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Gedela Venkata Hima Sameera
Ph.D. Scholar, Department of Plant Pathology, G.B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Sidh Nath Singh
Associate Professor, Plant Pathology, Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Anil Kumar
Associate Professor, Entomology, Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Corresponding Author:
Gedela Venkata Hima Sameera
Ph.D. Scholar, Department of Plant Pathology, G.B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Management of red rot of sugarcane by integration of biocontrol agents and fungicides

Gedela Venkata Hima Sameera, Sidh Nath Singh and Anil Kumar

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Abstract
Red rot is considered as one of the most dreadful diseases of sugarcane. A field experiment was conducted for management of red rot disease of sugarcane by integration of bio control agents and fungicides at Experimental Farm, Kalyanpur of Department of Plant Pathology, Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar) over one crop season 2022-2023 with the check variety CoSe 95422. Out of the treatments it revealed that treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar application with fungicide Azoxystrobin 11% + Tebuconazole 18.3% @ 0.1%) and treatment T_8 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar application with fungicide Thiophanate methyl 70 WP @ 0.1%) have the potential to control the disease and ultimately enhanced the performance of yield attributing characters, yield and quality such as brix, pol and purity percent. This finding established the fact that integration of bio control agents and fungicides can be used for effective management of the red rot disease of sugarcane.

Keywords: Integrated disease management, biocontrol agents, yield attributes, quality parameters, sugarcane

Introduction

Sugarcane (*Saccharum officinarum* L.) is grown in more than 80 different nations to produce white sugar, bioethanol, jaggery and other by-products and considered as the most significant cash crop in the world. India produces 20% of the world's sugarcane, and the largest producer of sugar. Sugar industry in India plays a considerable role towards socio-economic development in the rural areas by mobilising rural resources and generating higher income and providing employment opportunities. Almost of 7.5% of the rural population, of which 45 million sugarcane farmers, a huge number of agricultural labourers are involved in sugarcane cultivation, harvesting and subsidiary activities. Half a million professional and unprofessional workers, majorly from the rural areas are occupied in the sugar industry. About 240 sugarcane diseases caused by various plant pathogenic organisms have been reported all over the world (Ricaud *et al*., 1989 and Rott *et al*., 2000) [11, 12]. Red rot is regarded as one of the most important diseases of sugarcane caused by *Colletotrichum falcatum* Went. Epidemics caused by red rot have prevailed in both tropical and subtropical areas. It causes heavy yield loss to the cane growers and had a great impact on the sugar industries as well (Alexander and Viswanathan, 1996) [2]. It is considered as "Cancer of sugarcane" as it has become major constraints in the profitable cultivation of sugarcane (Chona, 1950) [3]. It reduces both yield and quality of cane juice. In general, the estimated losses vary from 3-25% in sugar content and 30- 90% in cane yield but there may be a lot of variation depending on incidence and environmental conditions prevailing (Agnihotri, 1990) [1]. According to various studies, it has been reported that integrated disease management has great potential to rise the durability of resistance when compared to use of same resistance in non- integrated manner (Mundt *et al*., 2002) [10]. Management using chemicals have ecological drawbacks, may be in pesticide residues or any non-target action. So, there might be a huge requirement of eco-friendly management of red rot pathogen which offers multiple barriers to the pathogen and ensures sustainability.

Singh *et al*., (2009) [13] conducted field experiments to manage the red rot disease with integrated disease management.

Malathi *et al*., (2002) [8] evaluated systemic fungicides Thiophanate methyl and Carbendazim along with bio agents like *Trichoderma* and *Pseudomonas fluorescens* to manage red rot disease of sugarcane caused by *Colletotrichum falcatum*.

Materials and Methods

A field experiment was conducted at Experimental Farm, Kalyanpur of Department of Plant Pathology, Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar) over a season 2022-2023 for the management of red rot of sugarcane by integration of bio control agents and fungicides.

The field experiment was conducted with a plot size of 27 m2 (6.0 x 4.5 m) and row to row spacing was maintained 90 cm apart in a Randomized Block Design (RBD) having nine treatments and three replications with the check variety CoSe 95422. Three budded setts were planted in the first week of February 2022. In this experiment 375 setts were planted in each treatment (125 setts in each replication).

Before planting, setts were pre- inoculated with the pathogen *Colletotrichum falcatum* isolate CF 08 before sett treatment with biocontrol agent and fungicide. The setts were inoculated with the test pathogen following the methodology of Duttamajumder and Mishra (2004). Precisely, a 10- day old sporulating culture of isolate CF 08 was washed with sterile water; spores were harvested and the conidial concentration was adjusted to 10^4 conidia/ml by using haemocytometer. Three budded setts were then dipped in the prepared pathogen inoculum suspension of 10^4 conidia/ml for 5 minutes and then incubated under a polythene cover for 16 hours at temperature 28^0 C. Pre-inoculated setts were then treated by dipping the setts in aqueous solution of carbendazim 50 WP @ 0.1% and with *Trichoderma harzianum* @ 0.6%. Soil drenching with carbendazim 50 WP @ 0.1% and with *Trichoderma harzianum* @ 0.6%.was done at 45 days of planting. Neem cake @ 100 kg/ha was applied in furrows at the time of planting. Foliar application was done with fungicides Spectrum, a commercial formulation of Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1% as well as with Roko, a commercial formulation of Thiophanate methyl 70% WP @ 0.1% just after appearance of the disease. Three foliar sprays were given at 15 days interval. First spray was given on 5th June, 2022 i.e. 120 DAP and subsequently second spray on 20th June and third spray on 4th July, 2022. The details of the treatments are given in the Table 1:

Table 1: Treatment details

No. of treatments	Treatment details
T_1	Sett treatment with carbendazim 50 WP @ 0.1%
T_2	Sett treatment with *T. harzianum* @ 0.6%
T_3	T_2 + soil drenching with *T. harzianum* @ 0.6%
T_4	T_1 + soil drenching with *T. harzianum* @ 0.6%
T_5	soil application with neem cake @ 100 kg/ha + T_3
T_6	T_2 + soil drenching with carbendazim 50 WP @ 0.1%
T_7	T_4 + foliar application with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1% commencing just after appearance of the disease
T_8	T_4 + foliar application with fungicide Thiophanate methyl 70% WP @ 0.1% commencing just after appearance of the disease
T_9	Control (setts soaked in water)

Observations recorded

(i) Quantitative parameters

To see the effect of sett treatment, observations on germination were recorded at 45 days of planting till 70 days, settling mortality at 70 days of planting till 120 days. Number of tillers/clumps were counted at 120 days of planting by counting side shoots growing from the base of the stem at ground level. Cane length was measured by using scale in centimetre, cane girth was calculated with the help of slide calliper in centimetre by using formula 2πr. Number of millable canes/clumps were counted at the time of harvesting and yield was recorded by weighing millable canes/plot in kg by using electronic balance and converted into tonnes/ha. The percent disease incidence was recorded at 180, 210 and 240 Days after Planting (DAP) by using formula:

$$\text{Percent disease incidence} = \frac{\text{Number of diseased plants}}{\text{Total number of plants observed}} \times 100$$

(ii) Qualitative parameters

Brix is the percentage of total solid in cane juice. Brix was determined by using ERMA hand refractometer by placing a drop of the cane juice on the prism of the refractometer and observing the coincidence of shadow of the sample with the reading on the scale and was expressed as brix. Pol percentage was measured by using Polariscope and purity percentage was calculated as purity coefficient by using the formula:

$$\text{Purity coefficient} = \frac{\text{Pol\%}}{\text{Brix\%}} \times 100$$

Statistical analysis

Data so obtained were subject for analysis by using the technique of analysis of variance. The value of standard error of means (SEm) and critical difference at one percent and five percent significance were computed.

Results

Red rot disease of sugarcane is difficult to control through chemical fungicides especially during grand growth and maturity phases. Although, some fungicides do control soil/sett borne inoculum during the germination phase (Malathi *et al*., 2010) [7]. Environmental risks are also posed by application of chemical fungicides. So, it has become desirable to seek ecofriendly measures to manage the disease. Hence, there might be a huge requirement of eco-friendly management of red rot pathogen which offers multiple barriers to the pathogen and ensures sustainability.

Considering this fact, this study was carried out for the management of red rot of sugarcane by integration of bio control agents and fungicides as sett treatment, soil treatment and foliar applications and their impact on germination, settling mortality, number of tillers, cane length, cane girth, number of millable canes and ultimately yield of sugarcane. Effect of different treatment combinations on brix, pol and purity were also observed during this study.

(i) Quantitative parameters

Effect of different treatment combinations on quantitative parameters of sugarcane

Germination

Data depicted in Table 2 clearly revealed that treatment T_5 (sett treatment with *Trichoderma harzianum* @ 0.6% + furrow application of neem cake @ 100 kg/ha at the time of planting) significantly enhanced the germination (36.6%) followed by 35.1% with treatment T_2 (sett treatment with *T. harzianum* @ 0.6%) and 33.7% with treatment T_1 (sett treatment with carbendazim @ 0.1%) over control (30.1%).

Settling mortality

To see the effect of sett treatment and soil drenching with biocontrol agents and fungicides on settling mortality, it was obvious from the data of Table 2 that all the treatments were significantly superior over control and numerically minimum (5.4%) settling mortality was found with treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) statistically at par (5.8%) with treatment T_8(sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Thiophanate methyl 70 WP @ 0.1%) followed by (5.9%) in treatment T_2 (sett treatment with *T. harzianum* @ 0.6%) and 6.0% in treatment T_5(soil application of neem cake @ 100 kg/ha + T_3). Maximum settling mortality (12.7%) was observed in control plots.

Number of tillers

Higher number of tillers/clumps (15.81) was found in treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) statistically at par (15.6%) with treatment T_8(sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Thiophanate methyl 70 WP @ 0.1%) followed by (14.94) with treatment T_5 (furrow application of neem cake @ 100 kg/ha at the time of planting + T_3), 14.68 with treatment T_3 (T_2 + soil drenching with *T. harzianum* @ 0.6%), 14.52 with treatment T_6 (T_2 + soil drenching with carbendazim 50 WP @ 0.1%), 14.22, 14.04 and 13.32 tillers/clump were recorded with treatments T_2 (sett treatment with *T. harzianum* @0.6%), T_4 (T_1 + soil drenching with *T. harzianum* @ 0.6%) and T_1 (sett treatment with carbendazim 50 WP @ 0.1%). Minimum number of tillers/clump (12.20) were recorded in control plots.

Cane length

Cane length ranged between 126.7 cm to 203.0 cm. Maximum length (203.0 cm) was recorded in treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) statistically at par (201.4 cm) with treatment T_8(sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Thiophanate methyl 70 WP @ 0.1%). 192.4 cm and 191.1 cm cane length were obtained upon treatment T_5 (furrow application of neem cake @ 100 kg/ha at the time of planting + T_3) and treatment T_6 (T_2 + soil drenching with carbendazim 50 WP @ 0.1%), respectively. Comparatively lesser cane lengths 157.5 cm in treatment T_4 (T_1 + soil drenching with *T. harzianum* @ 0.6%), 156.7 cm in treatment T_3 (T_2 + soil drenching with *T. harzianum* @ 0.6%), 152.8 cm in treatment T_2 (sett treatment with *T. harzianum* @ 0.6%) and 152.1cm in treatment T_1 (sett treatment with carbendazim 50 WP @ 0.1%). Minimum cane length (126.7 cm) was recorded in control plots.

Cane girth

Data presented in table 2 revealed the effect of different treatment combinationa on average cane girth (cm). Maximum girth (2.3 cm) was recorded in treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with T. harzianum @ 0.6% + three foliar applications with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) followed by 2.2 cm with treatment T_8 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Thiophanate methyl 70 WP @ 0.1%). 2.0 cm cane girth was obtained with treatment T_6 (T_2 + soil drenching with carbendazim 50 WP @ 0.1%) 1.9 cm with treatment T_3 (T_2 + soil drenching with *T. harzianum* @ 0.6%). Minimum cane girth (1.6 cm cm) was recorded in control plots.

Number of millable canes

Maximum number of millable canes/clumps (13.18) were recorded in treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) followed by 13.0 millable canes/clump with treatment T_8(sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Thiophanate methyl 70 WP @ 0.1%), 12.4 with treatment T_5 (furrow application of neem cake @ 100 kg/ha at the time of planting + T_3) and 12.1 with treatment T_6 (T_2 + soil drenching with carbendazim 50 WP @ 0.1%) Numerically minimum number of millable canes/clump 11.9, 11.7, 11.3 and 11.1 were recorded with treatments T_3 (T_2 + soil drenching with *T. harzianum* @ 0.6%), T_4 (T_1 + soil drenching with *T. harzianum* @ 0.6%), T_2 (sett treatment with *T. harzianum* @ 0.6%) and T_1 (sett treatment with carbendazim 50 WP @ 0.1%), respectively. However, all treatments were found significantly superior over control (10.1).

Cane yield

Yield data revealed that treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) was found to be best and yielded maximum 89.1 t/ha) statistically at par to 88.5 t/ha with treatment T_8(sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Thiophanate methyl 70 WP @ 0.1%), followed by 85.3 t/ha with treatment T_5 (furrow application of neem cake @ 100 kg/ha at the time of planting + T_3) and 80.6 t/ha with treatment T_6 (T_2 + soil drenching with carbendazim 50 WP @ 0.1%).77.9 t/ha, 77.8 t/ha and 75.8 t/ha were obtained with treatments T_3 (T_2 + soil drenching with *T. harzianum* @ 0.6%), T_4 (T_1 + soil drenching with *T. harzianum* @ 0.6%) and T_2 (sett treatment with *T. harzianum* @ 0.6%) respectively and statistically at par to each other. Treatment T_2 (sett treatment with *T. harzianum* @ 0.6%) and T_1 (sett treatment with carbendazim 50 WP @ 0.1%) yielded 75.8 t/ha and 74.0 t/ha respectively at par to each other. Minimum (67.3 t/ha) yield was obtained in control plots.

Red rot incidence

Data on red rot incidence were recorded at 180, 210 and finally at 240 days of planting which are depicted in Table 3 clearly indicated that red rot incidence varies from 5.0 to 17.0 percent during the course of investigation. All the treatments were significantly superior over control. Minimum disease incidence (5.0%) with maximum disease reduction over control (77.67%) was recorded when plots received treatment T_7 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) statistically at par to 5.6 percent red rot incidence and 75 percent disease reduction over control with treatment T_8(sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar applications with fungicide Thiophanate methyl 70 WP @ 0.1%). Among the treatments, maximum red rot incidence (17.0%) with minimum disease reduction over control (24.10%) was found when plots received treatment T_1 (sett treatment with carbendazim 50 WP @ 0.1%). In control plots significantly higher red rot incidence (22.4%) was recorded.

(ii) Qualitative parameters

Effect of different treatment combinations on qualitative parameters (brix, pol and purity) of sugarcane

Brix, Pól and Purity

Data depicted in table 4 clearly showed that maximum brix (21.2%), pol (18.35% and purity (86.6%) were recorded with treatment T_7(sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar application with fungicide Azoxystrobin 11% + Tebuconazole 18.3% SC @ 0.1%) statistically at par with brix 21.0% and pol 17.89% of treatment T_8 (sett treatment with carbendazim 50 WP @ 0.1% + soil drenching with *T. harzianum* @ 0.6% + three foliar application with fungicide Thiophanate methyl 70 WP @ 0.1%). Purity percent (85.2) was also higher in treatment T_8 in comparison to other treatments. Minimum brix (17.4%) and pol (13.48%) were obtained with treatment T_1 (sett treatment with carbendazim 50 WP @ 0.1%) whereas, purity percent was minimum (74.3) with treatment T_6 (T_2 + soil drenching with carbendazim 50 WP @ 0.1%) even as compared to control (75.0%). Data so obtained from Table 4 clearly illustrate that brix and pol values in all treatments were superior over control (brix 14.0% and pol 10.5%).

Table 2: Effect of various treatments on yield attributing characters and yield of sugarcane

Treatment		Germination (%)	Settling mortality (%)	No. of tillers/clump	Cane length (cm)	Cane girth (cm)	NMC/clump	Yield (t/ha)
T_1	Sett treatment with carbendazim 50 WP @ 0.1%	33.7	6.3	13.32	152.1	1.7	11.1	74.0
T_2	Sett treatment with *T. harzianum* @ 0.6%	35.1	5.9	14.22	152.8	1.7	11.3	75.8
T_3	T_2 + soil drenching with *T. harzianum* @ 0.6%	35.5	6.1	14.68	156.7	1.9	11.9	77.9
T_4	T_1 + soil drenching with *T. harzianum* @ 0.6%	34.8	6.3	14.04	157.5	1.8	11.7	77.8
T_5	Soil application with neem cake + T_3	36.6	6.0	14.94	192.4	2.1	12.4	85.3
T_6	T_2 + Soil drenching with carbendazim 50 WP @ 0.1%	36.0	6.5	14.52	191.1	2.0	12.1	80.6
T_7	T_4 + foliar application with Azoxystrobin 11% + Tebuconazole 18.3% w/w SC @ 0.1% commencing just after appearance of the disease	35.8	5.4	15.81	203.0	2.3	13.18	89.1
T_8	T_4 + foliar application with fungicide Thiophanate methyl 70 WP @ 0.1% commencing just after appearance of the disease	34.7	5.8	15.60	201.4	2.2	13.0	88.5
T_9	Control	30.1	12.7	12.20	126.7	1.6	10.1	67.3
	SEm±	0.26	0.21	0.19	1.58	0.06	0.06	0.86
	CD (0.05)	0.80	0.64	0.58	4.79	0.19	0.17	2.57
	CV%	7.31	5.38	9.25	11.46	5.73	6.82	8.41

Number of buds planted 325/plot

Table 3: Effect of different treatment combinations against red rot incidence in sugarcane

Treatment		Percent red rot incidence			
		180 DAP*	210 DAP	240 DAP	% Disease reduction over control
T_1	Sett treatment with carbendazim 50 WP @ 0.1%	7.20	10.00	17.00	24.10
T_2	Sett treatment with *T. harzianum* @0.6%	7.00	9.70	16.10	28.12
T_3	T_2 + soil drenching with *T. harzianum* @ 0.6%	6.80	9.30	14.20	36.60
T_4	T_1 + soil drenching with *T. harzianum*@ 0.6%	6.90	9.50	15.10	32.58
T_5	Soil application with neem cake + T_3	5.30	8.10	12.80	42.85
T_6	T_2 + Soil drenching with carbendazim 50 WP @0.1%	6.20	9.40	13.10	41.51
T_7	T_4 + foliar application with fungicide Azoxystrobin 11% + Tebuconazole 18.3% w/w SC @ 0.1% commencing just after appearance of the disease	3.40	3.70	5.00	77.67
T_8	T_4 + foliar application with fungicide Thiophanate methyl 70 WP @ 0.1% commencing just after appearance of the disease	3.60	4.10	5.60	75.00
T_9	Control (setts soaked in water)	11.40	15.60	22.40	-
	SEm±	0.57	0.68	0.67	
	CD (0.05)	1.72	2.06	2.02	
	CV%	14.94	13.43	8.62	

*DAP = Days after Planting

Table 4: Effect of different treatment combinations on qualitative (brix, pol and purity) parameters of sugarcane

Treatment		Brix (%)	Pol (%)	Purity (%)
T_1	Sett treatment with carbendazim 50 WP @ 0.1%	17.4	13.48	77.5
T_2	Sett treatment with *T. harzianum* @ 0.6%	17.8	13.99	78.6
T_3	T_2 + soil drenching with *T. harzianum* @ 0.6%	18.3	15.18	80.3
T_4	T_1 + soil drenching with *T. harzianum*@ 0.6%	18.1	14.09	77.9
T_5	Soil application with neem cake + T_3	19.7	14.99	76.1
T_6	T_2 + Soil drenching with carbendazim 50 WP @ 0.1%	19.1	14.19	74.3
T_7	T_4 + foliar application with fungicide Azoxystrobin 11% + Tebuconazole 18.3% w/w SC @ 0.1% commencing just after appearance of the disease	21.2	18.35	86.6
T_8	T_4 + foliar application with fungicide Thiophanate methyl 70 WP @ 0.1% commencing just after appearance of the disease	21.0	17.89	85.2
T_9	Control (setts soaked in water)	14.0	10.5	75.0
	SEm±	0.27	0.29	0.36
	CD (0.05)	0.82	0.89	1.11
	CV%	4.39	4.32	3.84

Discussion

In sugarcane there were few reports of integrated management where Joshi (2021) [5] evaluated seven fungicides, sett treatment with (Tebuconazole + Trifloxystrobin and Thiophanate methyl) resulted in more than 30 percent reduction in red rot incidence and the findings show Thiophanate methyl and Tebuconazole + Trifloxystrobin have a good potential for management of red rot which were like the present findings.

Udhayakumar *et al*., (2019) [14] used Amistar Top 325 SC@ 1.25 ml/lit of water which recorded greater sugarcane yields than in untreated check. Various other yield parameters like Sucrose%, Brix%, Commercial Cane Sugar (CCS) and NMC/clumps have also recorded greater values in almost all the doses of the fungicide Azoxystrobin as in the present investigation it recorded the maximum results. According to findings of Kumar (2016) [6] treatment with Azoxystrobin and Difenoconazole recorded PDI of about 6.06 and 5.12 against red rot which were like the present results. Mishra and Behera (2009) [9] in Odisha, India, determined the efficacies of fungicides and biological control agents against *Colletotrichum falcatum* [*Glomerella tucumanensis*], under artificial inoculated conditions showed the similar results. According to Singh *et al.,* (2008) [14] sett and soil treatments by *Trichoderma harzianum*, red rot was completely controlled in 47-48% canes and in remaining 52-53% canes the disease symptoms severity was reduced to 4-6 grade on 0-9 scale. In this experiment setts were taken from highly susceptible variety (CoLk 7701) and before treatment with *T. harzianum* inoculated with virulent pathotype Cf 09 identified from Variety CoS 767. This finding is almost similar to present finding.

Conclusion

Considering the above experimental findings, management of red rot disease can be effectively done by integration of bio control agents and fungicides and can be used as effective, holistic and feasible approach. Integration of biocontrol agents and fungicides significantly increased the quality parameters and yield attributes of sugarcane when compared to other practices. This experiment showed that *Trichoderma harzianum* along with Azoxystrobin had significant impact on increasing the quality of sugarcane.

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