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Rice Yellow Mottle Virus (RYMV) Disease: A National Problem in Tanzania

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Rice yellow mottle virus (RYMV) disease, is essentially restricted to the African continent. It is the most important disease on rice in the United Republic of Tanzania (comprising both mainland Tanzania and the islands of Zanzibar). To minimise yield lost to the disease, a thorough knowledge of the epidemiology of the virus and the vector biology/ecology are required. This review therefore puts together the fragment information already available on RYMV epidemiology and vector biology/ecology in Tanzania, with emphasis on progress made and where effort is still required.

Keywords: Epidemiology, rice, rice yellow mottle virus, Tanzania, vectors.

Rice is one of the most important cereal foods in the world. It is popular almost everywhere in Africa south of the Sahara (FAO, 1963). Tanzania is the second largest producer and consumer after Madagascar in the East, Central and South African region (Chinganga, 1985). Rice is grown in all the over twenty regions of the country at varied levels of importance. However, the main growing regions are Mbeya (17%), Morogoro (12%), Mwanza (16%) and Shinyanga (20%). It is grown in different ecologies; rainfed lowland (74%), irrigated lowland (6%) and upland (20%) (Kanyeka et al., 1995) with an average yield of 1.5 t per hectare. Tanzania is about 80% self sufficient and the production figure for 1998/99 season was 676,000 tons from an area under cultivation of 350,000 ha (MoA, 1999). However, the greatest constraints to higher rice yields are weeds, insect pests and diseases.

Rice yellow mottle virus (RYMV) is essentially restricted to the African continent and was first noticed in Kenya, East Africa in 1966 (Bakker, 1970). It is now found in all the rice growing countries of West Africa (Fomba, 1990; Awoderu, 1991; Abo et al., 1998), United Republic of Tanzania in East Africa (comprising both mainland Tanzania and island of Zanzibar) (Buddenhaggen and Rossel, in Rossel et al., 1982; Kanyeka et al., 1996; Ali, 1999), Madagascar (Reckhaus and Randriangaly, 1990) and lately in Mozambique both in the southern African region. In Tanzania, though the disease was first reported in the early 1980s, observations by farmers showed that it has been in existence much earlier and has been observed yearly in hotspot areas where since 1990 consistently high rates of spread occur in susceptibles (Banwo et al., 2001a). Different and recent surveys (Ali, 1999; Luzi-Kihupi et al., 2000) showed that RYMV is spreading fast both between and within the rice growing regions and it is currently the most important disease of rice in Tanzania (Ali, 1999). Unlike other RYMV prevalent countries in Africa where the lowland irrigated ecology is most affected, the lowland rainfed ecology is the most affected with the disease in Tanzania (Ali, 1999). A good control measure depends on a thorough knowledge of the virus epidemiology and biology/ecology of the vectors. This review therefore puts together the fragment information already available on the epidemiological studies on the disease in Tanzania. The progress made and where effort is still required are mentioned.

Causal virus

Rice yellow mottle virus (RYMV) which causes rice yellow mottle disease (RYMD) is a single stranded positive RNA with a molecular weight of 1.40×10^6 daltons. It is a spherical virus of 25 nm diameter (Bakker, 1974; Fauquet and Thouvenel, 1977). The particles are found in the cytoplasm of most cells (Bakker, 1974; Hull, 1988) and in the nuclei (Francki et al., 1985). The virus is a member of the sobemovirus group (Seghal, 1981; Hull, 1988). Sobemoviruses are transmitted mechanically and /or by vectors (Hull, 1988). Other members of this group include Cocksfoot mottle virus (CFMV), Cocksfoot mild mottle virus (CMMV), Southern bean mosaic virus (SBMV), Panicum mosaic virus (PMV), Turnip rossette virus (TROSV), Maize chlorotic mosaic virus (MCMV) and Blueberry shoestring virus (BBSSV). Most of the sobemoviruses are known to occur in relatively large concentrations in infected plants.

Virus isolates

Isolates from the same area could be quite different among each other and close to an isolate from a remote country (Fargette et al., 1995; N'guessan et al., 1995). Five strains (S1 to S5) have been reported to be present in Africa (Pinel et al., 2000) and at least two (S4 and S5) are known to exist in Tanzania (Ali, 1999; Pinel et al., 2000). The isolate (S5) obtained from Morogoro and Mbeya regions in Tanzania is very damaging. It is known to be of more economic importance than the S4 (Ali, 1999; Luzi-Kihupi, 2000) and has not been known to occur in any other RYMV prevalent country (Pinel et al., 2000). Using Mabs developed against an isolate from Madagascar, an isolate (S4) from Mwanza and Shinyanga regions in Tanzania was found similar to isolates from Madagascar and Mali but was different from those collected in Nigeria, Ivory Coast and Kenya (Ali, 1999). These isolates belong to the S1; S1, S2 and S2 groups, respectively (Pinel et al., 2000). It is yet to be shown how the isolates from other regions where RYMV has been observed lately in Tanzania (Z. L. Kanyeka pers. comm.) relate to the other strains (S1 to S5).

Vector transmission

The initial work by Bakker (1971; 1974) reported Chrysomelid beetles genus near *Aphophyla, Oulema dunbrodiensis, Monolepta flaveoli, Sesselia pusilla, Chaetocnema abyssinica, C. pulla, Dactylispa bayoni, Dicladispa paucispina, D. viridicyanea* and *Trichispa sericea.* However, in Tanzania, *C. pulla* and *Trichispa sericea* are known to occur (Banwo et al., 2000; M. Biondi, pers. comm.; Fakih et al., 1998; F. M. Kimmins, pers. comm.). In Tanzania, various species of *Chaetocnema* (species near *Chaeotcnema varicornis, C.*

pulla, C. bamakoensis and *C. kibonotensis*) known as the rice flea beetles and *Dactylispa lenta* (a hispid beetle) have been reported as vectors in the mainland (Banwo et al., 2000) while on the island (Zanzibar) *Trichispa sericea* and *Dicladispa gestroi* also hispid beetles were reported as vectors (Ali and Abubakar, 1995; Fakih et al., 1998). RYMV is transmitted in a semi-persistent manner. The virus is lost by the vector when it moults and does not multiply in the vector. Transovarial transmission has not been reported and does not require a helper virus for transmission (Bakker, 1974). The vectors of RYMV in Tanzania *(Table 1)* are described below. All aspects of vector biology affect their ability to transmit the disease. However, little seems to be known about some vectors.

Rice flea beetles (Alticinae)

Species near *Chaetocnema varicornis, C. pulla, C. bamakoensis* and *C. kibonotensis*

Biology: Little information exists on the biology of the over 100 described species of *Chaetocnema* (Bakker, 1974; Nwilene, 1999; D. Furth, pers. comm.). Bakker (1974) suggested that the larval stages take place in the soil.

Mode of damage: Adult beetle feeds by scratching the leaf surface leaving short, straight and narrow transparent lines (Nwilene, 1999). The damage is more pronounced in species near *C. varicornis* in which leaf is completely cut through in a parallel manner (O. O. Banwo, unpublished).

Host range: Gramineae, Cyperaceae, Marantaceae and Zingiberaceae (Heagreaves, 1937; Bakker, 1974; M. Biondi, in press).

Hispid beetles (Hispinae)

Hispid beetles are important pests of rice (ODNRI, 1976).

Dactylispa lenta

Biology: No information exists on the biology of this afrotropical species (C. Staines, pers. comm; L. Medvedev, pers. comm.).

Mode of damage: Larva mines in leaves while adult eat the surface through the leaves parallel to the veins (Banwo et al., 2001b).

Host range: Gramineae (Banwo et al., 2000; Banwo et al., 2001b)

Dicladispa gestroi

Biology: Reckhaus and Andriamasintseheno (1997) reported that in Madagascar, adults appear at the beginning of the raining season in October/November after a long diapause of about seven months. After a short feeding period, females produce a small crack in the lower side of the rice leaves to lay the eggs. Five to eight eggs are produced daily over a period of several weeks. The entire cycle takes three to four weeks. After three to four generations, large swarms are then formed that invade rice fields.

Mode of damage: Larvae mine leaves while adults eat leaf surface. Their attacks result in withered leaves and white patches (Reckhaus and Andriamasintseheno, 1997)

Host range: Gramineae (Reckhaus and Andriamasintseheno, 1997)

Table 1

Insect vectors of RYMV and their ecologies in Tanzania

Vectors	Common names	Ecology	Geographical distribution
Species near *Chaetocnema varicornis*	Rice flea beetles	Irrigated, lowland rainfed and irrigated	**
Chaetocnema pulla (syn. *C. zeae*)	-do-	Irrigated, lowland rainfed and irrigated	West Africa*, Kenya*, Madagascar*, Saudi-Arabia
Chaetocnema bamakoensis	-do-	Upland mainly	West Africa, East Africa, Sudan, Madagascar, Democratic Republic of Congo
Chaetocnema kibonotensis (syn. *C. kenyensis*)	-do-	Upland mainly	Democratic Republic of Congo, Rwanda, Kenya*, Republic of South Africa
Dactylispa lenta	rice hispa	Lowland rainfed	Sudan, Madagascar, Uganda, Republic of Benin and Democratic Republic of Congo
Dicladispa gestroi	-do-	Lowland irrigated	Madagascar*
Trichispa sericea	African rice hispa	Lowland irrigated mainly	Central, East*, West* and southern Africa

* Also reported as a vector of rice yellow mottle virus
Adapted from: Beart et al. (1960); Bakker, 1974; Awoderu, 1991; ODNRI (1976); Dale (1994); Reckhaus and Andriamasintseheno, 1997; Banwo et al. (2000) and M. Biondi, in press
** It is a newly recorded species and only reported to date to occur in Tanzania (Banwo et al., 2001a)

Trichispa sericea

Biology: Adult female lives for two weeks and lays about 100 eggs within this period. Hatching takes place after three to four days. Larval period lasts about 10 days with the larvae mining inside the leaves. In general, the pupal period lasts about six days with the emerging adults migrating to alternate host plants (Dale, 1994).

Mode of damage: Adults and larvae feed on the leaf tissues of young rice resulting into wafer thin and bleached leaves. Initial attack is highly localised but spreads rapidly and severe attack killing the plant (ODNRI, 1976).

Host range: Gramineae (ODNRI, 1976; Dale, 1994)

Vector abundance and dynamic nature of rice yellow mottle virus

The role of insect vectors in the dynamic nature of RYMV has been fully elucidated in Tanzania (Banwo et al., 2001a) unlike in other disease prevalent countries (Heinrichs et al., 1997; Nwilene, 1999; WARDA, 1999). Under the lowland rainfed ecology, Banwo et al. (2001a) reported that more species near *Chaetocnema varicornis* was found in hotspot than in non-hotspot areas. Also, differences in population of important vectors (species near *Chaetocnema varicornis* and *C. pulla*) was able to explain the disease situations in the three rice seasons under irrigated lowland ecology with the Masika season (February to May) being the most infected of the three seasons (Banwo, 2001).

Transmission by other means

Transmission of RYMV by mechanical means has been reported (e.g. Reckhaus and Andriamasintseheno, 1997; Abo et al., 1998; Ali, 1999), however, virus transmission by this means is highly unlikely to be of any significance under field conditions (Makkouk and Laterrot, 1983; Matthews, 1991). Infection from stubbles/crop residues from subsequent crop has not been reported in Tanzania (Ali, 1999; Banwo, 2001). The virus is not known to be transmitted through seed (Fauquet and Thouvenel, 1977; Awoderu, 1991; Abo et al., 1998; Ali, 1999).

Influence of weather on disease spread

It is not clear how environmental factors like temperature, rainfall and relative humidity bring about differences in vector population and RYMV incidence. In Tanzania, three rice seasons exist under the irrigated lowland ecology; 'Vuli' (October to January), 'Masika' (February to May) and 'Kiangazi' (June to September). RYMV incidence and populations of important vectors (species near *Chaetocnema varicornis* and *C. pulla*) were highest in "Masika" and least in "Vuli". However the temperature, rainfall and relative humidity values for "Masika" were (33.2 ºC, 101.6 mm and 85.6%), "Kiangazi" (30.9 ºC, 9.5 mm and 79.8%) and "Vuli" (35.4 ºC, 70.1 mm and 84.6%) indicating no correlation between the weather factors and the vector population/disease incidence (Banwo, 2001).

Effect on yield

The effect of RYMV on yield declines as crop age at infection increases (Fomba, 1990; Heyland, 1995; Reckhaus and Andriamasintseheno, 1997) and can be lethal to plant if infection occurs early. Yield reduction ranging from 5.7% to 100% has been recorded in Tanzania depending on variety and virus isolate used (Ali, 1999; Luzi-Kihupi et al., 2000). The isolate (S4) found in Mwanza and Shinyanga regions is mild and effects are less well described since it is of less economic importance.

Management strategy

RESISTANT VARIETIES

The use of resistant varieties is perceived by the growers as a cheap and effective method for disease control. Among the varieties so far tested in Tanzania, some showed high resistance to the disease, some had moderate reaction while a great deal were highly susceptible. Luzi-Kihupi et al. (2000) reported that RYMV resistant lines with intermediate amylose content such as Supa SSD5, SupaSSD35, CT6948-1-2-IP, WABIS 18, CT7244-9-1-52 and CABACU stand a good chance of being accepted as new varieties when recommended to farmers. Since consumers in Tanzania prefer long and translucent rice grains with intermediate amylose content which cook moist and fluffy. They also recommended that the use of varieties like FARO11, ITA235, IRAT133 in future breeding programmes as sources of resistance to RYMV. In Zanzibar, the rice variety 'Ali-Badru' introduced to farmers proved tolerant to RYMV. It also has good taste and is easy to harvest because of it's height (Fakih et al., 1998).

HUSBANDARY

Husbandary methods recommended in Tanzania include:

1. Planting at the "earliest safe sowing date" is recommended as a vector avoidance measure for Hispid (Fakih et al., 1998) and rice flea beetles (Banwo et al., 2001a) on the island and mainland respectively.
2. Simultaneous planting by all farmers in the valley to diminish the risk of Hispid beetles infestation and minimise RYMV problems (Fakih et al., 1998).
3. Controlling water levels in the fields since Hispid beetles readily attacks tender plants too deeply immersed in water (Fakih et al., 1998).
4. Keeping the bunds around rice fields clean to reduce the multiplication of vectors on alternate host plants (Luzi-Kihupi et al., 2000)
5. The use of *Tephrosia vogelii* (syn. *Cracca vogelii*) as an insect repellent. It is a leguminous plant native to Tropical Africa containing rotenone an important non-residual insecticide (Fakih et al., 1998; N. J. M. Kibanda, pers. comm.).

CHEMICALS

Though insecticides have been used in Mali (Coulibaly, 1995) and Madagascar (Reckhaus and Andriamasintseheno, 1995) to reduce vector population, they are of little use in Tanzania. These chemicals are beyond the reach of the poor resource-farmers and alongside other disadvantages for their use, they seem unlikely to prevent primary infection and their effect on secondary spread could be swamped by a continuous influx of infective vectors (Plumb, 1983).

Future

In general, an integrated approach is encouraged to minimise the yield losses due to this disease since each of the measures used so far provides only partial control. More work is needed on the epidemiology of the disease. The current distribution and pattern of this disease and the natural hosts of the virus need to be known. Also, the biology of the important vectors such as species near *Chaetocnema varicornis* and *C. pulla* and the relationship between vector population/RYMV incidence and weather are all of epidemiological significance and should be studied further. Species near *Chaetocnema varicornis* an important vector of RYMV and the S5 strain of RYMV have only been known to occur in Tanzania. Though unlike aphids, little is known regarding virus-vector specificity with beetle transmitted viruses, studies to determine this using *Chaetocnema varicornis* and S5 strain of RYMV should be carried out. Work on RYMV resistant varieties which will be acceptable to the farmers/consumers especially in mainland Tanzania should also continue. These items of information will bring about better control strategies and consequently enhance the production and self sufficiency of rice in Tanzania which is now being threatened by this devastating disease.

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