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Rice yellow mottle virus Infection and Reproductive Losses in Rice (*Oryza sativa* Linn.)

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ABSTRACT

The study on *Rice yellow mottle virus* (RYMV) infection and reproductive losses in rice was carried out under screenhouse condition in Nigeria. Thirty-five rice varieties were evaluated for RYMV resistance. Percent productive tillers, date to 50% flowering and percent spikelets fertility per plant were between 43.2-96.7%, 57.67-112 days and 0-71.8%, respectively. Number of panicles per plant, number of grains per panicle and 1000 grain weight per plant were between 8.33-45.67, 0-77 and 0-27.57 g, respectively. Yield losses of between 17-100% were obtained from all the rice varieties evaluated. Out of the 35 rice varieties studied, only Gigante (18%), Moroberekan (19%) and NERICA-L 42 (32%), have the least yield losses and RYMV resistance characteristics. The three varieties (Gigante, Moroberekan and NERICA-L 42) are known to possess stable resistance characteristic to RYMV disease and will comparatively be suitable for cultivation in areas where RYMV incidence is endemic and on a long term be used by rice breeders as sources for breeding for durable resistance to RYMV disease in Nigeria.

Key words: Productive tillers, spikelets fertility, disease incidence, flowering, resistance

INTRODUCTION

Rice is the most important crop in the developing world in terms of production and in contribution to diet (Peng, 2007). Notwithstanding, efforts aimed at increasing rice production especially within the African continent is seriously affected by the militating effects of *Rice yellow mottle virus* (RYMV) (Abo *et al.*, 2005). RYMV belongs to the sobemovirus group, it is very stable and highly infectious to rice (Abo *et al.*, 2005), especially the Asian *Oryza sativa* (indica type) in the lowland and irrigated ecosystem. The disease is wide spread in almost all the West African states including Nigeria (Banwo *et al.*, 2004; Rossel *et al.*, 1982).

Typical symptoms of the disease include mottling and yellowing of leaves, delayed flowering with poorly exerted panicles and bearing sterile and discolored spikelets (Gnanamanickam, 2009). Severely infected plants may be stunted or become dead, whereas, profuse tiller and leaf formation, as well as delayed senescence are associated with the disease.

RYMV is transmitted by insect vectors and through mechanical contact (Abo *et al.*, 2000; Nwilene *et al.*, 2009; Sere *et al.*, 2008). Yield losses of 50-100% have been recorded on rice crops in farmer's fields in Africa and surrounding islands (Banwo *et al.*, 2004; Fomba, 1988; Abo *et al.*, 2002; Onasanya *et al.*, 2006). Analysis of yield and yield component is essential in cereals since the growing population is currently depending on the consumption of starch from these crops (Singh *et al.*, 2007a, b; Khan *et al.*, 2007). RYMV came to limelight in Nigeria with the introduction of exotic rice varieties from Southeast Asia coupled with intensification of cropping practices without dry season gaps (Thresh, 1991; Abo *et al.*, 2002). This situation as well as lack of extensive adaptive testing of the exotic rice varieties in their environments led to the disruption of the apparent equilibrium that had been established between host rice and RYMV (Awoderu, 1991; Fomba, 1988; Onasanya *et al.*, 2006).

Screening of *Oryza* germplasm in Nigeria has indicated the existence of potential sources of resistance to RYMV disease in the indigenous African *Oryza* species, as well as traditional African upland rice varieties (Abo *et al.*, 2005). Therefore, the objective of this study was to evaluate the resistant status of inter-specific and intra-specific rice genotypes in order to establish the impact of RYMV on the establishment, growth and yield component of the rice plants. And this will invariably help to identify rice varieties comparatively suitable for cultivation in areas where RYMV incidence is endemic and on a long term, to identify sources for breeding for durable resistance to the disease among elite varieties in Nigeria.

MATERIALS AND METHODS

Location of experiment: The experiment was conducted under an artificial environment in a screen house at the National Cereals Research Institute Badeggi, Niger state from August 2008 to March 2009.

Virus 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 screen house (Onasanya *et al.*, 2006). Three weeks after inoculation, leaves bearing typical yellow mottle symptoms were harvested and used for inoculating the rice varieties.

Rice varieties: Thirty-five rice varieties were used for the study (Table 1). The NERICA varieties were obtained from Africa Rice Center (AfricaRice), Cotonou, Republic of Benin. Bouake 189 and FARO 29 were used as Susceptible Checks (SCK) and Moroberekan and Gigante as Resistant Checks (RCK) (Onasanya *et al.*, 2006).

Experimental design, treatment and treatment allocation: The experiment was a factorial in a Complete Randomized Design (CRD). One level of Factor A (virus treatment) represent the control with zero doses. The 2 by 35 factorial with 70 treatment combinations was replicated thrice. Two hundred and ten plastic buckets each measuring 16 cm diameter and filled with 2.5 kg sterilized fadama soil were used. The pots were laid 0.5 m apart on the screen house tables (1 m above ground level). Three seeds each of every entry were sown directly in the plastic buckets and later thinned to one seedling per pot. Pots were constantly supplied with fresh tap water in the mornings and evenings until maturity. Then 2 g Nitrogen-Phosphorous-Potassium (NPK) fertilizer was applied to the plants at 28 days after sowing (DAS). This was followed by a split application of 2 g of urea at 45 DAS and at early flowering stage.

Table 1: List of variety used for the study

S. No.	Rice variety	S. No.	Rice variety
1	NERICA-L 4	19	NERICA-L 41
2	NERICA-L 6	20	NERICA-L 42
3	NERICA-L 7	21	NERICA-L 43
4	NERICA-L 8	22	NERICA-L 47
5	NERICA-L 10	23	NERICA-L 49
6	NERICA-L 14	24	FARO 8
7	NERICA-L 15	25	FARO 29 (SCK)
8	NERICA-L 17	26	FARO 44
9	NERICA-L 19	27	FARO 51
10	NERICA-L 21	28	FARO 52
11	NERICA-L 22	29	NCRO 26
12	NERICA-L 23	30	NCRO 36
13	NERICA-L 24	31	NCRO 48
14	NERICA-L 25	32	Gigante (RCK)
15	NERICA-L 26	33	Moroberekan (RCK)
16	NERICA-L 34	34	CG-14
17	NERICA-L 36	35	Bouake 189 (SCK)
18	NERICA-L 38		

RCK: Resistant check; SCK: Susceptible check

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 extract was finger-rubbed on the plant leaves at 40 DAS. 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 percent productive tillers, date to 50% flowering (days), number of panicles per plant, number of grains per panicle, 1000 grain weight per plant and percent spikelets fertility per plant 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 AND DISCUSSION

The study on RYMV infection and reproductive losses in rice was carried out under screen house condition. Percent productive tillers, date to 50% flowering and percent spikelets fertility per plant were between 43.2-96.7%, 57.67-112 day and 0-71.8%, respectively (Table 2). Besides, number of panicles per plant, number of grains per panicle and 1000 grain weight per plant were between 8.33-45.67, 0-77 and 0-27.57 g, respectively (Table 3). Due to RYMV infection, 13 NERICAs, two FAROs, 2 NCROs and Moroberekan produced significantly lower percentage productive tillers per plant at maturity in relation to their respective control entries (Table 2). It is

Table 2: The effect of virus infection on reproductive capacity and yield components of rice genotypes under screenhouse condition

	%Productive tiller/plant		Date to 50% flowering/plant (days)		% Spikelets fertility/plant	
Rice varieties	V_1	V_0	V_1	V_0	V_1	V_0
NERICA-L 4	81.830	90.50	75.670	69.00	4.070	85.20
NERICA-L 6	67.000	82.10	88.670	85.00	2.230	70.63
NERICA-L 7	87.500	63.87	89.670	90.00	5.070	54.30
NERICA-L 8	86.870	90.20	97.330	90.00	30.900	73.70
NERICA-L 10	43.970	66.90	93.670	75.67	1.000	64.77
NERICA-L 14	85.870	89.40	68.000	67.33	0.000	7.400
NERICA-L 15	87.870	96.10	68.000	68.00	1.100	57.97
NERICA-L 17	72.670	84.83	81.330	75.00	0.530	76.90
NERICA-L 19	70.900	96.10	76.670	75.33	0.000	79.77
NERICA-L 21	83.870	76.73	90.330	87.67	19.570	62.93
NERICA-L 22	64.970	74.67	90.330	97.00	3.170	70.40
NERICA-L 23	81.770	93.97	86.000	67.67	9.100	64.67
NERICA-L 24	80.470	84.17	78.670	76.67	0.000	76.67
NERICA-L 25	77.630	70.27	80.330	83.33	8.630	81.90
NERICA-L 26	56.630	62.30	94.330	90.67	1.330	68.20
NERICA-L 34	79.930	73.30	82.670	90.00	2.200	60.77
NERICA-L 36	81.100	97.13	76.000	75.33	0.000	75.53
NERICA-L 38	43.200	65.77	89.330	83.33	29.970	76.87
NERICA-L 41	82.800	84.73	79.670	82.33	17.530	60.70
NERICA-L 42	81.570	77.70	88.670	82.67	35.200	67.77
NERICA-L 43	74.130	70.47	77.670	74.67	13.670	77.77
NERICA-L 47	58.970	77.80	79.000	74.67	42.900	68.50
NERICA-L 49	58.870	79.63	81.670	76.67	36.500	78.30
FARO 8	72.770	76.83	89.670	85.67	18.870	66.90
FARO 29 (SCK)	66.030	61.43	103.000	97.67	15.270	75.93
FARO 44	87.770	63.53	92.000	87.67	8.130	69.87
FARO 51	59.100	73.13	90.330	85.33	0.000	72.33
FARO 52	66.300	75.27	95.330	86.33	0.000	63.23
NCRO 26	90.630	64.97	82.330	84.33	0.870	63.00
NCRO 36	65.600	84.47	97.670	72.00	0.800	70.73
NCRO 48	62.700	84.97	68.670	60.33	9.070	74.20
Gigante (RCK)	96.700	98.87	70.330	67.33	71.800	76.90
Moroberekan (RCK)	62.630	71.50	112.000	112.00	42.000	63.33
CG-14	95.800	88.20	57.670	54.33	63.200	82.47
Bouake 189 (SCK)	77.770	79.27	99.330	95.33	17.270	65.43
CV (%)	15.000		3.900		17.800	
SE	6.620		1.862		4.266	

RCK: Resistant check; SCK: Susceptible check; V_1: RYMV inoculated entries; V_0: Entries not inoculated (control); CV: Coefficient of variation; SE: Standard error of mean

evident that virus infection delayed date to 50% flowering (days) in 24 rice varieties against their un-inoculated control entries (Table 2). Besides five varieties (NERICA-L 22, NERICA-L 25, NERICA-L 34, NERICA-L 41 and NCRO 26) gave a significantly lower mean effect compared to their control entries, while six other varieties were not affected significantly by virus infection with respect to date to 50% flowering (days). The study also indicated that virus infection significantly affected all rice varieties causing a lower mean effect on percent spikelets fertility per plant (Table 2). NERICA-L 14 gave the lowest mean effect of 3.70% spikelets fertility per plant, which was found to be significantly lower than mean effects obtained from other rice varieties screened.

However, 48.6% of the rice varieties used in the study produced higher mean effect on the number of panicle per plant as compared with their un-inoculated control entries (Table 3). Seven rice varieties (NERICA-L 6, NERICA-L 17, NERICA-L 23, NERICA-L 38, NERICA-L 49, FARO 52

Table 3: Effect of virus infection on the production and grain quality of rice genotypes under screenhouse condition

	No. of panicle/plant		No. of grain/panicle		1000-grain weight/plant	
Rice varieties	V_1	V_0	V_1	V_0	V_1	V_0
NERICA-L 4	41.330	41.33	3.000	76.67	16.670	21.37
NERICA-L 6	22.330	30.33	3.670	81.67	9.000	21.47
NERICA-L 7	30.330	26.33	4.000	51.00	14.370	19.13
NERICA-L 8	39.670	33.67	18.670	71.67	17.000	17.20
NERICA-L 10	21.000	23.67	1.000	66.00	5.070	22.23
NERICA-L 14	35.670	36.67	0.000	6.00	0.000	16.87
NERICA-L 15	36.330	24.33	1.000	77.67	12.230	17.90
NERICA-L 17	30.000	38.33	0.330	75.67	11.230	19.77
NERICA-L 19	45.670	40.33	0.000	76.67	0.000	19.27
NERICA-L 21	37.330	31.00	15.330	66.33	16.900	17.93
NERICA-L 22	32.000	27.67	3.330	99.67	4.030	20.70
NERICA-L 23	37.670	41.33	10.330	72.00	15.200	20.20
NERICA-L 24	42.330	35.33	0.000	69.00	0.000	19.87
NERICA-L 25	30.670	26.00	7.670	107.00	15.770	17.77
NERICA-L 26	25.330	25.33	1.000	66.33	11.130	21.20
NERICA-L 34	33.670	35.67	1.330	50.00	10.830	21.17
NERICA-L 36	37.670	34.67	0.000	79.00	17.570	20.67
NERICA-L 38	19.330	25.00	37.330	97.00	18.770	19.93
NERICA-L 41	28.330	27.67	25.330	77.67	16.070	81.77
NERICA-L 42	30.000	28.33	77.000	112.67	13.370	81.87
NERICA-L 43	31.330	31.00	5.000	131.33	12.100	16.93
NERICA-L 47	29.670	32.67	22.670	73.67	14.000	21.23
NERICA-L 49	22.330	26.00	46.330	144.00	15.170	20.07
FARO 8	31.670	34.00	13.670	72.67	17.470	19.27
FARO 29 (SCK)	27.330	26.00	11.330	69.33	18.970	24.30
FARO 44	43.670	28.67	5.330	76.67	15.330	18.90
FARO 51	31.330	33.33	0.000	76.33	0.000	16.60
FARO 52	25.330	36.00	0.000	73.67	0.000	18.87
NCRO 26	45.670	29.00	0.670	71.33	10.800	22.03
NCRO 36	26.000	29.00	0.670	73.33	4.670	18.60
NCRO 48	19.000	15.00	5.330	87.33	5.470	19.73
Gigante (RCK)	29.000	29.00	73.000	88.67	19.030	21.80
Moroberekan (RCK)	8.330	10.00	45.400	55.30	27.570	21.40
CG-14	15.330	15.00	26.000	44.00	19.900	22.33
Bouake 189 (SCK)	31.000	35.67	11.000	65.67	16.330	19.27
CV (%)	18.700		14.600		22.900	
SE	3.274		3.824		2.127	

RCK: Resistant check; SCK: Susceptible check; V_1: RYMV inoculated entries; V_0: Entries not inoculated (control); CV: Coefficient of variation; SE: Standard error of mean and Bouake 189) produced significantly lower mean effects on the number of panicle per plant against their un-inoculated control entries (Table 3). The higher number of panicles per plant observed in eleven rice entries for inoculated plant did not translate to higher number of grains per panicle as all the virus infected rice plants gave significantly lower mean number of grains per panicle against their un-inoculated control entries (Table 3). Except for the resistant indica and japonica types (Gigante and Moroberekan), only NERICA-L 38, NERICA-L 41, NERICA-L 47 and NERICA-L 49 gave between 20-40 grain per panicle in relation to their controls (Table 3). It is evident also that the 1000-grain weight per plant was significantly lower for all virus-infected entries as compared to their un-inoculated control entries (Table 3). Yield losses of between 17-100% were obtained from all the rice varieties screened (Fig. 1). Gigante and Moroberekan have the least yield losses and followed by NERICA-L 42 which has performed better than other rice varieties in their RYMV resistance under screenhouse condition (Fig. 1).

Prolonged vegetative lag phase as well as anatomical and histological changes resulting from virus infection might possibly cause the delay in date to 50% flowering observed in this study (Gnanamanickam, 2009). Previous study have shown that spikelets sterility have been associated with virus diseases meaning that virus infection might interfere with the carbohydrate build-up necessary for the spikelets development, triggering the degeneration of pollens and drying-up of the stigma resulting in spikelets sterility (Gnanamanickam, 2009). This could possibly explain why in the present study virus infection significantly affected all rice varieties causing lower mean effect on percent spikelets fertility per plant.

Grain weight differences might be attributed to the virus causing reduction of starch deposited in the endosperm (Abo *et al.*, 2002). This is evident in the present study as the 1000 grain weight per plant was significantly lower for all virus-infected rice varieties as compared to their un-inoculated control varieties. Yield losses usually depend on many variables including virus strain or isolate and host cultivars (Onasanya *et al.*, 2004; Bailiss and Senananyake, 1984; Onasanya *et al.*, 2006). In the current study, yield losses of between 17-100% was obtained from all the rice varieties screened thus establishes the fact that the varietal yield losses was due to RYMV infection (Bailiss and Senananyke, 1984; Onasanya *et al.*, 2004; Onasanya *et al.*, 2006). The is consequently explain why the higher number of panicles per plant observed in inoculated rice varieties did not translate to higher number of grains per panicle as a results of the significant effect of the RYMV infections. The least yield losses obtained in this study for Gigante,

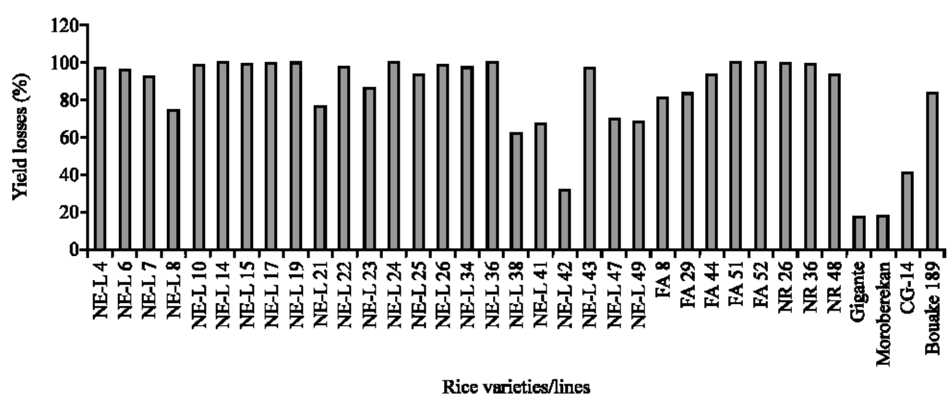

Fig. 1: The contribution of *Rice yellow mottle virus* (RYMV) to yield losses in 35 rice varieties under screenhouse condition

Moroberekan and NERICA-L 42 suggest their possible resistant characteristic to RYMV disease under screen house condition (Onasanya *et al.*, 2004; Onasanya *et al.*, 2006). However, similar results could be obtained under natural viral infestation under field condition (Heinrichs *et al.*, 1997; Rossel *et al.*, 1982).

CONCLUSION

The study on RYMV infection and reproductive losses in rice brings much hope about the availability of donor rice cultivars with durable resistance to RYMV in Nigeria. The three varieties such as Gigante, Moroberekan and NERICA-L 42 as revealed by this study are known to possess stable resistance characteristic to RYMV disease in Nigeria. And these identified RYMV resistant rice varieties will comparatively be suitable for cultivation in areas where RYMV incidence is endemic and on a long term be used by rice breeders as sources for breeding for durable resistance to the disease in Nigeria.

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