https://doi.org/10.33451/florafauna.v30i2pp311-316
FLORA AND FAUNA ISSN 2456 - 9364 (Online)
2024 Vol. 30 No.2 PP 311-316 ISSN 0971 - 6920 (Print)

# Assessment of Red-Rot Resistance in C-1 Generation of Sugarcane Genotypes in Eastern Uttar Pradesh, India

***Y. P. Bharti, Sanjay Kumar[1], V.K. Shukla and S.K. Shukla[2]**

Genda Singh Sugarcane Breeding Research Institute,
SEORAHI, KUSHINAGAR-274407 (U.P.), INDIA
[1]Department of Microbiology,
Bundelkhand University, JHANSI-284128 (U.P.), INDIA
[2]Indian Institute of Sugarcane Research,
P.O. Dilkusha-226 002, LUCKNOW (U.P.) INDIA
Corresponding Author
E-mail : ypyogesh2011@gmail.com

***Received*** **:** 15.09.2024; ***Accepted*** : 08.11.2024

## ABSTRACT

The fungal disease red rot is caused by the fungal pathogen *Colletotrichum falcatum*. It is one of the most destructive diseases of vital commercial crop sugarcane (*Saccharum officinarum*) at global level including in India. This disease adversely affects sugarcane yield and quality leading considerable economic losses. The current study aimed to assess the resistance of C-1 generation sugarcane genotypes to red rot under field conditions in Eastern Uttar Pradesh. The experiment was conducted at the Genda Singh Sugarcane Breeding Research Institute, Seorahi, Kushinagar as a trial of breeding program to evaluate resistance. A spore suspension of *C. falcatum* (10v spores/mL) was inoculated into 5036 sugarcane genotypes using the plug method. Sixty days post inoculation, the disease severity was assessed by longitudinal splitting at the inoculation site and the genotypes were rated on an international 0-9 scale, considering factors like top condition, lesion width, nodal transgression and white spot formation. Among the evaluated genotypes, 1856 were moderately resistant, 1078 moderately susceptible, 977 susceptible, and 1042 highly susceptible. A small portion of genotypes exhibited water shoot phases. The identified moderately resistant genotypes represent a significant resource for advancing breeding programs, contributing to the development of red rot-resistant sugarcane varieties with enhanced productivity and disease management potential.

Figures : 03 References : 16 Table : 01
KEY WORDS : *Colletotrichum falcatum,* $C_{-1}$ Genotypes, Red rot disease, *Saccharum officinarum*, Sugarcane

## Introduction

The global improvement of sugarcane through breeding has primarily progressed *via* inter-specific hybridization programs. These efforts have been instrumental in developing varieties with enhanced disease resistance, higher yields and broader environmental adaptability. By introducing traits like drought tolerance, increased sugar content and resilience to various biotic and abiotic stresses, these breeding initiatives have significantly contributed to the sustainability and advancement of sugarcane cultivation worldwide. An inter specific hybrid was produced in from a cross between *Saccharum officinarum* & *Saccharum spontanium* as a first commercial sugarcane variety Co205 released for cultivation in India[7]. Many such hybrid clones starting from Co 205 released in 1918 made a sugar revolution in the country, especially in the subtropical region[14] . Furthermore, these breeding initiatives have improved ratoonability, a vital factor for the prolonged cultivation of sugarcane, along with boosting sucrose content and enhancing resistance to pests like the sugarcane borer. These innovations are crucial for ensuring the future resilience and productivity of sugarcane crops in the face of global climate change. Afterward most of the sugarcane varieties were developed through inter-specific hybridization between the cultivated and wild *Saccharum* species, backcrossing of the hybrids of the cultivated species and their subsequent intercrossing. The successes of the early inter specific hybrids and their derivatives generated sustained interest in the collection, conservation, characterization and utilization of the *Saccharum* germplasm. As a result, one of the largest collections of sugarcane germplasm screening for red rot resistance, which well characterized and well documented. The microbial consortiums have the pivotal role in maintain

**TABLE-1: Behaviors of various genotypes in C-$_1$ generation against red rot of spring planted at Seorahi during four years - 2016 -17 to 2019-20**

| Years | Total genotypes | Red rot reaction by plug method inoculation in C-$_1$ genotypes | | | | |
|---|---|---|---|---|---|---|
| | | R/MR | MS | S | HS | NC |
| 2016-17 | 1888 | **539** | 463 | 448 | 400 | 38 |
| 2017-18 | 1584 | 693 | 364 | 268 | 241 | 18 |
| 2018-19 | 1234 | 506 | 190 | 173 | 346 | 19 |
| 2019-20 | 330 | 118 | 61 | 88 | 55 | 08 |
| **Total** | 5036 | 1856 | 1078 | 977 | 1042 | 83 |

Whereas R = Resistant, MR = Moderately resistant, MS = Moderately susceptible,
S = Susceptible, HS = Highly susceptible, NC = No cane/Water shoot phase

the soil health as well as crop productivity. However, understanding the response of soil bacterial population to the soil environment is a challenging task[9]. Red rot of sugarcane is the most threatening disease of sugarcane, rightly called as 'Cancer' of sugarcane[10]. The systematic and continued utilization of the germplasm had been an important feature of the varietal development and improvement programme for selection of red rot resistant genotypes.

Sugarcane (*Saccharum)* crop is attacked by all kinds of disease causing organism such as fungi, bacteria, viruses and phytoplasma. Also, the crop is available throughout the season in a year in the field thus exposed to the pathogens all the times. Additionally vegetative propagation favors carryover of the pathogens by their accumulation in the cane stalks. Ratooning is another factor in building up of diseases under field conditions and most of the times ratoons favour the disease development to an epidemic levels. Infection of necrotizing pathogens like red rot/leaf scald or vascular pathogens like wilt show disease leading to the crop loss in the same season[13]. Many other pathogens causing smut, RSD, GSD, Mosaic, YLD *etc* accumulate in the cane over season and causes the disease in the ratoons or slowly bring down the vigour of the variety. This phenomenon is referred to as 'varietal deterioration'. Hence poor performance of the varieties due to varietal deterioration needs replacement of varieties or rejuvenation through meristem culture or heat therapy or chemotherapy or both. However, the rejuvenated planting materials introduced to the field many succumb to the disease again. Hence, going for resistant varieties is the best option available in the sugarcane breeding center in the country like ours, where still the farmers are not resourceful, lack of knowledge on integrated disease management and in many instances lack of awareness on disease infection in their crop. Several important varieties like Co 205, Co 213, Co 290, Co 301, Co 312, C o 313, Co 357, Co 370, Co 385, Co 393, Co 419, Co 421, Co 453, Co 658, BO 3, BO 11, BO 14, BO 17, BO 54, Co 997, CoS 510, CoS 562 CoS 687, CoC 671, CoC 85061, CoC 86062, CoC 92061, CoLk 8102, CoJ 82, CoJ 84, CoS 767, CoSe 93232,CoSe 92423 and CoSe 98231 have been removed from the field due to their high susceptibility to red rot disease. All such efforts have resulted in the release of outstanding varieties from Sugarcane Breeding Institute which were high yielding and tolerant to major diseases resistance of sugarcane hybridization. The continuing efforts of sugarcane breeding have resulted in the red rot evaluation of sugarcane varieties from time to time to meet demand of farmer and greatly expanded sugar industry in the country.

## Virulency of the Pathogen

In Indian scenario there are five major races with characteristic of higher virulence of the tropical isolates as compared to subtropical isolates. It is well known holistically that *Colletotrichum falcatum* isolates are culturally, morphologically and pathologically dissimilar[3]. The average length and width of conidia varied between 27.0- 45.0 and 5.6-10.0 ìm, respectively[6]. The colour and texture of the mycelia, nature and degree of

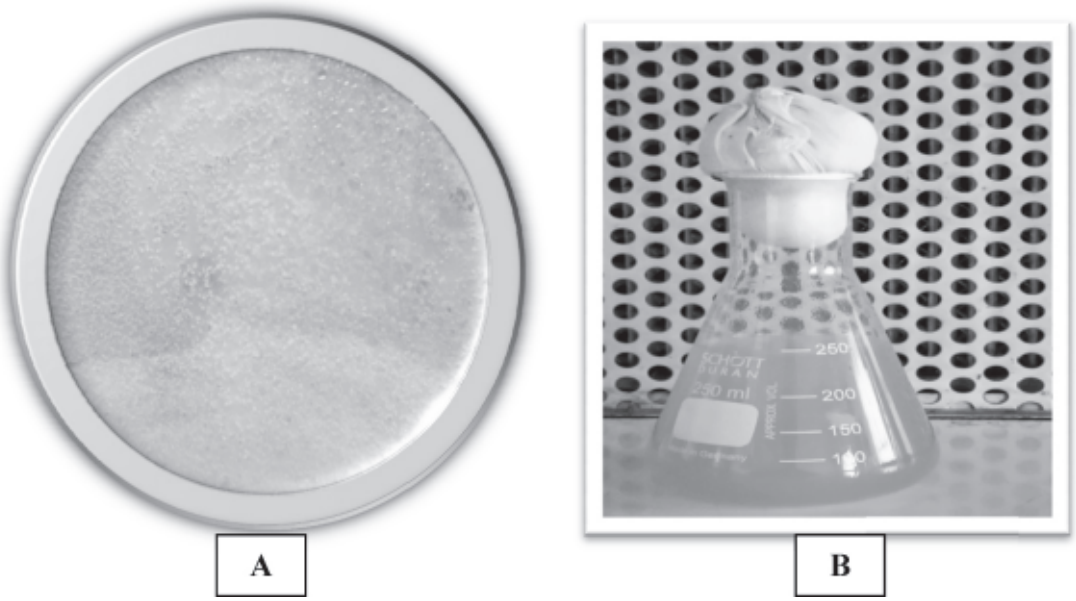



**Fig-1: Mass culture and spore suspension of *Colletotrichum falcatum* of reference pathotypes (A,B)**

sporulation appear to be inter-related to some extent with certain conidial characters as well as virulence[3] . Amelioration of new ways towards the Integrated Disease Management programme to manage the red rot disease will be the best option for control of the disease. Integration of IDM practices have reduced red rot incidence, enhanced several growth parameters and improved eminence attributes of sugarcane. The distinctive morphological and cultural features of *Colletotrichum falcatum* is seen as a facultative parasite including acervuli with setae, colony colour, sporulation and growth rate[15] . The factors like spontaneous natural mutations, genetic drift, gene flow and crop rotation have played significant role in terms of variation among the isolates of *C. falcatum*[1] . The molecular markers are also useful to study microbial diversity for detecting the variation between different populations[8] .

## Materials and Methods

The experiment was conducted at Genda Singh Sugarcane Breeding & Research Institute, Seorahi, Kushinagar with collaboration of breeding programme for spring planted four crop sessions (2016–17 to 2019–20). A total 5036 genotypes were planted in augmented design in 6.0 meter single row length with spacing 90 cm. Three recommended national reference pathotypes (CF07, CF08, CF09) prevailing in North Central and North West Zone and virulent local isolate (R1602Seo: Source-CoSe 92423) of Seorahi, location was used for mixed inoculations of each clones by plug method (Fig. 1). Fresh highly sporulating 7–9 days old cultures in petri-dishes were used for inoculums preparation. The conidial mass was harvested with 100 ml of sterile water and collected in a flask. Conidial concentration was adjusted to $10^6$conidia/ml spore using a haemocytometer. The spore suspension was placed in a hole made with 20 ml hypodermic needle having 16-G size on the 3rd exposed internodes from bottom[5]. The inoculation was done in 7th month old cane in the field from first week of August. This period coincided with active monsoon season which facilitates optimum conditions for disease development. About 25 clumps are required for taking up inoculation. In each clump at least five canes were inoculated. Inoculation is to be done in the middle of the third exposed internodes from bottom and two drops of spores were dropped into the bore hole (12 mm depth and 8 mm dia.) made using a red rot inoculators[13]. The tissue block removed was placed in the same bore-hole after dropping conidial suspension and injured area was covered with modeling clay, immediately (Fig. 2). The disease reaction on 5036 clones were evaluated against red rot for assessing the pathogenesis on the basis of the international scale (0 to 9) were adopted as suggested by researchers[12]. After 60 days of the inoculation, these genotypes were split open longitudinally along the point of inoculation for calculating the disease index.

## Results and Discussion

Sugarcane breeding programme screening for red rot resistant clones was very important procedure of selection of varieties. In this investigation, a total 5036 clones screened, out of which 1856 clones were found moderately resistant (MR), 1078 clones were moderately

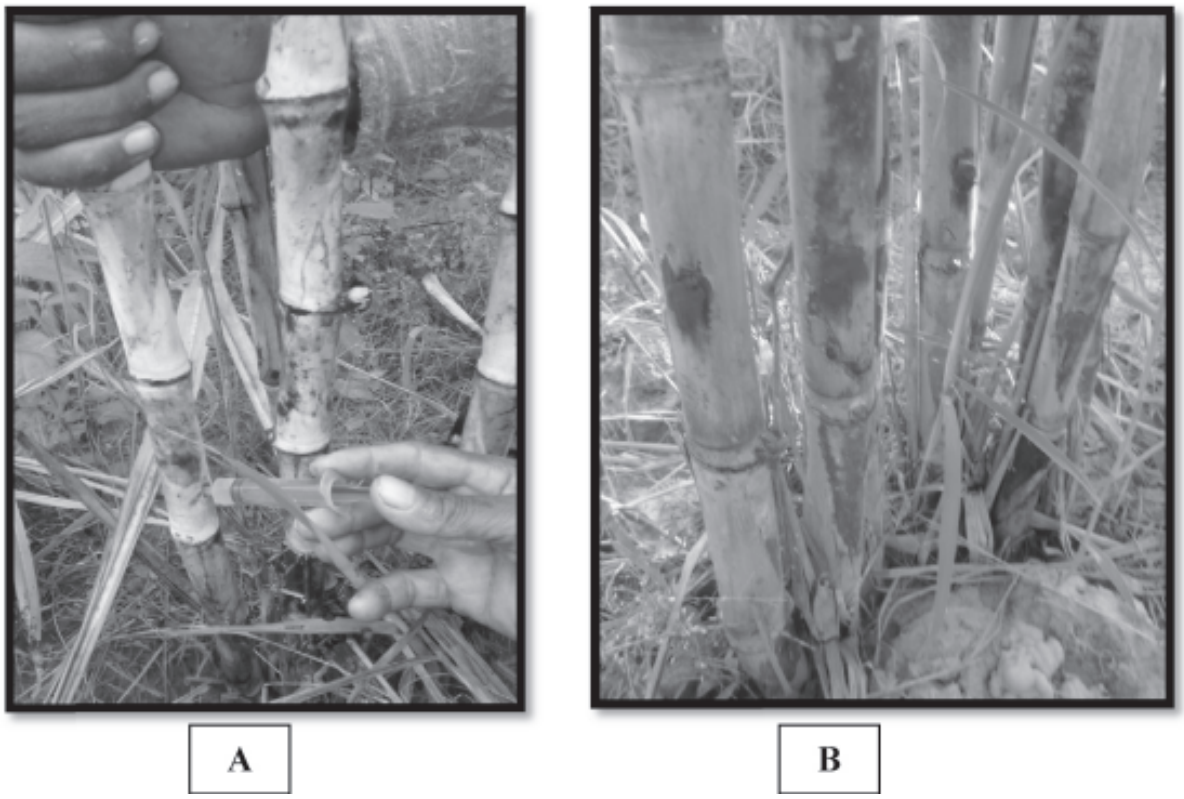


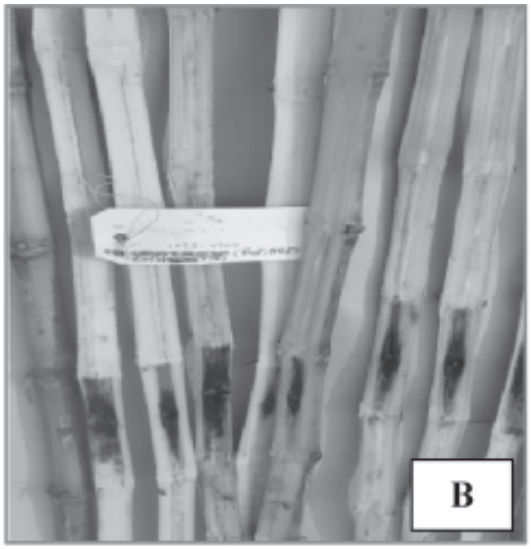

**Fig-2: Plug method inoculation of *Colletotrichum falcatum* in C-$_1$ genotypes (A,B)**

susceptible (MS), 977 clones were susceptible (S) and 1042 clones were found highly susceptible (HS), while rest clones were found water shoot phases (Fig. 3). Similarly, inter-specific hybrids and basic species in the sugarcane germplasm were screened for disease resistance regularly to prevailing pathogenic flora and were utilized as parental clones in breeding programmes[13]. A major part of the species- germplasm had been screened for red rot resistance. Among the *S. officinarum* germplasm 7 clones were reported to be resistant to red rot and 15 clones' moderately resistant[12]. In that study it was reported that 170 clones of *S. spontaneum* screened, 69 clones were resistant and 59 clones moderately resistant to red rot[4]. Among the *Erianthus* germplasm 10 clones were reported to be resistant to red rot[2]. A diverse management and conservation practices including inclined disease resistance, pathogen free seed were used and different fungicides were being adopted to combat the disease at every step but every approach has certain limitations as susceptible to new races of the pathogen which developed due to excessive use of pesticide *etc.* It was involved in the failure of important commercial varieties in different states of the country were removed for cultivation to red rot disease[16]. The incidents of red rot could be minimized by crop rotation. Mono cultivation of the same crop as well as variety results in a condition to favor disease development. The crops could be rotated after two to three years and ratooning could be downcast. The leaves having the symptoms of disease fallen in the field after withering and drying, might be collected and burnt. Recurrent outbreaks of red rot in epidemic forms resulted in the replacement of old varieties regularly and need to develop new resistant varieties. Sugarcane breeding and selection process gave emphasis to adaptability; yield, quality improvement and disease resistant especially red rot resistant varieties. Besides new approaches there is a need for comprehensive research which should be developed to control the disease and exploitation of induced systemic resistance and systemic acquired resistance require more research work to be done further.

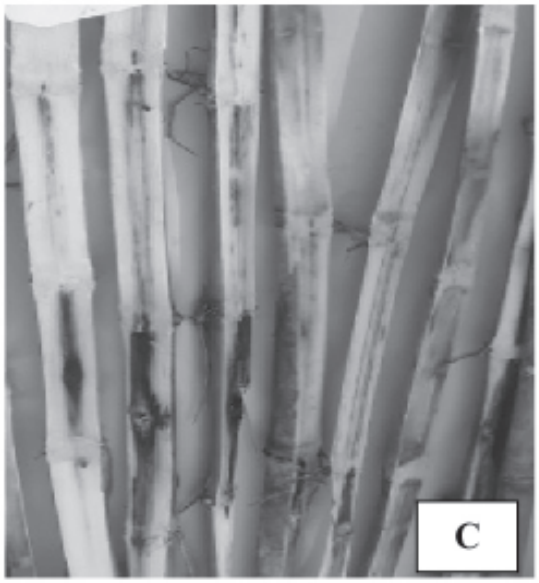
## Conclusion

The present study demonstrated the prospects of inheritance of red rot resistance; exact mechanism governing red rot resistance in sugarcane has not been understood. Considering the future perspectives sugarcane is an important crop of India but diseases are the major concern for it which reveals as responsible for its low yield. However, two kinds of resistance *viz*., the structural or mechanical that is static and the physiological or biochemical, which is dynamic, play a part in the defenses of the plant against the pathogen. Considering the above facts, the current study aimed to


R=Resistant genotypes




MR=Moderately Resistant genotypes




MS=Moderately Susceptible genotypes


S= Susceptible genotypes



HS= Highly Susceptible genotypes

**Fig-3 : Behaviors of various genotypes in C-$_1$ generation against red rot reaction in different clones (A-F)**

emphasis on the recent finding on physiological resistance that 1856 clones utilize, further studies in the breeding programme for next generation, such holistic approach of study could be effective for management of red rot, better serve towards humanity and prosperity of human being with sustainability.

## References


1. Alsultan W, Vadamalai G, Khairulmazmi A, Saud HM, Al-Sadi AM, Rashed O, Jaaffar AKM, Nasehi A. Isolation, identification and characterization of endophytic bacteria antagonistic to *Phytophthora palmivora* causing black pod of cocoa in Malaysia. *Eur J Plant Pathol.* 2019; **155** : 1077-1091.
2. Bakshi Ram, Sreenivasan TV, Singh VK, Singh N. Introgression of low temperature tolerance and red rot resistance from *Erianthus* in sugarcane. *Euphytica.* 2001; **122**(1) : 145-153.
3. Bharti YP, Kumar A, Sharma DDK, Singh SK, Shukla DN. Morphological, physiological and pathological variations among isolates of *Colletotrichum falcatum* that cause red rot of sugarcane. *African J Microbiol Res.* 2014; **8**(10) : 1040-1049.
4. Chaudhary BS, Mehta AS, Vrik KS, Pal R. Breeding for red rot resistance in sugarcane (*Saccharum hybrids complex*): Review concept and theory. *Proc National Seminar Sugarcane Production Constraints Strategies Research Management Red Rot.* (Eds.) Singh GB, Shukla US, Agnihotri VP, Sinha OK, Singh RP. IISR, Lucknow. 1995; 221-232.
5. Hussnain ZZ, Shahid-Afghan, Khalid-Hussain, Asia-Naheed, Saadia-Rizawan, Plosha-Khanum. Screening of promising sugarcane genotypes (*Saccharum officinarum* L.) against red rot *Colletotrichum falcatum* Went; through syringe method of inoculation. *Indian Sugar.* 2007; **8** : 23-26.
6. Kaur R, Kumar B, Vikal Y, Gulzar S. Genetic diversity among *Colletotrichum falcatum* isolates causing red rot of sugarcane in subtropical region of India. *Not Sci Biol.* 2014; **6**(3) : 308-315.
7. Nair NV. Sugarcane Genetic Resources: An Indian Perspective. In: Singh SB, Rao GP, Solomon S, Gopalasundram P, editors. Sugarcane Crop Production and Improvement. Studium Press LLC, Texas, USA. 2007; 1-20.
8. Rashed O, Abdullah NA, Alsultan W, Misawa T, Ahmad K, Kutawa AB. Characterization of inter and intra anastomosis group of *Rhizoctonia* spp. isolated from different crops in Peninsular Malaysia. *Trop Plant Pathol.* 2021; **46** : 422-434.
9. Sanjay K, Rajeeva G, Sanjeet KV, Ratna S. Isolation, characterization and assessing survival of bacteria in stress developed by simulated cadmium and lead contamination in soil. *Dev Microbiol Mol Biol.* 2012; **3**(1):1-7.
10. Sharma R, Tamta S. A review on red rot: The “cancer” of sugarcane. *Plant Pathol Microbiol.* 2015; pp.1-8.
11. Sreenivasan TV. Research strategies for breeding for red rot resistance in sugarcane. Proc National Seminar Sugarcane Production Constraints Strategies Research Management Red Rot. (Eds.) Singh GB, Shukla US, Agnihotri VP, Sinha OK, Singh RP. IISR, Lucknow. 1995; pp.233-239.
12. Srinivasan KV, Bhatt NR. Red rot of sugarcane-criteria for grading resistance. *J Indian Bot Soc.* 1991; **11** : 566-577.
13. Viswanathan R, Rao GP. Developing disease-resistant varieties and methods of disease screening in sugarcane. In: Singh SB, Rao GP, Solomon S, Gopalasundram P, editors. Sugarcane Crop Production and Improvement. Studium Press LLC, Texas, USA. 2007; pp.759-801.
14. Viswanathan R, Selvakumar R. Varietal breakdown to red rot in sugarcane revealed by comparing two *Colletotrichum falcatum* inoculation methods. *Sugar Tech.* 2020; https://doi.org/10.1007/s12355-020-00855-6.
15. Viswanathan R, Malathi P, Padmanaban P. Variation in sugarcane red rot pathogen *Colletotrichum falcatum* Went. In: Rao GP, Manoharachari C, Bhat DJ, Rajak RC, Lakhanpal TN, editors. Frontiers of Fungal Diversity in India. 2003; pp. 39-67.
16. Viswanathan R, Padmanaban P, Maharaj D. Comparison of three testing methods for the evaluation of red rot *Colletotrichum falcatum* Went; in sugarcane. *Indian J Agric Sci.* 1998; **68** : 226-230.