

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.912.313>

## Field Assessment of Red Rot and Smut Resistance in Sugarcane Germplasm under Artificial Inoculated Conditions

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### ABSTRACT

Sugarcane is an important cash crop grown in tropical and sub-tropical areas in India as a source of raw material for sugar and bio-ethanol production. Diseases are the major constraints in sugarcane production causing severe economic losses. Various fungi, bacteria, viruses and phytoplasma causes diseases in sugarcane resulting in loss of cane yield and juice quality, thus reducing sugar recovery. Among fungal diseases red rot and smut are major diseases in North coastal districts of Andhra Pradesh inciting huge losses. Hence, the present study was undertaken to identify red rot and smut resistance in fourteen sugarcane genotypes under field conditions upon artificial inoculation. Plug and nodal methods of red rot inoculation was done in 20 standing canes of each variety for two subsequent years, 7 months after planting. Inoculated canes were assessed by longitudinal splitting of the canes 60 days after inoculation. Among fourteen genotypes evaluated for red rot resistance, five genotypes, 2015A 51, 2015A 59, 2015A 228, 2015A 230 and 2015A 233, were found resistant to red rot disease under plug method of inoculation and the rest reacted as either moderately resistant/ moderately susceptible/ susceptible/ highly susceptible. Two budded sets of fourteen sugarcane genotypes soaked in smut chlamyospore suspension were planted under field conditions and emergence of smutted whips was recorded from first whip appearance till harvest. Only one genotype, 2015A 222, has consistently shown moderately resistant reaction to smut disease during two years of assessment. The genotypes showing resistance could be used as resistant donors for breeding programme or released as resistant varieties upon agronomic evaluation.

#### Keywords

Sugarcane,  
Red rot, Smut,  
Screening,  
Resistance

#### Article Info

Accepted:  
18 November 2020  
Available Online:  
10 December 2020

### Introduction

Sugarcane is one of the important cash crops grown in Andhra Pradesh and is a main source of raw material for sugar and bioethanol production. The crop is grown in an area of 1.02 lakh ha with 80.6 lakh tonnes production (DES, GOI, 2020). The productivity of the crop is low in Andhra Pradesh compared to other sugarcane growing

states of the country. This may be attributed to poor management of the crop, prevalence of ratoons, substantial area under rainfed situation, repeated use of the same cane for seed purpose, incidence of pests and diseases, etc. As the crop prevails throughout the year, the chance of damage due to various pests and diseases is also high. Red rot and smut are the major diseases recorded in various sugarcane growing areas of the state in different

varieties cultivated, thereby reducing cane yield and juice quality.

Red rot incited by *Colletotrichum falcatum* Went is one of the dreaded diseases of sugarcane and is responsible for phasing out of high yielding sugarcane cultivars from cultivation due to their susceptibility to the disease. Losses due to this disease are enormous as the pathogen infects sugar accumulating parenchyma cells of the stalk (Uys *et al.*, 2007), thus reducing sugar recovery, juice quality and cane yield (Viswanathan and Samiyappan, 2000). The reduction in juice quality parameters like Brix, polarity and purity were reported to be influenced by the resistance of cane varieties and pathogenic behaviour of *C. falcatum* isolates (Minnatullah and Kamat, 2018). Currently, none of the varieties are released without red rot resistance as most of the genotypes with high juice sucrose easily succumb to *C. falcatum* (Viswanathan *et al.*, 2018).

The pathogen is primarily transmitted through infected setts and soil. Secondary dissemination occurs through irrigation water, rain splashes and rain water (Agnihotri, 1996). The pathogen gains entry through leaf scars, growth rings, buds and root primordia and invades the host tissues under favourable weather conditions (Steib and Chilton, 1951). The presence of susceptible variety, water logged conditions, high relative humidity and temperatures ranging from 29.4°C to 31 °C are optimum for disease development (Singh *et al.*, 1988). Though several management options have been tried earlier for red rot management using fungicides, biocontrol agents and physical treatments, they are all prophylactic in nature to reduce the pathogen build up (Malathi *et al.*, 2016; Kishore Varma *et al.*, 2017; Loh, 1940). Once the disease is initiated under field conditions, management of the disease is impossible (Sharma and

Tamta, 2015). Hence, the use of resistant genotypes is the only practical, economical and effective strategy for management of red rot disease.

Similarly, smut caused by *Sporisorium scitamineum* Meike (*Ustilago scitaminea* Syd.) is another major fungal disease in sugarcane inciting considerable loss to sugarcane productivity especially to ratoon crop (Lal *et al.*, 2009). Magarey *et al.*, (2010) studied the losses incited by sugarcane smut in Queensland and reported maximum yield loss of 62% and an average loss of 26% in various genotypes. Smut incidence reduces the height and girth of the cane, tillering ability of the plant, cane tonnage, total solids and sucrose content in cane juice and ratio of sugars to fiber making sugar extraction difficult (Ramesh Sundar *et al.*, 2012; Sandhu *et al.*, 1969; Xiupeng *et al.*, 2019).

Though several fungicides were reported to be effective against whip smut of sugarcane (Bhuiyan *et al.*, 2012; Paramdeep *et al.*, 2014), concerns on the use of chemical fungicides such as ground water pollution, estimated costs and breakdown of host plant resistance are the key issues that need attention. Moreover, management of diseases of sugarcane through fungicide sprays is possible only upto few months after planting in sugarcane due to the increase in cane height, plant density and non-permeability of chemical solutions through the hard rind of the cane. Hence, the best management strategy for sugarcane disease management is through the use of resistant varieties. The present investigation was conducted with an aim to screen sugarcane genotypes for red rot and smut resistance.

## **Materials and Methods**

An experiment was conducted at Regional Agricultural Research Station, Anakapalli to

assess the disease resistance of sugarcane genotypes to red rot and smut during the crop seasons, 2018-19 and 2019-20. Fourteen sugarcane genotypes were obtained from the department of Genetics and Plant Breeding, RARS, Anakapalli and were evaluated for their resistance for two consecutive years to red rot and smut under artificial inoculation conditions.

### Screening for red rot resistance

Fourteen entries were planted under field conditions using three budded setts during February, 2018 and 2019 along with red rot susceptible entry, CoC 671. Each entry was planted in two rows of 5 m length placed at 80 cm apart. Twenty five sets were planted for each row. Crop management was done as per the recommendations of ANGRAU. Twenty standing canes of each variety were inoculated with *Colletotrichum falcatum* (pathotype CF06) conidial suspension by plug and nodal cotton swab methods. In plug method, canes were inoculated at the third exposed internode from ground level at seven months after planting. In nodal or cotton swab method of inoculation, twenty canes were inoculated by removing leaf sheath and immediately placing cotton swab dipped in freshly prepared inoculum around the cane covering nodal region. Observations on nature of tops, lesion width, nature of white spots and nodal transgression of the symptoms were recorded at 60 days after inoculation. The genotypes were classified into different groups of resistance or susceptibility based on 0-9 scale in plug method of inoculation (Kalaimani, 2000).

Disease grade	Disease reaction
0 to 2.0	Resistant (R)
2.1 to 4.0	Moderately resistant (MR)
4.1 to 6.0	Moderately susceptible (MS)
6.1 to 8.0	Susceptible (S)
Above 8.0	Highly susceptible (HS)

In nodal cotton swab method of inoculation, cotton swab above the nodal region is removed after 60 days and scraped with a knife to observe the presence or absence of lesions.

In case of lesions progressing into the stalk, the reaction was recorded as S (susceptible) and in case of no lesion development, the reaction was noted as R (resistant).

### Screening for smut resistance

*Sporisorium scitamineum* (Syn. *Ustilago scitaminea*) teliospores freshly collected from smut susceptible sugarcane varieties served as a source of inoculum. Freshly collected whips collected from various villages of Anakapalli mandal of Visakhapatnam district were air dried by keeping under shade. Teliospores from air dried smutted whips were collected by scraping in butter paper bags and are stored in desiccator under anhydrous calcium chloride. Spore viability was tested prior to inoculation.

Two budded sets of fourteen test entries from short crop was artificially inoculated by soaking in a viable smut spore suspension ( $1 \times 10^6$ ) for 30 minutes and planted in furrows. Each entry was planted in two rows of 5 m length placed at 80 cm apart along with smut susceptible variety, CoA 92081. Smut incidence was recorded at fortnightly intervals up to harvest of the crop. Percentage of infected clumps was calculated using the formula:

$$\text{Percentage of infected clumps} = \frac{\text{Number of affected clumps}}{\text{Total clumps assessed}} \times 100$$

The disease reaction was graded as resistant (0%), moderately resistant (>0 to 10%), moderately susceptible (>10 to 20%), susceptible (>20 to 30%) and highly susceptible (>30%).

## Results and Discussion

Among fourteen genotypes evaluated for red rot resistance, five genotypes were found resistant to red rot disease under plug method of inoculation. The genotypes, 2015A 51, 2015A 59, 2015A 228, 2015A 230 and 2015A 233 reacted as resistant to *C. falcatum* pathotype CF 06.

The entries, 2015A 93, 2015A 137, 2015A 152, 2015A 183, 2015A 199 and 2015A 222 were found moderately resistant to red rot. The entry, 2015A 85 was found moderately susceptible to *C. falcatum* during two years of evaluation and rest of the entries, viz., 2015A 37 and 2015A 67, were categorised as highly susceptible to the disease.

The results were consistent over two years of screening under artificial inoculated conditions. In nodal method of inoculation, none of the genotypes tested were found susceptible to red rot, except the red rot susceptible check varieties, Co 419, CoC 671 and Co 997. Hence, the entries found resistant or moderately resistant to red rot can be considered for varietal release based on their yield performance or could be utilized as resistant sources for breeding programme.

Minnatullah *et al.*, (2016) screened twenty five sugarcane genotypes against red rot disease and reported that three genotypes, CoP 11437, BO 130 and BO 153 had shown resistance to *C.falcatum* pathotypes, CF07 and CF08 at Sugarcane Research Institute, Pusa Bihar. Bharti *et al.*, (2017) tested 44 genotypes for red rot resistance in eastern Uttar Pradesh and found 35 genotypes as moderately resistant to *C.falcatum* pathotype CF07. In Shahjahanpur, Uttar Pradesh, out of 117 genotypes screened for red rot resistance, 6 were found to be resistant and 12 as moderately resistant and rest of the genotypes were either moderately susceptible or

susceptible or highly susceptible in reaction (Singh *et al.*, 2017).

Similarly, out of ten genotypes screened against red rot disease, two genotypes, NSG 59 and SPF 244 were found resistant under artificially inoculated conditions (Ghazanfar *et al.*, 2017). Lal *et al.*, (1990) found the sugarcane genotypes, UP5, UP6, CoS 767, CoS 8214, CoS 8312, Co Pant 84211, CoLK 7810, CoLK 8002, CoLK 8102 and CoLK 8402 as resistant to moderately resistant to both red rot and smut diseases of sugarcane.

A strong relationship was noticed between sugar content of the stalk and fungus propagation by Iqbal *et al.*, (2020). Marked genetic variation in 55 different sugarcane cultivars varying in their response for red rot resistance was revealed by resistant gene analog polymorphism (RGAP) markers (Sharma and Tamta, 2019).

In artificial screening for smut resistance, none of the entries were found resistant to *S.scitamineum*. Only one genotype, 2015A 222, has consistently shown moderately resistant reaction to smut disease. Variable smut reaction was observed in sugarcane entries, 2015A 93, 2015A 137, 2015A 152, 2015A 183, 2015A 199, 2015A 230 and 2015A 233 which may be attributed to prevailing weather conditions, maturity of the seed cane and prevalence of drought in initial stages of crop growth.

The genotypes, 2015A 37, 2015A 51, 2015A 59 and 2015A 67 have shown highly susceptible reaction to smut with disease incidence more than thirty per cent.

Most of the entries found moderately resistant during the first year of evaluation had shown either moderately susceptible or susceptible reaction in the subsequent year of evaluation (Table 1).

**Table.1** Reaction of sugarcane genotypes to red rot and smut diseases under artificial inoculation conditions

S. No.	Genotype	2018-19					2019-20				
		Red rot			Smut		Red rot			Smut	
		Plug method		Nodal method	Smut Incidence (%)	Disease reaction	Plug method		Nodal method	Smut Incidence (%)	Disease reaction
		Red rot Severity	Disease reaction	Disease reaction			Red rot Severity	Disease reaction	Disease reaction		
1	2015A 37	8.3	HS	R	44.44	HS	8.6	HS	R	35.14	HS
2	2015A 51	0.5	R	R	42.86	HS	0.8	R	R	33.33	HS
3	2015A 59	0.0	R	R	58.82	HS	0.2	R	R	41.03	HS
4	2015A 67	8.6	HS	R	43.33	HS	8.2	HS	R	36.36	HS
5	2015A 85	4.2	MS	R	17.65	MS	4.8	MS	R	12.82	MS
6	2015A 93	2.2	MR	R	30.77	HS	2.5	MR	R	23.53	S
7	2015A 137	2.9	MR	R	14.63	MS	3.4	MR	R	12.50	MS
8	2015A 152	2.7	MR	R	21.95	S	3.1	MR	R	17.95	MS
9	2015A 183	2.5	MR	R	23.08	S	2.1	MR	R	20.00	MS
10	2015A 199	2.1	MR	R	20.00	MS	2.3	MR	R	12.82	MS
11	2015A 222	2.4	MR	R	4.76	MR	2.4	MR	R	2.50	MR
12	2015A 228	0.4	R	R	78.13	HS	1.9	R	R	40.00	HS
13	2015A 230	0.6	R	R	25.00	S	0.2	R	R	18.42	MS
14	2015A 233	0.0	R	R	22.22	S	0.4	R	R	16.67	MS
<b>Check entries</b>											
15	Co 419	9.0	HS	S	40.74	HS	9.0	HS	S	32.50	HS
16	CoC 671	9.0	HS	S	13.64	MS	9.0	HS	S	12.50	MS
17	Co 997	8.3	HS	S	18.18	MS	8.3	HS	S	12.50	MS
18	CoA 92081	1.4	R	R	39.47	HS	1.3	R	R	43.59	HS

R- Resistant; MR-Moderately resistant; MS- Moderately susceptible; S- Susceptible; HS- Highly susceptible

Durable resistance to smut was reported in 23 genotypes of sugarcane which have shown resistant reaction to smut under artificially inoculated conditions for 10 years in Central Sugarcane Research Station, Padegaon (Nalawade *et al.*, 2013). Such genotypes are valuable sources of resistance and could be used by sugarcane Breeders for development of resistant varieties. Singh *et al.*, (2001) screened seventy four sugarcane genotypes under field conditions at Indian Institute of Sugarcane Research, Lucknow and found that 3 genotypes, viz., LG 9216, LG 9411 and LG 94269, were found resistant to both smut and red rot.

In conclusion the genotypes screened against *C. falcatum* pathotype CF06 and *S. scitamineum* revealed variable disease reaction. Five genotypes, viz., 2015A 51, 2015A 59, 2015A 228, 2015A 230 and 2015A 233, were found resistant to red rot pathotype CF06 with average disease grade less than 2.0. Only one genotype, 2015A 222 was found moderately resistant to *S.scitamineum* with disease incidence less than 10 per cent and rest of the genotypes recorded disease incidence over 10 per cent. The genotypes found resistant to red rot could be used as resistant donors for sugarcane breeding programme or could be released as resistant varieties upon agronomic evaluation.

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**How to cite this article:**

Kishore Varma, P., V. Chandrasekhar, M. Charumathi and Bharathalakshmi, M. 2020. Field Assessment of Red Rot and Smut Resistance in Sugarcane Germplasm under Artificial Inoculated Conditions. *Int.J.Curr.Microbiol.App.Sci.* 9(12): 2647-2654.  
doi: <https://doi.org/10.20546/ijcmas.2020.912.313>