Novelty Journals

International Journal of Novel Research in Life Sciences
Vol. 1, Issue 1, pp: (8-14), Month: September-October 2014, Available at: www.noveltyjournals.com

Spatial and Temporal Distribution of Rice Yellow Mottle Virus Vectors in Farmer's Fields in Kilombero District, Tanzania

[1]B.January, [2]G. M. Rwegasira, [3]P.J. Njau

[1]AfricaRice Centre, P.O.Box 33581, Daressalaam, Tanzania
[1,2] Department of Crop Science and Production, Sokoine University of Agriculture, P.O.BOX 3005 Chuo Kikuu, Morogoro, Tanzania.

Abstract: **Rice yellow mottle virus (RYMV), an endemic disease to Africa was reported in Kenya in 1966 and thereafter in Tanzania in 1980's but with limited incidences. It spread fast and it is now omnipresent in all rice growing areas in the country. The fast spread has been partly associated with climate change that has induced increased virulence of previously less virulent viruses and rapid population buildup of their vectors. In view of the increasing incidence and the impact of rice yellow mottle virus disease (RYMVD) on rice production in Tanzania, studies on the distribution of RYMV insect vectors were undertaken as a necessary step into designing the disease management strategies. The already documented list of known RYMV vectors in Africa was used as reference to the target species. Two sampling methods (sweep net and 4m^2 quadrant) were used to assess the population of insects vectors of RYMV in the three major rice growing divisions of Kilombero District in Morogoro Tanzania (Mngeta, Ifakara and Mang'ula) rice fields. Vector found existing in the location included *Chaetocnema* sp. and *Oxya hyla*. The vectors were more abundant at the border parts of the fields than at the middle. These vectors recorded, were widely distributed of in the fields with RYMV disease incidence level of up to 70% suggesting that they could be responsible for new infections and wide spread of RYMV disease in these areas.**

Keywords: **Climate change, Rice yellow mottle virus, Disease incidence, Virus vectors.**

I. INTRODUCTION

Rice *(Oryza sativa* L.*)* is one of the most important cereals in the world. It is the primary staple food for more than 51% of the world's population [17]. In Tanzania, rice is a key staple food but its productivity is affected by many diseases the most important of which is the Rice yellow mottle virus (RYMV) [2]. The virus disease which is endemic to Africa was first reported in Kenya in 1966 [8]. It is now known to occur in almost all irrigated and rain fed (flooded) lowland rice producing agro-ecologies in Africa [13]. RYMV is a highly infectious virus consisting of a single-stranded-positive sense RNA genome that specifically infects rice and is mechanically transmitted by several means in the field which includes insect vectors, vertebrates, wind mediated means and irrigation water [21, 18]. Population abundance of RYMV vectors can bring about differences in severity and incidence of the disease. The study by [10] reported that the wide distribution and abundance of *Chaetocnema* sp in Ivory Coast RYMV endemic areas suggests that the species could be the most important vectors responsible for new infections of RYMV in these areas. Information on the disease prevalent areas and vector identity already exist [10], [6]. However, the part of the field and crop growth stages where the vectors are tend to be abundant is not well known. Several insect species with chewing mouthparts, particularly Chrysomelid beetles and grasshoppers can bring the primary inoculums into the rice crop from wild hosts and weeds [9]. Different host plant growth stages may influence the abundance of the RYMV vectors. A report by [22] described that the identity of RYMV host species and vector population in relation to the availability of susceptible hosts are key determinants of the disease prevalence in the host community.

1.1 Climate Change and Spread of RYMV Vectors

The spread of RYMV has been partly associated with climate change that has induced increased virulence of previously less virulent viruses and rapid population buildup of their vectors [6]. However [9] revealed that climatic conditions such as rainfall temperature and Relative humidity bring about changes in incidence of RYMV disease and vectors of RYMV in rice fields.

1.2 RYMV Transmission by Insect Vectors

The insect species feed on an infected plant, collect the virus particles and pass them on to the next plant that they feed on [6]. The virus does not undergo any changes within the insect itself, but simply uses it as a vehicle hence the non-persistent mode of transmission [6], [10]. Insects infest rice at all stages and feed on all parts of the plant. RYMV is transmitted by insects with biting and chewing mouthparts. It is most efficiently transmitted by Chrysomelid beetles and grasshoppers possibly in a semi-persistent manner [8].

1.3 Insect borne transmission

In East Africa [8] reported several leaf beetle species with the potential to transmit the virus, namely *Sesselia pussilla* (*Galerucinae*), *Chaetocnema pulla* Chapius (*Halticinea*) and *C. dicladispa* (*Chrysispa*) Kraatz (*Hispinae*). *Dactylispa bayoni* Gest (*Hispinae*), and *Trichispa sericea* Guerin (*Hispinae*), *Oxya hyla*, *Conocephalus* sp, *Zonocerus variegates*, *Euscyrtus* sp. and *Parattetix* sp. *Cofana spectra*, *Cofana unimaculata* and *Locris rurba* was reported by [19] as a vector of the virus in Madagascar. However, the role of these vectors in rice yellow mottle disease epidemics is not well established.

1.4 Transmission specificity of plant viruses by vectors

The transmission of a virus by a vector is often characterized by some degree of specificity. Transmission specificity can be broad or narrow but it is a prominent feature for numerous viruses and vectors [16]. Specificity of transmission is defined as the specific relationship between a plant virus and one or a few vector species but not others [4]. For instance, a virus transmitted by aphids is not transmitted by nematodes or among arthropod vectors, a virus transmitted by leafhoppers is not transmitted by beetles. An extreme case of transmission specificity is exclusivity, when a vector transmits one virus or one serologically distinct virus strain and this virus or virus strain has a single vector [15]. As examples of the different degrees of specificity is green fold leaf virus (GFLV) which is naturally transmitted by a single nematode species, *Xiphinema index*[5], while some potyviruses are transmitted by more than 30 aphid species [14]. Also the whitefly *Bemisia tabaci* transmits numerous viruses from various genera and families, while the *Chaetocnema* sp transmits only RYMV. In contrast, closteroviruses are transmitted by aphids, mealybugs, or whiteflies. The specificity of transmission is explained by several characteristics, including a recognition event between the virion, or a viral protein motif and a site of reteined in the vector [12].

II. MATERIALS AND METHODS

2.1 Description of the Study Area

The experiments were conducted from 2010 to 2011 in Kilombero district, Morogoro Tanzania which is located at Longitude: 8° 15' 0 S, Latitude: 36° 25' 0 E. Three sites at least 100 km apart were sampled. These were (1) Mngeta : 8° 21'47.19S; 36° 24' 56.52E - 832 m a.s.l; Ifakara: 10° 50' 12N; 14° 56' 37E – 305 m a.s.l, and Mang'ula: 7° 46' 16.85S; 36° 31' 51.72E – 6029 m a.s.l. Five experimental fields of one acre each which were at least distantly apart of 1 acre in each site were selected for trial.

2.2 Field trials

A field experiment was conducted in a split-plot design. Three common rice varieties grown by farmers; Kalmata, India and Saro were selected in three different divisions (sites); Mngeta, Ifakara and Mang'ula and uses as blocks. From each site a total number of five fields from each site grown with the same rice variety were selected for trial at random. The

International Journal of Novel Research in Life Sciences
Vol. 1, Issue 1, pp: (8-14), Month: September-October 2014, Available at: www.noveltyjournals.com

sites were used as block, fields as main plot and field part as sub plot. The variables which were collected from each rice field were insect population.

2.3 Spatial and Temporal Abundance of RYMV vectors

Determination of population of insect vectors was done five times in each five rice fields from each site considering the major rice crop growth stages in monthly basis. That is before planting (before land clearing), four weeks after sowing (seedling stage), and eight weeks after sowing (vegetative phase), during panicle initiation and differentiation (reproduction stage) and at ripening stage. Each field was divided into three equal parts which are two border parts and middle part. RYMV vectors population were sampled using combinations of two methods as described by [10] as follows: (i) sweep net and (ii) in-situ counting in $4m^2$ quadrant. Ten random sweeps were made per sampling unit. During transportation from the field the insects were kept in screw-capped containers (bottles) with perforated lids.

III. RESULTS

Two insect species, *Oxya hyla* (Plate1) and *Chaetocnema* sp (Plate 2) were found to be the most abundant in all sampled fields. The population density of these vectors of RYMV in rice fields was higher on the border parts of the fields and less at the middle throughout the crop growth phases (Fig. 1). At each crop growth stage, the density of *Chaetocnema* sp was higher than of O. *Hyla (*Fig.1). Vectors number increased with plant growth stage to attain peaks at vegetative stage, there after started to decline during reproductive stages to attain the lowest number at ripening stage. Analysis of variance results (ANOVA) and mean separation tests (Tables 1 and 2) indicated significant variations between RYMV insect vector counts and part of field sampled and population density of insect vectors and crop growth stages. The highest values for each of the insect counts were recorded at the vegetative and reproduction stages of the crop (Fig.1)

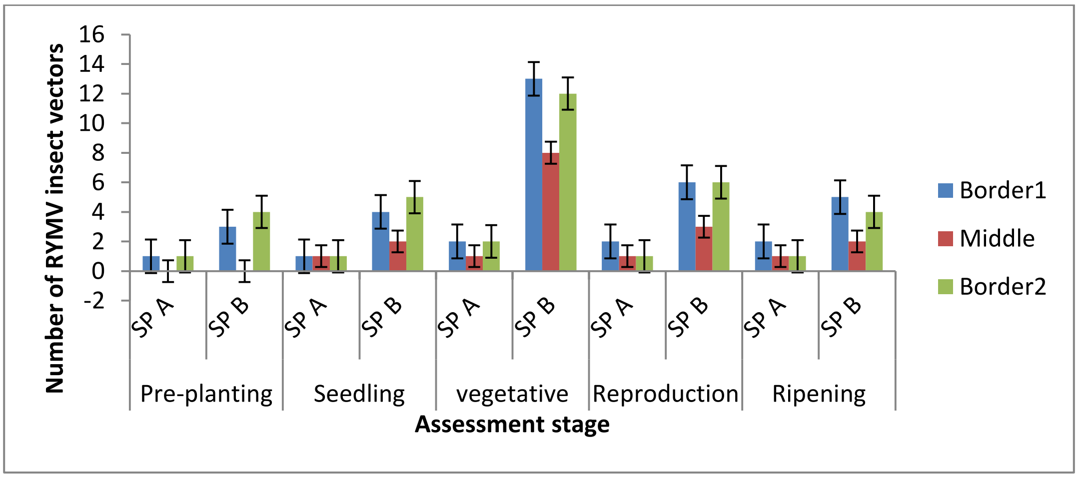

Figure 1: RYMV insect vectors catch in three rice field parts; two border parts and middle in five crop assessment stages

Table 1: Spatial and temporal abundance of RYMV insect vectors within the fields

Field Part sampled	Oxya hyla (Insects /$4m^2$)	Chaetocnema spp (Insects/$4m^2$)
	Mean ± Std Error	Mean ± Std Error
Border1	2 ± 0.14a	6 ± 0.52a
Middle	1 ± 0.12b	3 ± 0.38b
Border2	1 ± 0.14b	6 ± 0.47a
	LSD = 0.5528	LSD = .169

Values followed by different letters in a column were significantly different ($P \leq 0.05$)

International Journal of Novel Research in Life Sciences
Vol. 1, Issue 1, pp: (8-14), Month: September-October 2014, Available at: www.noveltyjournals.com

Table 2: Spatial and temporal abundance of RYMV insect vectors assessed at different crop growth stages

Growth stage	Oxya hyla (Insects/4m^2)	Chaetocnema sp (Insects/4m^2)
	Mean ± Std Error	Mean ± Std Error
Pre-planting	1 ± 0.12a	2 ± 0.35a
Seedling	1 ± 0.13b	4 ± 0.34b
vegetative	2 ± 0.19c	11 ± 0.65c
Reproduction	1 ± 0.18ab	5 ± 0.37b
Ripening	1 ± 0.16ab	4 ± 0.32b
	LSD = 0.52	LSD = 0.93

Values followed by different letters in a column were significantly different ($P \leq 0.05$).

Table 3: Proportional of RYMV vectors abundance with respect to crop growth stages

Growth stage	Total no of	Proportional of *O. hyla*	Proportional of *Chaetocnema*
	vectors/4m^2	per 4m^2	sp per 4m^2
Pre-planting	3	1 (33.33%)	2 (66.67%)
Seedling	5	1 (20.00%)	4 (80.00%)
Vegetative	13	2 (15.38%)	11 (84.62%)
Reproduction	6	1(16.66%)	5 (83.34%)
Ripening	5	1 (20.00%)	4 (80.00%)

Two insect Vectors cached in the study area

Plate 1.Oxya hyla

Plate 2: Chaetocnema sp

International Journal of Novel Research in Life Sciences
Vol. 1, Issue 1, pp: (8-14), Month: September-October 2014, Available at: www.noveltyjournals.com

Table 4: List of RYMV vectors existing in Kilombero District with reference to the reported vectors in Africa

Reported RYMV Vectors in Africa	RYMV vectors recorded in the current study		
Chaetocnema sp	Chaetocnema sp		
Cofana Sp	Oxya hyla		
Locris rurba			
Zonocerus variegates			
Euscyrtus sp			
Trichispa sericea			
Epilachna similis			
Conocephalus sp			
Dactylispa sp			
Sessilia pusilla			
Trichispa sericea			
Oxya hyla			
Aulocophora africana			
Trichispa sericea			

IV. DISCUSSION

Results from this study confirmed that insect vectors contribute to the transmission of RYMV. The average population density of grasshopper (*O. hyla)* in the study area was recorded as 1insects/ field part which is lower than that of the beetles (*Chaetocnema* sp) which was 5insects/field part. Since *Chaetocnema* sp. was found in the entire area under investigation to be more abundant and well distributed in RYMV infected area they may therefore be considered as important vectors of the disease in Kilombero District. The high populations of insect beetles in Kilombero District have been reported before [11]. In the rice fields, however, the population densities of *O. hyla* and *Chaetocnema* sp decreased with the distance from the field borders. In all the studied fields, both insect species were more abundant at the border parts of the field with average of 8 insects/4m^2 and 7 insects/4m^2 than at the middle which was 4insects/4m^2. This is possibly because the border parts of the fields are close to the surrounding bushy vegetations where most of the alternative host plants of the insect species may occur. The observations suggest that there could be many alternative host plants particularly of graminaceae family which supports the survivorship of the vectors during off season after the rice crop has been harvested. Thus, future work should target at identifying the alternative host plants to widen the choices for the control option of the vectors hence the RYMVD.

The results showed that the RYMV is transmitted by insects and that *Chaetocnema* sp and *O. hyla* are the main insect vectors of RYMV in Kilombero District. However, [10] reported only the occurrence *Dactylispa* sp and *Chaetocnema* sp as vectors of rice in Tanzania. The *O. hyla* was first reported as vector of RYMV in Ivory Coast by [2] but had never been reported in Tanzania. Thus, the current study reports the occurrence of this important RYMV vector for the first time in the country. The finding suggest that either the number of important vector species on rice might have increased over the years or the previous studies were restricted to few locations or comprised of few insect samples. Several insect species have been reported as vectors of RYMV in Ivory Coast [18], in Kenya [7], Madagascar [3] and Nigeria [1]. However, [8], [20] did not preclude the possibility of contamination of the plants by these vectors.

The current study also established that that population density of RYMV vectors were dependent on crop growth stages. The number of vectors increased with increase in crop age. At each crop growth stage, number of *Chaetocnema* sp was higher than that of O. *hyla*. The average insect population density in all crop growth stages for *Chaetocnema* sp was 6 insects/4m^2 and that of O. *hyla* was 2 insects/4m^2 which translates to proportional abundance of 78.96% and 21.04%

respectively. Vector numbers was lowest at pre-planting (3 insects/4m^2) and attained peaks at vegetative stage (13 insects/4m^2) and there after started to decline during reproductive stages and further at ripening stage with 6 and 5 insects per 4m^2 quadrant respectively. The causes of such variation may be due to the fact that insects prefer tender leaves which are always available for them during seedling and vegetative stage. During reproduction and ripening stage the crop is at its limited growth stage where no more tender leaves are produced, which cause insects to migrate to new locations in search of fresh tender leaves.

V. CONCLUSION

The population density of *Chaetocnema* sp and O. *hyla*, were variable with respect to the growth stage of the rice crop. High population were recorded during the reproductive stage and gradually decreased with crop maturity. The mature the crop the lesser the number of the two respective vectors. Therefore, the occurrence of RYMVD in Kilombero basin is influenced by the RYMV vectors that are endemic and omnipresent wherever rice is grown.

ACKNOWLEDGEMENT

My sincere gratitude and heartfelt appreciation go to my sponsor, Ministry of Agriculture, Food Security and Cooperatives (MAFSC); my supervisors Dr. G. M. Rwegasira and Dr. P. J. R. Njau of the Department of Crop Science and Production at Sokoine University of Agriculture, for the tireless guidance, close supervision and constructive criticisms throughout the study. Their contributions are highly appreciated.

REFERENCES

[1] Abo, M. E. (1998). Studies on the mode of transmission of RYMV. [Ph.D. Thesis.] Ahmadu Bello University,Zaria, Nigeria.

[2] Abo, M. E. and Sy, A. A. (1998). Rice Virus Diseases: Epidemiology and Management Strategies. Journal of Sustainable Agriculture, Vol. 11(2/3).

[3] Abo, M. E., Sy A. A. and Alebejo, M. D. (2000). Rice Yellow Mottle Virus (RYMV) in Africa: Evolution, distribution and economic significance on sustainable rice production and management strategies. Journal of Sustainable Agriculture 11:85-111.

[4] Andret-Link, P and Fuchs, M. (2005). Transmission specificity of plant viruses by vectors. Journal of Plant Pathology , 87 (3), 153-165.

[5] Andret-Link, P., Schmitt-Keichinger, C., Demangeat, G., Komar V., Fuchs M., (2004). The specific transmission of Grapevine fen leaf virus by its nematode vector Xiphinema index is solely determined by the viral coat protein. Journal of Virology 320: 12-22.

[6] Ali, F. H. (2001). Survey of rice yellow mottle virus disease in the two cropping systems in Tanzania. Paper presented at the workshop on Rice Research in Eastern and Southern Africa Region 12-16 March, 2001, Kilimanjaro Agricultural Training Institute, Moshi, Tanzania.

[7] Bakker, W. (1970). Rice yellow Mottle virus, a mechanically transmissible virus disease of Rice in Kenya.. Netherlands Journal of Plant Pathology 76: 53 - 63.

[8] Bakker, W. (1974). Characterisation and ecological aspects of rice yellow mottle virus in Kenya. Agricultural Research Report. Centre for Agricultural Publishing and Documentation, Wageningen pg 152.

[9] Kanyeka, Z. L., Sangu, E., Fargette, D., Pinel-Galz, A. and Herbrard, E. (2007). Diversity of local strains of rice yellow mottle virus in Tanzania. African Crop Science Journal 15: (4) 201 – 209.

[10] Banwo, O. O; Makundi, R. H; Abdallah, R. S and Mbapila, J. C. (2001). First Report of Dactylispa lenta Weise (Coleoptera: Chrysomelidae) as a Vector of RYMV. Arch. Phytopath. Pflanz., 2001, Vol. 33, pp. 395-403.

[11] Banwo, O. O., Alegbejo, M. D., Abo, M. E. (2004). Rice yellow mottle virus genus Sobemovirus. A continental problem in Africa. Plant Protection Science Journal 40: 26–36.

[12] Brown, D. J. F., Weischer, B. (1998). Specificity and complementarity in the transmission of plant viruses by plant parasitic nematodes: an annotated terminology. Journal of Fundamental Applied Nematology 21: 1-11.

[13] Hull, R. and Fargete, D. (2005). Sobemovirus. In: Virus Taxonomy: Classification and Nomenclature of viruses.`Eight`Report of International Committee on Taxonomy of Viruses. Fauquet, C.M, M.A. Mayo, J., Maniloff, U., Desselberger and L. A. Bal (Eds.).

[14] Jeger, M. J., Holt, J., Van den Bosch F., Madden, L.V. (2004). Epidemiology of insect-transmitted plant viruses: modelling disease dynamics and control interventions. Journal of Physiological Entomology 29: 291-304.

[15] Kanani, K., Reade, R., Rochon, D. (2006). Evidence that vector transmission of a plant virus requires conformational change in virus particles. Journal of Molecular Biology 338: 507-517

[16] Ng, J. C.K., Josefsson, C., Clark Q.J., Franz A.W.E and Perry K. (2005). Virion stability and aphid vector transmissibility of Cucumber mosaic virus mutants. Journal of plant virology 332: 397-405.

[17] Nguyen, J. and Tran, T. K. (1998). Global hybrid rice. Progress, Issues and Challenges. IRC Newsletter, Vol. 47, 52pp.

[18] Nwilene, F. E., Séré Y., Ndjiondjop M.N., Abo M.E., Traore A.K., Asidi A.N., Onasanya. A., Togola, A and Agunbiade T. A.(2008). Rice Yellow Mottle Virus (RYMV) and its Insect Vectors: Ecology and Control. Field Guide and Technical Manual.

[19] Nwilene, F. E; Traore,A. K; Asid,, A. N; Sere, Y; Osanya, 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(4):198-206.

[20] Reckhaus, P. M. and Andriamasintseheno, H. F. (1997). Rice yellow mottle virus inMadagascar and its epidemiology in the northwest of the Island. Z. Pflanzenkr. Pflanzenschutz. 104: 289 - 295.

[21] Sarra, S. (2005). Novel insights in the transmission of RYMV in irrigated rice. PhD Thesis, Wageningen University, Wageningen, the Netherlands.

[22] Sere, Y., Onasanya, A., Nwilene, F. E., Abo, M. E and Akator, K. (2008). Potential of insect vector screening method for development of durable resistant cultivars to rice yellow mottle virus disease. International Journal of Virology 4: 41-47.