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Maize Stripe Virus: A Disease of Sorghum Emerging in South India

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Introduction

During the growing season several foliar diseases of sorghum *(Sorghum bicolor)* affect grain and stover yields, stover quality and digestibility of the residues. While it is documented that foliar diseases of sorghum affect yields, no data were found in the literature on the effects of foliar diseases on crop residue yield and quality or the economic consequences for rural producers. Recently Rama Devi et al. (2000) indicated that diseased residues command much lower prices in the fodder market. Preliminary studies conducted at ICRISAT, Patancheru, India indicated that sorghum anthracnose *(Colletotrichum graminicola)* and maize stripe virus (MStV), a tenuivirus, reduce crop residue yield, quality and digestibility. Extensive on-farm surveys were conducted at various crop growth stages in India during 1999-2001 mainly to understand prevalence of foliar diseases, farmers' perceptions on sorghum diseases, feeding strategies and cropping pattern. In this article, we report the incidence and severity of MStV in farmers' fields and its likely effects on crop productivity based on the frequency of occurrence of MStV in inoculated and control plots.

Materials and Methods

Prevalence of MStV in farmers' fields. Maize stripe virus of sorghum was monitored in four states of India (Andhra Pradesh, Kamataka, Maharashtra and Tamil Nadu) from August 1999 to March 2001. The latitude and longitude of each of the fields surveyed were recorded using hand held global positioning system instrument (°1993 Magellan System Corporation, San Dimas, California, USA). A total of 939 sorghum fields were surveyed in 570 villages covering 202 farms in seven districts of Andhra Pradesh; 406 in 17 districts of Karnataka; 290 in 21 districts of Maharashtra and 41 in five districts of Tamil Nadu.

A total of 14 foliar, 5 panicle and one parasitic diseases of sorghum were identified using the identification keys of Williams et al. (1978) and Frederiksen and Odvody (2000). The incidence and severity of MStV in each field surveyed was recorded from an area of approximately 12 m^2 selected randomly at three different spots. Incidence (%) was calculated based on number of MStV plants out of the total plants counted and the severity (%) was based on individual plants damaged.

Prevalence of MStV in experimental plots. An experiment was conducted at ICRISAT, Patancheru research farm during the postrainy season 1999/2000 to understand the effect of MStV on grain and stover yields and digestibility under artificial inoculation. Three sorghum genotypes M 35-1, ICSV 93046 and ICSV 745 were planted in 8 rows, each of 4 m length in three replications. Four border rows were planted on either side of each plot to minimize insecticide drift from the control plot to the inoculated plots. Adult plant hoppers *(Peregrinus maidis)* feeding on MStV infected plants of CSH 9 were collected from early-sown ratoon and late-sown main crop of rainy season 1999/2000. Plant hoppers were collected using aspirators. Each plot was covered with nylon mesh nets (6 m wide x 4 m length x 2 m height); later, 4-5 viruliferous adult plant hoppers were slowly transferred into whorls of each plant from the aspirator using camel brush. All the plants in the 'inoculated' treatment were inoculated twice: first, 20 days after emergence and second, 10 days after first inoculation. Plants in control plots were not inoculated but carbofuran granules were placed in whorls at 20 days after emergence and sprayed with insecticide 10 days later. Plants were evaluated at weekly intervals for up to 9 weeks for MStV incidence and at maturity, disease severity was recorded on a 1-5 scale, where 1 = healthy, 2 = 75-100% panicle exertion and <25% stunting, 3 = 26-75% panicle exertion and 25-50% stunting, 4 = <25% panicle exertion and 51-75% stunting and 5 = no panicle exertion and >75% stunting. This scale was developed to include two distinct symptom types of MStV (stunting and panicle exertion).

Measurement of stover and grain yields. At maturity, leaves, stems and panicles from infected and healthy plants from the central four rows in each plot were collected separately in cloth bags, dried in dryers for 3 days at 60°C and dry mass (kg $plot^{-1}$) was recorded. After threshing, grain yield (kg $plot^{-1}$) was recorded. Within the inoculated plot, stover and grain yields of infected and healthy plants were recorded separately and the data was converted to t ha^{-1} considering 133500 plants ha^{-1}. Similarly, the data from the control plots was recorded.

In vitro digestibility measurements. Digestibility was measured based on incubation of sorghum stover in an in vitro gas production test as described by Menke and Steingass (1988). All handling of rumen inoculum was carried out under continuous flushing of carbon dioxide. Portions of about 200 mg air-dried stover were accurately weighed (in triplicate) into 100 ml calibrated glass syringes, fitted with plungers as described by Menke and Steingass (1988) but modified as described by Blummel and 0rskov (1993). In vitro digestibility was calculated as 15.38 + (0.8453* ml of gas produced after 24 h) + (0.595* % crude protein) + (0.181* % ash) as described by Menke and Steingass (1988).

Table 1. Prevalence of maize stripe virus (MStV) of sorghum in four southern states of India, August 1999-March 2001.

State	Year[1]	No. of fields surveyed	No. of fields with MStV	MStV range (%)		MStV mean (%)	
				Incidence	Severity	Incidence	Severity
Andhra Pradesh	1	94	13	<I-30	25-100	9	86
	2	108	5	<1-10	48-80	3	84
Karnataka	1	221	42	<I-50	40-100	15	85
	2	185	73	<1-48	20-100	9	81
Maharashtra	1	45	1	<1	40	<1	40
	2	245	128	<1-100	<1-100	8	94
Tamil Nadu	1	17	2	<I-30	50-60	16	55
	2	24	11	<I-25	75-100	7	97

1. 1 = August 1999 to February 2000; 2 = August 2000 to March 2001.

Table 2. Mean cumulative incidence (%) of maize stripe virus on sorghum over 9 weeks at ICRISAT, Patancheru, India, post rainy season 1999/2000[1].

Genotype	Treatment	1	2	3	4	5	6	7	8	9
ICSV 745	Control	0	0	0	0	0	0	0	0	0
		(0)[2]	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Inoculated[3]	3.9	5.2	8.4	11.2	12.8	15.3	16.6	17.5	17.6
		(3.9)	(1.3)	(2.8)	(2.5)	(1.6)	(1.9)	(1.0)	(0.4)	(0.1)
ICSV 93046	Control	0	0	0	0	0.2	0.2	0.2	0.2	0.2
		(0)	(0)	(0)	(0)	(0.2)	(0)	(0)	(0)	(0)
	Inoculated[3]	5.8	13.1	23.2	29.6	31.3	35.2	36.4	37.4	37.7
		(5.0)	(5.0)	(5.0)	(4.6)	(1.3)	(1.8)	(0.7)	(0.3)	. (0.2)
M 35-1	Control	0	0	0	0	0	0	0.2	0.2	0.4
		(0)	(0)	(0)	(0)	(0)	(0)	(0.1)	(0.1)	(0.1)
	Inoculated[3]	2.5	4.2	9.5	18.3	19.4	21	22.9	24.8	25.8
		(2.5)	(1.7)	(5.0)	(5.0)	(0.8)	(0.8)	(1.3)	(0.9)	(0.4)
SEm±		1.0	2.1	3.7	5.0	5.3	5.9	6.2	6.5	6.5
		(0.9)	(0.8)	(1.0)	(1.0)	(0.3)	(0.4)	(0.2)	(0.2)	(0.1)

1. Mean of 3 replications.
2. Data within parentheses indicate mean weekly severity scores on 1-5 scale, where 1 = healthy, 2 = 75-100% panicle exertion and <25% stunting. 3 = 26-75% panicle exertion and 25-50% stunting, 4 = <25% panicle exertion and 51-75% stunting and 5 = no panicle exertion and >75% stunting.
3. Artificially infected by placing 4-5 viruliferous plant hoppers $plant^1$.

Results and Discussion

Prevalence of MStV. Among 14 foliar diseases observed, MStV emerged as the most destructive disease with a mean incidence of 6% with 85% severity in Andhra Pradesh, 12% incidence and 83% severity in Karnataka, 5% incidence and 67% severity in Maharashtra and 12% incidence and 76% severity in Tamil Nadu across two years. The fields infected with MStV varied in the four states: 9% in Andhra Pradesh, 28% in Karnataka, 45% in Maharashtra and 32% in Tamil Nadu. The incidence and severity of MStV varied from year to year and were higher in year 1 (August 1999 to February 2000) than in year 2 (August 2000 to March 2001) (Table 1). This variation could be due to weather factors, vector survival, cropping pattern, host specificity, etc. Monocropping and survival of vector on ratoon crop, on tillers, and on main crop probably aggravate the infestation and spread of MStV. Therefore, it is essential to understand that variability in distribution of MStV in the states surveyed does not imply that the disease is necessarily restricted to a particular zone or location. On-farm survey indicated the characteristic of MStV in reducing stover and grain yields. This was evident from the type of symptoms observed as well as from the incidence and severity. We observed that if the MStV infestation occurs at the vegetative stage the losses were higher than when the infestation occurrs in later growth stages.

Table 3. Effect of maize stripe virus of sorghum on mean stover and grain yields, ICRISAT, Patancheru, India, postrainy season 1999/2000.

		Mean yield[1] (t ha^{-1})	
Genotype	Treatment	Stover	Grain
ICSV 745	Control	5.90	5.48
	Inoculated[2]	4.59	4.67
ICSV 93046	Control	11.72	4.21
	Inoculated[2]	8.14	2.45
M 35-1	Control	8.83	3.64
	Inoculated[2]	8.26	3.20
LSD (P <0.05)		1.49	0.73

1. Based on population of 133500 plants ha^{-1}.
2. Artificially infested by placing 4-5 viruliferous plant hoppers $plant^{-1}$, and the yield from the inoculated treatment was recorded both from (i) plants infected at 37, 46, 52, 58, 65, 72, 79, 86 and 91 days after emergence; and (ii) uninfected plants.

Effects of MStV on stover and grain yield and digestibility under artificial inoculation. An experiment conducted at ICRISAT, Patancheru to better understand the effect of MStV on sorghum grain and stover yields under artificial inoculation revealed 37.7% mean cumulative incidence in ICSV 93046 followed by 25.8% in M 35-1 and 17.6% in ICSV 745 (Table 2). Disease severity was higher in initial 4 weeks than in later weeks indicating that the vegetative stage is more susceptible to MStV than the reproductive growth stage (Table 2). Mean grain and stover yields and digestibility varied with inoculated and control treatments in all the three genotypes (Tables 3 and 4). Our observation on yields is similar to Narayana and Muniyappa (1995).

We also observed that MStV occurs in different agro-ecological zones. It is currently not known if the virus occurs as distinct strains. Resistant sources for the virus or to the vector have so far not been identified and also the epidemiology of the disease has not been thoroughly investigated. As a result control measures are currently not available. Therefore, hot spots for MStV need to be identified in major sorghum-growing areas of India and in other countries, thus facilitating large-scale screening of sorghum genotypes for MStV resistance. To have better understanding of the disease and causal agent, there is a need to collect isolates from different ecological zones, maintain, purify, develop diagnostic tools to distinguish different isolates, develop screening techniques and identify broad-based resistance.

Table 4. Mean digestibility (%) of maize stripe virus infected and healthy sorghum plants'.

		Leaf		Stem	
Genotype	Treatment	Healthy	Infected[2]	Healthy	Infected[2]
ICSV 745	Control	54.67	-	54.66	-
	Inoculated	58.67	59.33	54.33	55.00
ICSV 93046	Control	61.33	-	55.33	-
	Inoculated	60.67	60.00	53.00	60.00
M 35-1	Control	61.00	-	51.33	-
	Inoculated	61.33	60.67	50.00	60.00

1. Data arc means of three replications.
2. Plants infested at 37, 46, 52, 58, 65, 72, 79. 86 and 91 days after emergence were processed for digestibility and the values of infected plants were pooled.

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Entomology

Relative Susceptibility of Forage Sorghum Hybrids to Spotted Stem Borer *Chilo partellus*

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Introduction

Sorghum *(Sorghum bicolor)* is one of the most widely adopted forage crops in North India due to its high yielding ability and fast growth. It is mainly used as green chop, silage and hay. From sowing to harvest, this crop is attacked by more than 150 insect species, of which the spotted stem borer, *Chilo partellus,* is the most serious pest. Stem borer damage starts when the crop is two weeks old. In younger plants shot-holes caused by the early-instar larvae feeding in the leaf whorl are visible, while the older larvae leave the whorl and bore into the stem and damage the growing point, which results in deadheart formation. Feeding by the larvae inside the stem results in stem tunnelling, and reduction in plant vigor and fodder quality. Yield losses of about 40% have been reported in forage sorghum (Singh 1997). Though this pest can be effectively controlled by insecticides (Singh and Lodhi 1995), the expenditure involved is prohibitive and pesticide residues can also pose a hazard to livestock. The solution, therefore, lies in development of pest resistant varieties and their use to reduce insect damage.

Though forage sorghum hybrids are more prone to insect damage as compared to open-pollinated varieties, the demand for forage hybrids has gone up in recent years. This is because of their superiority, ie, multi-cut forage production as well as quick growth, high tillering, sweetness, and palatability to cattle. Very little emphasis has been given on screening forage sorghum hybrids against stem borer. This study was therefore conducted to evaluate the available forage sorghum hybrids for resistance to *C. partellus.*

Materials and Methods

Forty sorghum genotypes (consisting of 30 forage hybrids, five forage varieties, three resistant checks, and two susceptible checks) were sown during *kharif* (rainy) season 1996 at the Experimental Area of the Department