ASSESSMENT FOR GROWTH AND YIELD PARAMETERS OF SOME RICE CULTIVARS INFECTED WITH RICE YELLOW MOTTLE VIRUS (RYMV) GENUS SOBEMOVIRUS

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Abstract: Screenhouse trials were conducted from 2008 to 2010 cropping seasons to assess growth and yield parameters of ten (10) selected rice cultivars, which include; Faro 11, Faro 35, Faro 36, Faro 37, Faro 44, Faro 46, Faro 52, Faro57, Moroberekan and Bouake 189, infected with Rice Yellow Mottle Virus (RYMV) genus Sobemovirus. The experiment was laid out in a strip plot design and replicated three times, with ten rice cultivars in the vertical factors (main plot) and four inoculation regimes of RYMV at 4, 6, 8 and 10 Weeks after sowing (WAS) and un-inoculated control was in the horizontal factors (sub-plot). Significant interaction between the effects of inoculation regimes and rice cultivars were found between the growth and yield parameters and severity index of the virus. Combined analysis of the trials data showed that percentage reduction in plant height and number of tiller per plant, increase in days to 50% flowering, threshing percentage, paddy yield loss and Severity index ranged from 1.74% (Moroberekan) to 48.19% (Bouake 189) and 27.71% (Moroberekan) to 53.06% (Bouake 189), 1.78 (Faro 46) to 25.78 (Faro 57), 69.83% (Bouake 189) to 91% (Moroberekan), 6.59% (Moroberekan) to 79.11% (Bouake 189) and 17.04% (Moroberekan) to 77.61% (Bouake 189), respectively. The test cultivars were most critically affected by RYMV inoculation within 4 to 8 WAS. In order to obtain paddy yield comparable to that of virus free check for the respective test cultivars, it was required to keep the crop virus-free for up to 10 WAS and beyond, the information can be useful in integrated pest and production management for rice in RYMV endemic areas.

Keywords: RYMV, paddy yield, inoculation regimes, Sobemovirus

Introduction

Rice yellow mottle virus (RYMV) Genus Sobemovirus (Hull and Fargette, 2005) caused rice yellow mottle disease which is a major limiting factor in Africa rice production (Abo *et al*., 1998). It is endemic to the African continent (Kouassi *et al*., 2005; Zouzou *et al*., 2008) and is one of the most devastating pathogens of cultivated rice (Abo *et al*., 1998; Mghase *et al*., 2010), where it causes important yield losses (Kouassi *et al*., 2005; Paul *et al.,* 2003; Traore *et al*., 2006; Zouzou *et al*., 2008). Yield loss fluctuates between 10 and 100%, depending on plant age prior to infection, susceptibility of rice variety and environmental factors (Bakker, 1974; Kouassi *et al*., 2005; Zouzou *et al*., 2008). Control of RYMV is difficult because the virus is highly infectious, characterized by high rate of mutation which lead to emergence of several strains (Hebrand *et al*., 2006) and because the epidemiology and role of vector are not well understood (Yvonne *et al*., 1999).

Very few rice varieties are resistant to RYMV (Hebrand *et al*., 2006); because the useful lifespan of many resistant cultivars is only a few years due to the breakdown of the resistance (Traore *et al*., 2006), in the face of pathogenic variability of the pathogen population (Zhang *et al*., 2009). However, susceptibility of rice cultivars to RYMV could vary with plant age, with plant developing resistance at adult stage. Thus protection of the plant at early stages of growth by using chemical treatment against RYMV vectors would reduce the effect of the disease on yields (Soko *et al.*, 2010). Such strategies will be particularly important in cases where the source of resistance is not available. Therefore, the present study was conducted to investigated, the susceptibility of the host and most susceptible stage of the crop, experimentally with periodic inoculations with virus isolate in a screenhouse. So that the critical stage at which RYMV infection is most detrimental to growth and yield components of some common rice cultivar grown by the farmer can be established.

Materials and Methods

The source of plant material

Ten (10) cultivars of rice were used in this study. The rice seeds were obtained from the genetic resources unit of Rice Division, National Cereal Research Institute (NCRI), Badeggi, Nigeria.

The source of inoculums and maintained of RYMV isolate

The virus isolate was collected from infected rice plants in a farmer's field at Kura, Kano state, Nigeria. The infected rice leaves were divided into two parts; one part was preserved in the freezer while the other part was maintained and propagated by preparing into extracts and inoculated on Bouake 189, a highly susceptible rice variety, in the screenhouse at the Department of Crop Protection, Institute for Agricultural Research (IAR) Ahmadu Bello University, Zaria, Nigeria. Plants were inoculated at 3 – 5 leaf stage and maintained in an insect- proof screenhouse at a temperature 25 – 32^{o}C and relative humidity of 10- 85%. Appearance of symptoms was monitored and leaf samples were collected and use for inoculation in the experiment.

Preparation of inoculums and inoculation procedure

As stated above the virus isolates were first propagated by mechanical inoculation to the standard susceptible rice cultivar Bouake 189 to increase the virus content (Fargette *et al*., 2008). The inoculums was prepared from RYMV infected leaves of these Bouake 189 plant by grinding in 0.1 m phosphate buffer (pH 7.4) at the ratio of 1:10 (w/v) using sterile mortars and pestles. Carborundum powder (600 mesh) was then added to the inoculums and mixed thoroughly, to aid virus penetration into leaf tissues. Inoculation was carried out soaking a piece of cheese cloth in the virus extracts and then rubbing the whole plant, in order to avoid possible escapes from infection the whole plants were inoculated twice after a short interval from the base to top.

Experimental design and data collection

The experiment was laid out in a strip plot design and replicated three times, with the ten rice cultivars in the vertical factors (main plot) and four inoculation regimes of inoculums at 4, 6, 8 and 10 weeks after sowing (WAS) and un-inoculated control, was in the horizontal factors (sub-plot). Each treatment consisted of 3 plastic pots (18 cm diameter) filled with 2 kg, heat- sterilized fadama topsoil with 2 plants per pot. Each pot was placed in a 21cm diameter plastic basin containing water, to mimic lowland fadama rice field, and the water requirement of the plants. About 2.5 kg of NPK (15 15 15) fertilizer was dispensed in each pot at seedling stage when they were 5 weeks old. All plants were arranged on a table and maintained in a insect-proof screenhouse at a temperature 25- 32^{o}C and relative humidity of 10- 85%, at the Department of Crop Protection, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria in 2008, 2009 and 2010 cropping seasons. The effect of the different inoculation regimes of RYMV on the test plant growth parameter such as plant height, number of tiller per plant were determined by measuring the height of plant (in cm) and counting the number of tiller, the yield parameters such as days to 50% flowering threshing percentage and paddy yield were recorded. Days to 50% flowering was determined by counting the number of days taken by half of the entire plant population of each test plant to flower from time of sowing (data not shown) paddy yield was determined by weighing the quantity of rice grain produced at harvest by each test plant. Including the control and the average of each parameter mentioned early per replicate were determined. Disease severity was monitored and recorded weekly starting from 4 to 10 WAS. The standard evaluation system (SES) (IRRI, 1996) on a scale of 1–9 was used.

Threshing percentage was calculated using the formula;

$$Threshing\ percentage\ (\%) = \frac{weight\ of\ threshed\ grain}{weight\ of\ un\text{-}threshed\ grain}\ x\,100$$

Thereafter, the interaction effect of the diseases severity on the reduction of growth and yield parameter was assessed in each case (values are mean of three trials combined analysis), according to the following formula; RP% (CP – TP/CP) x 100; RP = percentage reduction in parameter, CP = mean value of control plant, TP = mean value of test plant.

Results and Disscusion

Interaction of rice cultivars and inoculation regimes of RYMV on percentage reduction in plant height and number of tillers per plant in the screenhouse ((mean of three trials data combined analysis)

Among the interaction treatments, Bouake 189 at 4 and 6 WAS inoculation regimes had significantly ($P \leq 0.01$) higher reduction in plant height. The lowest reduction in plant height was recorded on Moroberekan at 10 WAS, inoculation regime than the other interactions exception for Faro 46 at the same inoculation regime (Table 1). The percentage reduction in plant height varied significantly among the other interaction combinations. However, the results obtained showed that at 10 WAS inoculation regime Faro 46 and Moroberekan were statistically similar to the control treatment (Table 1).

The results obtained showed that the percentage reductions in the number of tillers produced per plant were significantly higher in rice cultivar Bouake 189 inoculated at 4 WAS than all the remaining treatments with the exception Faro 35 inoculated at the same period. Among the inoculated plant the lowest percentage reduction in tiller production per plant was recorded on Faro 11 inoculated at 10 WAS, though not significantly different from Faro 52 and Moroberekan inoculated at 10 WAS (Table 1).

Interaction of rice cultivars and inoculation regimes of RYMV on increase in number of days to 50 % flowering and threshing percentage in the Screenhouse (mean of three trials combined analysis)

Combined analysis of the trials data showed that Faro 57 inoculated at 4 WAS recorded significantly higher increase in number of days to 50% flowering than the other interaction treatments, with the exception of Faro 52 and Faro 57 inoculated at 4 and 6 WAS, respectively. While the least number of days increase to 50% flowering was recorded in Faro 46 at 10 WAS inoculation regimes, thought it was statistically similar to most of the treatments at 10 WAS inoculation regimes, with the exception of Faro 35,Faro 52,Faro 57 and Bouake 189 (Table 2). The highest threshing percentage was obtained with rice cultivar Moroberekan under the control treatment. However, it was not significantly different from other test cultivars, with the exception of Faro 44, Faro 52, and Faro 57. The lowest threshing percentage was recorded at 4 WAS inoculation regimes in Bouake 189. It was significantly different from most of the test cultivars, except Faro 36 and Faro 52 under 4 WAS inoculation regimes. Similarly, Faro 37 under control treatment recorded significantly higher threshing percentage, although it was statistically insignificant to most of the test cultivars under the control treatment except for Faro 35, Faro 44Faro 52 and Faro 57. The lowest threshing percentage was recorded on Bouake 189 at 4 WAS, inoculation regimes, however, it was statistically insignificant compared to Faro 36 and Faro 52 inoculated at 4 WAS (Table 2).

Effect of inoculation regimes and rice cultivars on the severity index and paddy yield loss due to RYMV in the Screenhouse from 2008 to 2010 cropping seasons

There were significant ($P \leq 0.05$) differences in the disease severity index among the inoculation regime during all the trials. The lowest severity index was recorded with inoculation regime at 10 WAS followed by at 8 WAS inoculation regime. While there was no significant difference in severity index between 4 and 6 WAS inoculation regime in 2008 and 2010 seasons, but it was significantly different in 2008 season. There were significant differences in the severity index of RYMV among the test cultivars in all the trials. Significantly lower RYMV severity index was recorded on Moroberekan irrespective of trial periods. Among the cultivars in 2008 season Bouake 189 recorded highest severity index of RYMV, though it was not significantly different from the remaining test cultivars, with the exception of Faro 46, Faro 57 and Moroberekan. The results recorded in 2009 seasons showed a higher RYMV severity index on Faro 44, though it was statistically similar to Faro 52, Faro 57 and Bouake 189. Furthermore, in 2010 season higher RYMV severity index was recorded on Faro 44, though it was statistically similar to Faro 36, Faro 52, Faro 57 and Bouake 189. Combined analysis of the three trials results indicated that there were significant variations in the severity index of RYMV among the rice cultivars, Moroberekan had significantly lower severity index than the remaining cultivars, while higher severity index was recorded on Bouake 189, although it was statistically similar to Faro 44 and Faro 52. There were no significant differences among Faro 11, Faro 35, Faro 36, and Faro 57 and also between Faro 11 and Faro 37 (Table 3).

Table 1: Interaction of rice cultivars and inoculation regimes of RYMV on percentage reduction of plant height and number of tillers per rice cultivar in the screenhouse (mean of three trials combined over from 2008 to 2010 cropping seasons)

Cultivar	Plant height reduction (%)					Number of tillers reduction per plant (%)				
	4 WAS	6 WAS	8 WAS	10 WAS	Control	4 WAS	6 WAS	8 WAS	10 WAS	Control
Faro 11	32.63^{def}	27.32^{g}	19.24^{j}	10.95^{lm}	0.00^{r}	40.13^{cde}	34.22^{g-j}	21.23^{n}	2.85^{qr}	0.00^{r}
Faro 35	31.49^{f}	23.82^{hi}	12.00^{lm}	5.66^{op}	0.00^{r}	50.75^{ab}	38.26^{c-g}	32.68^{i-k}	15.96^{o}	0.00^{r}
Faro 36	34.51^{cde}	28.47^{g}	11.49^{lm}	4.78^{p}	0.00^{r}	39.20^{c-f}	35.78^{f-i}	19.39^{n}	10.31^{p}	0.00^{r}
Faro 37	40.98^{b}	35.29^{cd}	22.17^{i}	9.64^{mn}	0.00^{r}	40.47^{cd}	36.15^{e-i}	22.67^{n}	14.12^{o}	0.00^{r}
Faro 44	38.88^{b}	31.74^{ef}	16.99^{k}	5.76^{op}	0.00^{r}	47.85^{b}	42.41^{c}	27.76^{lm}	15.79^{o}	0.00^{r}
Faro 46	26.74^{g}	19.62^{j}	12.63^{l}	3.81^{pqr}	0.00^{r}	39.06^{c-f}	33.94^{hij}	24.05^{mn}	10.20^{op}	0.00^{r}
Faro 52	39.41^{b}	32.08^{ef}	22.58^{i}	8.04^{no}	0.00^{r}	37.78^{d-h}	29.98^{kl}	20.82^{n}	10.00^{pq}	0.00^{r}
Faro 57	35.60^{c}	25.89^{gh}	17.20^{jk}	7.77^{no}	0.00^{r}	41.22^{cd}	35.07^{f-i}	23.01^{n}	13.20^{op}	0.00^{r}
Moroberekan	18.88^{j}	15.60^{k}	5.41^{op}	1.74^{qr}	0.00^{r}	27.71^{lm}	24.27^{m}	16.25^{o}	5.80^{q}	0.00^{r}
Bouake 189	48.19^{a}	45.44^{a}	32.17^{ef}	10.45^{lmn}	0.00^{r}	53.06^{a}	42.44^{c}	25.40^{mn}	13.60^{op}	0.00^{r}
SE ±			**1.58**					**3.69**		

Means and treatment under the same season followed by similar letter(s) are not significantly different at P = 0.05, according to Duncan's multiple range test (DMRT); WAS = Weeks after sowing; SE = Standard error of the mean

Table 2: Interaction of rice cultivars and inoculation regime of RYMV on the increase in number of days to 50 % flowering and Threshing percentage in the Screenhouse (mean of three trials combined over from 2008 to 2010 cropping seasons)

Cultivar	Increase in number of days to 50% flowering					Threshing percentage (%)				
	4 WAS	6 WAS	8 WAS	10 WAS	Control	4 WAS	6 WAS	8 WAS	10 WAS	Control
Faro11	12.67^{def}	9.78^{ghi}	6.44^{j-o}	2.67^{r-s}	0.00^{t}	$72.28t^{uv}$	75.43^{rs}	76.94^{pq}	88.83^{d-g}	91.40^{ab}
Faro 35	12.00^{efg}	9.88^{ghi}	6.78^{j-n}	4.44^{o-r}	0.00^{t}	71.94^{uv}	73.82^{stu}	76.00^{qr}	86.89^{i-l}	91.11^{abc}
Faro 36	7.11^{j-m}	6.56^{j-o}	4.00^{p-s}	3.11^{q-s}	0.00^{t}	71.00^{vwx}	72.33^{tu}	73.89^{st}	88.44^{c-i}	90.83^{a-d}
Faro 37	13.00^{def}	8.67^{hij}	6.67^{j-n}	3.78^{p-s}	0.00^{t}	81.56^{n}	83.94^{m}	86.39^{j-l}	89.22^{c-g}	91.33^{ab}
Faro 44	9.67^{hi}	8.33^{ijk}	7.00^{j-m}	3.33^{q-s}	0.00^{t}	$72.55t^{uv}$	73.36^{stu}	75.61^{qrs}	86.11^{klm}	89.89^{b-f}
Faro 46	5.78^{k-p}	$4.56o^{-r}$	3.00^{q-s}	1.78^{st}	0.00^{t}	85.77^{lm}	86.88^{i-l}	88.17^{f-j}	89.00^{d-g}	91.44^{ab}
Faro 52	23.67^{ab}	22.67^{b}	13.22^{de}	5.11^{n-q}	0.00^{t}	71.11^{uwx}	73.22^{tuv}	75.33^{rs}	87.72^{hij}	89.83^{b-f}
Faro 57	25.78^{a}	23.89^{b}	14.44^{cd}	6.33^{k-o}	0.00^{t}	78.67^{g-j}	80.33^{no}	81.89^{n}	88.11^{f-j}	90.06^{b-d}
Moroberekan	$7.89i_{-l}$	6.78^{j-n}	4.33^{o-r}	2.56^{r-s}	0.00^{t}	87.00^{h-l}	88.11^{f-j}	88.33^{f-j}	91.00^{abc}	91.67^{ab}
Bouake 189	16.44^{c}	13.33^{de}	10.78^{fgh}	5.00^{n-q}	0.00^{t}	69.83^{x}	71.00^{vwx}	73.89^{st}	89.89^{b-f}	92.00^{a}
SE ±			**0.96**					**0.69**		

Means and treatment under the same parameter followed by similar letter(s) are not significantly different at P = 0.05, according to Duncan's multiple range test (DMRT); WAS = Weeks after sowing; SE = Standard error of the mean

Percentage reduction of paddy yield varied significantly ($P \leq 0.01$) among the inoculated plants compared to the control. In all the experiments, significantly higher reduction in paddy yield was recorded on plants inoculated at 4 WAS while the lowest was recorded on plant inoculated at 6, 8 and 10 WAS in decreasing order. Among the cultivars, the lowest percentage reduction in paddy yield was recorded on Moroberekan in all the trial periods. However, the highest percentage reduction in paddy yield was recorded on different rice cultivars among the experiments. In 2008 trial, the highest reduction in paddy yield was recorded on Faro 52, though it was statistically similar to Faro 57 and Bouake 189. While during 2009 trial the highest reduction in paddy yield was recorded on Bouake 189, but it was statistically similar to that of Faro 44. Furthermore, in 2010 trial, the highest reduction in paddy yield was recorded on Faro 44 though it was statistically similar to Faro 52 and Bouake 189. Combined analysis of the trials season data showed that significantly lowest reduction in paddy yield was recorded on Moroberekan, while the highest percentage paddy yield loss was recorded on Bouake 189. There were no significant differences recorded between Bouake 189 and Faro 52, between Faro 11 and Faro 36, between Faro 35 and Faro 37 and also between Faro 57 and Faro 44. The effect of interactions of inoculation regimes and cultivars on paddy yield loss was significantly higher ($P \leq 0.01$) among the treatments in all experiments (Table 3).

Interaction of inoculation regime and rice cultivars on the severity index of RYMV and paddy yield loss in the Screenhouse ((mean of three trials combined analysis)

In the combined analysis of all the trials data, significantly highest and lowest RYMV severity index was recorded in rice cultivars of Bouake 189 and Moroberekan inoculated at 4 and 10 WAS, respectively. There was no significant difference in severity index of RYMV between the same cultivar at 4 and 6 WAS inoculation regimes, except for cultivar Moroberekan. However, there was significant different between the same test cultivar inoculated at 6 and 8 WAS with the exception of Faro 44, Moroberekan and Bouake 189 (Table 4). Bouake 189 inoculated at 4 WAS with RYMV, recorded significantly ($P \leq 0.05$) higher paddy yield loss than the other interaction combinations with the exception of Faro 52 under the same inoculation regime. The lowest paddy yield loss was recorded in Moroberekan inoculated at 10 WAS; it was statistically similar to Faro 35 under the same inoculation regime (Table 4).

The economic impact of RYMV is difficult to evaluate due to the influence of many factors such as local environment in which rice is grown, the virus strain, rice cultivars grown, date of infection and parameter selected (Awoderu, 1991; Ali 1999; Luzi-Khupi *et al*., 2000; Konate and Fargette, 2001; Kouuassi *et al*., 2005; Zouzou *et al*., 2008). Since the behavior of most rice cultivars in relation to the disease is not homogenous, it varies according to the cultivar and parameters selected (Zouzou *et al*., 2008). The assessment of growth and yield components allowed better determination among rice cultivars responses to a particular RYMV strain infection at different stage of the plant growth.

The reaction of the test cultivars to RYMV in this study resulted in highly significant reduction in plant height in susceptible cultivars such as Bouake 189, Faro 35, Faro 36, Faro 44 and Faro 57 compared to resistant cultivars of Moroberekan and Faro 46 in the combined analysis. The results are in agreement with that of other authors (Salaudeen *et al*., 2008b; Zouzou *et al*., 2008; Onwaghalu *et al*., 2010). These shows that impact of RYMV on growth parameters varied with cultivar and time of pathogen inoculations, stunted plants were obtained under 4 WAS inoculation regime thought not significantly different from that at 6 WAS inoculation regimes. The present result is consistent with those of Kouassi *et al*. (2005) who reported that when infection of RYMV occurs from 20 – 50 days after planting, the plant may continue to grow but will be stunted.

Table 3: Effect of inoculation regimes of RYMV on the severity index) and paddy yield loss of rice cultivars in the Screenhouse

Treatment	Severity index (%)				Paddy yield loss (%)			
	2008	2009	2010	Combined	2008	2009	2010	Combined
Inoculation regime								
4 WAS	76.43^{a}	66.15^{a}	73.57^{a}	72.05^{a}	57.71^{a}	65.13^{a}	62.73^{a}	62.86^{a}
6 WAS	72.94^{b}	63.94^{a}	71.67^{ab}	69.52^{b}	46.49^{b}	58.76^{b}	53.23^{b}	52.82^{b}
8 WAS	64.53^{c}	55.15^{b}	63.10^{b}	62.92^{c}	31.28^{c}	43.46^{c}	40.89^{c}	38.54^{c}
10 WAS	45.63^{d}	34.75^{c}	43.58^{c}	41.32^{d}	11.74^{d}	12.16^{d}	13.89^{d}	12.52^{d}
Control	0.00^{e}	0.00^{d}	0.00^{d}	0.00^{e}	0.00^{e}	0.00^{e}	0.00^{e}	0.00^{e}
Mean	51.91	43.99	51.58	49.16	29.44	35.90	34.10	33.15
SE ±	0.79**	0.79**	1.08**	0.96**	1.28**	0.57**	0.81**	0.98 **
Cultivar								
Faro 11	54.04^{abc}	43.54^{c}	52.33^{b}	49.97^{de}	29.34^{b}	38.43^{bc}	33.50^{cd}	33.82^{c}
Faro 35	53.45^{abc}	45.21^{bc}	52.20^{b}	50.28^{cde}	21.86^{c}	38.57^{bc}	33.09^{d}	31.17^{d}
Faro 36	54.83^{abc}	44.70^{bc}	57.04^{a}	52.17^{bcd}	30.66^{b}	37.29^{cd}	36.47^{cd}	34.81^{c}
Faro 37	51.23^{ab}	43.58^{c}	51.53^{b}	45..78^{e}	22.84^{c}	35.08^{d}	36.27^{cd}	31.40^{d}
Faro 44	55.29^{ab}	50.12^{a}	58.20^{a}	54.54^{ab}	26.36^{bc}	44.74^{a}	42.72^{a}	37.94^{b}
Faro 46	48.45^{d}	43.71^{c}	46.53^{c}	46.23^{ab}	22.33^{c}	27.51^{e}	24.37^{e}	24.37^{e}
Faro 52	53.57^{abc}	48.14^{ab}	57.27^{a}	52.99^{ab}	43.09^{a}	40.54^{b}	42.11^{ab}	41.92^{a}
Faro 57	53.03^{bc}	47.47^{ab}	57.20^{a}	52.56^{bcd}	38.06^{a}	38.94^{bc}	38..02^{bc}	38.67^{b}
Moroberekan	38.24^{e}	24.16^{d}	25.35^{d}	29.25^{g}	20.73^{c}	11.64^{f}	11.02^{f}	14.46^{f}
Bouake 189	56.93^{a}	49.34^{a}	58.20^{a}	54.82^{a}	38.97^{a}	46.30^{a}	42.46^{a}	42.57^{a}
Mean	51.91	43..99	51.58	49.16	29.44	35.90	34.10	33.15
SE ±	1.13**	1.13**	1.44**	1.36**	1.81**	0.82**	1.45**	1.39**
Interaction	**	**	**	**	**	**	**	**

Column means followed by the same letter(s) are not significantly different at P = 0.05 %, using Duncan's multiple range test (DMRT); ** = significant at P = 0.01 %

Table 4: Interaction of rice cultivars and inoculation regimes of RYMV on the severity index (%) and paddy yield loss (%) in the screenhouse (mean of three trials combined over from 2008 to 2010 cropping seasons)

Cultivar	Severity index (%)					Paddy yield loss (%)				
	4 WAS	6 WAS	8 WAS	10 WAS	Control	4 WAS	6 WAS	8 WAS	10 WAS	Control
Faro11	73.78^{a-d}	73.02^{b-e}	64.69^{ij}	38.35^{o}	0.00^{r}	69.56^{bc}	51.94^{ijk}	35.63^{no}	11.99st	0.00^{v}
Faro 35	74.87^{anc}	73.56^{bcd}	66.42^{ghi}	44.57^{n}	0.00^{r}	63.41^{def}	51.62^{ijk}	32.15^{o}	8.66^{tu}	0.00^{v}
Faro 36	74.44^{abc}	73.97^{a-d}	65.52^{hi}	46.95^{mn}	0.00^{r}	64.91^{d}	55.06^{hi}	41.65^{m}	12.43^{rst}	0.00^{v}
Faro 37	75.03^{abc}	71.79^{c-f}	61.51^{j}	35.56^{op}	0.00^{r}	57.79^{fg}	53.15^{ij}	33.6^{9o}	12.34^{rst}	0.00^{v}
Faro 44	75.88^{ab}	74.13^{a-d}	70.17^{d-j}	52.50^{lm}	0.00^{r}	63.88^{de}	60.56^{efg}	48.58^{kl}	16.66^{q}	0.00^{v}
Faro 46	72.15^{b-f}	69.46^{e-h}	55.61^{jk}	33.92^{p}	0.00^{r}	47.57^{l}	38.02^{mn}	27.26^{p}	10.82^{t}	0.00^{v}
Faro 52	74.63^{abc}	73.69^{a-d}	69.07^{e-h}	47.56^{mn}	0.00^{r}	77.45^{a}	66.20^{cd}	53.47^{ij}	12.46^{rst}	0.00^{v}
Faro 57	74.63^{abc}	73.97^{a-d}	68.60^{f-i}	46.40^{mn}	0.00^{r}	71.38^{b}	51.52^{ijk}	46.97^{l}	15.48^{qr}	0.00^{v}
Moroberekan	55.44^{k}	38.15^{o}	35.64^{op}	17.04^{q}	0.00^{r}	28.50^{p}	25.99^{p}	16.23^{q}	6.59^{u}	0.00^{v}
Bouake189	77.61^{a}	74.20^{abc}	71.98^{b-f}	50.32^{lm}	0.00^{r}	79.11^{a}	66.18^{cd}	49.79^{jkl}	17.78^{q}	0.00^{v}
SE ±			**3.05**					**3.12**		

Means and treatment under the same parameter followed by similar letter(s) are not significantly different at P = 0.05, according to Duncan's multiple range test (DMRT); WAS = Weeks after sowing; SE = Standard error of the mean

The interaction of inoculation regimes RYMV on different cultivars shows that test plants inoculated at 10 WAS were significantly taller than the other test plants under 4, 6 and 8 WAS inoculation regimes. This could be due to the difference in the inoculation regimes at varying stage of the plant growth. However, this report is not in agreement with the observation of Luzi Kihupi *et al*. (2000) that the plant height was not affected by this pathogen. This might be due to difference in the pathogenicity of the isolate used (N'Guessan *et al*., 2001). There was significant difference in reduction of number of tiller per plant among the various treatments. The lowest reduction in tiller production per plant was obtained in Moroberekan cultivar. The reason for this is not known but one explanation could be due to the lower disease severity recorded on this cultivar. Moreover, the significant reduction in number of tiller production per plant recorded on Bouake 189 cultivar is inline with the earlier report by Ghesquire *et al.* (1997) that susceptible lines were characterized by reduced tillering. The interaction effect of RYMV inoculation regime and cultivar show that plant inoculated at 10 WAS had significantly, lower number of tillers reduction per plant than the other inoculation regimes. This might be as a result of the more favourable growth conditions for the crop with virtually low pressure of RYMV on the plant during tillering stage before the inoculation at 10 WAS.

There was a significant difference in the mean number of days increase to 50% flowering among the rice cultivars the lowest increase in number of days to 50% flowering was recorded on Faro 46 (2.51) corroborates the finding of Salaudeen *et al.* (2008). This might be as a result of early maturity nature of the cultivars. However, the interaction effects of inoculation regimes of RYMV and cultivar show that inoculated plants had an increase of 11.35, 8.47, 6.02 and 2.93 days to 50% flowering at 4, 6, 8 and 10 WAS, respectively. This shows that RYMV infection has an inevitable consequence on the time of panicle emergence, particularly if infection occurs early and on susceptible host. A similar observation was also made by (Ghesquiere *et al*., 1997) that susceptible cultivars were characterized by delayed panicle emergence. It is evident that RYMV infection delayed days to 50% flowering in rice cultivars against their uninoculated control entries. Possibly, due to prolonged vegetative lag phase as well as other physiological changes resulting from virus infection causes the delay in days to 50% flowering observed in this study.

There was significant difference in threshing percentage of the test plant, during the trials. This change in yield component may be due to the plants response to the pathogen which may or may not permit the full genetic expression of the yield component. However, the mean threshing percentage was higher at the later stages of the inoculation regime than the earlier stage. The lower threshing percentage recorded might linked with the severity effect on the test cultivars. which might have hampered the normal growth, development and functioning of the leaves, thereby affecting the photosynthetic processes and consequently led to the reduction in seed formation and thus lower threshing percentage. This agrees with the report of Thomas *et al*. (1996) that severe foliar infection during grain formation can contribute to reduction in grain weight. The interaction effect of inoculation regime on rice cultivars had a significant effect on the threshing percentage. Inoculated plant had lower threshing percentage than to they respective uninoculated control treatment. This agrees with the report by Pixley *et al.* (1990) that healthier leaf canopy are more photo- synthetically effective than a canopy of leaf area index with higher chlorotic infection.

Plants inoculated at 4, 6, 8 and 10 WAS had average paddy yield losses of between 25.99-79.11%, 23.56-66.18%, 16.23-49.79% and 6.59-17.78%, respectively, in relation to their respective control entries, establishes the fact that yield losses to RYMV are strongly influenced by growth stages of the rice cultivar as well as time of virus infection (Rossel *et al.*, 1982a; Onwughala *et al.*, 2010). More so, this shows that period from 4 to 8 WAS represents the most vulnerable stage to RYMV infection in paddy yield losses phase in rice cultivars. The interaction effect of inoculation regimes of RYMV on cultivar had significant effects on paddy yield as revealed in this study, the highest yield loss of 79.11%,66.18%, 49.79% and 17.78% obtained in Bouake 189 at 4, 6, 8 and 10 WAS inoculation regimes, respectively This might be due to susceptibility of the test cultivar to the virus, which might have hampered the normal growth, development and functioning of the plant parts, which consequently led to the reduction in seed formation, among the inoculated plants resulting in lower paddy yield. Similarly, Bakker (1974) and Taylor (1990) stated that infected plants especially those which are infected early in the growing season, often fail to produce grains. This indicated that expression of RYMV symptom was strongly influenced by inoculation regimes differently in host plant. At maturity stage, RYMV show only mild symptom while at younger stage severe symptom developed and also greater expression of RYMV symptoms particularly on susceptible cultivar. Similar observations were made by Bakker (1974) and Albar *et al*. (1995) that severity index of RYMV was strongly influenced by susceptibility of the cultivar, the stage of the plant growth at which infection occurred among other factors.

Generally, the severity index recorded on test cultivars, inoculated at 4 and 6 WAS, were significantly higher compared to those at 8 and 10 WAS. This shows that plants infected early are more severely affected than those infected later and the symptoms were more pronounced and necrotic. When different stages of the plant growth were monitored large differences in susceptibility were observed among the different cultivars exposed to the pathogen. The virus significantly reduced plant height and number of tillers per plant, prolonged days to 50% flowering, decrease threshing percentage and led to paddy yield losses. The critical period of RYMV infection for most of the rice cultivars used in the current study was between 4 - 8 WAS. Keeping the rice RYMV free for up to 10 WAS resulted in grain yield almost similar to those kept RYMV free throughout crop growth. This information will surely assist breeder's programmes in the development of management strategies for rice cultivars to RYMV disease.

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