Occurrence of Rice Yellow Mottle Virus in Tanzania

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Abstract

Rice yellow mottle virus (RYMV) which was first recorded in Kenya in 1966, is now considered one of the most important diseases in tropical Africa. Surveys were conducted in rice growing areas in Tanzania to determine the incidence, severity and distribution of RYMV in the country. The virus was found in all rice growing areas surveyed. The incidence and severity of RYMV varied depending on the cultivar grown. In another study, one hundred and twenty varieties and introduced rice material were screened for resistance to RYMV. Thirty eight cultivars showed resistance to the disease in the field and of these, only sixteen cultivars were highly resistant to RYMV. Reduction in grain yield in susceptible varieties ranged from 25 to 100%. Some rice test plants which were not inoculated with the virus showed symptoms of RYMV while other symptomatic plants recorded no yield. High yielding and phenotypically acceptable cutivars, such as IR 53234-27-1, CT6948-7-4-2, CABACU and IR 47686-15-5-1 can be used as short-term replacement of the existing susceptible varieties in areas severely affected by RYMV.

Keywords: Disease, *Oryza sativa*, rice yellow mottle virus, yield loss.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops in Tanzania and is consumed by about 60% of the population (IRRI, 1994). Tanzania ranks the second, after Madagascar, as a major rice producer in Eastern, Central and Southern Africa (IRRI, 1994). The crop is grown in all regions of the country with varying levels of importance.

Several bacterial, fungal and viral pathogens are known to cause diseases in rice. About 70 major and minor diseases of rice have been reported in Asia and Africa (Ou, 1985). Virus diseases of rice have become increasingly important in the tropics since the 1960s after rice cultivation was intensified. There are about 14 rice virus diseases known in the world (Ou, 1985). Among the ten rice virus diseases which occur in the tropics; tungro; grassy stunt and ragged stunt are the major viruses in South and South-east Asia; hoja blanca virus in Latin America and rice yellow mottle virus in Africa.

Rice yellow mottle virus (RYMV) was first reported in 1966 at Otonglo near lake Victoria in Kenya (Bakker, 1970, 1971, 1974). Since then, the disease has been subsequently reported in various African countries, including Sierra Leone (Raymundo and Buddenhagen, 1976); Cote d'Ivoire (Fauquet and Thouvenel, 1977); Nigeria (Rossel *et al.*, 1982); Niger, Burkina Faso and Mali (John *et al.*, 1984); Zanzibar, Tanzania (Ali and Abubakar, 1995). In Tanzania, the first incidence of RYMV was reported at Mkindo irrigation scheme near Morogoro in 1993 (Kanyeka, *et al.*, 1996). The increasing importance of RYMV in East and West Africa has been attributed to the cultivation of highly susceptible ex-

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otic rice varieties from Asia and the availability of irrigation water which allows for sequential planting and maintenance of high crop intensity even during the dry season (IITA, 1981; Rossel *et al.*, 1982).

Symptoms of RYMV susceptible rice cultivars include yellowing and mottling of leaves,. Severely infested plants may wilt and dry or may not flower at all. Other symptoms include stunting, reduced tillering, and panicles malformation. The disease is systemic and is widely spread in rainfed lowlands and irrigated rice growing environments (Feakin, 1976). The severity of the disease depends upon the variety and the age of plant at the time of infection. If the infection occurs in the early stages of plant growth, fewer tillers are produced than when infection occur in the late stages of plant growth.

The virus is environmentally stable and is transmitted mechanically within the rice plants (Bakker, 1970; Fauquet and Thouvenel, 1977) and by chrysomelid beetles (Bakker 1971, 1974). *Dicladispa gestni* Chap., has been identified as the main vector of RYMV in Madagascar (Reckhaus and Andriamasintseheno, 1995) and in Zanzibar (Ali and Abubakar, 1995). The long-horned grasshopper (*Conocephalus merumontanus* Sjostedt) and mites from the families Eriophydidae and Tarsonemidae have been indicated as possible vectors of RYMV in Kenya (Bakker, 1974). Recent studies by Reckhaus and Andriamasintsehano (1997) indicated that *Oxyla* sp., a grasshopper commonly found in rice fields was capable of transmitting the RYMV. The virus has also been demonstrated to be transmitted through guttation fluid., irrigation water and farm implements such as sickles which are used in trimming shoots of rice seedlings during transplanting and harvesting (Tsuboi *et al.*, 1995). Soil of previous infested fields containing wide composed infected plant material is also infectious (Reckhaus and Adamou, 1989). The location of RYMV in the rice seed is known to be in the husk (seed coat) and no transmission of RYMV in the rice seed has been demonstrated, possibly due to inability of the virus to remain in the embryo (Abo *et al.*, 1998).

Indigenous African *Oryza* species such as *O. glabberrina* Steud: *O. longstaminata* Chev et Rodir and *O. barthii* Chev *et al* as well as traditional upland rice varieties such as OS 6, are highly immune, tolerant, or resistant. Fomba (1986) reported yield losses of 19.6% in cultivar Angkatta and 95-98% in ROK 5 at Rokupr. Sierra Leone. Reckhaus and Adamou (1986) reported yield losses ranging from 58-68% in Niger Republic. Taylor (1989) reported losses of 54% in LAC 23 and 84-97% in RN 623 in Sierra Leone. A study of yield losses from inoculated and naturally infected rice plants demonstrated losses of 84%, 67, and 4% in cultivars/lines Bouake 189, BG 90-2 and Moroberekan, respectively. (Sy *et al.*, 1993).

It is therefore imperative that awareness about this devastating disease is created and stern control measures taken to avoid further spread of the virus. This study was undertaken to determine the incidence, severity and distribution of the RYMV in Tanzania. It also aimed at screening and identifying resistant genotypes from rice germplasm currently available in the National Agricultural research system. Identified resistant genotypes could be used as new varieties or serve as donors of resistance genes to RYMV in breeding programmes.

Materials and Methods

Diagnostic surveys

RYMV diagnostic surveys were done in April and May, 1998 in farmers fields in Kyela district, Mbeya region. Turiani Division, Dakawa, Kilombero and in Kilosa District in Morogoro region. During the survey, farmers were interviewed about the presence of RYMV, when the disease was first observed, time of disease occurrence, its effect on yield and susceptibility of varieties grown. A check list was used to elicit farmers opinions. Interviews were also conducted with extension workers and researchers. In addition, RYMV diseased plants were identified based on symptomatology. Samples of such plants were collected and presence of RYMV was confirmed in the screenhouse. In order to confirm symptomatology, diseased samples collected were macerated individually, in a sterile blender containing sterile 0.1 M phosphate buffer (pH 7.4). The resulting inoculum suspensions were used to inoculate healthy plants by cutting rice leaves using a pair of scissors dipped in the suspensions. Sterile phosphate buffer (0.1M, pH 7.4) and a known RYMV isolate (Kyela-strain) were included as negative and positive controls, respectively. Each experiment was replicated three times and repeated twice.

Screening for resistance to RYMV

One hundred and twenty five rice varieties consisting of local, exotic and improved cultivars were screened for resistance or susceptibility to RYMV under upland conditions in the crop museum at Sokoine University of Agriculture (SUA). Each variety was planted in 5m rows, seeds were dibbled at a spacing of 20 cm between rows and between plants. The seedlings were thinned four weeks after planting, leaving one seedling per hill. Nitrogen fertilizer was applied at the rate of 100 kg N/ha split twice and phosphorus at 50 kg P_2O_5 per ha.

Inoculation

Leaves from naturally infected plants collected from Kyela, Mbeya region were blended in a sterile 0.1M phosphate buffer (pH 7.4), the resulting suspensions were used to inoculate healthy plants. Test plants were inoculated by dipping a pair of scissors into the suspensions followed by cutting leaves of ten rice plants in each row using viral contaminated scissors. For each line, ten plants served as a control and were cut using scissors dipped in sterile phosphate buffer. A known RYMV isolate (Kyela strain) was used as a positive control. Inoculated plants were observed for RYMV symptom development for up to 21 days. Rice plants were scored three times for RYMV at 7 days interval. Inoculated plants were left until maturity to assess other parameters such as reduction in plant height, days to 50% flowering and grain yield as compared to uninoculated control plants.

Screenhouse experiment

Lines and cultivars which were found to be resistant in the field were planted in the screenhouse to confirm their resistance to RYMV. Four seedlings of each variety were planted in one 4-litre pot. The potted rice plants were inoculated with suspensions at 35 days after seeding using the same procedure described above. Inoculated plants were incubated in the screenhouse at a temperature ranging from 24-30°C and observed for development. Rice plants were scored three times for RYMV symptoms at 7 days interval using a scale of 1-9 where 1 = Resistant and 9 = highly susceptible (IRRI, 1985). Inoculated plants were left until maturity to assess reduction in plant height, days to 50% flowering and grain yield as compared to uninoculated control plants.

Data analysis

Data were subjected to the t-test using MSTAT-C (Michigan State Univ., 1990) in order to compare the reaction of inoculated and uninoculated control plants.

Results

Diagnostic surveys

Results of the RYMV diagnostic surveys conducted during April and May, 1998 indicated that all areas visited including Kyela District in Mbeya, Morogoro and Kilombero districts in Morogoro region had high incidence and severity of RYMV. Findings from discussions with farmers during the diagnostic surveys indicate that the disease has been on the increase in farmers' fields since 1994. In Kyela district, farmers reported that about 450 ha of rice were affected in 1994 while more than 950 ha were affected in 1997; yield reduction ranged from 40 to 100%.

In the various fields visited, especially in Kyela and Kilombero districts, the predominant insects found were species of grasshoppers. Farmers and extension workers who were interviewed correlated the presence of such grasshoppers and RYMV disease. They indicated that in the years when there were many grasshoppers in rice fields, there were also high incidences of RYMV disease. The surveys in Kilosa district revealed that there was no serious outbreak of RYMV disease in 1998 cropping season. Neither the disease nor vectors of the virus were observed in the areas which were previously known to be affected. The farming system research (FSR) scientist at Ilonga Agricultural Institute also correlated the presence of grasshoppers in the field with the occurrence of RYMV disease. Farmers in the surveyed areas claimed that the incidence of the RYMV disease increased after hand weeding or rogueing of the diseased plants had occurred. All the varieties currently grown by the farmers such as Zambia, Kilombero, Faya, Supa and Shingo ya Mwali were susceptible to the disease.

Screening for resistance to RYMV

Field experiment

The reaction of rice varieties/lines screened is shown in Table 1. In susceptible rice varieties/lines, a significant reduction ($P \leq 0.05$) in plant height and grain yield was observed. The average RYMV disease severity rating ranged from 7 to 9. The highest reduction in plant height was observed in IR 32, mutant No. 9 and Nylon, while the least reduction in plant height was observed in Kibibi (Table 1). The reduction in grain yield ranged from 25 to 100%; however, in IR8, mutant No. 13 and IR54 no yield was recorded.

Grain losses of 100% were recorded for inoculated and uninoculated plants in varieties Mbawa Mbili, IR32, IR 6023-10-1-1 and Nylon; significant differences in plant height and grain yield between inoculated and uninoculated rice plants were observed ($t = 6.19$ at $= 0.05$).

The varieties which were resistant to RYMV disease are shown in Table 2. of 125 rice varieties tested, 30% were resistant to the disease. Varieties IR 55739-2-3-1, IRAT 156, FARO 11, WABIS 18, CT6948-1-1-P, FARO 300, TGR 78, ITA 305 and Mafunira yielded more than 12g of grain per plant (Table 2). In varieties CT6947-7-1-4-2, FARO 29 and IR 47686-15-5-1 plant height was not affected by RYMV disease. Varieties LAC 23, BG 380-2 and Supa were the latest to flower among all the varieties tested. There was no significant correlation between plant height, and grain yield and between grain yield and day to 50% flowering. Significant correlation was however, observed between plant height and days to 50% flowering ($r=0.67$).

Table 1. Varieties which showed significant reduction in plant height and grain yield (average disease score 7 & 9).

Variety	Source	Perecent Reduction in	
		Plant height	Grain yield
Kibibi	Local	19.1	62.4
Faya mzinga	Local	11.4	53.9
Mbawa mbili	Local	9.2	100
Faya mafuta	Local	15.5	36.2
Rufiji	Local	9.4	94.7
Katrin	Local	20.8	85.0
Mwarabu	Local	22.7	90.9
Kaling'anaula	Local	9.7	25.6
Rangimbili	Local	6.2	63.4
Mwanza	Local	10.8	82.2
Mutant No.9	Local (Improved)	32.1	35.6
Mutant No.13	Local (Improved)	9.8	No yield
Kivuli	Local	12.6	84.4
Nylon	Local	32.9	100.0
Kioo	Local	10.7	92.0
Supa (Susceptible check)	Local	9.6	89.3
IR 54	IRR	25.2	No yield
IR53722 - B-3-6-2	IRR	6.8	73.1
Chianung sen Yu	China	13.1	81.5
ML 214	Zanzibar	9.1	83.2
Subarmanti	India	13.6	64.6
IR8	IRR	15.5	No yield
IRI 13429 - 2 -1-3	IRR	25.5	58.3
IR 32	IRR	39.9	100.0
ITA 173	IITA	21.1	38.3
IR 6023 - 10 - 1 - 1	IRRI	23.2	100.0
BKN 3036 A	Zanzibar	24.0	64.0
Colombia	Zanzibar	8.0	87.2
IR 56	IRRI	9.1	84.2

Table 2. Varieties which showed resistance to RYMV in the field and their average score in the screenhouse.

Variety	Source	Plant Height (cm)	Days to 50% Flowering	Grain Yied/ plant (g)	Score²
Dakawa 83	Local (Impoved)	109.8	84	4.9	5
Afaa Kikangaga	Local	125.4	92	15.5	5
Jaribu 220	Local (Improved)	107.0	93	10.2	7
TXD 276-4-5-11	Local (Improved)	109.8	84	1.1	np
Limota	Local	137	93	1.2	np
Kula na Bwana	Local	129	89	4.3	5
Usiniguse	Local	128.8	88	5.6	5
Afaa Mwanza 1/59	Local	123.0	93	10.0	7
IR 53234-27-1	IRRI	112.2	73	7.4	1
IR 55740-B-5-4-2-2-1	IRRI	84.6	81	10.8	3
IR 55739-9-3-3-1	IRRI	88.6	78	12.5	5
IR 6771 - 8 - 14- 1- 2 - 1	IRRI	92.2	82	11.5	3
IR 53466-B - 12 - 1-B-B-17	IRRI	96.4	78	7.2	np
CT 6515-18-1-3-1-2	CIAT	107.2	77	10.9	3
Pishori	Local	128.2	85	6.7	9
Colombia 25592	Zanzibar	107.6	93	3.8	5
BG 380-2	Sri Lanka	108	97	7.2	5
Koshinikari	Bagamoyo	56.2	51	2.3	np
Mangutsumochi	Bagamoyo	51.4	51	1.9	np
CT 6947-7-1-4-2	CIAT	137.6	94	2.9	1
IRAT 161	IRAT	116	91	3.5	1
FARO 29	Nigeria	126.4	88	10.5	1
IR 47686-15-5-1 (Resistant check)	IRRI	133.6	86	9.1	1
IRAT 156	IRAT	110.8	80	16.2	1
FARO II	Nigeria	137.6	83	12.4	1
WABIS 18	WARDA	141.0	89	14.1	1
CT 6948-1-2-1-P	CIAT	126.0	84	13.4	1
IRAT 133	IRAT	117	75	15.3	1
FARO 300	Nigeria	145.0	82	15.1	1
TGR 78	Togo	122.6	79	13.9	1
ITA 305	IITA	118.8	84	17.1	1
LAC 23	IITA	123.4	106	6.1	np
CABACU	Zanzibar	132.2	93	10.9	1
Mafunira	Mozambaque	117.2	79	16.0	1
IRAT 302	IRAT	117.2	93	11.0	1
WABIS 844	WARDA	130.4	91	11.5	1
BG 1165	Sri Lank	89.8	77	10.8	5
Supa (Susceptible check)	Local	116	98	Nil	7

np=not planted, 1=resistant, 9= Very susceptible

Screenhouse experiment

The results from screenhouse experiments revealed that varieties Jaribu 220, Afaa Mwanza and Pishori were very susceptible to RYMV while Dakawa 83, Afaa Kikangaga, Kula na Bwana, Usiniguse, Colombia 25592, BG 380-2 and BG 1165 were moderately susceptible (Table 2). On the other hand, IR 55740-B-5-4-2-1, IR 6771-8-14-1 and CT 6515-18-1-3-1-2 were moderately resistant. Sixteen varieties were rated as highly resistant (score = 1). These included those from West Africa (13 varieties), two from IRRI (IR 53234-27-1 and IR 47686-15-5-1) and one from Zanzibar (Cabacu) (Table 2).

Discussion

The frequency of RYMV disease in rice growing areas of Tanzania is causing great concern to rice producers and researchers. RYMV was reported in Tanzania mainland in 1993 but farmers insist that it existed since the late 1980s. In 1995, the Kilimanjaro Agricultural Training Centre (KATC) conducted a survey across the country and reported that RYMV is widely distributed in all rice growing regions in Tanzania (Yamamoto, *et al.*, 1997). Results from the current study support the previous findings. In Kyela plains, the disease is considered as the most important disease (Mwalyego, F. Pers. Comm.). In 1998 cropping season, some farmers could not harvest any crop while others had abandoned their fields altogether.

The current field surveys revealed that the severity of RYMV varies greatly from year to year. In 1998 growing season, for example, the damage due to the disease in Kilosa district was minimal while in the previous year the damage was more severe (Chilagane, A. Per. Comm.). Such findings may be due to variation in vector population and changes in environmental conditions that favour disease development and vector multiplication.

Yields losses estimated using susceptible varieties in this study ranged from 25% to 100%. This is an alarming situation taking into consideration that some of the susceptible local varieties are popular such as Supa, Rangi Mbili and Katrin. The variety IR54 which is grown in some irrigation schemes in Tanzania showed high levels of yield losses ranging from 70 to 100%. Varieties LAC 23, IRAT 161, IR 47686-15-5-5-1, IRAT 156, WABIS 18, FARO 300 and ITA 305 which were resistant to RYMV in this study, were also reported to be resistant by WARDA (WARDA 1992, 1994) The varieties, IRAT 161, IRAT 156 and ITA 305 were also reported to be resistant by Awodern (1991). Such findings confirm that these rice varieties can be used in breeding programmes

as sources of resistance to RYMV. Some varieties did not produce any yield for both inoculated and uninoculated rice plants, indicating that the virus might have been transmitted by insect vectors or mechanically to uninoculated rice plants. There were differences in reaction of some cultivars between field and screenhouse experiments. Such observed differences may be due to differences in the environmental conditions. That is why it is important to conduct screening trials both in the field and screen house.

Work conducted at KATRIN Agricultural Research Institute, Ifakara indicated that LAC 23, FARO 11, ITA 235, IRAT 133, ITA 156 and Moroberekan were resistant to RYMV (Kanyeka, *et al.*, 1996). However, in the current study Moroberekan was found to be susceptible under Morogoro conditions. High yielding and phenotypically acceptable cutivars, such as IR 53234-27-1, CT6948-7-4-2, CABACU and IR 47686-15-5-1 can be used as short-term replacement of the existing susceptible varieties in areas severely affected by RYMV.

Management of RYMV requires an integrated approach that will involve the use of resistant varieties and various cultural control methods. Early planting to escape high levels of vector population, destruction of stubbles, removal of alternate hosts by slashing and proper weeding of bunds are methods that can be used to manage RYMV. The use of chemicals to reduce vector populations during the growing season is limited by high cost, which is unaffordable for rice producers.

Conclusion

Results of this study indicate that RYMV is important disease in Tanzania and it has spread to many rice growing areas in the country. A number of local and introduced rice varieties were found to be resistant to RYMV under Morogoro conditions. Such varieties will be useful to the breeding programmes and may replace the prevailing susceptible varieties grown in the country, especially in areas where RYMV is a serious constraint to rice production. An integrated approach is needed in order to effectively manage RYMV disease.

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