

Prevalence and Detection of viruses Associated with Mosaic Disease of Sugarcane in Andhra Pradesh

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ABSTRACT: Sugarcane represents third largest crop in terms of value next to rice and wheat in India and it is one of the most important commercial crops cultivated worldwide for products like white sugar, bagasse and ethanol. Among the diseases of sugarcane, mosaic disease is one of the most destructive viral disease which imposes serious threat to sugarcane cultivation by reducing both sugar content and cane yield. Since diagnosis is very crucial for effective management of the disease, a comprehensive and systematic survey was conducted in 126 fields belonging to 126 villages spread over 14 districts of Andhra Pradesh, India for assessing the incidence of mosaic disease. Mosaic incidence varied across the districts in the range of 14 % to 90 % in commercial varieties. Highest mosaic incidence was observed in Anakapalle district (66.64 per cent (%)) followed by Krishna district (64.66 %) and least incidence was observed in Alluri Sitharamaraju district (17.08 %) followed by Parvathipuram Manyam district (31.77 %). Almost all the varieties grown in Andhra Pradesh viz., 2009A 107, 87A 298, 2003V 46, Co 86032, 81V 48, 2015A 311, Si-2010-123, Si-2010-309, ROC-16 and VCF-517 were affected, but percent incidence varied from genotype to genotype, location, stage of the crop and type of the crop. Symptoms varied from cultivar to cultivar. Symptomatic sugarcane leaf samples were collected, total RNA was isolated from infected samples and RT-PCR assays were performed using *Sugarcane mosaic virus* and *Sugarcane streak mosaic virus* primers. Samples were found to be infected by SCMV and SCSMV showed the expected amplicon size of 891bp and 690 respectively during RT-PCR.

Keywords: Prevalence, Mosaic, Incidence, RT-PCR. SCMV and SCSMV.

INTRODUCTION

Sugarcane represents third largest crop in terms of value next to rice and wheat in India and it is one of the most important commercial crops cultivated worldwide for products like white sugar, bagasse, ethanol, etc. Mosaic is an important viral disease of sugarcane with significant yield losses in India (Vishwanathan and Balamuralikrishnan 2005). Andhra Pradesh has an area of 0.99 lakh hectares with a production of 65.5 lakh tonnes and productivity of 76.14 tonnes per hectare (Anonymous, 2022). It is affected by more than 50 diseases caused by fungus, bacteria, virus, phytoplasma and nematodes which substantially reduce cane yield and quality (Rott *et al.*, 2000; Viswanathan, 2018). Among the viral diseases of sugarcane, mosaic disease is the most destructive and has become serious threat to sugarcane cultivation by reducing both sugar content and cane yield. Vegetative propagation in sugarcane is the major factor which encourages transmission of most of the viral, bacterial, fungal and phytoplasmal pathogens through the seed cane material. Sugarcane mosaic was first reported in India from Pusa in 1921 on sugarcane variety D 99 and Sathi 131, an indigenous cane of Bihar (Dastur, 1923). In India, Incidence of

mosaic disease is almost 100% and cause and results in significant yield losses considering the vast area under sugarcane cultivation (Bhargava, 1975; Agnihotri, 1996; Singh, 2001). It can infect sugarcane together with *Sugarcane streak mosaic virus* (SCSMV) (Hema *et al.*, 2003; Chatenet *et al.*, 2005). The most common symptoms of the disease are interveinal chlorotic specks, streaks or stripes especially on young leaves of sugarcane (Viswanathan and Rao 2011). SCMV was readily transmitted by infected setts, mechanical inoculation and several aphid species viz., *Aphis gossypii*, *Longiunguis sacchari*, *Myzus persicae* and *Rhopalosiphum maidis* (Rao and Ford 2001; Singh *et al.*, 2005). SCMV is also reported to affect many poaceous plants species which serve as collateral host of the virus (Rao *et al.*, 1990).

In Andhra Pradesh, many varieties of sugarcane are being grown were also found to be affected by mosaic epidemic form and drastically affecting many of the ruling varieties of sugarcane (Varma *et al.*, 2020). Nevertheless, no extensive studies has been made to find out the exact status of the disease incidence, factors responsible for incidence in this region. The present study was therefore undertaken to conduct detailed survey at different major sugarcane growing belts in

Andhra Pradesh to find out the incidence of the mosaic disease and to further study the factors responsible for incidence.

MATERIALS AND METHODS

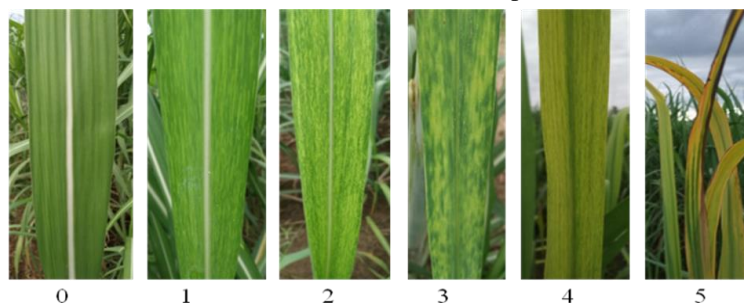
A comprehensive and systematic surveys during 2021-22 were conducted to record the prevalence of mosaic disease in sugarcane growing regions of Andhra Pradesh. In each district three taluks/mandals and in each taluk/mandal three villages and two fields from each village were surveyed. Five locations, *i.e.*, one at the centre and four corners of the sugarcane field were

selected to record the incidence of mosaic. Number of plants infected out of 50 plants in each corner of the field and at the center were assessed by visual observation and per cent incidence of the disease was calculated.

The ratio of diseased plants relative to the total number of plants assessed is referred to as disease incidence. Scale of 0-5 grading system was constructed to score the disease severity of mosaic (Table 1 & Fig. 1).

Percent incidence of the disease was calculated by using formula

$$\text{Per cent disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$



0. Plants with no mosaic symptom; 1. Light green streaks or chlorotic areas in the crown region; 2. Typical mosaic symptoms with dark green islands throughout the canopy; 3. Extensive yellowish blotches throughout the lamina; 4. Systemic yellowing of leaves; 5. Extensive yellowing and drying of foliage.

Fig. 1. Disease severity scale for mosaic disease.

RESULTS AND DISCUSSION

A comprehensive and systematic survey was carried out in Andhra Pradesh to determine the incidence of mosaic disease in major sugarcane growing regions of Andhra Pradesh during 2021-2022 crop season. Surveyed areas and the data was summarized in Table 1. In the surveyed areas, farmers cultivated sugarcane crop in varied soils (red loamy, red sandy, sandy loam and black loamy) under rainfed conditions as sole crop.

In Andhra Pradesh, the crop is cultivated mainly as sole crop. In surveyed locations, mean maximum mosaic incidence was observed in Anakapalle district (66.64 per cent (%)) followed by Krishna district (64.66 %) and least incidence was observed in Alluri Sitharamaraju district (17.08 %) followed by Parvathipuram Manyam district (31.77 %). In Anakapalle district highest incidence was noticed in ratoon crop (cv. 2009A 107) in RARS, Anakapalle (90.00 %) and least incidence was observed in Lakshampuram village of Waddadimandal (58.00 %). The overall incidence of was ranged from 14.00 to 90.00 % across all the districts and mandals. Similar reports were observed by Varma *et al.* (2020); Rajkumar and Kumar (2019). None of the variety was found to be free from mosaic incidence. Almost all the varieties grown in Andhra Pradesh *viz.*, 2009A 107, 87A 298, 2003V 46, Co 86032, 81V 48, 2015A 311, Si-2010-123, Si-2010-309, ROC-16 and VCF-517 were affected, but percent incidence varied from genotype to genotype, location, stage of the crop and type of the crop (plant or ratoon). Higher incidence was observed in cultivar 2009A 107 in almost all sugarcane growing areas indicating the susceptible nature of the variety to

mosaic. 2003 V46, the genotype that is largely grown in Andhra Pradesh was also affected, but it is dominated by *Sugarcane yellow leaf virus*. ROC 16 a cultivar which is widely grown in Krishna and Godavari zones recorded severe incidence of the disease. VCF 517 which is largely grown in Rayalaseema districts recorded higher incidence of the disease. Moderate to severe incidence was observed in cv. 87A 298. Irrespective of the genotype, disease increased to multifold in ratoon crops. Percent incidence, vector incidence as well as symptom expression was much more in ratoon crops compared to plant crops. The disease intensity was much more in hot summer months and severity extends with increase in the age of crop. Tillering stage is the stage where prominent symptoms can be observed, later disease incidence extends from one plant to other plant in a clump due to horizontal transfer as well as vector association and abiotic factors. Severe incidence of mosaic in early stages of crop growth was found detrimental to the crop as it completely retards the plant growth. As most of the sugarcane area is under rainfed conditions in majority districts of Andhra Pradesh, delayed application of fertilizers till the occurrence of monsoon rains is a common practice, thus reducing the plant vigour, thereby making the plants easily prone to viral diseases. Sugarcane growers in Rayalaseema districts were not following intercultural operations as well as propping may be the reason for severe occurrence of the disease. Severe occurrence of the disease was noticed in most of the areas surveyed in susceptible cultivars. Aphids like sugarcane aphid and rusty plum aphid and pink mealy bug were commonly observed in various districts surveyed aiding in the horizontal spread of the disease

under favourable conditions. According to Perera *et al.* (2012), varietal susceptibility, strain of the virus, vector population and prevailing weather conditions have a marked influence on mosaic incidence and severity.

Higher disease incidence may be attributed to larger area under cultivation of susceptible sugarcane cultivars, the practise of ratooning, the climate favouring the population of vectors, and non-adoption of management practises. Exchange of contaminated planting material, vectors association as well as vegetative propagation is the major factor for higher incidence of the disease. Lack of virus management and continuous cropping may have caused a build-up of disease threat in fields, which could explain for higher incidence in the locations investigated.

Symptomatology. Mosaic infected plants were diagnosed based on symptoms such as chlorotic specks, chlorotic streaks, pale green specks, mild mottling, green islands, yellow blotches, systemic yellowing, marginal drying, necrosis and stunting of plants.

The characteristic symptoms appeared more prominently on young, rapidly growing leaves, particularly near the basal portion of the leaf. Chlorotic or yellow stripes alternate with normal green portions of the leaves gives a mosaic pattern. The symptoms were prominently noticeable from tillering stage of the crop and its severity extends to increase with increase in the age of crop. The disease starts as chlorotic areas or chlorotic streaks alternate with green portions on the

basal portion of young leaves followed by dark green islands alternate with chlorotic areas or streaks throughout the canopy. Later these chlorotic areas diffuse results yellow blotches which leads to systemic yellowing followed by marginal drying, necrosis and stunting of plants (Fig. 2). Many irregular yellow and green inlays, stripes, or mottles alternate with parallel veins on symptomatic leaves, more clearly visible against the sunlight in case of streak mosaic. Some are mostly normal green with only a few narrow pale-yellow streaks, some show very obvious whole leaf chlorosis, and the seriously infected leaves turn yellow or yellow white, leaving only a few green islets or a small amount of red punctate necrosis or the tips of new leaves are abnormally twisted. Similar kind of mosaic symptoms on sugarcane were also observed by Lu *et al.* (2021); Varma *et al.* (2020); Viswanathan and Rao (2011). Symptoms of mosaic varied from cultivar to cultivar. *i.e* chlorotic areas, chlorotic streaks, green islands, yellow blotches, systemic yellowing, marginal drying, necrosis and stunting. Chlorotic areas alternate with green portions resembling mosaic pattern is the most common symptom observed in most of the genotypes followed by increasing the severity turning in to yellowing, reddening and drying of leaves. Mosaic followed by systemic yellowing of leaves is most commonly observed symptom in the genotype 2009A 107.

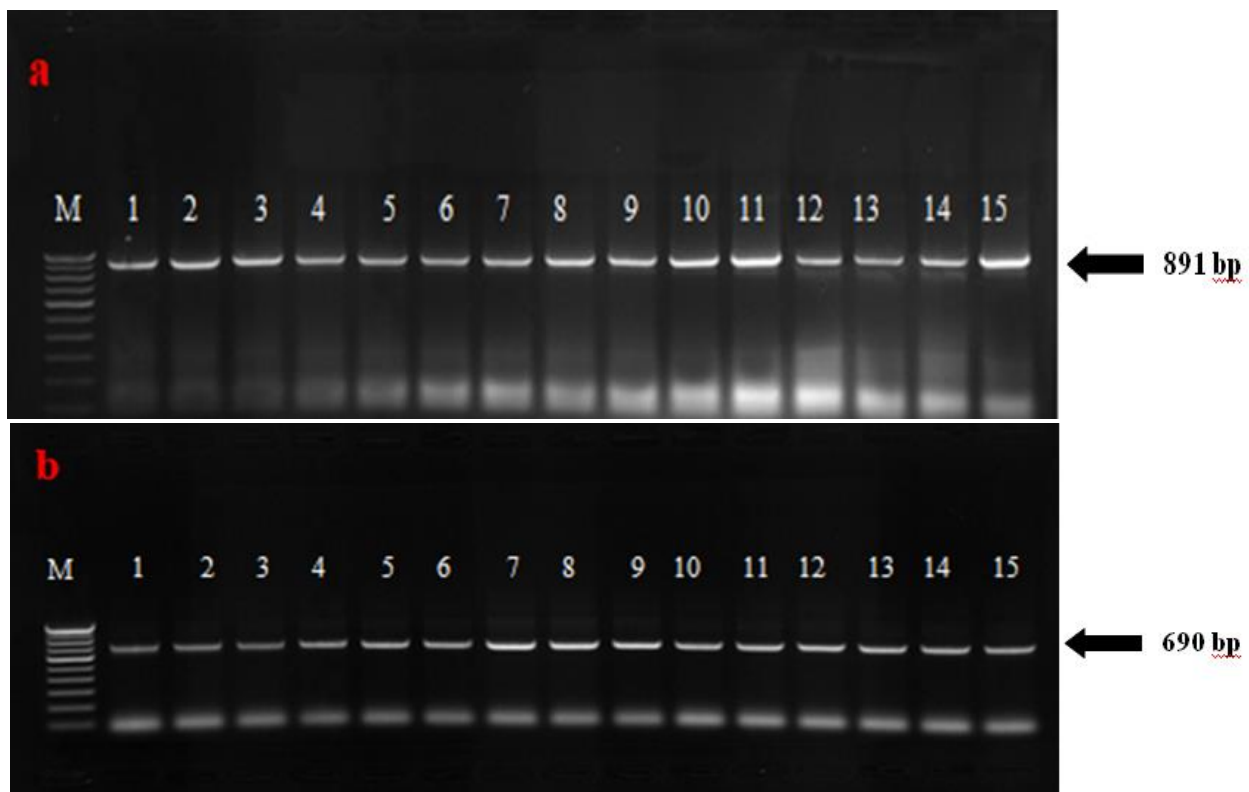


Fig. 1. Reverse transcription-polymerase chain reaction (RT-PCR) amplification (690bp) of coat protein gene of a) SCMV, b)SCSMV from mosaic affected sugarcane samples collected in Andhra Pradesh. {lane M: 100 bp ladder, lane 1 to 15: SCMV and SCSMV isolates from different places}.

Systemic yellowing indicates the severe expression of the disease in the crop. Mild mottling to severe mosaic was observed in 93A 145 and 87A 298. Most varieties 2003V 46, Co 86032, 81V 48, 2015A 311, Si-2010-123 and Si-2010-309 under cultivation exhibited chlorotic areas alternate with green portions on the basal portion of young leaves as initial symptoms, later results in systemic yellowing and stunting of plants. Almost all the leaves were observed to express symptoms in case of infected plants in cv ROC 16. Systemic yellowing, necrosis and stunting of plants were commonly observed in VCF-517. In case of ratoon crop the disease incidence as well as symptom expression was more in combination with chlorotic streaks, systemic yellowing, marginal drying, necrosis and stunting of plants.

Disease severity scale was constructed to score the severity of the disease.

Detection. RT-PCR analysis were subjected to collected samples during survey with SCMV and SCSMV specific primers targeting coat protein. SCMV and SCSMV infection in the widely-cultivated popular cultivars was validated by the amplification of 891bp and 690bp amplicons which indicated positive SCMV and SCSMV detection respectively in sugarcane growing areas of Andhra Pradesh. He *et al.* (2022); Singh *et al.* (2009); Viswanathan and Rao (2011) who reported that mixed infections of two viruses are associated with mosaic disease in India as well as other countries.

Table 1: Survey for the prevalence of mosaic disease of sugarcane in Andhra Pradesh during 2021-2022.

Sr. No.	District	Mandal	Village	DI (%)	Mandal Mean	District Mean	Varieties	Symptoms	Stage of crop	Plant crop/ratoon
1.	Srikakulam	Burja	Burja	46.00	43.33	42.66	2009A 107 87A 298 2003V 46 Co 86032	Mild mosaic, Streaks, Mottling, Necrosis, yellowing	Formative	Plant crop and ratoon
			Vavam	44.00						
			Mamidivalasa	40.00						
		Narsannapeta	Devadi	38.00	40.00					
			Mabagam	40.00						
			Urlam	42.00						
		Pothuru	Nivagam	48.00	44.66					
			Mathala	42.00						
			Madhanapuram	44.00						
2.	Parvathipuram Manyam	Palakonda	Ampili	36.00	32.60	31.77	87A 298 2003V 46 2009A 107 81V 48	Streaks, Mosaic, Mottling, Necrosis.	Formative	Plant crop and ratoon
			Annaram	32.00						
			ChinnaMangalapuram	30.00						
		Veeraghattam	Talavaram	34.00	34.00					
			P.Nandivada	32.00						
			Motta Venkatapuram	36.00						
		Seethampeta	Addakulaguda	28.00	28.66					
			Vajjaiguda	26.00						
			Kusumi	32.00						
3.	Vizianagaram	Merakamudidham	Yadiki	32.00	38.00	41.99	2003V 46 2009A 107 87A 298	Intense mosaic, Streaks, Chlorotic areas, Mottling, Reddening.	Tillering	Plant crop and ratoon
			Itamvalasa	38.00						
			Garugubilli	44.00						
		Garividi	Geddapuvalasa	46.00	42.66					
			Duggivalasa	42.00						
			Appannavalasa	40.00						
		Rajam	Boddam	46.00	45.33					
			Soperu	42.00						
			Punugutivalasa	48.00						
4.	Alluri Sitharamaraju	Paderu	Thumpada	16.00	16.66	17.08	87A 298 2006A 223 2009A 107 2003V 46	Mild mosaic, Streaks, Chlorotic areas.	Grand growth stage	Plant crop and ratoon
			R. Kothuru	14.00						
			Gaddamputtu	20.00						
		Hukumpeta	Neelamputtu	22.00	18.60					
			Vanukuru	18.00						
			Rapa	16.00						
		G.Madugula	Bandaveedhi	16.00	16.00					
			Vennela	18.00						
			Thummedala Nerudu	14.00						
5.	Anakapalli	Anakapalli	RARS, Anakapalle	90.00	73.33	66.44	2009A 107 2003V 46 81V 48 87A 298 2017A553 2015A311 Co 997 Co 7706	Intense mosaic, Streaks, Chlorotic stripes, Flecks, Mottling, Reddening	Formative	Plant crop and ratoon
			Thummapala	66.00						
			Venkupalem	64.00						
		Chodavaram	Chodavaram	68.00	66.00					
			Lakkavaram	64.00						
			Juttada	66.00						
		Waddadi	Lakshmipuram	58.00	60.00					
			Bangarumetta	60.00						
			Pottidorapalem	62.00						
6.	Kakinada	Peddapuram	Marlava	48.00	46.00	45.75	Si-2010-123 Si-2010-309 2003V 46 87A 298	Intense mosaic, Streaks, Chlorotic areas, Flecks, Mottling.	Grand growth stage	Plant crop and ratoon
			Kandrakota	46.00						
			Sriwada	44.00						
		Kirlampudi	Veeravaram	42.00	46.66					
			Divii	48.00						
			Rajupalem	50.00						
		Yeleswaram	Peddannapalli	48.00	44.60					
			Yarravaram	42.00						
			Krishnavaram	44.00						
7.	East Godavari	Nallajerla	Anantapalli	44.00	44.00	42.22	2009A 107 Si-2010-	Mottling, Streaks, Flecks,	Grand growth stage	Plant crop and ratoon
			Gundepalli	38.00						
			Pothavaram	50.00						

		Devarapalle	Duddhukuru	48.00	42.00	123 Si-2010-309 2003V 46	Reddening.								
			Gowripatnam	42.00											
			Bandapuram	36.00											
		Kovvuru	Kovvuru	44.00	40.66										
			Nandhamuru	42.00											
			Pasivedala	36.00											
8.	Eluru	Dhendhuluru	Muppavaram	34.00	32.66	87A 298 2009A 107 Si-2010-123 Si-2010-309 ROC-16 2003V 46	Mild mosaic, Streaks, Mottling, Necrosis, Stunting.	Formative	Plant crop and ratoon						
			Sriramavaram	28.00											
			Thimmanagudem	36.00											
		Bimadole	Surappagudem	38.00	35.33										
			Polasaniipalli	36.00											
			Amberpeta	32.00											
		DwarakaTirumala	M.Nagulapalli	38.00	33.33										
			Timmapuram	28.00											
			Vempadu	34.00											
		9.	West Godavari	Tadepalligudem	Kommugudem					46.00	45.33	87A 298 2009A 107 Si-2010-123 Si-2010-309 ROC-16 2003V 46	Yellowing, Mild mosaic, Streaks, Mottling, Necrosis	Grand growth stage	Plant crop and ratoon
					Neeladripuram					42.00					
					Apparaopeta					48.00					
Tanuku	Velupuru			48.00	48.00										
	Komaravaram			50.00											
	Duvva			46.00											
Penugonda	Cherukuwada			44.00	44.00										
	Ramannapalem			42.00											
	Munamarru			46.00											
10.	NTR District	Vijayawada Rural	Pathapadu	60.00	62.00	ROC-16 93V 297 2009A 107 2003V 46 87A 298	Mild mosaic, Streaks, Mottling, Necrosis Stunting.	Formative	Plant crop and ratoon						
			Nidamanuru	70.00											
			PhiryadiNainavaram	56.00											
		Ibrahimpatnam	Kotikalapudi	48.00	56.00										
			Kethanakonda	62.00											
			Mulapadu	58.00											
		G.Konduru	Velagaleru	56.00	59.33										
			Narasayagudem	62.00											
			Chegireddipadu	60.00											
		11.	Krishna	Thotlavalluru	Kummamuru					62.00	61..33	ROC-16 93V 297 2009A 107 2003V 46 87A 298	Mosaic, Streaks, Mottling, Necrosis	Grand growth stage	Plant crop and ratoon
					Kanakavalli					58.00					
					Penakamuru					64.00					
Pammidimukkala	Pammidimukkala			60.00	64.66										
	Veerankilaku			66.00											
	Meduru			68.00											
Penamaluru	Penamaluru			68.00	68.00										
	Vanukuru			66.00											
	Gosala			70.00											
12.	Nellore			Buchireddypalem	Damaramadugu	38.00	35.33	2003V 46 2009A 107 VCF-517 87A 298	Yellowing, Intense mosaic, Streaks, Mottling.	Maturity	Plant crop and ratoon				
					Panchedu	32.00									
					Penuballi	36.00									
		Varikuntapadu	Varikuntapadu	36.00	32.00										
			Kaniampadu	28.00											
			Bhasakarapuram	32.00											
		Kovur	Kovur	30.00	30.00										
			Inamadugu	28.00											
			Leguntapadu	32.00											
		13.	Sri Balaji	Nindra	M.G. Kandriga	60.00	58.66					VCF-517 2003V 46 2009A 107 87A 298	Yellowing, Mild mosaic, Streaks, Mottling	Grand growth stage	Plant crop and ratoon
					Athur	64.00									
					Varuvuripeta	52.00									
Pichaturu	Vengalathur			64.00	66.00										
	Velur			66.00											
	Sivagiri			68.00											
Vijaypuram	Kaliambakam			62.00	64.66										
	SamireddiKandriga			64.00											
	Pannur Substation			68.00											
14.	Chitoor	Sri Rangaraju Puram	SNJ sugars	52.00	52.00	Co 11015 VCF-517 2003V 46 2009A 107 87A 298	Intense mosaic, Streaks, Mottling, Necrosis Stunting.	Maturity	Plant crop and ratoon						
			Nelavoy	56.00											
			Giddamakarajapuram	48.00											
		Karvetinagaram	R.K.V.B Peta	46.00	46.00										
			Katherpalle	48.00											
			Karvetinagar	44.00											
		Narayanavanam	Bopparajupalem	48.00	48.00										
			Keelagaram	50.00											
			Kasimmitta	46.00											



Fig. 2. Mosaic disease symptoms of sugarcane (a) Chlorotic areas alternate with green portions on basal portion of young leaf (b) Typical mosaic symptoms with dark green islands throughout the canopy region (c) Leaves of mosaic showing extensive yellow blotches in lamina region (d) Systemic yellowing of leaves and drying of leaves due to severe mosaic incidence (e) Pronounced stunting of plants with extensive yellowing and drying of leaves (f) Sugarcane Aphid (*Melanaphis sacchari*) (g) Rusty plum aphid (*Hysteroneura setariae*).

CONCLUSIONS

The study serves as a comprehensive report to date on the mosaic disease incidence in sugarcane growing regions of Andhra Pradesh. The findings of this study shows that SCMV and SCSMV infections have occurred in sugarcane fields in Andhra Pradesh and has spread to new areas, primarily through infected setts, vectors and planting material. Some of the cultivars were found more susceptible to mosaic compared to others. This study emphasize the importance of SCMV and SCSMV indexing in planting material prior to distribution of seed setts to the farmers by the sugar industries of Andhra Pradesh which will ensure healthy planting material to the growers leading to higher sugarcane productivity and cane quality.

FUTURE SCOPE

Researchers need to identify the resistant varieties to mosaic.

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Conflict of Interest. None.

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