New Findings on Epidemiology and Management of Rice Yellow Mottle Virus Disease in the Southern Highlands of Tanzania

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Abstract: *Three studies were conducted at Kyela district with the objective of adding knowledge on epidemiology and management of rice yellow mottle virus disease. The contribution of different weed management practices on disease transmission and effectiveness of Alvirus (C14H21O_3N_2), a botanical pesticide in disease control were each evaluated in a randomized complete block experimental design with three replications under two lowland and one upland rice cultures. Twenty elite rice genotypes were also evaluated for resistance to the virus and farmer acceptance in the same sites and on station at Kikusya upland ecology. The results indicated that the first hand weeding in seed broadcasted plots (farmer practice) led to 90% increase in disease incidence compared to 6% and 2% with hand hoe weeding in row planting and use of herbicides (Rilo 250EC 1.5l/ha and 2-4Damine 4l/ha) respectively. Use of the latter resulted in 70 – 90% reduction of disease incidence and yield increase of 1.3 to 1.8t/ha or monetary gain of Tsh 614,000/= per hectare on average. Alongside capacity building, these practices were recommended to primary stakeholders. Alvirus achieved 100% disease control when used to soak seed 24 hours prior to planting followed by spraying 14 and 21 days after emergence or where only spraying was used. This new finding was useful for research purposes but warranted further studies to enhance applicability. Existence of differences in pathogen strains was evident between the locations where the genotypes were planted but nine appeared resistant across locations out of which 5 were new, highly acceptable and required promotion to farmers.*

Key words: Rymv, management, Tanzania, alvirus, Kikusya, upland rice, lowland rice

INTRODUCTION

Rice yellow mottle caused by a sobemovirus is a fairly recent but most devastating and fast spreading disease of rice in Sub Saharan Africa (Abo *et al.,* 1998; Banwo *et al.,* 2004). It was first discovered in Kenya in 1970 but up to mid 1990s it was reported from all the major rice producing countries in Africa including Tanzania (Bakker, 1970; Raymundo *et al.,* 1976; Luzi – Kihupi *et al*., 2000; Mabagala *et al*., 2001). Perennial wild rice species have been cited as primary hosts of the virus and other plants restricted to the Graminea and Eragrostidae families (Bakker, 1974). About 12 insect species primarily chrysomelid beetles and grasshoppers are known so far to be vectors of the disease in Africa (Bakker, 1971; Abo *et al*., 2000; Mwilene *et al*., 2009).

Transmission is also through any mechanical injury to the plant in the presence of virus particles such as during transplanting, weeding operations, wind mediated leaf contacts and cattle damage (Abo *et al*., 2000). Characteristic symptoms are mottling or yellow orange discoloration of leaves, stunting and panicle sterility (Bakker, 1974). Its major economic impact is on lowland rain fed and irrigated rice cultures but upland cultures have of recent years suffered damage too (Awoderu *et al*., 1987). These ecologies respectively cover about 72%, 8% and 20% of rice produced in Tanzania mostly by small holder farmers for food and cash income (Banwo, 2003). About 1,334,000 metric tons of paddy are produced from a total of 904,508 hectares (Ministry of Agriculture, 2008). Over 30% of the premium crop is produced in the southern highlands of Tanzania (SHT) covering Iringa, Njombe, Mbeya, Ruvuma, and Rukwa regions where most severe epidemics and virulent strains of the virus have been reported (Mabagala *et al*., 2001; Luzi – Kihupi *et al*., 2000; Mwalyego *et al*., 2003). The average yield from this regions is low and varies from 1 to 2t/ha instead of the achievable 4t/ha (ECARRN, 2006). Consequently the volume produced is insufficient to meet demand of the fast growing population, 60% of which depend on rice for livelihood (ECARRN, 2006).

Varied factors in drought; weeds, insect pests, low soil fertility contribute to low productivity (ECARRN, 2006), but a reduction in yield from 10 – 100% can occur as a result of RYMV infection (Reckaus, 1986; Mabagala *et al*., 2000; Mwalyego *et al*., 2003). The loss from RYMV in the SHT can be estimated at between $ 5m and 57m annually. Ever since epiphytotics of the disease erupted international and regional collaborative research efforts have dramatically increased what is known about the virus at structural and molecular levels (Pinel *at al*., 2000). Generated information so far on host genetic resistance which is a control strategy affordable by resource poor farmers have shown that there is virtually no source of sound resistance to RYMV in the agronomically desirable rice varieties intensively grown in Africa (Awoderu *et al*., 1987; Fomba, 1988).

Nevertheless, use of single control measure cannot be effective for this virus which shows variability and a number of transmission mechanisms. A combination of different control methods in an integrated approach is advisable so as to exploit synergistic interactions. To date, there are still a lot of quantitative and qualitative knowledge gaps existing in our understanding of the epidemiological processes essential for devising appropriate management interventions. Surveys carried out in the SHT (Ndunguru *et al*., 2012) revealed that certain cultural practices such as time of planting, weed management, field sanitations, seedling and crop management influence disease occurrence and spread. The objectives of these studies were to evaluate the effects of different weed management practices on disease epidemiology together with varietal and chemical components which may be used directly by farmers or breeders in the management of RYMV.

MATERIALS AND METHODS

Weed Management

Five weed management practices comprising of hand weeding, pre and post emergence herbicides (Rilo 250EC. 1.5.2l/ha, 2-4Damine 4.0l/ha) singly combined and hand hoe in row planting at 20 x 20cm were evaluated using a randomized complete block design (RCBD). The experimental trial was replicated twice under two lowland and one upland rice ecologies in Kyela district during 2014/2015 growing seasons. Glyphosate 360EC at rate of 4l/ha was applied in the entire field 4 weeks prior to ploughing to control perennial reservoirs of RYMV. Rice varieties Saro5 in lowland, Zambia and URO1 in upland rice cultures were used. Fertilizers were applied according to blanket recommendation of 20kg P_2O_5 and 40kg N/ha. Plot size measured 4 x5m^2 and a uniform seed rate of 40kg/ha, 20kg/ha were used in broadcasted and row planting respectively. Hand weeding was supplemented in herbicide applied plots as necessary. Incidences and severity of RYMV were recorded two weeks after emergence, three weeks after hand weeding and thereafter at two week intervals to end of grain fill. Incidence was measured by counting number of infected plants/plot while severity of RYMV and other diseases was rated on 1 – 9 scale (IRRI, 1996) where 1 – 3 denoted very mild infection or resistance, 4 - 6 moderate and 7 – 9 quite severe infections accompanied by plant death. Cost of inputs, all field operations, yield and components were also recorded. Treatment effects were analyzed using GENSTATI3 statistical package.

Efficacy of 'Alvirus'

The chemical product was evaluated in a RCBD with three replications on station at Kikusya, Kyela district during 2014 growing seasons. Zambia, a local rice variety susceptible to RYMV was used for testing. Five treatments were evaluated where 1. Chemical used to soak seeds overnight at rate of 1ml/200ml water/250g. 2. Seed soaking was used as in No 1 followed by spraying 5ml/l water at 21 and 30 days after emergence (recommended practice). 3. No seed soaking but chemical applied as above. 4. No chemical applied. 5. Control (Water applied). Except for the last treatment, all others were inoculated with the virus sap from surrounding fields 5 to 6 days before chemical spraying or visual symptom development. Incidence and severity of RYMV and data analysis were evaluated as above.

Host Resistance

Germplasm for testing was obtained from Sokoine University of Agriculture (SUA) and Uyole Agricultural Research Institute gene banks. The resistance of 20 most promising genotypes including resistant and local susceptible checks was verified on farm with farmers at two lowland and one upland rice ecologies. Six rows each 3m length at spacing of 20 x 20cm per entry were planted by direct seeding, 3 seeds/hole. Triple super phosphate (TSP) and Calcium ammonium nitrate (CAN) were broadcasted at rates of 20kg P205 and 60kg N/ha respectively in planting furrows followed by top dressing with urea at 60kg N/ha. Three rows of each entry were inoculated by farmers with virus strain from surrounding area a month after germination leaving other set of rows as un-inoculated controls. Inoculums' was prepared by crushing 200g disease infected leaves per litre of water and suspension inoculated by firmly touching and squeezing the seedlings from base of leaves to the top with hands soaked in the inoculums. Disease incidence and severity were rated as previously narrated at 21, 45, and 60 days post inoculation. Farmers rated the entries at flowering and grain maturity for RYMV as resistant, moderately resistant or highly susceptible. Height and desired agronomic traits were rated as highly acceptable, average and unacceptable.

RESULTS AND DISCUSSION

At all locations, use of herbicides significantly controlled weeds and reduced incidences of RYMV (Table 1). Combined use of pre and post emergence herbicides Rilo and 2-4Damine respectively achieved the highest weed control and recorded the lowest incidences of RYMV. No hand weeding was supplemented before grain fill in this treatment, hence reduced chances of mechanical transmission. Weed dry matter was highest where row planting was used as spacings left between rows and plants favoured vigorous weed growth, supporting the findings of Johnson (1996). The highest RYMV incidence and severity occurred where only hand weeding was practiced undoubtedly due to mechanical transmission enhancement through close contact between plants under broadcasted seed plantings used by most farmers.

Table 1: Effect of five management practices on mean weed control RYMV and yield across three locations

	Treatment	Weed densities plants/m²			Weed dry wt (g)	RYMV incidence infected plants/plot)	RYMV severity (1-9)	Yield kg/ha
		Grasses	Broad leaves	Sedges				

1.	Hand weeding	18.8a	69.8a	60.4a	452.3ab	47.7 a	9a	1844 a
2.	Pre emergency herbicide (Rilo)	1.1b	17.8b	5.1b	392.3ab	8.7 b	9a	3028 bc
3.	Pre-Post mergence (Rilo +2=4Damine)	1.3b	3.8c	4.0b	255.3ba	4.4 b	8a	3344 c
4.	Post emergence herbicide 2-4Damine	41.5c	18.6b	45.1c	266ba	12.9b	8a	3200 b
Hand hoe in row planting		49.5c	92.4d	72.8d	891.3a	14.4b	7b	3689d
Mean		22.6	40.6	37.6	451.4	17.6	8.2	3021
CV %		112.5	46.1	40.7	47.8	57.9	4.9	5.4
LSD		11.84	12.0	13.73	618	20.39	1.1	293.7

Disease incidence was highest in this treatment after the first weeding which increased by 90% compared to a mean of 2% and 6% with herbicides and hand hoe weeding respectively (Figure 1). This finding confirms farmer's observations that their fields were turned yellow due to rapid and severe infection two to three weeks after weeding (Ndunguru *et al.*, 2012). In the latter treatments the number of infected plants showed slow increase throughout the season attributed to insect vector and limited mechanical transmissions between plants. Overall yields were significantly higher with hand hoe weeding in row seed drills but lowest in the hand weeded or control treatment attributed to optimum plant populations, reduced RYMV incidences and weed competitions.

The results indicate that adoption of row planting and use of pre and post emergence herbicides to ease weeding can reduce incidences of RYMV in fields by about 70% to 92% resulting into average yield increase of 1.3 to 1.8t/ha equivalent to net monetary gain of Tsh. 614,733 per hectare. Means followed by same letters in a column are not significantly different.

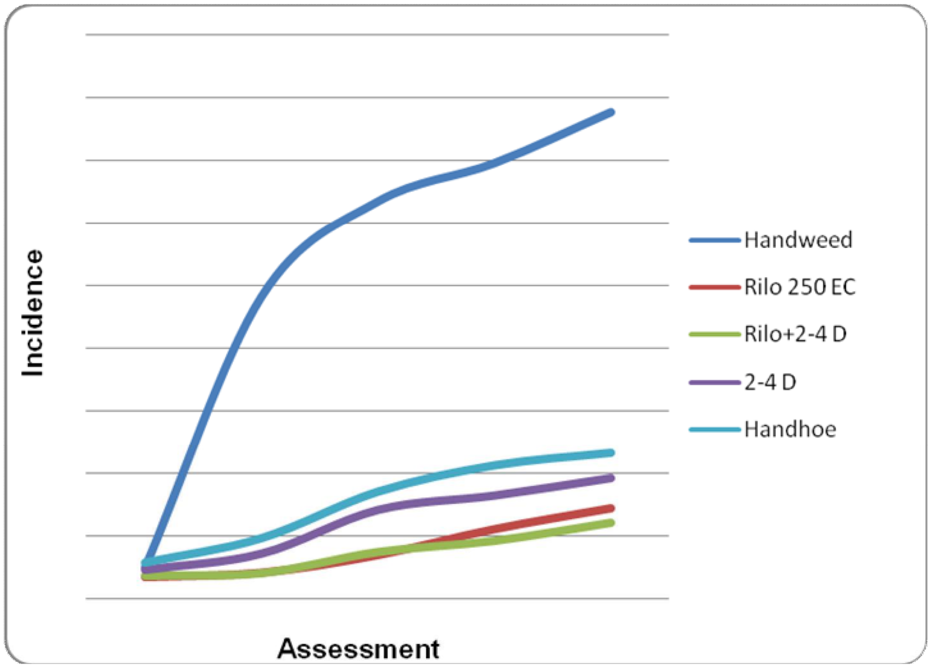

Figure 1: Progress of RYMV disease in weed management treatments across three locations in Kyela district

CHEMICAL CONTROL

Highly significant differences in RYMV disease incidence, severity and yield were observed between the treatments (Table 2). Highest incidences, severity and lowest yields were recorded in the control where no chemical was applied. The chemical product was not very effective when it was used only as seed soak since the results did not differ significantly with the control. On the other hand it was quite effective when it was used as a preventive spray before symptoms of disease were observed or when it was used to soak seed followed by spraying as recommended by manufacturers. No disease incidence was noted where the chemical product was applied as recommended whereas plots inoculated with RYMV in absence of chemical spray were almost wiped out. Yield was highest where the disease was significantly controlled as a result of increased number of effective panicles and kernel weight. The number of plants infected under natural field inoculums was quite low, as such inoculation of plants before chemical spray assured effective control. Possibly the chemical inhibits entry of the virus into the plant or boosts immunity system of rice plants to overcome the virus. The results suggest that the chemical can be used for RYMV disease control for research purposes. However, further research is necessary before appropriate recommendations can be made.

Table 2: Effect of Al Virus on RYMV disease control and yield of Kilombero rice variety

S/N	Chemical Treatment	RYMV incidence (%)	RYMV Security 1-9	Plant Heigh t (cm)	Tillers /plant	Panicles /plant	Yield kg/ha	1000 kemel wt (gm)
1.	Seed soak	80 a	8 a	110 a	9 a	6 a	310 a	26 a
2.	Seed soak + spray	0.1 b	1 b	117 b	10 a	9 b	2050 b	29 b
3.	Spray only	0.1 b	1 b	116 b	10 a	9 b	2000 b	28.6 b
4.	Water spray (Control)	100 a	9 a	105 a	8 a	2 c	101 a	25.5 a

5.	No chemical, natural infection	11[b]	9 [a]	116 [b]	8 [a]	6 [a]	1410 [c]	28.2 [b]
Mean		38.6	5.6	112.8	9	6.4	1418.2	27.4
CV %		41.8	31.4	13.3	15.1	28.3	27.8	3.9
LSD (5%)		36.9	1.67	9.3	2.11	2.72	221.3	0.87

Figures followed by same letters in a column are not significantly different

Host resistance
Most of the genotypes showed differential reactions to the isolates, showing susceptibility in some locations but resistant reactions in others implying existence of different virus strains in different locations (Table 3). About 9 entries scored resistant to highly resistant scores (1 – 3) across the four locations while only 4 were susceptible across locations. Strains at Lugombo and Mpunguti lowland areas appeared to be more virulent compared to Kisale and Kikusya upland strains. Even Kalalu, a resistant check from previous years succumbed to infection by the Lugombo strain. Gigante, which is claimed to possess the recessive *Rymv 1 – 2 gene* conferring high resistance to the virus reported to be resistant to the virus in West African countries was quite susceptible to the strains at all locations observed also in Uganda (Ochola *et al.*, 2011).

Most of the resistant genotypes had other agronomic traits that were acceptable to farmers but Salama varieties M55, 19, M57, M35, Mwangaza, IITA 235 were highly acceptable and in high demand at all locations. Promotion of these varieties is recommended while the resistant but unacceptable genotypes such as Moroberekan, Lunyuki, Faro II, IRAT 252 can be used in breeding to improve the very susceptible local checks.

Table 3: Performance of 20 rice genotypes inoculated with RYMV strains from 4 locations in Kyela district

SEVERITY OF RYMV (1 – 9)							
	Rice genotype	**Mpunguti**	**Kisale**	**Lugo mbo**	**Kikusya**	**Mean scores Category**	**Farmer acceptance***
1	Salama	1	1	1	1	1-HR	HA
2	Moroberekan	1	1	1	1	1-HR	A
3	Nerica 1	4	8	9	1	5.2 = MR	A
4	Kalalu	4	1	7	1	3.2 R	A
5	SSD – 5	2	1	8	7	4.5 MR	A
6	Gigante	7	8	7	8	7.5 HS	A
7	Salama M1	7	7	7	5	6.5 S	P
8	Lunyuki	3	1	1	1	1.5 R	P
9	IRAT 256	3	9	7	4	4.8 MR	A
10	Bonake	6	4	7	6	5.8 MR	P
11	Salama M55	4	4	1	6	3.8 R	HA
12	Salama M57	1	1	1	1	1.0 HR	HA
13	Rangi Mbili	8	8	7	7	7.5 HS	P
14	Mwangaza	1	1	1	1	1.0 HR	
15	BG 380-2	9	3	7	7	6.5 S	P
16	Faro II	2	2	1	1	1.5 HR	VP
17	Salama M35	7	1	3	1	3.0 R	A
18	Nerica L-25	8	7	8	6	7.3 HS	VP

19	IRAT 252	2	1	4	1	2.0 R	A
20	IITA 235	3	2	4	1	2.5 R	HA
Mean Local check		9	9	9	8	8.8 HS	VP
Mean entries		4.2	3.6	4.6	3.4		

Ha = Highly acceptable
A = Acceptable (average)
P = Poor, not acceptable
VP = Very poor , not acceptable

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References

Abo, M. A. and Alegbejo, M. (1998). Rice yellow mottle (RYMV) in Africa; Evolution, distribution economic significance and sustainable rice production and management strategies. *Journal of sustainable Agriculture*, 11:85-111;

Bakker, W. (1970). Rice yellow Mottle, a mechanically transmitted virus disease of rice in Kenya. *Netherland. Journal of Plant Pathology*, 76:53-63;

Mabagala, R.B. and Ashura Luzi – Kihupi (2001). Rice yellow mottle virus: A fast spreading disease in Tanzania. *Plant Pathology News*/January 2001.

Raymundo, S. A. and Buddenhagen, I. W. (1976). A rice disease in West Africa. *International Rice Community Newsletter*, 25:58;

Mwilene, F. E., Traore, A.K., Asidi, A.N., Sere, Y., Onasanya, A. and Abo, M.E. (2009). New records of insect vectors of Rice Yellow Mottle Virus (RYMV) in cote d'Ivoire. *West Africa Journal of Entomology*, 6: 198 – 206;

Bakker, W. (1974). Characterization and ecological aspects of rice yellow mottle virus in Kenya. *Wageningen Agricultural Research Report*, 829; 1 – 152;

Awoderu, V. A., Alam. M.S., Thottappilly, G. and Allure, K. (1987). Ivory Coast rice yellow mottle virus in upland rice. *FAO Plant Protection Bulletin,* 35: 32 – 33;

Banwo, O. O., Alegbejo, M.D. and Abo, M.E. (2004). Rice yellow mottle virus genus Sobemovirus: A continental problem in Africa. *Plant Protection Science*, 39:26-36;

Mwalyego, F. M., Ndunguru, A., D. Kabungo, R. Maganga, and A. Kihupi (2012). Baseline survey report: Evaluation and disseminate of integrated disease management options for rice yellow mottle virus in the Southern highlands of Tanzania ARI Uyole, Mbeya Tanzania pp 1 – 30.

Luzi - Kihupi, A., M. R. S. Mlozi, R.B. Mabagala, D.M.K. Mushobozy and S. Msolla – Nchimbi (2000). Occurrence of rice yellow motle virus in Tanzania. *Tanzania Journal of Agricultural Science*, 3: 87 – 96;

Reckhaus, P. M. and Adamou, I. (1986). Rice diseases and their economic importance in Niger. *FAO Plant Protection Bulletin*, 34: 77 – 82;

Abo, M. legbejo, M., A. A. S.Y,. and Misari, S. (2000). An overview of the mode of transmission, host plants and methods of detection of rice yellow mottle virus. *Journal of sustainable Agriculture*, 17:19-36;

Bakker, W. (1971). Three new beetle vectors of rice yellow mottle virus in Kenya. *Netherland Journal of Plant Pathology*, 77: 201 – 206;

Awoderu, V.A. (1991). The rice yellow mottle virus situation in West Africa. *Journal of Basic Micro-biology*, 31: 91-99;

Shao – Mwalyego, F., Kayeke, J., Myoya, T. and A. Mussei. (2004). Effect of chemical weeding in the management of rice yellow mottle virus in a rain fed lowland rice production culture. Paper presented.

Banwo, O.O. (2003). Rice yellow mottle virus disease: A national problem in Tanzania. *Acta Phytopathologica Entomological Hangarika*, 38 (1-2) 99-107);

Ministry of Agriculture (MoA) (2008). Status of Food situation in Tanzania and ECA region. *MAFS Review Report*, 2008;

Eastern and Central Africa Rice Research Network (ECARRN) (2006). Priority setting for Eastern and Central Africa. *ASARECA – ECARRN report*, 79pp;

Reckhaus, P.M. and Adamous, I. (1986). Rice diseases and their economic importance in Niger. *FAO Plant Protection Bulletin*. 34: 77 – 82;

Pinel, A. N., Guessan, P. Bousalem, M. and Fargette, D. (2000). Molecular variability of geographically district isolates of rice yellow mottle virus in Africa. *Arebic Virology*, 145: 1621 – 1638;

Fomba, S. N. (1988). Screening for seedling resistance to rice yellow mottle virus in some rice cultivars in Sierra Leone. *Plant Disease*, 72: 641 – 642;

International Rice Research Institute (IRRI) (1996). Standard Evaluation system for rice, 4th edition, July 1996, Manila, Philippines p. 25.

Ochola, D. and G. Tusiime (2011). Pathogenicity of rice yellow mottle virus and the potential sources of resistance against the disease in Eastern Uganda. *Asian Journal of Plant Pathology*, 5: 1 – 15.