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RESEARCH ARTICLE

Red rot disease resistance in interspecific hybrids of sugarcane derived from diverse cytotypes of *Saccharum spontaneum* L.

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Abstract

Red rot disease causes major loss to sugarcane crop for more than hundred years. It is caused by the fungal pathogen *Colletotrichum falcatum* Went. In sugarcane breeding, the development of resistant varieties through inter varietal hybridization is a major challenge. Pre-breeding is an ideal approach to incorporate resistance. *Saccharum spontaneum,* the wild species of sugarcane has been utilized in sugarcane breeding since 1912 owing to their wider adaptability to biotic and abiotic stresses. It shows cytomorphological diversity with 41 cytotypes from 2n=40-128.The major cytotypes are 2n=40, 2n=48, 2n=56, 2n=60, 2n=64, 2n=72, 2n=80, 2n=88, 2n=96, 2n=112, 2n=120 and 2n=128, of which the cytotype 2n=64 is the predominant one. The actual frequency and level of red rot resistance in the hybrids derived from different ploidies /cytotypes of *S. spontaneum* are yet to be ascertained. About 588 hybrids derived from 37 interspecific crosses involving eight commercial varieties and 16 clones of *S. spontaneum* with eight cytotypes (2n=40, 56, 60, 64, 72, 80, 88, 112) were evaluated for red rot resistance at 6^{th} month under controlled condition using the pathotype CF 06 (Cf 671). Resistance observed in 44.3% of the hybrids in which 28.9% was MR and 15.4% of R types. Differential segregation of chromosomes from different cytotypes imparted differential reactions in the progenies to red rot pathogen. The progenies with 2n=40, 64, 72, 80, 88 and 112 imparted resistance at higher frequency from 31.5% to 56.0%. The contribution of lower cytotypes for imparting resistance was 43.5% (2n=40), 19.4% (2n=56) and 16.0% (2n=60). Among the lower cytotypes, higher frequency of resistance with 2n=40 is due to the segregation of the whole genomic complement of 40 chromosomes of male gamete (*S. spontaneum*) to the progenies through n+2n transmission. Though 64 cytotype derived hybrids had 32 chromosomes through n+n transmission they sustained resistance in 48.7% of progenies. Among the higher cytotypes, 88 and 112 produced maximum resistant progenies at a frequency of 56%. It indicates that enhanced ploidies with the higher male genomic/gametic component impart resistance at a higher frequency. It is advantageous for sugarcane breeding to attain stable resistance. Hence this study suggests utilizing the resistant hybrids of the higher cytotype derived crosses for nobilisation to achieve horizontal/stable resistance.

Keywords: Red rot; Resistance; Hybrids;Cytotype;*S. spontaneum*; Frequency

Introduction

Red rot is the most severe disease of sugarcane and was reported by Barber in 1900. It is caused by the fungal pathogen *Colletotrichum falcatum* Went (Viswanathan 2010). The pathogen evolves new virulent pathotypes progressively which resulted in a series of red rot epidemics and it led to the devastation of many popular varieties such as Co 312, Co 419, Co 421, Co 453, Co 658, Co 997, Co 1148, Co 6304, Co 7805, Co 89003, CoC 671, CoC 92061, CoJ 64, CoSi 86071, CoS 8436, CoSe 95422, CoSe 92423, CoLk 8102, CoV 09356, BO 11, BO 17, BO 54 etc. (Chaudhary et al.1988; Natarajan et al.1998; Viswanathan 2016, 2017). In sugarcane breeding, the development of stable resistant varieties through inter varietal hybridization is a major challenge due to vertical resistance (Natarajan et al.1998). Identification of suitable resistant sources with horizontal resistance is crucial in sugarcane breeding and it could be achieved only through prebreeding (Natarajan et al. 2001a; Baksha 2003; Singh 2018). Among the members of *Saccharum* complex, *S. spontaneum* L. is the potential wild species to impart red rot resistance as it possesses resistant clones at higher frequency with profuse flowering (Natarajan et al. 2001b). Stable resistance could be achieved through the involvement of *S. spontaneum* in the parental clones which impart horizontal resistance to their progenies (Natarajan 2001b; Babu 2010; Singh 2019).

S. spontaneum is the most cytomorphologically diverse species with wider range of chromosome number from 2n=40-128 (Janakiammal 1936; Panje and Babu 1960). Cytological characterization revealed the existence of about 41 cytotypes of which 25 cytotypes are native to India. The major cytotypes are 2n=40, 2n=48, 2n=56, 2n=60, 2n=64, 2n=72, 2n=80, 2n=88, 2n=96, 2n=112, 2n=120 and 2n=128, of which the cytotype 2n=64 is the predominant cytotype with wider distribution (Sreenivasan 1987; Sobhakumari 2013). *S. spontaneum* has been utilized in sugarcane breeding since 1912. It shows wider adaptive plasticity to withstand biotic and abiotic stresses. It is exploited for the improvement of sugarcane in vigor, hardiness, tillering, ratooning ability, biomass and stress tolerance (Sreenivasan 1987; Selvi et al. 2005; Suganya 2014a). Several hybrids have been identified for climate resilience and dual purpose energy canes (Govindaraj et al. 2012).

S. spontaneum has been utilized for red rot resistance in interspecific crosses and observed differential reactions to red rot pathogen in different cross combinations (Natarajan et al. 2001a; 2001b; Ram et al. 2005; Baksha et al. 2003; Alarmelu et al. 2010; Babu 2009,2010; Sobhakumari 2013; Nisha et al. 2019). Clones of *S. officinarum* and commercial varieties of sugarcane were used as female parents and resistance at various levels has been observed. However, the influence of cytotypes with different chromosome number in imparting susceptibility/resistance in the progenies has not been reported. The actual frequency and level of red rot resistance in the progenies derived from different ploidies/ cytotypes of *S. spontaneum* are yet to be ascertained. Hence, progenies derived from the crosses of commercial varieties of sugarcane and different cytotypes of S. *spontaneum* were subjected to red rot reaction and the results are discussed in the present study.

Materials and methods

In the present study, 588 hybrids developed through biparental crossing method from 37 interspecific crosses involving eight commercial varieties and 16 clones of *S. spontaneum* with eight cytotypes (2n=40, 56, 60, 64, 72, 80, 88, 112) were evaluated for red rot resistance at 6th month. The commercial varieties were Co 89029, Co 1148, Co 8371, CoH 114, BO 102, BO 110, and BO 130. Since the cytotype 64 is the predominant type, 248 hybrids derived from 7 clones with 2n=64 were included.

In each cross 10-29 clones were tested for red rot disease reaction under controlled condition testing (CCT) method as described by Viswanathan et al. (1998) for two years. Spore suspension of *Colletotrichum falcatum* pathotype CF 06 (Cf 671) has been used. Ratings were given as HS (highly susceptible), S (susceptible), MS (moderately susceptible), MR (moderately resistant) and R (resistant). Frequency of disease reaction in different cytotype derived hybrids was calculated.

Results and discussion

Response of lower cytotypes (2n=40, 2n=56 and 2n=60) derived hybrids for red rot reaction

Among the 55 hybrids of the cytotype 2n=40 from four crosses tested, 43.5% were under resistant category with 7.2% R and 36.3% MR types. Susceptibility has been observed at a frequency of 56.5% in these crosses. Resistance was observed in a frequency of 19.4% from 41 hybrids of 4 crosses with 2n=56 where MR and R were noticed with 17.0% and 2.4% respectively. Majority of the hybrids (80.6%) developed from 2n=56 cytotype were susceptible. The 2n= 60 cytotype derived progenies showed resistance in a frequency of 16.0% among the 31 hybrids tested. MR and R types exhibited in a frequency of 9.6 and 6.4% respectively. About 84.0% were rated under susceptible category (Fig.1).

Response of 2n=64 derived hybrids for red rot reaction

Among the 248 hybrids tested from 12 crosses, 48.7% were rated under the resistant category with 29.0% MR and 19.7% R types. Susceptibility was noticed in 51.3% of clones. Among the female parents, the varieties BO 102, BO 110, BO 130 and Co 89029 generated maximum resistant hybrids. Most of the hybrids of Co 8371 and Co 1148 rated under susceptibility category (Fig.1).

Response of higher cytotypes (2n=72, 2n=80, 2n=88 and 2n=112) derived hybrids for red rot reaction

Among the 33 hybrids from the two crosses of the cytotype 2n=72 tested, 48.3% hybrids rated under the resistant category while 51.7% of the hybrids were susceptible. In 2n=80 derived hybrids, resistance was observed in 31.5% of 57 progenies tested, of which 17.5% was MR while 14.0% was R. Among the 98 hybrids of the cytotype 2n=88 screened, 56.0% belong to resistant category with a frequency of 37.7% MR and 18.3 % R. About 44 % clones were susceptible. Among the four resistant female parents, Co 89029, BO 102 and BO 110 produced resistant progenies at higher frequency. It was minimum in Co 1148 (susceptible) derived hybrids. In the 2n=112 derivatives, maximum of 56.0% of hybrids among 25 hybrids had shown resistance, with a frequency of 32.0% MR and 24.0% R. Susceptibility noticed in 44.0% of the hybrids tested (Fig.1).

Among the 588 hybrids tested, 44.3% were rated as resistant category with 28.9% MR and 15.4% R types (Fig.2). About 45.7 % were S type. In the susceptible parent derived plants (304) tested,

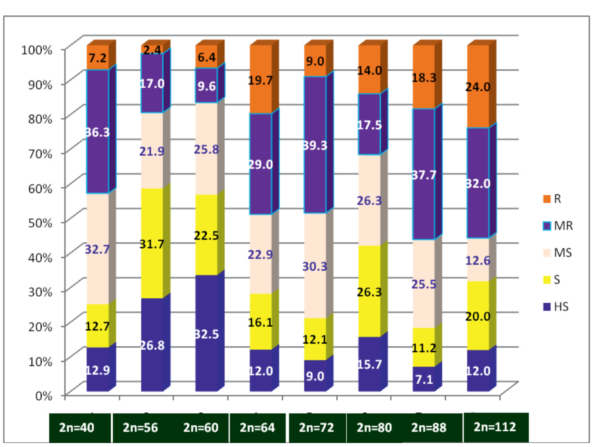

Figure 1 Comparative analysis of different cytotypes derived progenies of *S. spontaneum* for red rot resistance

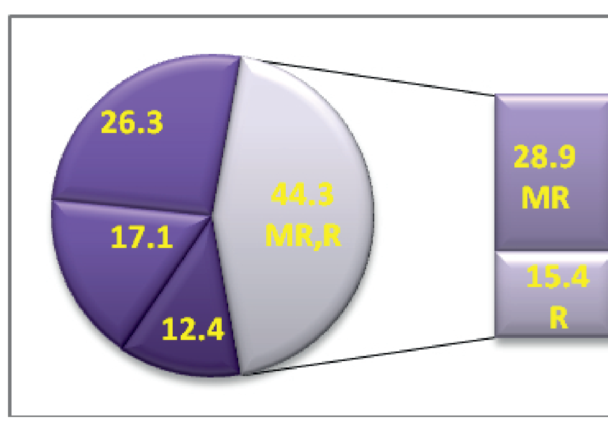

Figure 2 Red rot reaction of hybrids derived from susceptible and resistant parents and cytotypes.

resistance observed in 33.8% hybrids with 22.3% MR and 12.8% R. Among the 324 progenies derived from the four female resistant parents, resistance conferred with 29.9% R and 39.4% MR (Table 1).

in the cytotype 2n=64 was normal. In this study also differential segregation of chromosomes from different cytotypes imparted differential reaction in the progenies to red rot pathogen. Suganya et al. (2015) observed differential chromosome transmission pattern (n+n, n+2n, 2n+n) with aneuploidy in different cytotype-derived hybrids. The progenies with 2n=40, 64,72,80,88,112 imparted resistance (MR and R) at higher frequencies from 31.5% to 56.0%. The contribution of lower cytotypes for imparting resistance was 43.5% (2n=40), 19.4% (2n=56) and 16.0% (2n=60). Among the lower cytotypes, higher frequency of resistance with 2n=40 is due to the segregation of the whole genomic complement of 40 chromosomes of male gamete (*S. spontaneum*) to the progenies which exhibited n+2n transmission as observed by Suganya et al. (2015). Though 64 cytotype derived hybrids had 32 chromosomes through n+n transmission it sustained resistance in 48.7% of hybrids. Earlier studies revealed that the predominant cytotype 64 undergoes regular meiosis which resulted in stable progenies without chromosome loss and these hybrids possessed the expected chromosome number (Suganya et al. 2012, 2014a: Sobhakumari and Asmita 2014). 2n=64 cytotype is able to sustain resistance with balanced chromosome number of the both the parents. Among the higher cytotypes, 88 and 112 produced maximum resistant progenies at a frequency of 56%. It indicates that enhanced ploidies with genome size increases resistance.

Table 1. Frequency of resistance in the susceptible and resistant parents of *S. spontaneum*

Parent (s)	No. of hybrids studied	MR (%)	R (%)
Sucesptible	304	22.3	12.8
Resistant	284	39.4	29.9

Red rot resistance in inter varietal crosses and interspecific crosses have been analyzed in several studies (Choudhary et al.1988; Natarajan et al. 2001a, 2001b; Ram et al. 2005; Alarmelu et al. 2010; Babu 2010; Sobhakumari 2014; Nisha et al. 2019; Singh et al. 2019). The susceptible and resistant parents have been crossed in different combinations. Their findings indicated the existence of an additive gene effect which resulted in resistance progenies from the susceptible parents. When *S. spontaneum* or its derivatives is used, presence of one resistant parent enhanced resistance (Natarajan et al. 2001b; Alarmelu 2010; Singh 2019).

Among the 588 hybrids tested, 44.3% were rated under resistant category with 28.9% MR and 15.4% R types. It indicates that the inheritance for red rot resistance did not follow any specific segregation ratio in the hybrids as observed by Chaudhary et al. 1988; and Babu 2010.

Increase in resistance in *S. spontaneum* derived progenies occurred by action of one or more genes through segregation of whole chromosomes (Alarmelu et al. 2010). Suganya et al. (2012) noticed meiotic abnormalities in the cytotypes 2n=56, 2n=60, 2n=72, 2n=88 and 2n=112. Meiosis

Even though the higher ploidy showed abnormal meiosis with laggards and the resultant hybrids exhibited elimination of chromosomes, the higher male genomic/gametic component imparted resistance at higher frequency (Suganya et al. 2014a; 2019). It is advantageous for sugarcane breeding to attain stable resistance. An increase in *S. spontaneum* chromosomes/alleles in the progenies increases horizontal resistance component of resistance (Natarajan et al. 2001b; Selvi et al. 2005). Careful choice of parental clones and cross based selection led to increase in the population level of red rot resistance (Yin et al. 1996). Hence this study suggests utilizing the resistant hybrids of the higher cytotype derived crosses for nobilisation to achieve horizontal / stable resistance. *S. officinarum* is preferable in backcrosses to increase sucrose and cane yield and reduce the breeding cycle.

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References

Alarmelu S, Nagarajan R, Shanthi RM, Mohanraj D, Padmanabhan P 2010. A study on genetics of red rot resistance in sugarcane. Electronic Journal of Plant Breeding, 1: 656-659.

Babu C, Koodalingam K, Natarajan US, Shanthi RM Govindaraj P 2009. Genetic enhancement of sugarcane (*Saccharum* sp. hybrids) for resistance to red rot disease and economic traits. The Journal of Agricultural Sciences, 4: 97-107.

Babu C, Natarajan, US, Shanthi RM, Govindaraj P, Ramesh Sundar A Viswanathan R 2010 Inheritance of red rot resistance in sugarcane (Saccharum sp. hybrids). Sugar Tech. 12: 167-171.

Baksha R, Alam MM, Kamal B, Podder P, Rahman ASMM 2003. Screening of different sugarcane species (*Saccharum officinarum* and *Saccharum spontaneum*) for red rot disease resistance. Pakistan Journal of Plant Pathology, 2(2):111-113.

Chaudhary BS,Virk KS, Ram K 1988. Inheritance of red rot resistance in sugarcane. Agricultural Science Digest, 8:210-212.

Govindaraj P, Nair NV, Suganya A, Sreenivasa V 2012. Development and biomass characterization of new energy canes. Proceedings of International Symposium on New Paradigms in Sugarcane Research, 335.

Janakiammal EK 1936. Cytogenetic analyses of *S. spontaneum* L. 1. Chromosome studies in some Indian forms. Indian Journal of Agricultural Science, 6:1-8.

Natarajan US, Ramana Rao TC, Balasundaram N, Palanichamy K, Tripathi BK, 1998. Red rot resistance in sugarcane-a critique. Sugar Cane, 1:11-14.

Natarajan US, Balasundaram N, Ramana Rao TC, Padmanaban P, Mohanraj D, Karthigeyan S, Kannan R, Damodaran S 2001. Red rot resistance in sugarcane in terms of vertical and horizontal resistance. Proceedings of Diamond Jubilee Symposium, Hundred years of Post-Mendelian Genetics and Plant Breeding –Retrospect and Prospects,106.

Natarajan US, Balasundaram N, Ramana Rao TC, Padmanaban P, Mohanraj D, Karthigeyan S, Damodaran S 2001b. Role of *Saccharum spontaneum* in imparting stable resistance against sugarcane red rot. Sugarcane International,17-20.

Nisha M, Chandran K, Manjunatha T, Viswanathan R, Gireesan PP 2019. Genetic variability for agro morphological traits among the interspecific hybrids of *Saccharum*. Journal of Sugarcane Research, 9(1):55-63

Panje R R, Babu C N 1960. Studies on *Saccharum spontaneum*: distribution and geographical association of chromosome numbers. Cytologia, 25**:**152-172.

Ram B, Singh N, Sahi BK 2005. Combining ability and heterosis for disease index of red rot in sugarcane (*Saccharum officinarum* L.). Indian Journal of Genetics and Plant Breeding, 65: 112-114.

Selvi A, Nair NV, Noyer JL, Singh NK, Balasundaram N, Bansal KC, Koundal KR and Mohapatra T 2005. Genomic constitution and genetic relationship among the tropical and sub tropical Indian sugarcane cultivars revealed by AFLP. Crop Science, 45: 1750-1757.

Singh SP, Vishwakarma SK, Das SP, Kumar MM Srivastava VK 2019. Frequency of red rot resistance in the progeny population of various cross combinations. Agricultural Science Digest, 39(3): 232-235.

Sobhakumari VP 2013. New determinations of somatic chromosome number in cultivated and wild species of *Saccharum.* Carylogia, 66: 268-274.

Sobhakumari VP, Asmita D 2014. Cytogenetics and performance analysis of pre-breeding hybrids of *Saccharum officinarum* and *Saccharum spontaneum*. Journal of Sugarcane Research, 4 (1): 33-39.

Sreenivasan TV, Ahloowalia BS, Heinz DJ 1987. In: Sugarcane improvement through breeding. Ed. Heinz DJ, Elsevier, 211–253.

Suganya A, Nithiyanantham R, Premachandran MN, Balasundaram N, Govindaraj P, Selvi A, Nair NV 2012. Cytological studies in hybrids between a sugarcane cultivar and three cytotypes of wild S*accharum spontaneum* L. Journal of Sugarcane Research, 2(2): 34-40.

Suganya A 2014a. Cytotype diversity in *Saccharum spontaneum* L. and its utilization for sugarcane improvement. Proceedings of National Seminar on Emerging trends in Biodiversity conservation and sustainable utilization, 28.

Suganya A, Amudha A, Valarmathi R 2014b Differential elimination of chromosomes in interspecific hybrids of sugarcane derived with different cytotypes of *Saccharum spontaneum*, L. Proceedings of National seminar on Challenges and innovative approaches in crop improvement, 157.

Suganya A, Selvi A 2015. Chromosome transmission patterns in interspecific hybrids of sugarcane derived with different cytotypes of *Saccharum spontaneum* L. Proceedings of 5th International Conference on Next Generation Genomics and Integrated Breeding for Crop Improvement, 31.

Viswanathan R 2010. Plant Disease: Red rot of Sugarcane. Anmol Publications, 301.

Viswanathan R 2017. Pathogen virulence in sugarcane red rot pathogen versus varieties in cultivation: Classical case of loss in virulence in the pathotype CF06 (Cf671). Sugar Tech,19: 293-299.

Viswanathan R 2016. Varietal degeneration in sugarcane and its management in India. Sugar Tech, 18: 1-7.

Viswanathan R, Mohanraj D, Padmanaban P 1998. Comparison of three testing methods for evaluation of resistance to red rot caused by *Colletotrichum falcatum* in sugarcane (*Saccharum officinarum*). Indian Journal of Agricultural Sciences, 68 (4): 226-230.

Yin Z, Hoy JW, Milligan SB 1996. Evaluation and heritability of resistance to sugarcane red rot. Phytopathology, 86(6): 662-667.