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Farmers' Knowledge and Perceptions of *Rice yellow mottle virus* in Selected Rice Growing Areas in Tanzania

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Abstract: ***Surveys were conducted in eight rice growing regions of Tanzania, namely; Morogoro, Pwani, Arusha, Kilimanjaro,Shinyanga, Kigoma, Mbeyaand Rukwa regions, to determine farmers' field practices, knowledge and perceptions onRice yellow mottle virus(RYMV). The study also examined challenges faced by rice farmers due to RYMV in order to ascertain the proper disease management approach. Rice yellow mottle virus disease was assessed in the fieldsusing quadrats of 1 m x 1 m.Symptoms of RYMV and Direct Antibody Sandwich - Enzyme-linked Immunosorbent Assay (DAS-ELISA) were used for disease diagnosis. A total of 126 samples tested positive for RYMV with polyclonal antiserum.Rice farmers were allowed to narrate problems, setbacks and achievements encountered in rice production in relation with RYMV. The lowest RYMV disease prevalence (25 %) and severity (25 %) of the disease were recorded in Shinyanga region, while the highest prevalence(82 %) and severity (55 %) were recorded in Morogoro region. Most of the farmers interviewed (91 %) cultivated their own saved rice seeds while very few farmers (5 %) were purchasing improved seed and only 4 % received seeds from district council via agriculture extension officers.Forty five (45 %) of farmers used the broadcasting method to plant rice seeds while 55 % established nurseries and transplanted rice seedlings 14 -21 days after sowing. There was a positive correlation (P≤0.05)between weeding method, source of seed, line spacing and occurrence (but not prevalence) of RYMV disease. The majority of farmers interviewed weeded once per crop season and about 80 % used a hand hoe, while 20 % used herbicides.All farmers indicated that RYMV disease occurred each season at different incidences depending on variety grown.Thirty two percent of farmersindicated that the existence of RYMV disease over the past five years was due to local rice cultivars they used. The findings indicate that RYMV disease remains a major problem in rice production in Tanzania. There is thus, a need for capacity building of rice farmers on management of RYMV in the country.***

Keywords: Farmers'knowledge, *Rice yellow mottle virus*prevalence, Management

1. Introduction

Rice yellow mottle virus (RYMV) belongs to the genus *Sobemovirus.*It is a variable, widespread and highly infectious rice (*Oryza sativa* L.) pathogen in Africa [1],[15]. It was first observed in 1966 in Kenya [4] and later reported in nearly all rice-growing countries of Sub-Saharan Africa [2]. In Tanzania mainland, the first incidence of the virus was reported in 1993 in Mkindo, Morogoro region[12]. Since then, the disease has been reported almost in all the rice growing areas of Tanzania. *Rice yellow mottle virus* is a variable and very serious disease in Tanzania. The disease has different local names (Fagia, Kimyanga, Kimbwengu, Kinasa, Mbekese - means a rice plant killer) depending on locality. It is now known to occur in almost all irrigated and rain-fed (flooded) lowland rice producing agro-ecologies in Africa [9]. The virus is readily transmitted when the sap of infected leaves come in contact with healthy leaves either through mechanical injuries or through insect vectors. Wind, mammals such as cows, donkeys and rats are also agents of dispersal of RYMV [29]. The disease is characterized by mottling and yellowing symptoms, stunted growth, reduction of tiller formation and grain sterility. In severe cases, infected plants may die. However, symptoms are not always enough to identify the disease. The ELISA techniques using antibodies is recommended in order to ascertain the presence of the virus in infected rice plants. Most rice cultivars, especially those of the *Oryza sativa*indica species are susceptible to RYMV.

Farmers in developing countries have been using their own knowledge in managing plant diseases [5]. However, the information on farmers' knowledge and perceptions of RYMV disease in Tanzania is limited and farmers' disease management is often ineffective. Such knowledge requires proper document for improvement purposes. Selener[24] documented the advantages of involving farmers in research, extension and development efforts. Collaboration of farmers with the formal research sector may offer researchers a mechanism to ensure that their work is relevant to farmers' needs and conditions [11]. Rhoades and Booth [22] reported that, the involvement of farmers in the research process has increased the chance of success in the generation of appropriate agricultural technology. Participatory plant breeding has been shown to be an effective way to select locally adapted rice genotypes and to improve farmers' access to useful crop genetic diversity [11],[26],[31].

Rice farmers continue to count losses due to RYMV disease. The disease is a major problem in rice production in

Tanzania. The purpose of this study was to investigate farmers' field practices, knowledge and perceptions on RYMV and to examine the RYMV disease challenges faced by rice farmers in order to ascertain the proper disease management options.

2. Materials and Methods

2.1. *Rice yellow mottle virus* disease survey in farmers' rice fields

The study was conducted in farmers' rice fields in April to May, 2013 and 2014. The majority of the respondents were small scale farmers, growing rain fed-lowland rice. A total of 56(7 fields/region) farmers' rice fields in selected rice growing areas in Morogoro, Pwani, Arusha, Kilimanjaro, Shinyanga, Kigoma, Mbeyaand Rukwa regions were selected randomly and assessed for RYMV using quadrats of 1 m x 1 m. Three quadrats were established diagonally in each field. At each quadrat the total number of plants and number of infected plants were counted and disease severity scored according to standard evaluation system for rice [10]. Disease prevalence was calculated using the formula described by [18].The number of infected plants within the three quadrants was summed up and divided by the number of quadrants to obtain an average for each field. The average obtained was used to determine the disease prevalence by taking the number of infected plants in each field as a percentage of the total number of plants sampled in that field. The diseased rice leaf samples collected were placed in paper bags, labeled and brought to the African Seed Health Center Laboratory, Sokoine University of Agriculture (SUA) for further studies. The longitudes and latitudes were recorded for each sampled locations using the GPS handset (GARMIN-GPS 60).

2.2. Sampling methodology

Questionnaires for the farmers' field survey were constructed and included various issues addressed during research. Rice farmers were allowed to narrate problems, setbacks and achievements encountered in rice production in relation with RYMV. The collected questionnaire data included field characteristics (average size of the rice field, rice variety cultivated, rice ecology and source of rice seeds used), farmers' agricultural practices (planting method used, line spacing and number of seedlings per hill), rice field management (weeding method, type of fertilizer used and its dosage, time of re-sowing or transplanting in the same field) and farmers' perceptions on *Rice yellow mottle virus* (knowledge of RYMV, years since RYMV was first observed over the past five years, yield estimates after occurrence of the disease, resource use and the control measures taken due to RYMV). It involved farmers' interviews, personal observations and secondary data from different sources in the wards, divisions, districts and regions.A farmer was a sampling unit. In each of the eight regions, seven farmers were selected for the study, making a total of 56 farmers. Information obtained from field surveys was documented for further use.

2.3. Immunological analysis of *Rice yellow mottle virus*

Direct antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) was used to test for the presence of RYMV in 126 leaf samples collected following procedures described by [7],[19]. The polyclonal antiserum produced against a Madagascan RYMV strain was used as a primary antibody in this study. Samples considered positive, were those with optical density values greater than twice the value for the healthy control samples.

2.4. Data Analysis

The collected questionnaire data were analyzed using Statistical Package for Social Sciences (SPSS) Version 9.1. Descriptive statistics analysis of means and frequencies was used to summarize the farmers' agricultural practices, rice field management and their perceptions on*Rice yellow mottle virus*. Relationship between each parameter was analyzed using the Spearman's rho Correlation tool of the SPSS. This was conducted at 1 % and 5 % probability levels.

TheRYMV disease prevalence and severity data were analysed as one way Randomized Block using GenStat Software Package. The data were subjected to Arcsine transformation to normalize the data before analysis [30]. A constant value (0.5) was added to each observation, before taking Arcsine transformation [16].The mean separation test based on the different locations and rice cultivars tested for disease prevalence and severity were done using the Turkey's Multiple Range Test at P = 0.05.

3. Results and Discussion

3.1. Rice yellow mottle virus disease surveys

Results of the RYMV disease surveys in farmers' rice fields are summarized in Tables 1, 2 and 3. The results showed that *Rice yellow mottle virus* was a widespread disease in farmers' fields in all the regions covered in this study. The prevalence and severity of the disease ranged between 25 and 82 % and 25 and 55 %, respectively. The lowest RYMV prevalence (25 %) and severity (25 %) were recorded in Shinyanga region, while the highest prevalence (82 %) and severity (55 %) were recorded in Morogoro region (Figure 3). The regions could be splitted in two groups: Shinyanga, Kigoma, Rukwa and Kilimanjaro where prevalence and severity were similar (and low), and Morogoro, Mbeya, Arusha and Pwani where prevalence was higher than severity. The result of this study confirmed the widespread occurrence and severity of the RYMV disease in all the rice-growing areas of Tanzania. *Rice yellow mottle virus* remains a major problem in rice production in Tanzania. It was observed through questionnaires that, farmers had no knowledge of managing their rice plants in the field after infection by RYMV.

3.2. Relationship between rice cultivars and RYMV prevalence and severity

There was a positive correlation ($P \leq 0.05$) between rice cultivars and the prevalence of RYMV disease. However, rice cultivar and fertilizer application were also correlated (Table 2). The prevalence was highly variable depending on

Table 1: Relationship between farmers' agricultural practices and their perceptions on *Rice yellow mottle virus* disease

Farmer agriculture practices	*Type of practices*	*% of Respondents*	*Reasons*
Source of rice seeds	Farmer's saved seeds	91	Strong aromatic, good cooking qualities, good milling, drought resistance, medium and high yield
	Seed company	5	Very good agronomic performance
	District council	4	No option
Line spacing	15 cm	7	Many plants for high yield
	20 cm	39	Normal spacing
	25 cm	2	Advised by Agriculture Extension Officers
	Random	52	Easy and fast transplanting
Weeding method	Hand hoe	80	Affordable
	Herbicides	20	Expensive
Rice plant weeding stage	One week before sowing	14	No need of re-weeding
	Seedling	7	Planting on weedy fields
	Tillering	43	Good for better booting
	Booting	36	Opportunity of weeding once
Planting method	Broad casting	45	Easy for more than 1 ha, need enough seeds
	Transplanting	55	Economize seeds, heavy vegetative, to follow good agriculture practices such as spacing
RYMV disease control	None	43	Lack of knowledge
	Fertilizer application	23	Suspected nutrient deficiency
	Uprooting infected rice plants	12	Reduce transmission of disease to healthy plants
	Burying infected rice residuals	11	Eradicate RYMV
	Fallowing	7	Disease may disappear
	Burning rice residuals	4	To destroy RYMV and their insect vectors

The rice variety (Table 3). Except the rice variety Supa that showed a moderate level of prevalence (51%), the preferred varieties were mostly highly infected by RYMV (SARO-5 70%, Zambia 90%, Kilombero 77%, Karimata 60%, Kihodo red 85%). Due to the high prevalence of RYMV on rice cultivars Zambia (90.33 %), Kihogo-red (85.00 %), Kilombero (77.00 %), Tondogoso (78. 00 %) and SARO-5 (70. 00 %) (Table 3), farmers were advised to replace these cultivars with RYMV-resistant varieties (Figure 7). However, it was found that where the RYMV prevalence was high the susceptibility of the varieties to RYMV was low or moderate. The severity of RYMV was also highly variable in the rice cultivars and ranged from the cultivar Zambia (27 %) to SARO-5 (50 %). The prevalence of RYMV was found to be correlated with the rice varieties. The prevalence of RYMV on cultivar Zambia (90.33 %) was high with low disease severity (27.00 %). Twenty one percent of the rice farmers preferred the variety SARO-5, which had moderate RYMV prevalence (70.00 %) with high severity (50. 67 %) (Table 3). Sérée*t al*. [25] reported that the identity of RYMV host species and vector population in relation to the availability of susceptible hosts were key determinants of the disease prevalence in the host community. It is therefore, possible that the cropping practices and the presence of mobile insect vectors in the surveyed regions have contributed to the prevalence of RYMV in those areas. Several insect species with chewing mouthparts, particularly Chrysomelidbeetles and grasshoppers have been reported to transmit RYMV fromwild hosts and weeds to rice plants [13]. However, rice fields

Table 2: Correlation coefficient between rice cultivars, seed source, rice ecosystem, line spacing, weeding method, UREA fertilizer application and occurrence, prevalence and control of *Rice yellow mottle virus* in Tanzania (n = 56)

	Rice cultivar	Seed source	Rice ecosystem	Planting method	Line spacing	Weeding method	UREA fertilizer	Disease occurrence	Disease control	Prevalence (%)
Rice cultivar	1.000									
Seed source	-.243	1.000								
Rice ecosystem	-.136	-.195	1.000							
Planting method	-.250	.148	-.267*	1.000						
Line spacing	-.122	.127	.265*	-.406**	1.000					
Weeding method	.230	.315*	.016	-.098	.297*	1.000				
UREA fertilizer	-.299*	-.128	.355**	.059	.101	-.202	1.000			
Disease occurrence	.196	-.037	.220	-.186	.184	.331*	-.387**	1.000		
Disease control	-.006	.193	.015	.262	.033	.034	-.302*	.130	1.000	
Prevalence (%)	.092*	.163	-.341**	-.082	-.016	.049	-.328**	-.177	-.072	1.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

That was weeded late after the occurrence of RYMV disease had high disease prevalence.

3.3. Farmers' Agronomic Practice

Most of the farmers interviewed (91 %) used their own saved rice seeds while very few farmers (5 %) purchased improved seed from seed companies and only 4 % received improved seed from district council via agriculture extension officers because they were not able to buy seeds (Table 1 and Figure 1a). Varieties produced and released by seed companies and breeders, respectively, have not yet been adopted by farmers. This is because farmers prefer to use their local cultivars due to some reasons including strong aroma, good cooking qualities, good milling, medium and high yielding and sometimes drought tolerance during periods of low rainfall. However, some local varieties are high yielding but not aromatic and these were cultivated for the market to increase farmers' income.

There were positive correlations ($P \leq 0.05$)and ($P \leq 0.01$)between rice planting method and rice ecology and linespacing, respectively (Table 2). Forty five percent of farmers used broadcasting as a planting method while 55 % established nurseries and practiced transplanting of rice seedlings 14 -21 days after sowing (Table 1 and Figure 1b). *Rice yellow mottle virus*-infected seedlings from the nurseries have been reported as potential source of inoculumintroduced into the field through transplanting [21]. Line spacing used by farmers during transplanting was mainlyrandom, 52 % did not consider line spacing during sowing or transplanting or 20 cm spacing (39 %) (Figure 1c).There was a positive correlation ($P \leq 0.05$)between weeding method, source of seed, line spacing and occurrence (but not prevalence) of RYMV disease (Table 2). The majority of farmers weeded once per crop season and about 80 % used a hand hoe, while 20 % used herbicides (Table 1 and Figure 1d).

Table 3: The prevalence and severity of *Rice yellow mottle virus* disease on commonly grown rice cultivars in Tanzania

Rice cultivar	*Farmers' preference (%)*	*Rice yellow mottle virus disease*	
		Prevalence (%)	*Severity (%)*
Japan	2	58.00d	20.33fg
Karimata	9	60.00d	31.00cd
Kihogo red	7	85.00a	44.67a
Kilombero	9	77.00b	40.00b
Matela	4	58.33d	24.00ef
Msonga	2	40.00f	18.00g
Rangimbili	5	64.67cd	34.33c
SARO-5	21	70.00c	50.67a
Sena	2	55.33de	18.67g
ShingoYaMwali	4	45.00e	46.00a
Sukarisukari	2	18.00g	38.67b
Supa	13	51.33de	34.33c
Tondogoso	2	78.00b	30.33fg
Usiniguse	4	45.33e	20.67fg
Wahiwahi	5	68.00c	42.00ab
Zambia	11	90.33a	27.00de
Mean		60.27	32.54
$LSD_{0.05}$		1.281	2.236
F test		***	***
CV (%)		0.9	1.1

* Values are means of three replicates. Numbers followed by the same letters in a column are not significantly different at P<0.05, using Tukey's Multiple Range Test. *** = highly significantly different (P<0.001)

3.4. Rice cultivars preferred by farmers

Rice farmers in Tanzania preferred six rice cultivars which were grown in the study area. These were SARO-5, Supa, Zambia, Kilombero, Karimata and Kihogo red (Figure 2). Ten other varieties (Japan, Matela, Msonga, Rangimbili, Sena, ShingYaMwali, Sukarisukari, Tandogoso, Usiniguse and Wahiwahi) were occasionally planted.

There was a positive correlation ($P \leq 0.05$) between rice cultivars and the prevalence of RYMV (Table 2). Twenty one percent of the farmers interviewed preferred a rice variety SARO-5 (Table 3 and Figure 2). However, the variety was the most severely (50.67 %) affected by the disease (Table 3). The variety SARO-5 was promoted for use by the Tanzania Agricultural Partnership (TAP) Project and agriculture research institutes but it was susceptible to many diseases including RYMV [13]. However, cultivar Rangimbili was mostly grown (100 %) by farmers in Morogoro region (Figure 2). Rice variety SARO-5 was mostly cultivated (87 %) by farmers in Kilimanjaro and Morogoro regions while Supa and cultivar Zambia were also preferred mostly (87 %) in Morogoro region. Rice cultivar, Kihogo red was grown in Mbeya (62 %) (Figure 2). Two other rice cultivars grown in Morogoro and Kigoma but to a lesser extent than the other varieties were Matela and Usiniguse, respectively (Figure 2).

Supa, Zambia, Karamata, Kilombero and Kihogo red were preferred by 13 %, 11 %, 9 %, 9 % and 7 % of farmers interviewed, respectively (Table 3 and Figure 2). A ricecultivar, Japan that was cultivated by 2 % of farmers in Ndungu Irrigation Scheme Project, Kilimanjaro region was provided by Japan International Cooperation Agency (JICA). All the rice cultivars grown by the farmers in the areas surveyed were susceptible to RYMV (Table 3).

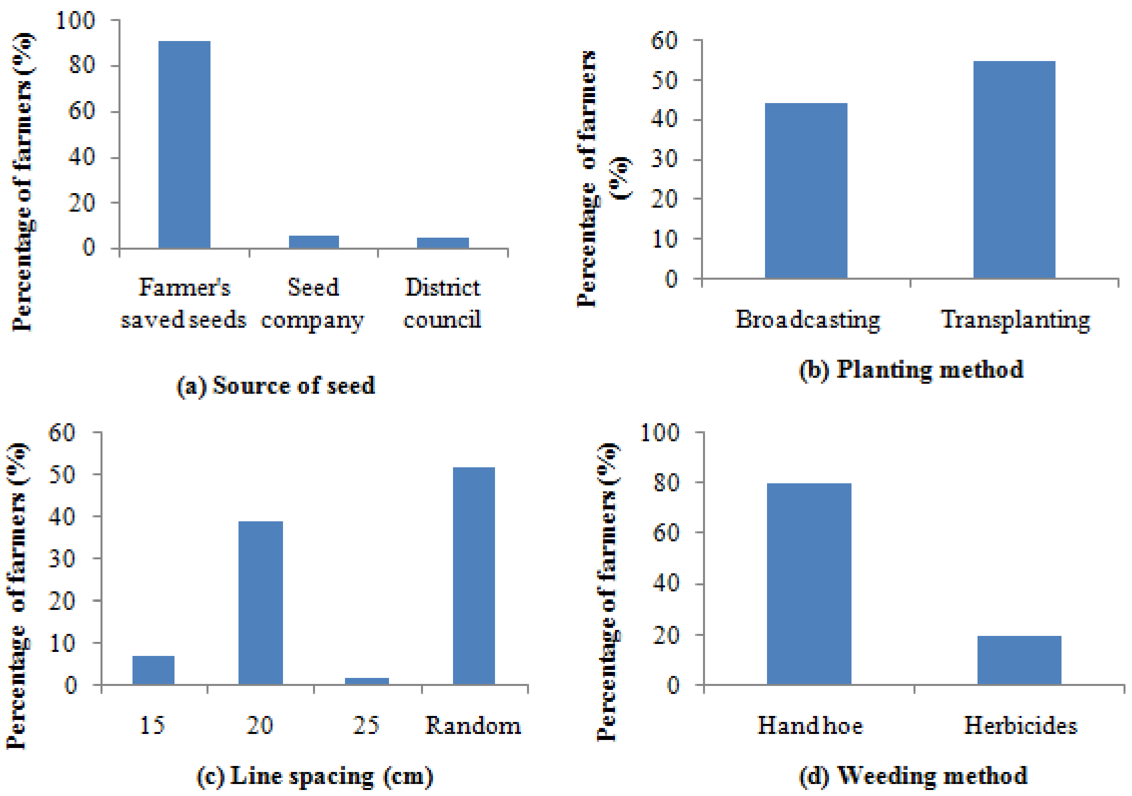

Figure 1: Farmers' rice agronomical practices in the study area in Tanzania (a) source of seed (b) planting method (c) line spacing and (d) weeding method

The use of these cultivars correlated positively with high disease prevalence, indicating that they were highly susceptible to the disease. This is because farmers maintained their local rice seeds that may be grown to the same rice fields over a long time. Farmers value their local rice varieties because of their strong aroma, good cooking qualities, good milling, drought resistance, medium and high yield. Farmers in Mwea region, Kenya indicated that a local cultivar, BW196 was very heavy and provided a lot of energy compared to Basmati cultivar due to lack of aroma and poor cooking qualities [14]. Other studies confirmed the absence of genetic resistance to RYMV disease in all the locally available rice cultivars [20], [27]. It has been reported by several authors that host genetic resistance is the most effective strategy in managing RYMV [17], [27].

This study has demonstrated the need for continued breeding for resistance of rice cultivars being grown by farmers in Tanzania. In undertaking such breeding work, consideration should be given to consumer preferences, as indicated by the farmers interviewed. Zambia, the ricecultivar preferred by most of the farmers, is an indigenous cultivar, with good adaptation to the local environment. We are of the view that it should serve as one of the candidatefor genetic improvement to address its susceptibility to *Rice yellow mottle virus*.

3.5. Rice ecosystem of surveyed farmers' fields in Tanzania

The rice ecosystems recorded in this study were rain-fed lowland, rain-fed upland and irrigated ecology (Figure 3). The results showed that most of rice fields in all visited regions were under rain-fed lowland. Farmers grew rice during the rainy season and under irrigation during the dry season between August and December.

In Mbeya region, 87 % of rice fields were cultivated under rain-fed lowland where RYMV prevalence (80 %) and severity (53%) were very high compared to other regions (Figure 3). The rice ecology was positively correlated with RYMV disease prevalence (Table 2). By contrast, the results showed that 93 % of rice fields in Shinyangaregion were cultivated on rain-fed lowland, 5 % rain-fed upland while 2 % under irrigated ecology (Figure 3). Farmers in this region relied mainly on rainfall for rice cultivation. This situation caused some farmers, particularly those that planted rice late after the onsets of rains, to lose their rice crop due to drought. *Rice yellow mottle virus* was found in abundance in the drought stricken fields. However, disease prevalence and severity were low, 25 % and 25 %, respectively, compared to other regions. Furthermore, cattle grazed on the stumps, ratoons and volunteer rice plants after rice harvesting. While the cows were feeding they dropped dung in the fields. Cow dung has been implicated in the transmission of RYMV in Madagascar [21] and thus, could also be involved in transmitting RYMV in the areas covered by the current study.

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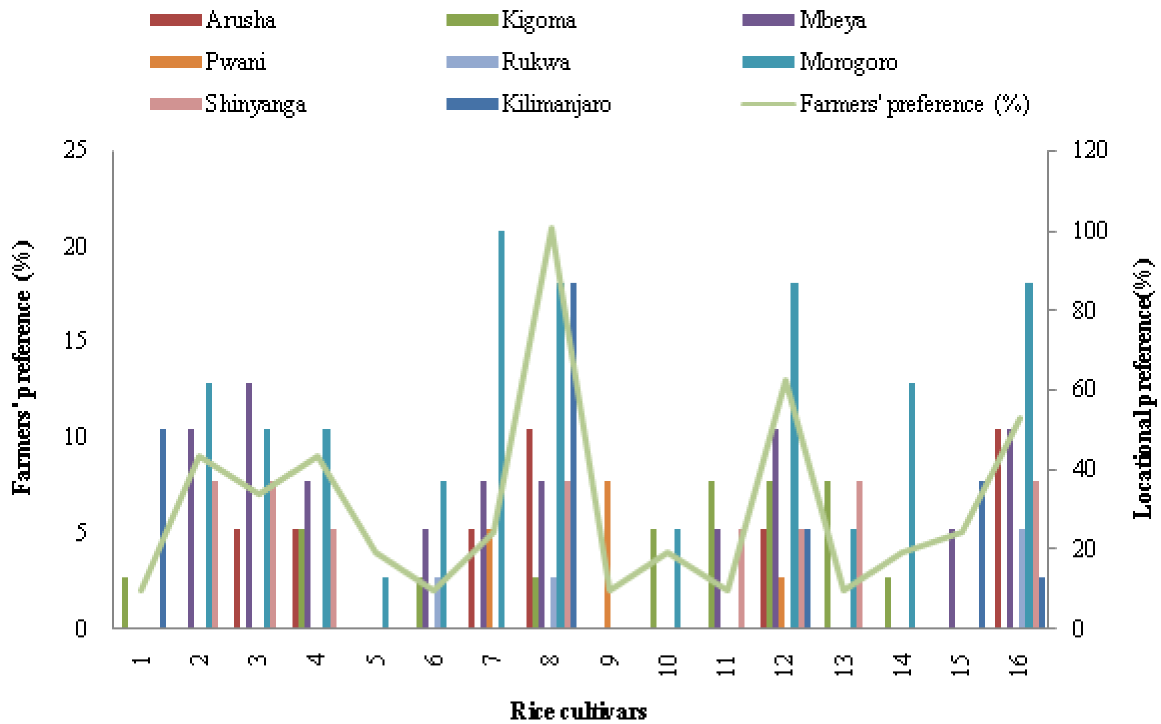

Figure 2: Farmers' preference of commonly cultivated rice cultivars in main rice growing areas in Tanzania
1= Japan, 2 = Karimata, 3 = Kihogo red, 4 = Kilombero, 5 = Matela, 6 = Msonga, 7 = Rangimbili, 8 = SARO-5, 9 = Sena, 10 = ShingoYaMwali, 11 = Sukarisukari, 12 = Supa, 13 = Tondogoso, 14 = Usiniguse, 15 = Wahiwahi, 16 = Zambia

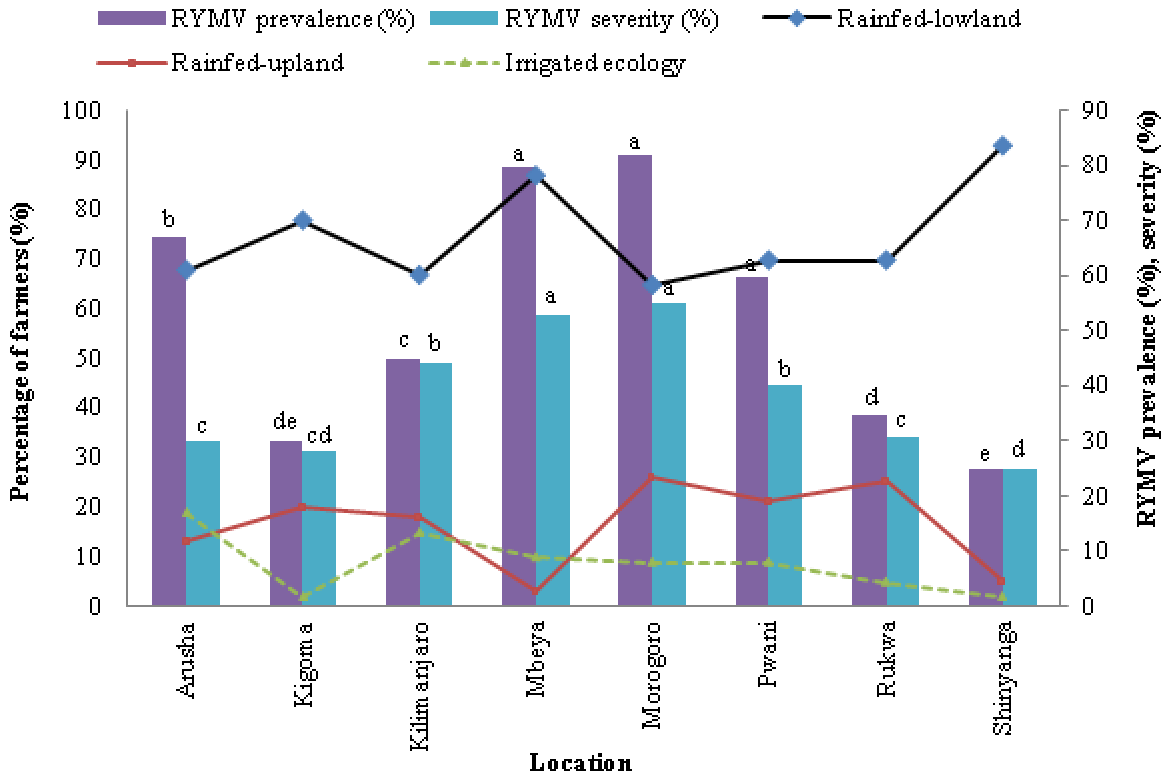

Figure 3: Relationship between rice ecosystems and prevalence and severity of *Rice yellow mottle virus* disease in selected rice growing areas in Tanzania

Values are means of three replicates. Numbers followed by the same letters on a graph bar are not significantly different at P<0.05, using Tukey's Multiple Range Test

3.6. Occurrence of *Rice yellow mottle virus* disease over past five years in farmers' rice fields

There were positive correlations (P≤0.05) and (P≤0.01) between RYMV disease occurrence and weeding method and UREA fertilizer application in rice fields, respectively (Table 2). Occurrence of RYMVdisease is widespread in the rice growing regions in the country. The results in Figure 4 showed that 100 % of the farmers interviewed in Arusha, Mbeya and Pwani rice fields indicated that RYMV disease occurred each season at different incidences depending on the varieties grown. Such findings were also reported by 98, 92 and 60 % of the farmers interviewed in Rukwa, Morogoro and Kilimanjaro, respectively. Sixty seven percent and 40 % of the farmers interviewed in Kigoma and Kilimanjaro, respectively, indicated that, RYMV occurred in their rice fields in 2014 following a period offive years without the disease (Figure 4). The RYMV disease symptoms were reported in the rice fields in some parts of Shinyanga in 2012 & 2014 and 2013 & 2014,as indicated by 33 % of farmers interviewed. However, RYMV virus symptoms in the field vary considerably depending on the rice genotypes, strain, stage of infection and the environment [1], [8], [20]. This may confuse farmers to differentiate between nutrient deficiencies or physiological disorders and RYMV symptoms.

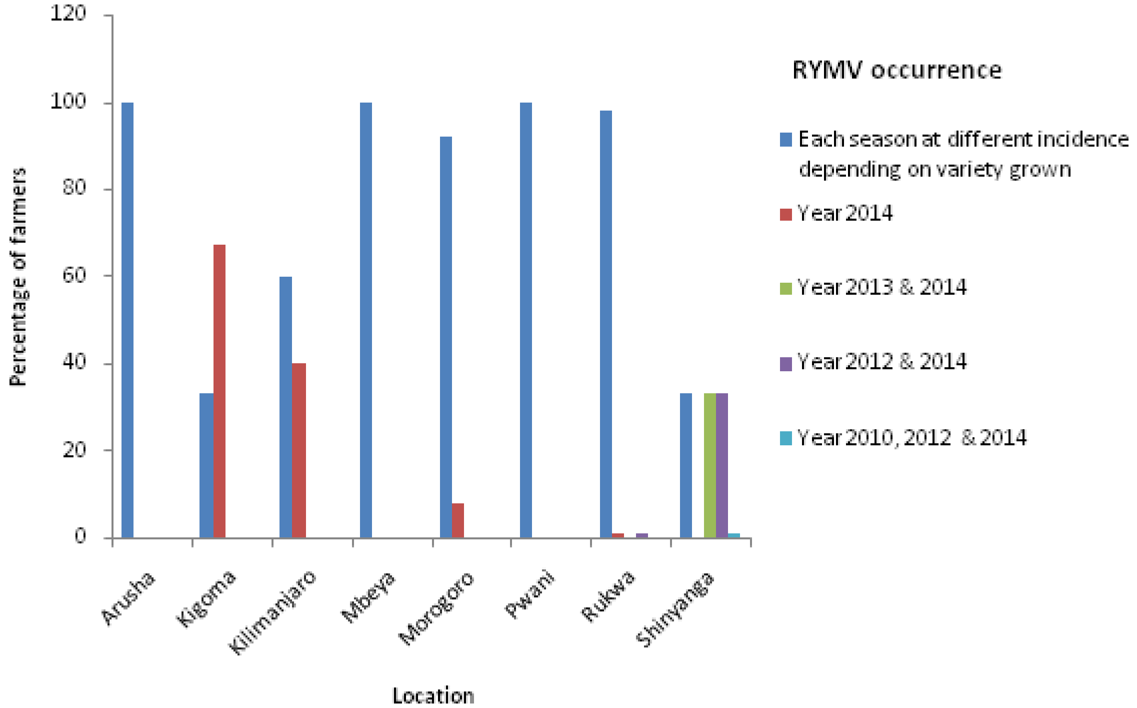

Figure 4: Farmers response on *Rice yellow mottle virus* disease occurrence in rice fields in the surveyed regions in Tanzania

3.7. Factors influencing occurrence of *Rice yellow mottle virus*

Thirty two percent of farmers interviewed responded that the existence of RYMV disease over the past five years was due to local rice cultivars they used (Figure 5a). Twenty percent (20 %) of farmers interviewed suspected that it was due to poor rice field management while 17 % of them suspected the rice residuals and weed grasses as sources of the virus (Figure 5b). This study found that rice residues were sometimes used for demarcating fields to differentiate between their rice plots from one farmer to another (Figure 5c). In other locations visited, farmers interviewed (15 %) indicated that heavy rainfall and floods during rice cultivation influenced the virus occurrence(Figure 5a) while 7 % of the farmers suspected presence of trees and heavy grass vegetation and 4 % of them disposal of weeds in water canals.

Such rice fields surrounded by heavy tree and grass vegetation may be the source of insect vectors of RYMV. Water in streams and irrigation canals may introduce initial RYMV disease inocula in the strawsto other areas, thus increasing the incidence of RYMV. These results are consistent with those of Sarra[23] who reported that in irrigated rice, RYMV can be distributed randomly across the same region and across the same field. This is because farmers dispose weeds which may be infected by RYMV in the water canals after weeding their rice fields and such weeds are taken far-away by water. This may be the source of spreading RYMV disease from one field to another. However, rice field hygiene is not considered an important rice management factor for the farmers of Tanzania, due to labour constraints for weeding. Most of them therefore, leave infected rice residues in the fields after harvesting and sow or transplant seeds within a short time in the same field. Two percent of farmers indicated that that cows, burying of infected rice residuals and drought may influence the spread of RYMV (Figure 5a).

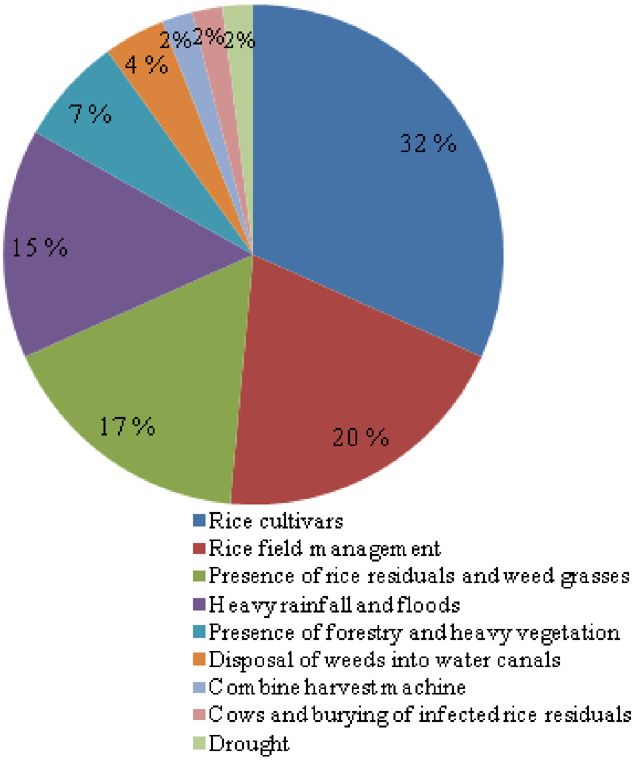

Figure 5b: Demarcation between farmers' plots using rice weeds after weeding at Kiwowo, Monduli district, Arusha region (Photo: Judith Hubert)

Figure 5c: Accumulation of weeds and RYMV symptoms in flooded rice field at Lupiro ward, Ulanga district, Morogoro region. (Photo: Judith Hubert)

Figure 5: The diverse ecological background of rice management and possible influence on dissemination of *Rice yellow mottle virus* in Tanzania based on thevisits to farmers' rice fields

3.8. Control strategies used by farmers against *Rice yellow mottle virus* disease

There was a positive correlation ($P \leq 0.05$) between RYMV disease control and UREA fertilizer application (Table 2). The results also showed that most of farmers interviewed (43 %) abandoned the RYMV-infected portions of their rice fields and did not always destroy infected rice plants (Figure 6). These practices contribute to additional sources of RYMV inoculum in the field. Twenty three percent of farmers interviewed applied UREA fertilizers in their farms after disease symptoms appearance as a management strategy for the disease. Some farmers did not consider and use the recommended UREA dosage during fertilizer application. Seven percent of farmers interviewed fallowed their rice fields as RYMV disease control measure in areas where land availability was not limiting. . *Rice yellow mottle virus* cannot be managed using chemicals, thus, the use of resistant varieties is very important. Thiémélé et al. [27] and [28] identified a few resistant accessions in *O. glaberrima* and its wild ancestor *Oryzabarthii*.

However, majority of the rice farmers (67%) who did not take any control measure against RYMV disease in their fields reported that they were expected to harvest 1.26-2.26 t/ha (Figure 6). This was followed by 63 % and 37 % of farmers interviewed who expected to obtain 0.42-0.7 t/ha and 0.72-1.25 t/ha, respectively, without any RYMV disease control measure (Figure 6). Forty percent of farmers interviewed were not satisfied by their yields (0-0.3 t/ha) after the application of UREA fertilizer as a management measure of RYMV disease. However, 33 and 21 % of farmers interviewed and who applied UREA expected to get the yield of 1.26-2.26 t/ha and 0.42-0.7 t/ha, respectively. UREA fertilizer was used because some farmers thought that the disease occurred due to soil fertility deficiency problems.

Other farmers interviewed mentioned that the poor rice yields (0-0.3 t/ha) were caused by uprooting infected rice plants (13 %), burying of infected rice residuals of previous season (7 %), fallowing (13 %) and burning previous harvested rice residuals (7 %) as disease control measures (Figure 6). This indicated that farmers uprooting diseased plants can transmit RYMV from diseased plant to health plants that may lead to low rice yield. Although farmers

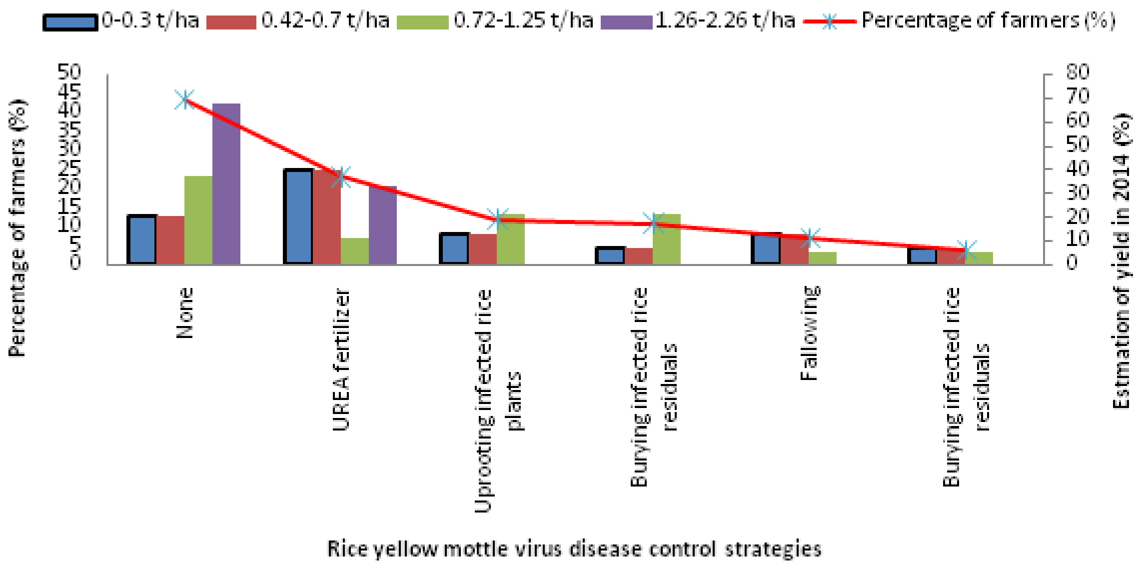

Figure 6: *Rice yellow mottle virus* disease control measures taken by rice farmers after the disease occurrence and yield in their rice fields

have tried to burn and burry the previous rice residuals, their rice fields were surrounded by grassy vegetation that may be harboring the RYMV insect vectors. Several authors have reported yield losses of 25 to 100% due to RYMV infection,depending on the date and time of infection and rice genotypes [1], [3], [6], [15].

3.9. Farmers'perceptions on *Rice yellow mottle virus* disease

The results in Figure 7 indicate that among 56 respondents interviewed in eight regions, 29 % perceived that RYMVdiseasewas a major problem in rice production while 21 % reported that resistant varieties to RYMV were deemed to solve the problem. Eighteen per cent of the interviewed farmers reported that grass weeds, forest and heavy vegetation influencedRYMV disease development, while 11 % showed the need of training on identification and management of RYMV disease. Weather conditions like high rainfall, wind and clouds were perceived by 11 % of the respondents to influence the RYMV disease problem.

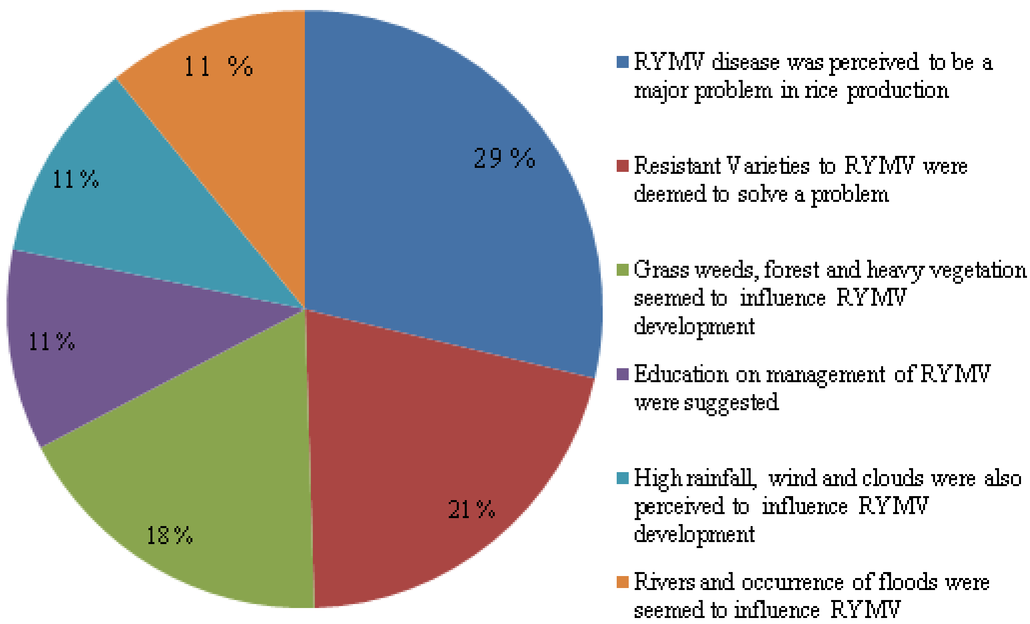

Figure 7: Farmers' response on *Rice yellow mottle virus* (N =56), from different rice growing areas covered by the current study in Tanzania

4. Conclusion and Recommendation

The present study revealed that the lowest RYMV disease prevalence (25 %) and severity (25 %) were recorded in Shinyanga region, while the highest prevalence (82 %) and severity (55 %) were recorded in Morogoro region, Tanzania. *Rice yellow mottle virus* infection was mostly detected where local rice cultivars [Zambia (90.33 %), Kihogo-red (85.00 %), Kilombero (77.00 %), Tondogoso (78. 00 %) and SARO-5 (70. 00 %) prevalence] were grown on a large scale under all rice ecosystems. Most of the farmers interviewed (91 %) cultivated their own saved rice seeds. Twenty one percent of the farmers interviewed preferred a rice cultivar SARO-5although it was the most severely (50.67 %) affected by RYMV disease. This cultivar was mostly cultivated by farmers (87 %) in Kilimanjaro and Morogoro regions. However, cultivar Rangimbili was mostly grown (100 %) by farmers in Morogoro region. The results showed that 100 % of the farmers interviewed in Arusha, Mbeya and Pwani rice fields indicated that RYMV disease occurred each season at different incidences depending on the rice varieties grown. Thirty two percent of farmers interviewed responded that the existence of RYMV disease over the past five years was due to local rice cultivars they used.

The study demonstrated that *Rice yellow mottle virus* disease is a major constraint in farmers' rice fields in Tanzania. The farmers indicated that in some seasons they harvested nothing due to RYMV disease. The highest RYMV disease prevalence was observed in the irrigated and lowland rice growing areas. Many farmers were complaining about RYMV and the adoption of released varieties resistant to RYMV disease is still a challenge because most of such rice varieties do not have qualities preferred by famers.

This study has also demonstrated the need for breeding for resistance to RYMV in Tanzania. In undertaking such breeding work, consideration should be given to consumer preferences, and local rice varieties as indicated by the farmers interviewed. Zambia, the rice cultivar preferred by most of the farmers, is an indigenous cultivar, with good adaptation to the local environment. We are of the view that it should serve as the candidate for genetic improvement to introduce resistance to RYMV. Adoption of farmers' knowledge on rice field management, training on field practices for management of RYMV disease and development of rice varieties resistant to RYMV disease with preferable characteristics required by farmers and consumers is recommended.

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