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EFFECT OF RICE YELLOW MOTTLE SOBEMOVIRUS ON YIELD IN SOME RICE CULTIVARS

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ABSTRACT

The impact of Rice yellow mottle virus (RYMV) on rice yield and yield components was studied under screenhouse and field conditions. The screenhouse experiment was arranged as a completely randomized design with three repetitions while the field experiment was laid out in a randomized complete block design with three replicates. A total of 14 rice cultivars were inoculated with the virus. The effect of RYMV on all the measured parameters was significant both in the screenhouse and under field conditions. The screenhouse results showed that four cultivars (GIGANTE, WAB 189 B38HB, WAB 450 38HB and WAB 450 160HB) were moderately resistant to the virus while the remaining ten (BOUAKE 189, FARO 29, FARO 35, FARO 44, FARO 46, FARO 52, FARO 54, FARO 55, ITA 306 and YARDAS) were moderately susceptible. Plant height ranged from 60.9 (FARO 35) to 108.4 cm (WAB 450-160 HB), number of tillers per plant varied from 4.3 (FARO 46) to 10.2 (BOUAKE 189), days to 50 % heading was in the range of 74 (FARO 46 and FARO 55) to 122 (FARO 29) while paddy yield per plant varied from 0.8 (FARO 54) to 2.3 t ha^{-1} (WAB 450-38HB). However, field experiments indicated that BOUAKE 189, FARO 29, FARO 35, FARO 44, FARO 52, FARO 54 and GIGANTE were moderately resistant to the virus regardless of the location while the rice cultivars WAB 450-160HB was moderately susceptible to the disease at both locations. The rice cultivar FARO 46, FARO 55, WAB189 - B38HB and WAB 450-38HB showed moderate resistance to the pathogen at Bomo alone. On the other hand, ITA 306 and YARDAS rice cultivars exhibited moderate resistance and susceptibility to the virus at Sayen Gobirawa and Bomo, respectively. Plant height, number of tillers per plant, days to 50 % heading and paddy yield ranged from 38.9 (BOUAKE 189) to 67.7 cm (FARO 54), 3.1 (WAB 189-B38HB) to 15.8 (FARO 52), 80 (FARO 46 and FARO 55) to 124 (FARO 29), and 1.4 (FARO 46 and WAB 189 B38BHB) to 3.6 t ha^{-1} (FARO 52), respectively. Plant breeders can take advantage of this information to develop RYMV resistant and high yielding rice cultivars.

Key words: Rice yellow mottle virus, rice cultivars, yield

INTRODUCTION

Rice yellow mottle virus (RYMV) Genus Sobemovirus was first observed in 1966 at Otonglo, Kenya (Bakker, 1970). It later spread to other parts of Africa, Madagascar and Europe (Raymundo and Buddenhagen, 1976; Reckhaus and Randrianangaly, 1990; Tradré *et al.*, 2001; Köklü and Yilmaz, 2004). Symptoms of infection include mottling and yellowing of the leaves of infected rice plants, leaf streaking and malformation, delayed flowering, spikelet and grain discolouration, sterility and death of infected young plants (Bakker, 1970,1974; Fauquet and Thouvenel 1977).

RYMV is RNA virus, which is characterized by high rate of mutation, hence emergence of several serotypes. Six serotypes of the virus have been reported so far: S1, S2 and S3 in West Africa while S4, S5 and S6 have been reported from East Africa (Mansour and Baillis, 1994; Banwo *et al.*, 2002; Fargette *et al.*, 2002; Pinel-Galzi and Fargette, 2006). Out of these serotypes only one (S1) has been reported in Nigeria (Mansour and Baillis, 1994). The best management strategy for this virus is the use of resistant rice cultivars. In Nigeria, the rice cultivars FARO 10, 11, 12, 14, GIGANTE and MOROBEREKAN are resistant to the virus (Abo *et al.*, 2001). However, recent investigations have reported the emergent of resistance- breaking isolates of the pathogen in Burkina Faso, Cameroon, Chad, Mali and Togo (Traoré *et al.*, 2006). Considering that the problem of rice production is heightened by the occurrence of the resistance-breaking isolates of the virus, this study was initiated to investigate the influence of the pathogen on the yield and yield components of some rice cultivars.

MATERIALS AND METHODS

Screenhouse experiments

The screenhouse experiments were conducted using 18 cm-diametre plastic pots. The pots were filled with 1.5 kg heat-sterilized heavy soil and each of them was placed in a 21 cm diametre plastic basin containing water. Fourteen rice cultivars [BOUAKÉ 189, FARO 29 (BG 90-2), FARO 35 (ITA 212), 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 (TÉTE), ITA 306, WAB 189-B38HB, WAB 450-38HB, WAB 450-160HB, AND YAR DAS] were used. The rice cultivars BOUAKÉ 189 and GIGANTE were included as susceptible and resistant check, respectively. The pots were arranged in completely randomized design with three replications for each treatment. The seeds were sown in their designated pots at the rate of nine seeds per pot. The seedlings were thinned to 3 per pot. N.P.K. fertilizer (15-15-15) was applied at 4 and 8 weeks after sowing (WAS) at the rate of 2.5 g per pot. The test plants were watered daily in the mornings and evenings. Paddy rice was harvested when the plants were matured and paddy colour turned yellow.

Inoculum preparation and inoculation

The inoculum was prepared by homogenizing 1g of the leaf tissue of RYMV-infected plants collected from Gwargwaji, northern Nigeria in 10 ml of 0.1M phosphate buffer (pH 7.4) using mortar and pestle. Carborundum powder (600 mesh) was then added to the inoculum at the rate of 5 mg ml^{-1} (Konate *et al.* 1997). Seedlings were inoculated at 3 WAS. Inoculation was carried out by soaking a piece of cheesecloth in the homogenate and then using it to streak the upper surface of the older leaves thrice. The inoculated plants were then washed with distilled water. The plants were incubated at a temperature of 22 -30 °C and relative humidity between 10 and 65 %.

Field experiments

The field experiments were laid out in a randomized complete block design with three replications at Bomo (11 11´N; 7°38´E; 695m above sea level) and Sayen Gobirawa (10°59´N; 7°47´E ; 650m above sea level), both in northern Nigeria, under lowland conditions. Each plot was 1x1.5m^2. Plots and replicates were 0.1 and 0.5m apart, respectively. Seeds were sown at the rate of 60 kg ha^{-1} on 9 and 10 June, 2006, at Bomo and Sayen Gobirawa, respectively at an intra and inter row spacing of 0.20 m. Seedlings were thinned to 1 plant per stand resulting in 28 plants per plot. Ten plants from the two inner rows were inoculated at 3 WAS with the virus, as described above. The field was hoe-weeded six times at 2,4, 6, 8, 10 and 12 WAS and fertilized at 4 and 8 WAS with NPK fertilizer (15-15-15) at the rate of 200 kg ha^{-1}.The mean annual rainfall of both locations was approximately 1,100 mm while temperature and relative humidity varied between 29 and 34 °C, 11 and 85 %, respectively.

Data collection

The inoculated plants were scored for RYMV severity at weekly interval beginning from 4 WAS. The scoring was based on Standard Evaluation System (SES) for rice (IRRI, 1996): 1-3 = resistant (R), characterized by green leaves with sparse dots or streaks and less than 5 % of height reduction; 5 = moderately resistant (MR), where leaves are green or pale green with mottling, 6-25 % of height reduction and flowering slightly delayed; 7= moderately susceptible (MS), in which leaves are pale yellow or yellow, 26-75 % of height reduction and flowering delayed, 9= highly susceptible (HS) with characteristics yellow or orange leaves, more than 75 % of height reduction and some plant dead.

Plant height, number of tillers per plant, days to 50 % heading and paddy yield were recorded. Plant height was taken weekly with a metre rule by measuring from the ground level to the tip of the flag leaf. Number of tillers per plant was also assessed every week, by counting. Days to 50 % was determined by counting from the date of sowing to the number of days taken by half of the entire plant population of each cultivar to flower. Paddy yield was determined by weighing the quantity of paddy rice produced at harvest by each test cultivar.

Data analyses

The data were subjected to analysis of variance and where F-ratio was significant; means were separated with Student Newman Keuls (SNK) test at 5 percent level of probability. Additionally, results from the two locations were compared using t test. Statistical analysis was performed with Statistical Analysis System (SAS, 2002).

RESULTS

Screenhouse experiments

The rice cultivars differed in their reaction to the virus. Four cultivars (GIGANTE, WAB 189-B38HB, WAB 450-38HB and WAB 450-160HB) were moderately resistant to RYMV while the remaining cultivars (BOUAKE 189, FARO 29, FARO 35, FARO 44, FARO 46, FARO 52, FARO 54, FARO 55, ITA 306 and YARDAS) were moderately susceptible In both categories, expressions of the typical symptoms of the virus began one week after inoculation. The moderately resistant cultivars exhibited pale green to mottled leaf colour while yellow or yellow leaf coloration was observed in the moderately susceptible cultivars (Table 1).

The RYMV resulted in significantly (P=0.01) reduced plant height in BOUAKE 189 (62.0 cm), FARO 29 (65.0 cm), FARO 35 (60.9 cm),FARO 44 (64.4 cm), FARO 52 (63.0 cm), FARO 55 (64.8 cm), ITA 306 (62.9 cm) and YARDAS (69.6 cm). The cultivars WAB 450-160HB was the tallest (108.4 cm) while FARO 35 was the shortest (60.9 cm). However, height of the resistant check (GIGANTE) did not differ from the height of FARO 46, FARO 54, WAB 189-B38HB and WAB 450-38HB at P = 0.05. The impact of the virus on tiller production was highly significant (P 0.01). The highest number of tillers was obtained from BOUAKE 189 (10.2) and FARO 44 (10.0) while FARO 46 produced the least tillers (4.3). The differences between the number of tillers produced by FARO 29 (8.4) and FARO 52 (8.3); WAB 450-160HB(6.7) and YARDAS (6.9) and among FARO 54 (6.1), WAB 189-B-38HB (5.8) and WAB 450-38HB (5.4) were not significant (Table 1).

Days to 50% heading varied from 74 to 122. The number of days to 50 % heading of FARO 46 and FARO 55 was 74 days and were the first cultivars to flower. These were followed by WAB 450-38HB and YARDAS at 86 days after sowing. Furthermore, there were no significant differences in the days to 50 % headings among the rice cultivars FARO 35, FARO 44, FARO 52, GIGANTE and WAB 450-160HB. Days to 50% heading was significantly highest in FARO 29 (122 days) and consequently was the last cultivar to flower (Table 1).

The influence of the virus on paddy production was highly significant (P 0.01). The minimum and maximum paddy yield per plant was 0.8 and 2.3 g, respectively. The significantly highest paddy yield was produced by cultivar WAB 450 38HB while FARO 54 produced the lowest (Table 1).

Field experiments

Of the 14 rice cultivars, seven (BOUAKE 189, FARO 29, FARO 35, FARO 44, FARO 52, FARO 54 and GIGANTE) were moderately resistant to the virus irrespective of the location while only one (WAB 450 160 HB) was moderately susceptible at both locations. The rice cultivars FARO 46, FARO 55, WAB 189 B38HB and WAB 450 38HB were moderately resistant to the disease at Bomo alone. On the other hand, ITA 306 and YARDAS rice cultivars were moderately resistant and susceptible to the virus at Sayen Gobirawa and Bomo, respectively (Table 2).

The reaction of the test cultivars to RYMV resulted in highly significant (P 0.01) height differences at Bomo and Sayen Gobirawa. However, there was no significant difference (t = 0.32 at P = 0.05) when the plant height from both locations were compared. At Bomo, the differences in the height of the rice cultivars FARO 46 (64 cm), FARO 54 (65.5cm), GIGANTE (64.3 cm), and WAB 189 B38HB (63 cm) were not significant. Similarly, the mean height of FARO 52 was statistically similar to that of YARDAS at Bomo. Furthermore, there were no significant height differences among BOUAKE 189, FARO 29, FARO 35, FARO 55, ITA 306 and WAB 450 38HB. FARO 44 was the shortest (41.4 cm) while FARO 54 was the tallest (65.5 cm). At Sayen Gobirawa, BOUAKE 189 was the shortest (38.9 cm) while FARO 54 was the tallest (67.7 cm). However, there was no significant difference between the height of FARO 46 (59.2 cm) and WAB 450 160 HB (58.6 cm), between WAB 450 -38HB (56.3 cm) and YARDAS (55.7 cm). Similarly, no significant height differences occurred among the test cultivars FARO 35, FARO 52, FARO 55 and WAB 189 B38 HB (Table 2).

The effect of RYMV on the number of tillers per plant was highly significant (P 0.01) at Bomo and Sayen Gobirawa. The minimum number of tillers per plant was produced by WAB 189 B38HB at Bomo (3.1) and Sayen Gobirawa (4.2). However, FARO 52 produced the highest (15.8) number of tillers at Bomo while FARO 35 and FARO 44 produced the highest (11.5) at Sayen Gobirawa. At Bomo, there were no significant differences in the number of tillers produced by the test cultivars BOUAKE 189, FARO 29, FARO 35 , FARO 44, FARO 52, GIGANTE, ITA 306 and YARDAS. Similarly, the differences in tillers produced by the cultivars FARO 46, FARO 54, FARO 55, WAB 189 B38HB, WAB 450 38HB and WAB 450 160HB were all statistically similar. At Sayen Bobirawa, the mean number of tillers produced by the test cultivars BOUAKE 189, FARO 29, FARO 35, FARO 44, FARO 52, GIGANTE, ITA 306, WAB 450 38HB and YARDAS were not significantly different. Furthermore, statistically similar number of tillers were produced by FARO 46, FARO 55 and WAB 450 160HB. Moreover, there was no significant location effect on the number of tillers per plant ($t = 1.70$ at $P = 0.05$) (Table 2).

The effect of the pathogen on days to 50 % heading was highly significant (p 0.01) irrespective of the location. In contrast, the number of days to 50% heading at Bomo did not differ significantly from those observed at Sayen Gobirawa ($t = 0.10$ at $P = 0.05$). The highest number of days to 50 % heading was 124 (FARO 29) at each location. However, the least number of days to 50 % heading at Bomo was 80 (FARO 46 and FARO 55) but 83 (YARDAS) at Sayen Gobirawa. At Bomo, mean separation showed that there was no significant difference in days to 50 % heading between FARO 44 and FARO 52; and FARO 46 and FARO 55. Also, days to 50 % heading did not differ significantly among the cultivars GIGANTE, WAB 189 B 8HB and WAB 450 160 HB. However, at Sayen Gobirawa, days to 50 % heading between FARO 44 and WAB 450 38HB, FARO 52 and ITA 306; and among FARO 46, FARO 55 and WAB 450 160HB were all statistically similar (Table 2).

The influence of the pathogen on paddy yield was significant at $P = 0.01$ and $P = 0.05$ at Bomo and Sayen Gobirawa, respectively. At Bomo, the highest paddy yield was 3.6 t ha $^{-1}$ (FARO 52) while the lowest was 1.5 t ha $^{-1}$ (FARO 54, GIGANTE and ITA 306). Comparison of the means showed that there were no significant differences in paddy yield among the cultivars BOUAKE 189, FARO 35, FARO 44, FARO 55, WAB 189 B38HB and WAB 450 38HB. Similarly, paddy yield was statistically similar among the test cultivars FARO 29, FARO 54, GIGANTE, ITA 306, WAB 450 -160HB and YARDAS. At Sayen Gobirawa, the paddy yield obtained from BOUAKE 189, FARO 29, FARO 44, FARO 52, FARO 54, FARO 55, GIGANTE, ITA 306, WAB 450 38 HB, WAB 450 160 HB, and YARDAS were all statistically similar. Moreover, there was no significant difference between the paddy yield produced at Bomo and Sayen Gobirawa ($t = 1.65$ at $P = 0.05$) (Table 2).

Table 1: Effect of Rice yellow mottle virus on rice yield and yield components in the screenhouse

Cultivar	Disease severity	Plant height (cm)	Number of tillers per plant	Days to 50% heading	Paddy yield per plant (g)
BOUAKÉ 189 (susceptible check)	6^{MS}	62.0^{b}	10.2^{a}	108^{b}	1.9^{b}
FARO 29	6^{MS}	65.0^{b}	8.4^{abc}	122^{a}	1.0^{g}
FARO 35	6^{MS}	60.9^{b}	9.1^{ab}	94^{d}	1.7^{c}
FARO 44	6^{MS}	64.4^{b}	10.0^{a}	93^{d}	1.5^{d}
FARO 46	6^{MS}	80.6^{ab}	4.3^{e}	74^{g}	1.2^{f}
FARO 52	6^{MS}	63.0^{b}	8.3^{abc}	93^{d}	1.5^{d}
FARO 54	6^{MS}	81.4^{ab}	6.1^{cde}	89^{e}	0.8^{i}
FARO 55	6^{MS}	64.8^{b}	4.6^{de}	74^{g}	1.8^{b}
GIGANTE (resistant check)	5^{MR}	81.7^{ab}	7.5^{a-d}	92^{d}	1.4^{e}
ITA 306	6^{MS}	62.9^{b}	9.5^{ab}	104^{c}	1.2^{f}
WAB 189 B38HB	5^{MR}	86.4^{ab}	5.8^{cde}	83^{f}	1.7^{c}
WAB450-38HB	5^{MR}	93.3^{ab}	5.4^{cde}	86^{ef}	2.3^{a}
WAB450-160HB	5^{MR}	108.4^{a}	6.7^{b-e}	93^{d}	1.8^{b}
YARDAS	6^{MS}	69.6^{b}	6.9^{b-e}	86^{ef}	1.2^{f}
SE±		8.5	0.7	0.5	0.0

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Table 2. Effect of Rice yellow mottle virus on rice yield and yield components in the field

Cultivar	Disease severity Bomo	Disease severity Sayen Gobinawa	Plant height (cm) Bomo	Plant height (cm) Sayen Gobirawa	Number of tillers per plant Bomo	Number of tillers per plant Sayen Gobirawa	Days to 50% heading Bomo	Days to 50% heading Sayen Gobirawa	Paddy yield ($t\ ha^{-1}$) Bomo	Paddy yield ($t\ ha^{-1}$) Sayen Gobirawa
BOUAKÉ 189	5^{MR}	5^{MR}	46.5^{bc}	38.9^{e}	15.6^{a}	10.5^{a}	116^{b}	120^{b}	2.9^{ab}	1.7^{ab}
FARO 29	5^{MR}	5^{MR}	44.9^{bc}	43.5^{cde}	12.4^{a}	10.8^{a}	124^{a}	124^{a}	1.6^{b}	1.6^{ab}
FARO 35	5^{MR}	5^{MR}	46.5^{bc}	48.6^{a-e}	13.6^{a}	11.5^{a}	93^{e}	93^{e}	3.0^{ab}	3.2
FARO 44	5^{MR}	5^{MR}	41.4^{c}	40.8^{de}	15.4^{a}	11.5^{a}	96^{d}	95^{d}	2.2^{ab}	2.5^{ab}
FARO 46	5^{MR}	6^{MS}	64.0^{a}	59.2^{abc}	7.8^{b}	4.2^{bc}	80^{i}	89^{f}	3.3^{a}	1.4^{b}
FARO 52	5^{MR}	5^{MR}	52.9^{abc}	51.8^{a-e}	15.8^{a}	10.1^{a}	97^{d}	101^{c}	3.6^{a}	2.3^{ab}
FARO 54	5^{MR}	5^{MR}	65.5^{a}	67.7^{a}	8.2^{b}	8.0^{ab}	85^{h}	85^{g}	1.5^{b}	1.5^{ab}
FARO 55	5^{MR}	6^{MS}	49.1^{bc}	52.7^{a-e}	6.1^{b}	5.7^{bc}	80^{i}	88^{f}	2.5^{ab}	1.9^{ab}
GIGANTE (resistant check)	5^{MR}	4^{MR}	64.3^{a}	64.0^{ab}	13.2^{a}	10.5^{a}	87^{g}	85^{g}	1.5^{b}	2.4^{ab}
ITA 306	6^{MS}	5^{MR}	47.7^{bc}	47.2^{b-e}	13.6^{a}	10.6^{a}	110^{c}	100^{c}	1.5^{b}	1.7^{ab}
WAB 189 – B38HB	5^{MR}	6^{MS}	63.0^{a}	54.8^{a-e}	5.4^{b}	3.1^{c}	87^{g}	94^{de}	2.5^{ab}	1.4^{b}
WAB 450 – 3B 11B	5^{MR}	6^{MS}	48.8^{bc}	56.3^{a-d}	6.2^{b}	10.9^{a}	89^{f}	95^{d}	2.7^{ab}	2.0^{ab}
WAB 450 – 160HB	6^{MS}	6^{MS}	60.2^{ab}	58.6^{abc}	6.6^{b}	3.7^{bc}	87^{g}	88^{f}	1.9^{b}	1.6^{ab}
YAR DAS	6^{MS}	5^{MR}	54.7^{abc}	55.7^{a-d}	13.8^{a}	10.4^{a}	86^{gh}	83^{h}	1.9^{b}	1.9^{ab}
SE ±			3.5	3.8	0.9	1.3	0.4	0.5	0.4	0.3

MR = Moderately Resistant, Moderately Susceptible

SE ± = Standard Error of the Mean: Means with the same letter(s) in a column are not significantly different at 5% level of probability (SNK)

DISCUSSION

The rice cultivar GIGANTE has been reported to be highly resistant to RYMV under screenhouse study (N'Guessan *et al.*, 2001) contrast to the findings of this work. This may be an indication of resistance breaking effect of the virus isolate. Similar observation had been made by Traore *et al.* (2006) that resistance breaking isolates of the virus are now prevalent in some West African countries. Moreover, Konate *et al.* (1997) and Fargette *et al.* (2002) earlier reported mild symptoms on GIGANTE when it was challenged with the virus. The moderately resistant status of WAB 189 B 38 HB, WAB 450 38 HB and WAB 450 160HB confirms the earlier report of Fomba (1988). Additionally, Abo *et al.* (2005) documented that FARO 29 and FARO 52 were moderately susceptible to RYMV in the screenhouse experiment and similar results were obtained in this study.

In the screenhouse experiments, the non significant differences observed in the height of the test cultivars BOUAKE 189, FARO 35, FARO 44, FARO52, FARO 55, ITA 306 and YARDAS implies that the severity, virulence and pathogenicity of the virus on these cultivars were similar. Although the rice cultivars GIGANTE, WAB 189 B38HB and WAB 450 38HB were moderately resistant to the virus, they were not as tall as the cultivars BOUAKE 189, FARO 29, FARO 35, FARO 44, FARO 52, FARO 55, ITA 306 and YARDAS, which were moderately susceptible to the disease, indicating that a cultivar with genetic potentiality for resistance to infection may lack traits for one or more agronomic qualities. Similarly, the rice cultivar BOUAKE 189 and FARO 44 which were moderately susceptible to the virus produced the highest number of tillers compared to GIGANTE, WAB 189 B 38HB, WAB 450 38HB and WAB 450 160HB which exhibited moderate resistance to the pathogen. Additionally, the wide variability observed in the number of days to 50 % heading of the test cultivars was only partly due to the RYMV infection. This was probably responsible for the early maturity observed in FARO 46 and FARO 55 which were moderately susceptible to the virus, instead of the cultivars that were moderately resistant to it. However, the rice cultivar WAB 450 38HB combined RYMV resistance with high paddy yield, the dual qualities that are desirable to farmers.

The moderately resistance status of GIGANTE to the virus under field conditions disagrees with the report of Sorho *et al.* (2005) who found it to be highly resistant. This does not absolutely imply that the RYMV isolate used in this study was more virulent than that reported by the last authors since the rice cultivars BOUAKE 189 and GIGANTE which were to act as susceptible and resistant check, respectively showed moderate resistance, indicating that the virus only exhibited preferential pathogenicity on the resistant check. The consistence status of the test cultivars BOUAKE 189, FARO 29, FARO 35, FARO 44, FARO 52, FARO 54 and GIGANTE at both locations implies that climatic factors such as temperature, sunlight and relative humidity had no significant effect on the severity and pathogenicity of the virus (N' Guessan *et al.*, 2001). The rice cultivars FARO 46, FARO 55, WAB 189 B38HB and WAB 450 38HB which were moderately resistant to the disease only at Bomo indicates the influence of climate on the severity of the virus on these cultivars at Sayen Gobirawa.

The results of the field experiments which showed that the height of the rice cultivar WAB 450 160 HB which was moderately susceptible to the disease at both locations did not differ significantly from that observed in FARO 54 and GIGANTE which were moderately resistance to the pathogen, indicates that the effect of disease infection on a cultivar can be enhanced or reduced by factors other than the invading pathogen. The variability which existed among the moderately resistant cultivars where BOUAKE 189 was the shortest at Sayen Gobirawa and FARO 54 was the tallest at the same location can also partly be attributed to disease infection.

Although, in all the test cultivars there was no consistence in the number of tillers produced per plant, when the results of the two locations were compared, the highest number of tillers per plant observed in FARO 52 at Bomo and FARO 35 and FARO 44 at Sayen Gobirawa indicates that these cultivars combined RYMV resistance with high tiller production. However, there were some moderately susceptible cultivars including ITA and YARDAS which competed favourably well with some moderately resistant cultivars (FARO 29, FARO 35, FARO 44, FARO 52 and GIGANTE) in terms of tiller production. This implies that genetic weakness for disease resistance may be compensated by desirable agronomic performance.

The rice cultivars FARO 46 and FARO 55 which were moderately resistant to the virus combined this potential with early maturity, suggesting their suitability to the study area. A similar observation was also made at Sayen Gobirawa in these cultivars and WAB 450 160 HB, indicating the possibility of their acceptability by the rice growers in this locality. Meanwhile, the average number of days to 50 % heading recorded in FARO 52 (97 days) corroborates the findings of Abo *et al.* (2005).

Moreover, the inability of some moderately resistant cultivars to mature early in the season can partly be explained by their genetic make up. The ability of FARO 46 and FARO 52 to resist RYMV infection and consequently produced significantly highest paddy yield at Bomo indicates that their cultivation should be encouraged in the study area. It also implies that these cultivars can serve as gene donors in RYMV-resistance breeding programme. The rice cultivar FARO 35 which performed in the same way at Sayen Gobirawa could also be recommended to farmers in the locality. The phenomenon where the high yielding moderately resistant cultivars at one location produced poorly at another location suggests that resistant selection made at one location are unlikely to remain resistant in other.

Comparatively, some results obtained in the screenhouse differed considerably from the field experiments probably due to the differences in climatic factors such as temperature and relative humidity under which the study was conducted (Awoderu, 1991). The higher plant height recorded in the screenhouse, compared to the field indicates the significant effect of the prevailing climatic conditions on the activity of the virus. However, the non significant effect observed on plant height between Bomo and Sayen Gobirawa shows that pathogenicity and virulence of the virus was similar at both locations. All things being equal, it also implies that attack of any of the cultivars by the virus could reduce plant height in the same magnitude, irrespective of the location. The higher number of tillers observed in the field, compared to the screenhouse experiments could also be ascribed to negative effect of the prevailing climate on the virus' ability to reduce tiller production. The longer number of days to 50 % heading in the field, compared to the screenhouse experiments was an indication of favourable effect of the enviromental conditions on the pathogenicity of the virus which consequently delayed heading.

The use of resistant cultivars is the most effective and sustainable management practice for RYMV (Onasanya *et al.*, 2004). Since many of the rice cultivars planted by farmers are susceptible to the virus the need for a continuous search for immunity and / or resistance to the disease is inevitable. Meanwhile, rice growers in study area could take advantage of the information provided in this study to select cultivars that are resistant to RYMV and are high yielding too.

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