Eco. Env. & Cons. 29 (4) : 2023; pp. (1860-1866)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i04.067

A review on integrated disease management of red rot of sugarcane caused by *Colletotrichum falcatum*

Jyothi Anna Kurian[1] and *M.D. Jehani[2]

[1-2]Department of Plant Pathology, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

(Received 20 May, 2023; Accepted 8 July, 2023)

ABSTRACT

Red rot of sugarcane caused by *Colletotrichum falcatum* Went is one of the devastating diseases of sugarcane, causing significant loss to sugarcane production in India and other countries. However, varietal breakdown to red rot caused severe epiphytic in countries, particularly in Asia, where resistant varieties fail on a regular basis. In India between 1932 and 1942, a virulent strain of red rot materialized, which resulted in the withdrawal of numerous susceptible types and finally endangered the sugar industry. Among the pathogens of sugarcane *Colletotrichum falcatum* causes the most substantial economic loss (5-50%) in sugarcane. Because of the pathogen's highly variable nature, which breaks red rot resistant varieties in a short period of time, breeding resistant varieties is the major challenge for sugarcane breeders. Currently, there is no feasible way to prevent the disease from spreading, so we need to follow integrated disease management. The red rot of sugarcane management will benefit from integration of cultural practices, resistant varieties, physical practices, biocontrol practices and chemical practices.

Key words: *Red rot, Sugarcane, Management, Colletotrichum falcatum, Resistant varieties, Chemical, Biocontrol.*

Introduction

Sugarcane (*Saccharum officinarum*) is an important agro industrial and leading crop because it improves the socio-economic livelihood of many sugarcane growers in the world. About 26.3 million hectares of sugarcane are grown globally, with a gross yield of about 1.9 billion tonnes. Brazil, India, Thailand, Pakistan, China, Mexico, United State of America and Australia are the leading sugarcane producing countries.

Presently, the sugarcane growers are facing many challenges including biological and non-biotic factors. Extreme heat, drought, flooding, poor soil fertility *etc*. are the abiotic factors. The crop is attacked by a large number of pathogenic microorganisms such as fungi, bacteria, viruses, and mycoplasma as well as nematodes. Out of these Red rot caused by *Colletotrichum falcatum* Went (Perfect stage *Glomerella tucumanensis* (Speg.) V. Arx and E. Muller) is a constant threat to the successful cultivation of sugarcane varieties (Viswanathan, 2010). It reduces the quality and yield of susceptible sugarcane cultivars. It decreases the cane quality, productivity and weight of sugarcane cultivars in Indian sub-continent (Satyavir, 2003; Duttamajumder, 2008; Singh *et al*., 2008). Red rot is widely scattered and has been confirmed in 68 sugarcane growing countries in the world (Bharti *et al*., 2012).

Red rot of sugarcane was first reported from Java (now Indonesia) in 1893 (Went, 1893). The presence of this disease during the Buddhist period itself was supported by a few evidences (Derr, 1949; Daniels and Daniels, 1976). In India, the first scientific observation of this disease was made by Barber (1901) reporting large-scale destruction of the cane by red rot in the Godavari delta of Andhra Pradesh in the cultivar of Red Mauritius. In India, the first documented epidemic occurred in the years 1895-1901, and several massive outbreaks were reported in subsequent years in tropical and sub-tropical regions of the country. Red rot disease causing heavy losses in yield and quality of sugarcane has been reported from many countries of the world (Agnihotri, 1996). Damage due to red rot has been reported from the West Indies, India, Hawaii, U.S.A, Australia and Indonesia (Chona, 1980). In 1926, red rot disease brought the cane industry to almost to the brink of ruin in India (Carvajal and Edgerton, 1944).

Severe losses due to failure of several cultivated varieties by the epidemic of this disease have been recorded in India. The disease attracted special attention during the years 1938-40 when it appeared in an epidemic form in northern Bihar and eastern Uttar Pradesh resulting in the failure of the most popular variety Co 213 (Chona and Padwick, 1942; Chona, 1943). The disease again appeared in an epidemic form during 1946-47 in several districts of Uttar Pradesh, resulting in the failure of popular variety Co 312. In 1950-51 localized red rot epidemic affecting Co 312, Co 313 and Co 421 was reported from Punjab (Chona and Srivastava, 1960). Subsequent epidemics were responsible for elimination of 5 of popular varieties *viz*., BO 10, BO 17, BO 54 and CoS 510 from Bihar and Uttar Pradesh (Agnihotri, 1996). Severe epiphytotics were reported in cultivars Co 312, Co453, Bo 11, BO 17, and BO 54 in the Punjab and Terai regions during 1946-47 (Nageswararao and Patro, 2005).

Disease cycle of *Colletotrichum falcatum*

Pathogen grows in soil and produce asexual fruiting body acervuli. Conidia/setae/ chlamydospores present in the soil act as infective propagule. Conidia/chlamydospore germinate and produce germ tube and enter into the setts and produce mycelium. The pathogen spread throughout the plant and produce typical symptoms on leaf, node, internodes. In infected plants contains pathogen structures such as mycelium, acervuli and conidia. Pathogen survives in the form of dormant mycelium and chlamydospores. Surviving structure disseminates through irrigation water or infected plating materials. Infected seed or setts act as the primary source of inoculums. Secondary infection produced by conidia derived from acervuli and transmits through insects, wind and water (Figure 1).

Integrated disease management

Integrated disease management of red rot of sugarcane has become an evaded in the successful cultiva-

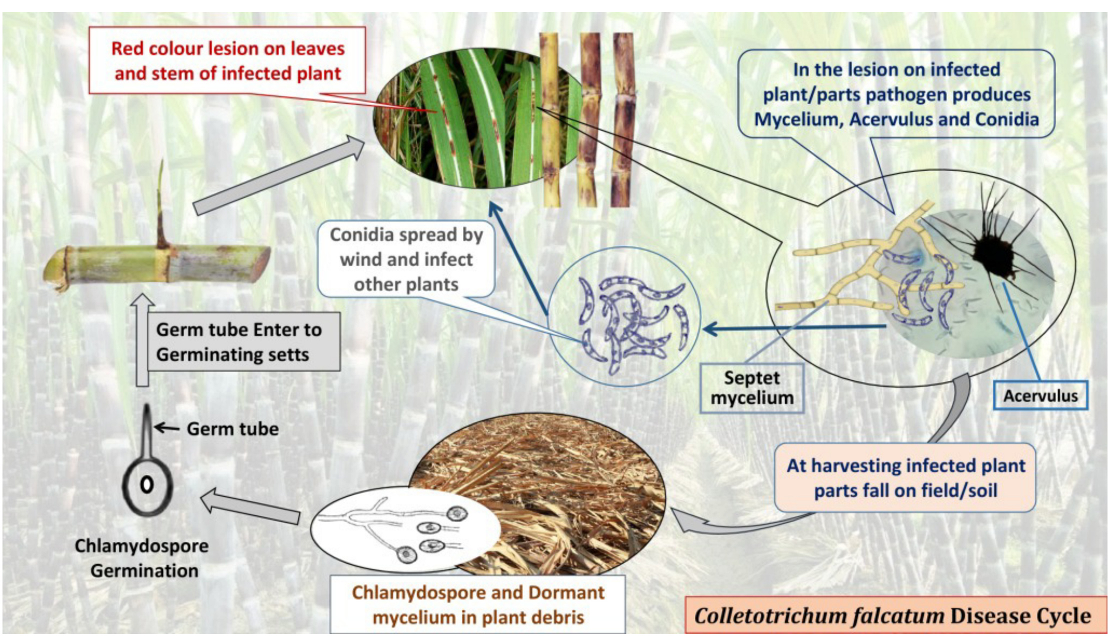

Fig. 1. Disease cycle of *Colletotricum falcatum* causing red rot of sugarcane

tion of sugarcane in India and other countries. Whereas there are many factors are involved in the integrated management of red rot of sugarcane, such as cultural practices, use of resistant varieties, physical practices, biocontrol agents and chemical practices, among others. However, the management tactics for reducing red rot incidences have not produced satisfactory outcomes. Thus, for disease control approaches, integrated disease management (IDM) is one of the best practices. IDM practices decreases the red rot incidences, increase the characteristics of sugarcane performances and increase growth parameters as compared to non-IDM practices. It involves all the practices to control the disease incidences.

Cultural practices

Healthy cultural practises are always considered as the right choice. Disease can be reduced by using certified seeds, healthy planting materials, proper drainage facilities, field sanitation, and crop rotation. These cultural practises are used not only to decrease the inoculums from the field, but also reduce the crop loss. In field sanitation, the crop debris and stubble should be removed and burned because it is helpful and must be done in the field before planting (Agnihotri, 1996). The disease is considered seed/sett-borne in nature, so a disease free zone should be managed in the field and farmers' fields (Satyavir, 2003) .It is necessary to guarantee that seed material is free of diseases, pests, and mixes of different types. Nurseries with less than 1% red rot infection must be removed from the seed programme. Sugarcane setts with reddish cut ends, reduced nodes, stalk borer holes, and damaged buds should be avoided. This alone will increase germination by 10% and minimise the incidence of red rot.

Rotation of the sugarcane crop should happen every two to three years. Red rot disease is typically spread by irrigation water; hence suitable drainage systems must be implemented. Water should never flow from an infected area to a healthy field. Jain reported that molecular and pathologic heterogeneity had not been connected to the geographic origins of pathogen isolates. This implies that using disease-free planting inputs in commercial production is the most efficient strategy to prevent this damaging illness. Before planting, it is essential to use field cleanliness techniques such as collecting and burying crop waste, withered leaves, and other debris. The field should be maintained properly and have sanitary growing conditions. Regular field inspection and roughing of diseased plants could minimize the occurrence of red rot disease. Anwar *et al*., (2010) revealed that three to four budded sugarcane setts play a significant role in soil borne inoculums control. Gupta *et al*., (2018) reported that red rot assault caused an increase in nitrogen and iron content while decreasing phosphorus, potash, copper, and zinc concentration, so fertilizer management is essential.

Breeding for resistance

Earlier, Indian breeding programmes were focused on creating new sugarcane varieties for subtropical India only to replace Indian sugarcane (*Saccharum barberi*), which was relatively low yielding. However, the situation changed as a consequence of red rot outbreaks occurring repeatedly under epiphytotic conditions, and breeders tried to develop red rot resistant cultivars. Utilizing wild species like *S. spontaneum*, *S. officinarum*, and *S. bareri*, the breeding and selection procedure gave an emphasis on adaptability, yield and quality enhancement, and red rot disease resistance. The breakdown of new variations in a shorter life period is considered to be mainly caused by the emergence of new pathogen races. In 1972, Alexander and Rao reported that red rot resistance in sugarcane species is being transferred through interspecific, intraspecific or intergeneric crosses. Out of the various sugarcane species, *Saccharum spontanium* is regarded as a primary source of resistance, but *Saccharum officinarum*, cultivated sugarcane, has a low degree of resistance.

The breeding of resistant cultivars is a critical endeavour. Because of the red rot disease, several sugarcane cultivars have been eliminated from cultivation. The adoption of resistant cultivars is the most cost-effective and feasible approach of disease control and it is a key component of an integrated disease management strategy. To control the disease effectively and reduce red rot epiphytotics, resistance breeding is unavoidable.

The production of red rot-resistant cultivars through inter specific crosses is the focus of breeding efforts in the Indian subcontinent. However, because the pathogen develops, after 8 to 10 years of releasing a disease-resistant variety for commercial operations, it becomes susceptible to red rot disease because the pathogen mutates into a new and more virulent strain. Singh *et al*. (2017) reported that six accessions were resistant to red rot, while twelve clones exhibited a moderately resistant response, which may be used in a breeding programme to develop new resistant sugarcane types against *Colletotrichum falcatum*.

Physical Treatment

For the annual recurrence of red rot disease, infected planting materials serve as the primary source of pathogen inoculums (Viswanathan and Alexander, 1997). The most effective strategy for pathogen management is the use of setts free of illness. Since one of the most effective methods to prevent this serious disease is by the use of pathogen-free planting materials in commercial production, the geographical origins of the isolates could not be connected with molecular and pathological diversity (Jain and Chahal, 2011).

Many studies have shown that heat treatment can inhibit sett borne red rot infection. Talukdar *et al.* (2010) reported that sett transmitted illness may be eliminated by moist hot air therapy (54 °C for 3 hours and RH 95%). Red rot was controlled by combining artificial chemicals in hot water with heat and chemotherapy.

Singh and Singh reported that pathogen from contaminated setts can be removed using an aerated stream at 52°C or a sett soaked in cold running water for 48 h, followed by 150–180 min of hot water treatment at 50°C. Various workers also reported that heat therapy at 54°C for 4 hours was found effective against red rot disease (Srivastava *et al*., 1977, Singh *et al*., 1980, Dhillon *et al*., 1983; Agnihotri, 1984). Burning garbage, maintaining enough soil moisture, and proper harvesting of contaminated or susceptible crops are other measures that had been advised for the control of red rot. The benefits of physical therapy include that it is affordable, simple to use, and environmentally friendly while also killing soil-borne infections. Even as this technique is time -consuming.

Biological Control

In comparison to other popular control methods, biological control seems to offer the greatest long-term sustainability and management of soil-borne illnesses (Fravel, 2005). For the treatment of various diseases in different crops, various bio-control agents have been combined with cultural methods, soil solarization, fungicides, and disease resistant cultivars (Gogoi *et al*., 2007). These bio-agents can be used independently or in conjunction with other management techniques.

Biological control with *Pseudomonas* sp.

The fluorescent pseudomonads FPs, also known as plant growth-promoting rhizobacteria (PGPR), have grabbed a large amount of attention among the possible bacterial antagonists connected to plant roots because of their prevalence in the rhizosphere. The FPs has been demonstrated to develop systemic resistance in plants against certain pathogens in addition to direct antagonistic action against bacterial and fungal disease in plants.

According to the definition, induced systemic resistance (ISR) is the systemic protection provided to plants after exposure to an inducing substance in a specific plant component (Kloepper *et al*., 1992). PGPR belonging to FPs induces systemic resistance (ISR) against *C. falcatum* Went causing red rot disease in the sugarcane stalks by three different resistance evaluation methods. All the tested PGPR strains reduced drastically disease growth in the stalks, and *Pseudomonas* spp. strains produce systemic resistance against *C. falcatum*, which causes red rot in sugarcane. The bacterial strains significantly reduced pathogen growth in stalk tissues, and disease development was monitored (Viswanathan and Samiyappan, 1997 and 1999). The development of the red rot disease in the crop in pathogen-infected soil has also been inhibited by sett treatment followed by soil application of bacterial strains. When pathogen-infected setts were treated with bacterial strains, the germination rate of the treated setts was greater than that of the untreated setts. These facts imply that the bacterial strains have direct antagonistic action against the pathogen in addition to systemic resistance effects on the host (Viswanathan and Samiyappan, 2000).

Biological control with *Beauveria bassiana*

Beauveria bassiana is antagonistic entomopathogenic fungal strains ARSEF-6646, ARSEF-6647, ARSEF-6648, ARSEF-6650, and ARSEF-2417 (Bals.-Criv.) . When the lytic enzymes were synthesised by using chitin as a carbon source, they increased the pathogen mycelium's level of lysis and suppressed the sugarcane red rot pathogen *C. falcatum*. This inhibitory impact was more evident (Sanivada and Challa, 2014).

Biological control with *Trichoderma* sp.

Trichoderma harzianum is another bio-agent which is being used to management of red rot disease. According to Singh (1994), sett treatment or foliar sprays containing *T. harzianum* Rifai and *Chetomium* sp. increased germination and were successful in preventing the field development of red rot disease. The protection provided may be attributable to both systemic resistance generated in sugarcane and direct parasitic activity of *T. harzianum* on *C. falcatum*. Reduced economic losses in vulnerable kinds are another benefit of its use. Due to greater shoot biomass and germination, the yield was also increased by 15-20 t/ha. *Trichoderma* biopesticide application is cost-effective, efficient, and also has a positive impact on soil health (Singh *et al*., 2008). The use of *T. harzianum* to sugarcane helps control red rot because it directly affects *C. falcatum* and causes systemic resistance in plants grown from treated setts (Yadav *et al*., 2008).

Biocontrol with plant extracts

Extracts from plants have been reported to inhibit *C. falcatum*. Garlic, onion, and ginger extracts are said to be able to stop *C. falcatum* from developing mycelia. Applying essential oils like menthol, patchouli, peppermint, and palm oil might help lessen the effects of a *C. falcatum* infection. *Datura metal* and *Curcuma domestica* leaf extracts to limit the red rot pathogens' ability to proliferate on both their mycelia and their conidia. Similar to tobacco, dhup smoke (incense) is believed to prevent the genesis of red rot conidia. These findings were not obtained from field experiments. Thus, stages and detailed studies on their effectiveness in field evaluations are required. Utilizing natural products and biocontrol agents are beneficial for long-term disease suppression, soil health improvement, and economic efficiency.

Chemical Control

Red rot has been combated using a variety of fungi toxicants, but only with sporadic effectiveness. This could be due to the rind's imperviousness, the presence of fibrous nodes at the cut ends, the poor solubility of fungicides, the lack of broad-spectrum fungicides, and the abundance of nutrients in the sett. Red rot incidence was reduced when diseased setts were treated for 1-2 hours with carbendazim and benomyl, which are no more commercially available. Aretan, Agallol (0.25%) during a 5-10 minute dip helps in the removal of surface inoculum but not deep-seated mycelium. Chand *et al.* also reported that Vitavax reduced the red rot incidence in sugarcane. According to Malathi *et al*., (2004), soaking sugarcane setts in a 0.25% solution of Thiophanate Methyl was beneficial against red rot disease.

Fungicides have a key role in updating and improving the state of agriculture (Subhani *et al*., 2008). According to Subhani *et al*., (2008), the fungicides Benomyl, Folicur and Ridomil performed the best against red rot of sugarcane. Khan *et al*., (2009) investigated the use of fungicides to suppress red rot disease. Bharadwaj and Sahu reported Bavistin showed complete inhibition of mycelial growth of the *C. falcatum*. According to Shailbala and Kumar (2019), the control of red rot disease could be accomplished by using a new generation fungicide, namely Azoxystrobin 18.2% + Difenoconazole 11.4% SC @ 1.00 ml/l. They also reported that Azoxystrobin 23% w/w SC, a fungicide, greatly decreased the red rot disease.

Malathi *et al*., (2017) remarked that among the various fungicides, thiophanate methyl was shown to be very suited under automated treatment against red rot among the numerous fungicides. Thiophanate methyl, a fungicide also enhanced germination rate, tiller count, number of millable cane, weight of single cane, length of cane, diameter of cane, and yield of cane. The advantage of using chemical methods is that they work more effectively than other approaches, but they are not environmentally friendly.

Conclusion

Red rot is the most dangerous and severe sugarcane fungi disease, posing a significant threat to global sugarcane production. An integrated disease management strategy is the best possible option for controlling this disease, rather than relying on a single method. The first step in managing a disease is to understand the pathogen, which may be done by using molecular diagnostic methods to identify the pathogen quickly and accurately in seed cane. To overcome the disease, a variety of management techniques have been used, including the use of pathogen-free seed, the development of disease-resistant varieties, and various fungicides. However, each strategy has some drawbacks. The newly developed resistant varieties become susceptible to new races of the pathogen that develop due to the overuse of pesticides. The use of pathogen-free seed is successful; however, the pathogen typically enters the crop through irrigation. Few fungicides are effective in controlling disease, but they are banned due to their health-hazardous effects. Rather than depending on a single method, integration of all the controlling methods is the best choice. Integration of IDM principles improved sugarcane quality attributes, increased growth parameters, and decreased the occurrence of red rot.

References

Agnihotri, V.P. 1984. Control of Leaf Scald of Sugarcane by Streptomycin and Heat Therapy. *Indian Sugar Crops Journal.* 10: 17–18.

Agnihotri, V. P. 1996. Current Sugarcane Disease Scenario and Management Strategies. *Indian Phytopathology.* 49: 109–26.

Alexander, K. C. and Rao, M. M. 1972. Comparative Evaluation of Genotypes in the Centres in India for Resistance to Red Rot and Smut.In *Proceedings of the Diamond Jubilee Symposium of Sugarcane Breeding Institute*, 12–24. Coimbatore, India.

Anwar, M. S., Khan, H. M. W. A., Chattha, A. A. and Zia, A. 2010. Integrated Control Strategies for Sugarcane Disease. *Pak. Sugar. J. XXV*, 7–9.

Barber, C. A. 1901. Sugarcane Disease in Godawari and Ganjam Districts. *Madras Department Land Records and Agriculture Bulletin.* 512: 181–94.

Bharti, Y. P., Vishwarkarma, S. K., Kumar, A., Singh, A., Sharma, M. L. and Shukla, D.N. 2012. Physiological and Pathological Aspects of Some New Isolates of *Colletotrichum falcatum* Causing Red Rot Disease in *Saccharum* spp. Complex. *Acta Phytopaihologica Entomologica Hungarica.* 47(1): 35–50.

Carvajal, F. and Edgerton, C. W. 1944. The Perfect Stage of *Colletotrichum falcatum* Went. *Phytopathology*, 34: 206–13.

Chona, B. L. 1943. Red-rot of sugarcane and its control. *Indian Farming*. 4: 27-32.

Chona, B. L. 1980. Red rot of sugarcane and sugar industry - a review. *Indian Phytopathology*. 33: 191-207.

Chona, B. L. and Padwick, G.W. 1942. More light on the red rot epidemic. *Indian Farming*. 3(2): 70-73.

Chona, B. L. and Srivastava, D.N. 1960. Variations in *Colletotrichum falcatum* Went, the causal organism of red rot of sugarcane. *Indian Phytopathology*. 13: 58-65.

Daniels, J. and Daniels, C. A. 1976. A note on red rot disease, *Physalospora tucumanensis* Speg. and origin of sugarcane. Sugarcane Breeds. *Newsl.* 37: 17-19.

Deerr, N. 1949. The History of Sugar. Vol. 1. Chapman & Hall, London. 258 pp.

Dhillon, P. S., Kanwar, R. S. and Bedi, J. S. 1983. Effect of Moist Hot Air Treatment on the Control of Gsd and Rsd and Productivity of Sugarcane. *Indian Sugar Crops J.* 9: 3–4.

Duttamajumder, S. K. 2008. Red Rot of Sugarcane. Indian Institute of Sugarcane Research, Lucknow, 132pp.

Fravel, D. R. 2005. Commercialization and Implementation of Biocontrol. *Annual Review of Phytopathology.* 43 (1): 337–59.

Gogoi, R., Saikia, M., Helim, R. and Ullah, Z. 2007. Management of Potato Diseases Using *Trichoderma viride* Formulations. *Journal of Mycology & Pant Pathology,* 37(2): 227–30.

Gupta, R. N., Sah, S. B., Kumar, S., Kumar, A., Kishore, C. and Chand, G. 2018. Impact of Red Rot Disease on Nutrient Status of Sugarcane. *Int. J. Curr. Microbiol. App. Sci.* 7: 3533–38.

Jain, S. and Chahal, S. S. 2011. Molecular and Morpho-Pathological Variation in *BipolarisOryzae* (Breda de Haan) Shoem. Causing Brown Spot of Rice in North India. *Crop Improvement.* 38(2): 103–8.

Khan, S. H., Shahid, M. and Mustafa A. Safurehman, 2009. Control of Red Rot Disease of Sugarcane through Screening of Varieties and Seed Dressing Fungicides. *Pakisthan Journal of Phytopathology.* 21(1): 61–65.

Kloepper, Joseph W., SadikTuzun, and Joseph A. Kuæ. 1992. Proposed Definitions Related

Malathi, P., Padmanaban, P., Viswanathan, R., Mohanraj, D. and Ramesh Sundar, A. 2004. Efficacy of Thiophanate Methylagainst Red Rot of Sugarcane. *Acta Phytopathologica et Entomologica Hungarica.* 39(1–3): 39–47.

Malathi, P., Viswanathan, R. and Ramesh Sundar, A. 2017. Mechanized Means of Sett Treatment: An Effective Way of Delivering Fungicides for the Management of Red Rot in Sugarcane. *Sugar Tech: An International Journal of Sugar Crops & Related Industries.* 19(2): 176–82.

Nageswararao, G. V. and Tssk Patro, 2005. Pathotypes in *Colletotrichumfalcatum* Went and Identification of Resistant Sugarcane Clones. *Journal of Mycology and Plant Pathology.* 35: 305–9.

Sanivada, S. K. and Challa, M. 2014. Mycolytic Effect of Extracellular Enzymes of Entomopathogenic Fungi to *Colletotrichum falcatum*, Red Rot Pathogen of Sugarcane. *Journal of Biopesticide.* 7: 33–37.

Satyavir. 2003. Red Rot of Sugarcane Current Scenario. *Indian Phytopathology.* 56: 245–54.

Shailbala, Kumar A. and Sharma, S. K. 2019. Management of Red Rot of Sugarcane Caused by *Colletotrichum Falcatum* Went: A Review.*International Journal of Chemical Studies.* 7(3): 5029–39.

Singh, Atul, Pratap Singh, Tiwari, A. K. and Sharma, B. L. 2017. Assessment of Sugarcane Germplasm (*Saccharum* Spp. Complex) Against Red Rot Pathogen *Colletotrichum falcatum*. *Brazilian Archives of Biology and Technology.* 60 (0).

Singh, K., Misra, S. R., Shukla, U. S. and Singh, R. P. 1980. Moist Hot Air Therapy of Sugarcane: Control of Sett-Borne Infections of GSD, Smut and Red Rot. *Sugar J.* 43: 26–28.

Singh, N. 1994. *Trichoderma harzianum* and *Chaetomium* Sp. as Potential Biocontrol Fungi in Management of Red Rot Disease of Sugarcane. *Journal of Biological Control.* 8: 65–67.

Singh, N., Singh, N., Gupta, M. L., Kumar, S. and Kumar, S. 2008. Assessment of Losses Due to Red Rot Disease in Plant and Ratoon Crops of Sugarcane. *Indian Sugar.* 8: 47–55.

Singh, V., Joshi, B. B., Awasthi, S. K. and Srivastava, S. N. 2008. Ecofriendly Management of Red Rot Disease of Sugarcane with Trichoderma Strains. *Sugar Tech.* 10(2): 158–61.

Srivastava, Nsl, Singh, K. and Sharma, M. P. 1977. The IISR Moist Hot Air Treatment Plant for Seed Cane. *Sugar News,* 9: 96-102.

Subhani, M. N., Chaudhary, M. A., Khaliq, A. and Muhammad, F. 2008. Efficacy of Various Fungicides against Sugarcane Red Rot (*Colletotrichum falcatum*). *International Journal of Agriculture and Biology.* 10 (6): 25–27.

Viswanathan, R. 2010. *Plant Disease: Red Rot of Sugarcane, 306*. Vol. 306. New Delhi: Anmol Publishers.

Viswanathan, R. and Alexander, K.C. 1997. Management of sugarcane diseases. *Indian Journal of Sugarcane Technology*. 12: 37-48.

Viswanathan, R. and Samiyappan, R. 1997. Plant Growth Promoting Rhizobacteria for the Management of Red Rot Disease in Sugarcane. In *Proceedings of the International Symposium on Integrated Disease Management for Sustainable Agriculture*. New Delhi, India; New Delhi: Indian Phytopathological Society.

Viswanathan, R. and Samiyappan, R. 1999. Induction of Systemic Resistance by Plant Growth Promoting Rhizobacteria against Red Rot Disease in Sugarcane. *Sugar Tech: An International Journal of Sugar Crops & Related Industries.* 1(3) : 67–76.

Viswanathan, R. and Samiyappan, R. 2000. Efficacy of Pseudomonas Strains against Soil Borne and Sett Borne Inoculum of *Colletotrichum falcatum* Causing Red Rot Disease in Sugarcane. *Sugar Tech.* 2 (3): 26–29.

Went FAFC. 1893. Het rood snot. Arch. Java-Suikerindus; 1: 265–82.

Yadav, R. L., Singh, S. N., Srivastava, R. J., Lal, S. K. and Awasthi, B. B. 2008. Use of *Trichoderma harzianum* for the Control of Red Rot Disease of Sugarcane. *Sugarcane International*. 26(4) : 28–33.