orthoptera; Tettigonidae), and *Trichispa sericea* Guerin (Coleoptera : Chrysomelidae). Besides, the virus can be spread by domestic cows (*Bos spp.*), donkeys (*Equus asinus*), grass rats (*Arvicanthis niloticus*), contact between the leaves or roots of healthy and infected plants, guttation fluid, irrigation water, harvesting tool such as sickle and undecomposed dung of cow that has grazed RYMV-infected field (Bakker, 1974; Reckhaus and Andriamasintseheno 1995; Tsuboi *et al.*, 1995; Abo *et al.*, 2002; Sarra and Peters, 2003).

The pathogen can be managed through diversification of rice cultivars, roguing of infected plants followed by immediate replanting, early planting before the outbreak of insect vectors, control of irrigation water, regular and effective weed control, destruction of plant residue and volunteer plants, moderate and balanced application of fertilizer and use of insecticides against its insect vector (Reckhaus and Adamou, 1986; Coulibaby, 1995; Abo *et al.*, 1998). Planting of resistant rice cultivars is the best management practice against the virus (Onasanya *et al.*, 2004). The rice cultivars FARO 10, FARO 11, FARO 12, Gigante and Moroberekan have been reported to be resistant to the pathogen (Abo *et al.*, 2005). Knowledge of the impact of disease severity and incidence on the paddy yield of different rice cultivars would enable farmers to select and cultivate cultivars that have high genetic potentialities to resist RYMV infection. Moreover, severity and incidence of the virus vary from one region to another (Awoderu, 1991). Therefore this study was initiated to evaluate the impact of RYMV severity and incidence on the paddy yield of 14 commonly grown rice cultivars at two different locations in northern Nigeria.

Table 1. Effect of *Rice yellow mottle virus* severity and incidence on the paddy yield of rice cultivars in the screenhouse

Rice cultivar	Disease severity (%)	Disease incidence (%)	Paddy yield per plant (g)
Bouaké	64.4^{a}	99.1b	1.9^{b}
FARO 29	62.2^{a}	100.0^{a}	1.0^{g}
FARO 35	63.1^{a}	73.4^{i}	1.7c
FARO 37	62.4^{a}	99.0^{c}	1.2^{f}
FARO 44	62.4^{a}	100.0^{a}	1.5^{d}
FARO 46	64.4^{a}	97.7^{ab}	1.2^{f}
FARO 52	63.8^{a}	100.0^{a}	1.5^{d}
FARO 54	64.3^{a}	91.0^{ab}	0.8^{i}
FARO 55	60.2^{ab}	97.9^{b}	1.8^{b}
Gigante	54.4^{b}	98.7^{ab}	1.4^{e}
WAB 189 – B38HB	54.4^{b}	98.3^{ab}	1.7^{c}
WAB 450 – 38HB	54.3^{b}	100.0^{a}	2.3^{a}
WAB 450 – 160HB	54.4^{b}	100.0^{a}	1.8^{b}
Yardas	64.3^{a}	100.0^{a}	1.2^{f}
± SE	2.4	0.0	0.0

± SE = Standard Error of the Mean; Means with the same letter(s) in a column are not significantly different at P = 0.05 (SNK)

METHODS

Screenhouse study: The screenhouse experiment was arranged as a completely randomized design with three replications. Seeds of 14 rice cultivars [Bouaké 189, FARO 29 (BG 90-2), FARO 35 (ITA 212), FARO 37 (ITA 306), FARO 44 (SIPI 692033), FARO 46 (ITA 150), FARO 52 (WITA 4), FARO 54 (WAB 189-B-B-B-B), FARO 55 (NERICA 1), Gigante (Tété), WAB 189-B38HB, WAB 450-38HB, WAB 450-160HB and Yardas] were sown in 18 cm – diameter plastic pots, filled with 1.5 kg heat sterilized heavy soil. The rice cultivars Bouaké 189 and Gigante were included as susceptible and resistant check, respectively. Each pot was placed in a 21 centimetre-diametre basin containing water. Seedlings were thinned to three plants per pot. N.P.K. fertilizer was applied to each pot at the rate of 2.5 g at 4 and 8 weeks after sowing (WAS). The test plants were watered daily either in the morning or evening. Paddy rice was harvested when the test plants were matured.

Source of virus and inoculation: Isolate of the dominant RYMV serotype (SB) in the study area (Salaudeen unpublished data) was used for inoculation. Earlier, the virus was maintained on a highly susceptible rice cultivar Bouaké 189 in the screenhouse by sap inoculation to 2 week old seedlings of the same variety. The infected leaves were harvested at four weeks after inoculation and used as source of inoculant. Inoculum was prepared by grinding 1g of the infected leaf tissue in 10 ml of 0.1 M phosphate buffer, pH 7.4, using mortar and pestle. Carborundum powder (600 mesh) was added to the homogenate at the rate of 5 mg ml^{-1}. The plants were inoculated at 3 WAS by dipping a piece of cheesecloth in the homogenate and then using it to gently streak the upper surface of the older leaves thrice. The test plants were maintained at 22 - 30 °C and 10 – 65 % relative humidity.

Field study: The field experiment was laid out in a randomized complete block design with three replications, at Bomo (11° 11' N, 7° 38' E; 695 m above sea level) and Sayen Gobirawa (11° 1' N; 7° 40' E, 650 m above sea level) in the northern Guinea Savanna agro-ecological zone of Nigeria. The soil of both fields was sandy-loam with approximately 0.4 % organic carbon, 0.1 % nitrogen and 9.7 cation exchange capacity. Plots were 1.5 m x 1 m, separated by 0.1 m unplanted strip while replicates were 0.5 m apart. The same 14 rice cultivars evaluated in the screenhouse were investigated under lowland field conditions. Seeds were sown in the second week of June, 2006, at an intra and inter-row spacing of 0.20 m. Seedlings were thinned to one plant per stand to give a total number of 28 plants in each plot. The two outer rows served as guard rows while 10 plants from the two inner rows were inoculated with the virus at 3 WAS and used for all the assessments. Inoculation was done as described earlier. Fields were kept clean with six hoe-weedings which commenced at 2 WAS and done at 2 weekly interval. Compound fertilizer (NPK 15-15-15) was applied at 4 and 8 WAS at the rate of 200 kg ha^{-1}. The mean annual rainfall at each location was approximately 1,100 m. The average monthly temperature and relative humidity were in the range of 29 – 34 °C, and 11 – 85 %, respectively.

Data collection and analyses: Plants were assessed at weekly interval for RYMV severity, using the Standard Evaluation System (SES) for rice (IRRI, 1996). In the scale, 1 - 3 = no symptoms, leaves green but with sparse dots or streaks and less than 5 % height reduction; 5 = green leaves or pale green with mottling. 6 – 25 % height reduction and flowering slightly delayed; 7 = pale yellow or yellow leaves, 26 – 75 % of height reduction and flowering delayed; 9 = leaves yellow or orange and more than 75 % height reduction, no flowering and some plant dead. Disease severity index was calculated as follows:

$S = [(\Sigma n) / (9N)]\ 100$,

where; S = severity of RYMV (%), N = total number of plants assessed, 9 = highest score on the severity scale.

Disease incidence was also evaluated on weekly basis by using the formula:

$I = [X_i/X_t]\ 100$,

where: I = incidence of RYMV (%), X_i = mean number of infected tillers per pot/stand, X_t = mean number of tillers per pot/stand.

Paddy yield was determined by weighing the quantity of paddy rice produced at harvest, by each cultivar. All the data collected were subjected to analysis of variance (ANOVA) and means separation was done using Student – Newman-keuls (SNK) test at 5 % level of probability. Additionally, t – test was used to compare the results of the two locations. ANOVA was performed using Statistical Analysis System (SAS, 2002).

RESULTS

Secreenhouse study

Disease severity: The effect of RYMV on disease severity indices was significant (P<0.05). The highest and lowest disease severity was 64.4 and 54.3 %, respectively (Table 1). Although the disease severity was highest on the rice cultivars Bouakè 189 and FARO 46, there were no significant differences in the disease severity indices observed among the test cultivars Bouakè 189 FARO 29, FARO 35, FARO 37, FARO 44, FARO 46, FARO 52, FARO 54 and Yardas. Similarly, there were no significant differences in the disease severity indices which occurred among the rice cultivars Gigante, WAB 189 – B38HB, WAB 450 – 38HB and WAB 450 – 160HB.

Disease incidence: The impact of RYMV on disease incidence was highly significant (P<0.01). The highest and lowest disease incidence was 100 and 73.4 %, respectively (Table 1). The differences in the disease incidence were statistically similar among the test cultivars FARO 29, FARO 44, FARO 52, WAB 450 – 38HB, WAB 450 – 160HB and Yardas while FARO 35 recorded the lowest incidence.

Paddy yield: The effect of RYMV on the paddy yield was highly significant (P<0.01). The highest (2.3 g) and lowest (0.8 g) yield was produced by the test cultivar WAB 450 – 38HB and FARO 54, respectively (Table 1). However, there were no significant differences in the paddy produced by Bouaké 189, FARO 55 and WAB 450 – 160HB. Similarly, the difference between the paddy yield observed in FARO 35 and WAB 189 – B38HB, and between FARO 44 and FARO 52 was not significant. Furthermore, the differences in the paddy yield among the test cultivar FARO 37, FARO 46 and Yardas were not statistically significant.

Field study

Disease severity: The influence of RYMV on the disease severity indices was significant (P<0.05) at the two locations (Table 2). At Bomo, the highest and lowest disease severity was 60.4 and 53 % respectively. There were no significant differences in the disease severity indices which occurred among the rice cultivars FARO 29, FARO 35, FARO 37, FARO 44, FARO 46, FARO 52, FARO 54, FARO 55, WAB 189 – B 38HB, WAB 450 – 38HB, WAB 450 – 160HB and Yardas. Similarly, the difference in the disease severity indices between Bouaké 189 and Gigante was not significant. At Sayen Gobirawa, the peak disease severity was 64.3 % while 44.4 % was the lowest. The differences in the disease severity indices were statistically at par among the test cultivars FARO 46, FARO 55, WAB189-B38HB, WAB 450 – 38HB and WAB 450 – 160HB. Also, the differences in the disease severity indices among the rice cultivars Bouaké 189, FARO 29, FARO 35, FARO 37, FARO 44, FARO 52, FARO 54 and Yardas

Table 2: Effect of *Rice yellow mottle virus* severity and incidence on the paddy yield of rice cultivars in the field in 2006

	Disease severity (%)		Disease incidence (%)		Paddy yield (tha^{-1})	
Rice cultivar	Bomo	Sayen Gobirawa	Bomo	Sayen Gobirawa	Bomo	Sayen Gobirawa
Bouaké	53.0^{b}	54.1^{b}	88.5^{g}	94.3^{i}	2.9^{ab}	1.7^{ab}
FARO 29	54.4^{b}	54.2^{b}	94.8^{d}	92.6^{h}	1.6^{b}	1.6^{ab}
FARO 35	54.3^{a}	54.0^{b}	99.3^{b}	98.3^{c}	3.0^{ab}	3.2^{a}
FARO 37	60.4^{a}	54.4^{b}	100.0^{a}	93.1^{g}	1.5^{b}	1.7^{ab}
FARO 44	54.1^{a}	54.3^{b}	98.1^{e}	99.1^{b}	2.2^{ab}	2.5^{ab}
FARO 46	54.3^{a}	64.3^{a}	92.3^{f}	80.8^{m}	3.3^{ab}	1.4^{b}
FARO 52	54.2^{a}	54.4^{b}	100.0^{a}	95.1^{d}	3.6^{a}	2.3^{ab}
FARO 54	54.4^{a}	54.1^{b}	98.8^{c}	95.0^{e}	1.5^{b}	1.5^{ab}
FARO 55	54.4^{a}	64.3^{a}	98.4^{d}	89.5^{l}	2.5^{ab}	1.9^{ab}
Gigante	45.3^{b}	44.4^{c}	100.0^{a}	90.5^{j}	1.5^{b}	2.4^{ab}
WAB 189 – B38HB	54.3^{a}	63.9^{a}	100.0^{a}	90.3^{k}	2.5^{ab}	1.4^{b}
WAB 450 – 38HB	54.4^{a}	64.3^{a}	100.0^{a}	66.1^{n}	2.7^{ab}	2.0^{ab}
WAB 450 – 160HB	60.4^{a}	63.8^{a}	100.0^{a}	91.9^{i}	1.9^{b}	1.6^{ab}
Yardas	60.3^{a}	54.4^{b}	100.0^{a}	100.0^{a}	1.9^{b}	1.9^{ab}
± SE	2.4	2.3	0.0	0.0	0.4	0.3

± SE = Standard Error of the Mean; Means with the same letter(s) in a column are not significantly different at $P = 0.05$

were not significant. Additionally, the disease severity indices observed at Bomo were not significantly different from those recorded at Sayen Gobirawa (t =1.02 at P =0.05) Although the effect of location was not significant, the interaction between the cultivar and location resulted in a significant effect on the severity of RYMV.

Disease incidence: The impact of RYMV on the disease incidence was highly significant (P<0.01). At Bomo, incidence ranged from 88.5 to 100 % but at Sayen Gobirawa, it varied from 66.1 to 100 % (Table 2). At Bomo, there were no significant differences in the disease incidence observed among the test cultivars FARO 37, FARO 52, Gigante, WAB 189 – B38HB, WAB 450 – 38HB, WAB 450 – 160HB and Yardas. Similarly, the difference in the disease incidence which occurred between FARO 29 and FARO 55 was not significant. At Sayen Gobirawa, disease incidence was significantly highest in Yardas and lowest in WAB 450 – 38HB. The influence of location of the experiment showed a significant effect (t = 0.05 at P = 0.05) on the incidence of RYMV. However, the effect of interaction between cultivar and location of the experiment on the level of RYMV incidence was highly significant.

Paddy yield: The effect of RYMV on the paddy yield was significant at P = 0.01 and P = 0.05 at Bomo and Sayen Gobirawa, respectively. At Bomo, the highest paddy yield (3.6 t ha^{-1}) occurred in the rice cultivar FARO 52 (Table 2). However, there were no significant differences in the quantity of paddy rice produced among the test cultivars Bouaké 189, FARO 35, FARO 44, FARO 46, FARO 55, WAB 189 – B38HB and WAB 450 – 38HB. Similarly the differences in the paddy rice yielded among the test cultivar FARO 29, FARO 37, FARO 54, Gigante, WAB 450 – 160HB and Yardas were not significant. At Sayen Gobirawa, the highest paddy yield (3.2 t ha^{-1}) was observed in the test cultivar FARO 35. On the other hand, the lowest paddy rice (1.4 t ha^{-1}) was yielded by the rice cultivars FARO 46 and WAB 189 – B38HB. Moreover, there were no significant differences in the paddy yield among the rice cultivars Bouaké 189, FARO 29, FARO 37, FARO 44, FARO 52, FARO 54, FARO 55, Gigante, WAB 450 – 38HB, WAB 450 – 160HB and Yardas. There was no significant difference between the paddy yield at Bomo and Sayen Gobirawa (t =1.65 at P = 0.05). However, the effect of interaction between cultivar and location on paddy rice was significant.

DISCUSSION

The consistently high variability observed in the severity and incidence of RYMV on the test cultivars demonstrate that pathogenicity of the virus was cultivar dependent. This result is in conformity with the earlier findings of Bakker (1970) who reported that the level of infection by the pathogen was influenced by the rice genotypes involved. The significantly highest disease severity observed in the test cultivar Bouaké 189 indicates that it was highly susceptible to the virus. However, on the average, this result was not consistent, indicating that there was no pathogenic preference for the cultivar. Similarly, the statistically similar severity indices of RYMV observed in the screenhouse and under field conditions at Sayen Gobirawa in the test cultivars Bouaké 189, FARO 29, FARO 35, FARO 37, FARO 44, FARO 52 and Yardas implies that the virus could be pathogenic on many rice cultivars. However, the highest disease severity recorded in Bouaké 189 agrees with the earlier report of Abo *et al.* (2001) in which the cultivar was reported to be highly susceptible to the virus. Moreover, the significantly lowest disease severity recorded in the test cultivar Gigante under screenhouse and field conditions is similar to the findings of Abo *et al.* (2001) and Sorho *et al.* (2005) in which the cultivar was reported to be highly resistant to the pathogen.

The 100 % disease incidence recorded in some test cultivars indicates that rice infection by the pathogen was systemic. Additionally, the expressions of typical symptoms of RYMV in the uninoculated plants may be associated with the activity of insect vectors and running water among other factors in the transmission of the virus (Bakker, 1974).

The non-significant effect of location on all the parameters evaluated showed that the prevailing environmental factors such as temperature, sunlight and rainfall contributed little or no effect to the pathogenicity and virulence of the virus (N'Guessan *et al.*, 2001). However, the significant interaction effect of cultivar x location on the severity and incidence of RYMV, and paddy yield shows that the magnitude of susceptibility or resistance of the cultivars to the virus was influenced by combined effects of these parameters. This is in conformity with the earlier work of Awoderu (1991) and Bos (1999) which showed that virus diseases in plant population result from interplay between virus, host and environment. In conclusion, the results of this work have identified some rice cultivars that possess high genetic potentiality to resist RYMV infection in the study area, and are high yielding too.

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