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Hereditary pattern of red rot resistance in sugarcane parental line

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Red rot pathogen (*Colletotrichum falcatum* Went.) displays huge disparity in pathogenicity on host crop. Resistant varieties are most effective to manage red rot and the emergence of new races of pathogen is the main hurdle for sustaining the resistance in promising high sugar yielding cultivars. The development of varieties having stable resistance is prerequisite with vigorous testing against red rot pathotypes prevailing in the area. This study was carried out at Sugarcane Research Institute, Shahjahanpur during 2016-2017. Thirty three newly developed genotypes/varieties and tested against red rot pathogens (Cf 07, Cf 08, Cf 09) along with their mixture by plug method of inoculation. Results revealed that, all the pathotypes and their mixture were produced almost similar disease index. Over all mean disease indexing was computed as 4.61, 4.24, 4.29, 4.33 for Cf 07, Cf 08, Cf 09 and their composite inoculum, respectively. Mean disease index of moderately resistant was calculated 3.34, 3.01, 3.33, 3.07 to Cf 07, Cf 08, Cf 09 and their mixture, respectively. Based on correlation coefficient study, highly significant positive correlation was found 0.889 between Cf 08 and Cf 09. Pathogenic disease indexing indicates that all the pathotype displayed the almost the similar significant positive correlation among them. Hence, selection of genotypes with single existing pathotype could be well discriminated for effective and economic screening process of red rot resistant varieties.

Key words: Sugarcane, Red rot, *Colletotrichum falcatum,* pathotypes, correlation coefficient

INTRODUCTION

Sugarcane (*Saccharum* spp. L.) is a commercial crop of India and economy of country pivot around the sugarcane production and its products like sugar and ethanol. The crop is grown worldwide in tropical and sub-tropical region. Red rot caused by *Colletotrichum falcatum* Went causes serious damage in both tropical and subtropical sugarcane growing areas. The low sugar yield and other agronomical traits are major concern for sugar industries as well as cane growers. Red rot is one of the major constraints in sugarcane yield. *Colletotrichum falcatum* is highly variable in nature. Heavy loss in yield, during several years in India has been observed. This disease infects to any part of the standing crop, causes yield losses by reduction in plant growth and 8-15 % losses in germination in susceptible cultivars. Till now there is no well known chemical control of this disease.

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The use of disease resistant varieties is the easiest and most convenient way of accomplishing disease control. To develop resistant constant and continuous breeding is necessary, as well as testing varieties against pathotypes prevailing the area is also needed (Dattamajumder, 2008; Viswanathan, 2010).

Genetic resistance to *C. falcatum* is not stable in certain condition due to the high variability present in the pathogen population. The race specific resistance explored to obtain stable resistance genotypes/varieties to *C. falcatum.* Continuous processes of identification of sources of resistance with variable pathotypes are needed in breeding program (Viswanathan, 2017). It is also exploring the management strategies to increase the stability of red rot resistance. Varietal replacement is a common feature in India because red rot resistance in sugarcane varieties is unstable due to the emergence of virulent pathotypes of *C. falcatum*. Due to the complex polyploidy of sugarcane, heritability of red rot resistance in

sugarcane is poorly understood (Viswanathan, 2010, 2017). This type of variability creates through gene-for-gene relationship among sugarcane plant and *C. falcatum*, in which more resistance genes of sugarcane against red rot and also sudden rapid collapse of these resistance genes to develop new races of the pathogen. Physiological and pathogenic strains of *C. falcatum* are described earlier for this disease (Malathi and Viswanathan, 2012a,b).

The elite sugarcane cultivars with good performance at the time of release may not established same performance at later stage. This is due to the development of a new race of the pathogen. Major emphasis is given in this study to identify the sources of resistant genotypes using four various races of the pathogen. The regular screening and selection of resistant varieties are best suited to our climatic conditions using prevailing pathotypes.

MATERIALS AND METHODS

Plant materials

The studies were carried out for the screening of sugarcane varieties in Uniform Regional Varietal Trial (URVT) against red rot disease was carried out in the field Sugarcane Research Institute, Shahjahanpur (Longitude 79°37'E and latitude 27°35'N) during 2016-2017. The basic plot of each individual was 0.90 x 6 square meters and the row were spaced 0.90 m apart. Newly developed thirty three genotypes/varieties were planted with two budded in spring season, cultivated and fertilized according to standard agronomical practices were used. All these genotypes/varieties were developed from Shahjahanpur, Seorahi and Lucknow. Three varieties Co 453, CoJ 64 and CoPant 97222 were used as susceptible standard to red rot disease.

Varietal evaluation

Twenty cane stalk of each variety were inoculated with freshly sporulating culture of red rot pathogen in the 2nd week of August by standard plug method. Spore concentration in conidial suspension was 10^6 conidia per ml for inoculation. The relative humidity was maintained between up to 90% and temperature was 31°C during the incubation. All the 33 genotypes/varieties including three standards were screened for red rot resistance against three prevailing pathotypes viz; Cf 07 (CoJ 64), Cf 08 (CoJ 64), Cf09 (CoS 767) and their mixture using the standard plug method of inoculation. A puncture was made in the middle of the 3rd exposed internode from ground level and two drops of the spore suspension was placed into the hole using syringe and sealed with stalk bit from inoculators. Finally, it was sealed with modelling clay (plasticine). Observations were taken after 60 days of inoculation by split open longitudinally. Inoculated canes free from borer infestation and other damages are taken for evaluation. The disease severity was rated based on the international scale of 0-9. The disease indexing were rated Resistant (0-2), Moderately Resistant (2.1-4), Moderately Susceptible (4.1-6), Susceptible (6.1-8), and Highly Susceptible (above 8).

Correlations analysis

Correlations analysis was performed with disease index data of thirty three genotypes including three standards against all pathotypes of red rot. It was analyzed using the OPSTAT statistical package (O.P. Sheoran, CCS Haryana University).

RESULTS AND DISCUSSION

Results revealed that the most prevalent pathotypes Cf 07 (CoJ 64), Cf 08 (CoJ 64), Cf 09 (CoS 767) exhibited significant positive correlation among the reaction of red rot. Out of thirty genotype/varieties, maximum 20 genotypes were found MR to Cf 08 and 16, 16, 15 genotype/ varieties screened using Cf 07, Cf 09 and composite inoculum. Twelve sugarcane genotype/ varieties viz; CoLk 13201, CoLk 09204, CoLk 14201, CoS 09232, CoS 11244, CoS 13231, CoS 13452, CoS 14232, CoS 14465, CoS 15451, CoSe 06460 and CoSe 11453 were recorded as MR to all three and composite races of red rot whereas two varieties CoS 06279 and CoSe 14453 were recorded as highly susceptible to all races (Table 1).

The varieties such as CoSe 11456, CoSe 11451 and CoSe 12451 were rated as MR to Cf 08 and composite inoculum. Two varieties (CoS 12231, CoS 10239) were found as MR to Cf 07, Cf 08 and Cf 09. Six varieties CoS 10239, CoS 12452, CoLk 11201 and CoSe 11455 and CoSe 12451

Table 1: Detail of all disease rating with index of all pathotypes for all genotypes/varieties

Existing pathotypes	Disease rating	Genotypes/varieties	Range of disease index
Cf 07, Cf 08, Cf 09, Mix inoculum	MR	CoSe 11453, CoSe 06460, CoS 15451, CoS 14465, CoS 14232, CoS 13452, CoS 13231, CoS 11244, CoS 09232, CoLk 14201, CoLk 13201, CoLk 09204	2.6-4
	MS	CoLk 09202, CoSe 09455	4.1-5.4
	S	CoSe 13451	5.3-6.6
	HS	CoS 06279, CoSe 14453	9
Cf 07		CoSe 11456, CoSe 11453, CoSe 11233, CoSe 06460, CoS 15451, CoS 14465, CoS 14232, CoS 13452, CoS 13231, CoS 12231,CoS 11244, CoS 10239, CoS 09232, CoLk 14201, CoLk 13201, CoLk 09204 (16)	3-4
Cf 08		CoSe 12451, CoSe 11456, CoSe 11455, CoSe 11453, CoSe 06460, CoS 15451, CoS 14465, CoS 14232, CoS 13452, CoS 13231, CoS 12452, CoS 12231, CoS 11244, CoSe 11451, CoS 10239, CoS 09232, CoLk 14201, CoLk 13201, CoLk 11201, CoLk 09204 (20)	2.7-4.0
Cf 09	MR	CoSe 14455, CoSe 11453, CoSe 11233, CoSe 06460, CoS 15451, CoS 14465, CoS 14232, CoS 13452, CoS 13231, CoS 12231, CoS 11244, CoS 10239, CoS 09232, CoLk 14201, CoLk 13201, CoLk 09204 (16)	2.5-3.7
Mix		CoSe 12451, CoSe 11456, CoSe 11453, CoSe 06460, CoS 15451, CoS 14465, CoS 14232, CoS 13452, CoS 13231, CoS 11244, CoSe 11451, CoS 09232, CoLk 14201, CoLk 13201, CoLk 11201, CoLk 09204 (16)	2.6-3.7

Table 2: Mean data of disease index of all existing pathotypes

Pathotypes	MR	MS	S	HS
Cf 07	3.34	4.89	6.67	8.60
Cf 08	3.32	4.78	6.05	9.00
Cf 09	3.01	4.70	6.57	9.00
Mix	3.07	4.65	6.60	8.70

exhibited moderately resistance reaction to Cf 08 pathotype. However, these same moderately resistant cultivars showed turned in their disease reaction to the pathotype Cf 07 and Cf 09 as moderately susceptible (MS) and CoSe 12451 as S to Cf 07. The pathogenic behaviour of five

Table 3: Virulence frequency of existing pathotypes against disease rating of all genotypes/varieties

Pathotypes	MR	Virulence frequency (%)	MS	Virulence frequency (%)	S	Virulence frequency (%)	HS	Virulence frequency (%)
Cf 07	16	53.33	8	26.67	3	20	3	10
Cf 08	20	66.66	4	13.33	4	20	2	6.67
Cf 09	16	53.33	9	30	3	16.66	2	6.67
Mix	16	53.33	10	33.33	1	13.33	3	10

Table 4: Correlation coefficients among the disease index of the three pathotypes of red rot

Pathotypes	Cf 07	Cf 08	Cf 09
Cf 07			
Cf 08	0.850**		
Cf 09	0.839**	0.889**	
Mix	0.856**	0.820**	0.809**

varieties with MS and S behaviour clearly revealed a higher virulence of Cf 07 and Cf 09 as compared to Cf 08 (Table 1). This is agreement with the recent finding using Cf 06 (Cf671) and Cf 94012 (Co 94012) for screening of sugarcane cultivars and found higher virulence of Cf 94012 isolate than Cf 06 (Viswanathan, 2017). These types of differentiation may be due to partially presence of

various races with their virulence, already reported by the earlier workers.

Three prevailing pathotypes (Cf 07, Cf 08, Cf 09) along with their composite inoculum were used for the screening of resistant varieties by plug method of inoculation. Results revealed that, all the pathotypes and their mixture were produced almost similar disease index. Over all mean disease indexing was computed as 4.61, 4.26, 4.29, 4.33 for Cf 07, Cf 08, Cf 09 and their composite inoculum, respectively. Mean disease index of MR was calculated 3.34, 3.30, 3.01, 3.07 for Cf 07, Cf 08, Cf 09 and their mixture, respectively. The majority of genotypes/varieties were moderately resistant to Cf 08 and genotypes in same number were displayed consistent resistance against rest of the pathotypes (Cf 07, Cf 09 and Mix). Highest virulence frequency was found 66.66 per cent for Cf 08 followed by 53.33 per cent for each pathotypes Cf 07, Cf 09 and mix inoculum (Table 1, 2). The virulence frequency of moderately susceptible was computed similar for three pathotypes (Cf 07, Cf 09 and Mix). Maximum genotypes were screened MR with the reaction to the most virulent red rot pathotype Cf 08 isolated from CoJ 64 followed by most prevalent pathotype Cf 07 from CoJ 64 and Cf 09 from CoS 767 under UP conditions. The most popular varieties CoJ 64, Co 453, CoPant 97222 showed susceptible reaction to all (Table 3) races of red rot in same environment. Similar findings reported by Singh *et al.* (2016), in which highest frequency was found by Cf 08 (88.5 %), followed by Cf 01 (75.5 %) and Cf 09 (67.5 %). Vertical (Single-gene resistance)) and horizontal (Many-gene resistance) resistance to red rot could be associated with the earlier findings (Babu *et al.* 2010; Kumar *et al.* 2010) and the susceptibility to red rot described to be race-specific. The pathogenic consistency of Cf 08 pathotype were displayed maximum resistance with high frequency than other pathotypes, which were used in our study. This variability generates via gene-for-gene action among sugarcane plant and *C. falcatum*, in which more resistance genes of sugarcane against red rot and also sudden rapid collapse of these resistance genes with physiological changes of *C. falcatum* and to creates new races of the pathogen (Malathi and Viswanathan, 2012a, b).

Similarity correlation coefficients among the disease index of the three pathotypes of red rot revealed in present study that Cf 08 and Cf 09 showed significant positive correlation with each other. Least significant positive association (0.809) was computed with Cf 09 and mix inoculum. Prevalent pathotype Cf 07 showed the significant positive association with Cf 08 (0.850) and Cf 09 (0.839). This is may be due to gene-for-gene activity and found very close variation among pathotypes (Table 4). This may be explained by the fact that the standard resistant varieties whose was found similar entirely and both pathotypes Cf 08 and Cf 09 reacts same pathogenic behaviour against genotype (Singh *et al.,* 2016). Pathogenic disease indexing indicates that all the pathotype displayed the similar significant positive correlation among them. Hence, Selection of genotypes with single existing pathotype could be well discriminated for effective and economic screening process of red rot resistant varieties. This finding depicted that the pathogenicity studies could not be used with more pathotypes, only one virulent pathotype could be adequate to screen resistant varieties.

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