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Evaluation of elite sugarcane clones/varieties against red rot disease (*Colletotrichum falcatum*) and their suitability in crop improvement programme

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Abstract. *To manage red rot disease in sugarcane, several methods like use of bio-control agents, hot water and hot air treatment of setts, chemical fungicides, various cultural practices like use of disease free setts, rouging, crop rotation, irrigation management, avoiding rationing, etc. are practised. But none of the practices are able to control the disease. The most viable strategy is to manage through host plant resistance. Thus, a field experiment was conducted for two consecutive years during 2019 and 2020 at the Research Farm of Sugarcane Research Station, Bethuadahari (West Bengal), India to evaluate some elite sugarcane clones/varieties against red rot disease. The elite clones/varieties were laid out in Completely Randomized Block Design with a plot size of 2R x 6m x 0.90m with 2 replications and two red rot pathotypes Cf 07 and Cf 08 were used for artificial inoculation in plug and nodal method. The experiment revealed that the sugarcane clones CoP 16436, CoP 16437, CoP 16438, CoLk 16466, CoLk 16467, CoLk 16468, CoSe 16451, CoP 16439, CoP 16440, BO 156, CoLk 16469, CoLk 16470, CoLk 16471, CoSe 16452, CoSe 16453, CoSe 16454, CoP 17436, CoP 17437, CoP 17438, CoP 17440, CoP 17441, CoSe 17451, CoSe 16455, CoSe 16456, CoP 17444, CoP 17446 and CoSe 17452 were found as moderately resistant (MR) in plug method and resistant (R) in nodal method to both pathotypes and can be used for further evaluation in subsequent varietal developmental as well as breeding programme. The popular sugarcane varieties, namely CoLk 94184, CoSe 01421, BO 91, CoP 9301 and CoP 06436 were found as moderately resistant (MR) in plug method and resistant (R) in nodal method and can be continued for commercial cultivation as well as red rot breeding programme. As the existing popular variety CoSe 95422 was found moderately susceptible (MS) in plug method and susceptible (S) in nodal method to Cf 07 and Cf 08 red rot pathotypes, thus the variety must be discarded from commercial cultivation with immediate effect.*

Keywords: sugarcane red rot, *Colletotrichum falcatum*, plug method, nodal method, sustainability

Introduction

Sugarcane (*Saccharum* sp. hybrids) is a C4 plant belonging to *Poaceae* family under *Andropogoneae* tribe cultivated globally in the tropical and subtropical regions. It is one of the important cash crops which provides raw materials to sugar industry and jiggery (Gur) units. Bagasses, molasses and press mud are the main by-products produced in sugar industry, the second largest agro-based industry in India after textile. Sugar industry provides livelihood security to 4% rural population by generating significant employment in ancillary and allied activities (Anonymous, 2011). However, sugarcane suffers from various pests and diseases and abiotic factors such as water logging, drought, salinity etc. which leads to severe yield and quality reduction in sugarcane (Nair, 2011). In India, among all the constraints, diseases are the major concern in sugarcane cultivation. Among the diseases, red rot caused by *Colletotrichum falcatum* Went (Teleomorph: *Glomerella tucumanensis* [Speg.] Arx Muller) is one of the most important diseases of concern causing heavy yield losses to sugarcane growers in India (Viswanathan, 2010; Viswanathan and Rao, 2011). The disease has been reported from 77 countries of the world. However; its severity is felt mostly in South and South East Asian countries (Viswanathan et al., 2018). It causes

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drastic yield reduction and also deteriorates the quality of the juice affecting both sugarcane growers and sugar millers. Many popular varieties like CoC 671, CoJ 64, CoS 8436, CoSe 95422, etc. were withdrawn from commercial cultivation in the tropical and subtropical regions due to their susceptibility to red rot. A variable virulence pattern in *C. falcatum* isolates was recorded on most of the host differentials (Chhabra et al., 2016). Several methods like use of bio-control agents, hot water and hot air treatment of setts, chemical fungicides, various cultural methods like use of disease free setts, rouging, crop rotation, irrigation management, avoiding rationing, etc. have been reported for the integrated management against red rot (Malathi et al., 2004; Viswanathan 2012a,b). Most importantly, they are not always effective under varied soil and climatic situations and play a supplementary role in red rot management. It is also important to remember that hot water and hot air treatments do not completely inactivate the sett borne infections of red rot pathogen residing inside the setts but also affect the germination of buds, if not properly handled. Emergence of new variants of *C. falcatum* is very common, thus it causes the frequent breakdown of resistant sugarcane varieties due to its ongoing evolution (Kaur et al., 2014; Sharma and Tamta, 2015). Non-availability of systemic fungicides for controlling red rot disease under field condition, breeding for red rot resistance remains the most practical, effective and economical option (Meeta et al., 2007; Sanghera et al., 2017).

Thus, the present study was conducted to evaluate the inbuilt resistance of elite sugarcane clones/varieties against different pathotypes of *C. falcatum* causing red rot disease in field condition.

Material and methods

The experiments were conducted at the research farm of Sugarcane Research Station, Bethuadahari, Nadia, West Bengal, India for two consecutive years during 2019-2020. The experimental site was located at the longitude of 88022′22″E and 23036′54″N latitude with 15 m altitude from mean sea level. The soil of the experimental field was sandy loam in texture with pH 7.2. The experiments involving 17 genotypes and 6 varieties during 2019 and 16 genotypes and 6 varieties during 2020 are listed in Table 1. The elite clones/varieties were laid out in completely randomized block design with a plot size of 2R x 6 m x 0.90 m with 2 replications.

Table 1. List of elite sugarcane clones/varieties used in the study

Sl. No	Sugarcane clones	Year	Sl. No	Elite clones/varieties	Year
1	CoP 16436	2019	1	CoSe 16454	2020
2	CoP 16437	2019	2	CoP 17436	2020
3	CoP 16438	2019	3	CoP 17437	2020
4	CoLk 16466	2019	4	CoP 17438	2020
5	CoLk 16467	2019	5	CoP 17440	2020
6	CoLk 16468	2019	6	CoP 17441	2020
7	CoSe 16451	2019	7	CoSe 17451	2020
8	CoBln 16501	2019	8	CoBln 17501	2020
9	CoP 16439	2019	9	CoSe 16455	2020
10	CoP 16440	2019	10	CoSe 16456	2020
11	BO 156	2019	11	CoP 17444	2020
12	CoLk 16469	2019	12	CoP 17446	2020
13	CoLk 16470	2019	13	CoSe 17452	2020
14	CoLk 16471	2019	14	CoBln 17502	2020
15	CoSe 16452	2019		Varieties	
16	CoSe 16453	2019	15	CoLk 94184	2020
17	CoBln 16502	2019	16	CoSe 95422	2020
	Varieties		17	CoSe 01421	2020
18	CoLk 94184	2019	18	BO 91	2020
19	CoSe 95422	2019	19	CoP 9301	2020
20	CoSe 01421	2019	20	CoP 06436	2020
21	BO 91	2019			
22	CoP 9301	2019			
23	CoP 06436	2019			

The package and practices for raising good crops were followed as per the All India Co-ordinated Research Project on Sugarcane guidelines by Shukla et al. (2017). The materials for the study were supplied by the Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samasthipur, Bihar distribution centre of Zonal Varietal Trials of North Central and North Eastern Zone of All India Co-ordinated Research Project (AICRP) on Sugarcane.

For evaluation of elite sugarcane clones/varieties against red rot disease, the pathological culture of pathotypes Cf 07 and Cf 08 were freshly revived by sub culturing in laboratory and used for inoculation in sugarcane plants separately under field conditions. Both pathotypes (Cf 07 and CF 08) were multiplied on oat meal agar medium in petri dishes at 25±1°C. Freshly sporulating, 7-10 days' old culture in petri-dishes was taken. The spore masses were washed with 100 ml of sterile water and collected in a flask. Conidial suspension at a spore concentration of $2x10^4$ per ml was prepared for inoculation for plug and nodal method. In Plug method, two canes in each of the 20 clumps were inoculated in the middle of the 3rd exposed internode from bottom and 1.0 ml of the spore suspension were injected with a large syringe in each cane and sealed with plastic clay (Plasticine-local made). In Nodal method, separate two canes in each of 20 clumps were inoculated by removing leaf sheath (lower most green lea sheath) and immediately placing cotton swab (dipped in freshly prepared inoculum suspension) around the cane covering nodal region. The cotton swab was held in place by wrapping parafilm around the cane stalk. Disease score was recorded at 60 days after inoculation for pathogenicity parameters presented in Table 2 and disease reaction following 0-9 scale presented in Table 3 according to Srinivasan and Bhatt, 1961. The elite clones/varieties are categorized as resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible(S) and highly susceptible (HS) accordingly.

Table 2. Pathogenicity parameters used for screening of sugarcane against red rot disease

Symptoms	Numerical scale	Severity of symptoms
Condition of tops	0	Green
	1	Yellow or drying
Nodal transgression	0	No lesion spread. Lesion restricted to the inoculated node
	1	Lesion transgression of one node above the inoculated node.
	2	Lesion transgression of two nodes above the inoculated node.
	3	Lesion transgression of more than two nodes above the inoculated node.
Lesion width	0	No lesion spread.
	1	Lesion spread to about 25% of the width of the stalk.
	2	Lesion spread to about half the cane width.
	3	Lesion spread to more than half the width of the cane.
White spots	0	No white spots.
	1	Sparse presence of white spots.
	2	Moderate to profuse presence of white spots.

Table 3. Screening of sugarcane varieties against red rot and their reaction (0-9 scale) according to Srinivasan and Bhatt, 1961

Sl. No	Score on 0-9 scale	Reaction category
1	0.0-2.0	Resistant (R)
2	2.1-4.0	Moderately resistant (MR)
3	4.1-6.0	Moderately susceptible (MS)
4	6.1-8.0	Susceptible (S)
5	8.1-9.0	Highly susceptible (HS)

Results and discussion

In the present red rot screening studies, the clones/varieties exhibited differences in resistance in field condition. Red rot is the most important disease of sugarcane causing great loss to the growers as well as sugar industry, thus it is extremely necessary to screen the clones/varieties frequently and replace the susceptible one as quickly as possible. The reactions of these genotypes were scored against both the red rot pathogens and the results obtained are presented in Tables 4 and 5.

Table 4. Reaction and score of sugarcane genotypes against Cf 07 and Cf 08 red rot pathotypes under field conditions in Plug and Nodal method during 2019

Genotypes	Plug Method				Nodal Method	
	Cf 07		*Cf 08*		*Cf 07*	*Cf 08*
	Score	Reaction	Score	Reaction	Reaction	Reaction
CoP 16436	3.3	MR	3.6	MR	R	R
CoP 16437	3.5	MR	3.4	MR	R	R
CoP 16438	3.2	MR	3.3	MR	R	R
CoLk 16466	3.1	MR	3.2	MR	R	R
CoLk 16467	3.3	MR	3.6	MR	R	R
CoLk 16468	3.6	MR	3.6	MR	R	R
CoSe 16451	3.8	MR	3.9	MR	R	R
CoBln 16501	5.6	MS	5.8	MS	S	S
CoP 16439	3.4	MR	3.5	MR	R	R
CoP 16440	3.8	MR	3.9	MR	R	R
BO 156	3.9	MR	4.0	MR	R	R
CoLk 16469	3.7	MR	3.7	MR	R	R
CoLk 16470	3.6	MR	3.8	MR	R	R
CoLk 16471	3.8	MR	3.9	MR	R	R
CoSe 16452	3.7	MR	3.5	MR	R	R
CoSe 16453	3.6	MR	3.6	MR	R	R
CoBln 16502	5.7	MS	5.8	MS	S	S
CoLk 94184	3.2	MR	3.4	MR	R	R
CoSe 95422	5.3	MS	5.5	MS	S	S
CoSe 01421	3.8	MR	3.9	MR	R	R
BO 91	2.9	MR	3.1	MR	R	R
CoP 9301	3.4	MR	3.8	MR	R	R
CoP 06436	3.7	MR	3.7	MR	R	R

Table 5. Reaction and score of sugarcane genotypes against Cf 07 and Cf 08 red rot pathotypes under field conditions in Plug and Nodal method during 2020

Genotypes	Plug Method				Nodal Method	
	Cf 07		*Cf 08*		*Cf 07*	*Cf 08*
	Score	Reaction	Score	Reaction	Reaction	Reaction
CoSe 16454	3.7	MR	3.8	MR	R	R
CoP 17436	3.5	MR	3.7	MR	R	R
CoP 17437	3.5	MR	3.6	MR	R	R
CoP 17438	3.8	MR	3.9	MR	R	R
CoP 17440	3.9	MR	3.7	MR	R	R
CoP 17441	4.0	MR	3.7	MR	R	R
CoSe 17451	3.6	MR	3.9	MR	R	R
CoBln 17501	5.8	MS	5.9	MS	S	S
CoSe 16455	3.7	MR	3.7	MR	R	R
CoSe 16456	3.4	MR	3.6	MR	R	R
CoP 17444	3.7	MR	3.5	MR	R	R
CoP 17446	3.8	MR	3.7	MR	R	R
CoSe 17452	3.7	MR	3.9	MR	R	R
CoBln 17502	5.7	MS	5.9	MS	S	S
CoLk 94184	3.2	MR	3.5	MR	R	R
CoSe 95422	5.4	MS	5.7	MS	S	S
CoSe 01421	3.8	MR	3.9	MR	R	R
BO 91	2.8	MR	3.2	MR	R	R
CoP 9301	3.7	MR	3.7	MR	R	R
CoP 06436	3.8	MR	3.9	MR	R	R

The tested genotypes showed differential reactions against both the pathotypes ranging from moderately resistant (2.1-4.0) to moderately susceptible (4.1-6.0) in plug method during the year 2019 and 2020 indicating genetic variability for disease resistance in field conditions. In nodal method also, it has been found that a few genotypes showed resistant to susceptible during the study years. Reaction to Cf 07 and Cf 08 red rot pathotypes in artificial inoculation by plug method revealed that sugarcane clones like CoP 16436, CoP 16437, CoP 16438, CoLk 16466, CoLk 16467, CoLk 16468, CoSe 16451, CoP 16439, CoP 16440, BO 156, CoLk 16469, CoLk 16470, CoLk 16471, CoSe 16452 and CoSe 16453 and varieties like CoLk 94184, CoSe 01421, BO 91, CoP 9301 and CoP 06436 were found to be moderately resistant (MR) having disease score between 2.9 to 4.0 under field conditions during 2019. During 2020, sugarcane clones like CoSe 16454, CoP 17436, CoP 17437, CoP 17438, CoP 17440, CoP 17441, CoSe 17451, CoSe 16455, CoSe 16456, CoP 17444, CoP 17446 and CoSe 17452 and varieties like CoLk 94184, CoSe 01421, BO 91, CoP 9301 and CoP 06436 were found to be moderately resistant (MR) having disease score between 2.8 to 4.0 against both pathotypes under field conditions. The sugarcane clones, namely CoBln 16501 and CoBln 16502 during 2019 and CoBln 17501 and CoBln 17502 during 2020 were found to be moderately susceptible (MS) in plug method having disease score between 5.6-5.8 and 5.7-5.9 against both pathotypes, respectively. A popular sugarcane variety CoSe 95422 was also found to be moderately susceptible (MS) against both pathotypes in plug method and having disease score between 5.3-5.5 and 5.4-5.7 during 2019 and 2020, respectively. All the sugarcane clones under study were found resistant (R) against both pathotypes in nodal method except CoBln 16501 and CoBln 16502 during 2019 and CoBln 17501 and CoBln 17502 during 2020. The only commercial sugarcane variety CoSe 95422 was found susceptible (S) and the rest five popular varieties, namely CoLk 94184, CoSe 01421, BO 91, CoP 9301 and CoP 06436 were found resistant (R) against both pathotypes in both years under field conditions. As the sugarcane clones CoBln 16501 and CoBln 16502 during 2019 and CoBln 17501 and CoBln 17502 during 2020 were found moderately susceptible (MS) in plug method and susceptible (S) in nodal method against both pathotypes, these clones were discarded for further evaluation in subsequent varietal developmental programmes. Most importantly, the popular commercial variety CoSe 95422 was found moderately susceptible (MS) in plug method and susceptible (S) in nodal method against both pathotypes in both study years and this was a great concern from the sugarcane growers' as well as sugar millers' point of view. Red rot in sugarcane is difficult to control by hot water and fungicide treatment. The most viable strategy is to manage it through host plant resistance and stop cultivation of susceptible varieties as the pathogen spreads through planting materials (Singh et al., 2008). Thus, the variety CoSe 95422 should not be cultivated in the future to avoid great loss.

Conclusion

It can be concluded from the present study that the sugarcane clones like CoP 16436, CoP 16437, CoP 16438, CoLk 16466, CoLk 16467, CoLk 16468, CoSe 16451, CoP 16439, CoP 16440, BO 156, CoLk 16469, CoLk 16470, CoLk 16471, CoSe 16452, CoSe 16453, CoSe 16454, CoP 17436, CoP 17437, CoP 17438, CoP 17440, CoP 17441, CoSe 17451, CoSe 16455, CoSe 16456, CoP 17444, CoP 17446 and CoSe 17452 were categorized as moderately resistant (MR) in plug method and resistant (R) in nodal method to Cf 07 and Cf 08 red rot pathotypes and can be used for further evaluation in subsequent varietal developmental as well as breeding programmes. The popular sugarcane varieties, namely CoLk 94184, CoSe 01421, BO 91, CoP 9301 and CoP 06436 were also categorized as moderately resistant (MR) in plug method and resistant (R) in nodal method to Cf 07 and Cf 08 red rot pathotypes and can be continued for commercial cultivation as well as red rot breeding programmes. As the existing popular variety CoSe 95422 was found moderately susceptible (MS) in plug method and susceptible (S) in nodal method to Cf 07 and Cf 08 red rot pathotypes, it must be discarded from commercial cultivation with immediate effect.

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