Developing biocontrol strategies for the management of set rot disease of sugarcane under wider row planting

Abstract

Sugarcane (*Saccharum officinarum* L.) is one of the economically valuable agricultural crops grown worldwide in tropical and subtropical areas mainly for their sugar source. Among the 110 sugarcane cultivated countries, India and Brazil contribute half of global production [1].During the period of last five decades the production, productivity and sugarcane recovery has also shown remarkable resilience in productivity growth rate. One of the reasons for the low productivity and recovery is increasing incidence of insect pests and diseases. An ecologically friendly alternative to these problems is biological control using rhizobacteria and their metabolic products [2].In order to develop a technology capsule Surveys and surveillance were conducted in sugarcane fields both in plant and ratoon crops distributedin Orthanadu and Vallam block in New Cauvery delta area of Thanjavur dictrict during three consecutive years 2019-22 with an objective to assess the incidence of sett rot, red rot and smut in New Cauvery delta area of Thanjavur dictrict. Fortnightly fixed plot observation was taken. The Maximium and minimum temperature, RH and quantity of rain and rainy days also recorded daily and consolidated on monthly basis and weather parameters were correlated with the incidence of disease. Theresultsrevealedthatthemaximumincidencesett rot negatively correlated with temperature. Similarly the number of rainy days and rainfall is positively correlated (r = 0.7523) with incidence of sett rot. For managing sett rot disease of sugarcane through biological approach, studies were conducted on biocontrol agents viz., *Trichoderma asperellum*(TNAU), *Bacillus subtilis* (TNAU), *Chaetomium globosum*(Cg6) with fungicide check propiconozole 0.1%. Among the treatment, highest millable cane (91,080/ha) and yield (91.39 tonnes / ha) and sugar yield (10.63 tonnes/ha) were recorded in **M1**- (Single bud treated with *Trichoderma asperellum*(TNAU)@ 4 g l^{-1} + soil application @ 2.5 kg ha^{-1}) followed by **M_{2}**- (Single bud treated with *Bacillus subtilis* (TNAU)@ 10 g l^{-1} + soil application @ 2.5 kg ha^{-1}) in which, the cane yield of 88.54 tonnes/ha and sugar yield of 10.68 tonnes/ha were recorded. This study providesa technology capsule for the management of important disease of sugarcane.

Key words: Sugarcane,Sett Rot, Biological control.

1. INTRODUCTION

Sugarcane is one of the important commercial crops in tropics and serves as the main source of sugar in the world. In Tamil nadu, sugarcane is cultivated in 3.20 lakhs hectares with a production of about 350 lakhs tonnes of canes. Productivity of Tamil Nadu is higher (108 t/ha) than the national average [3,4].Sugarcane red rot caused by *Colletotrichum falcatum* and smut disease caused by

Sporisoriumscitamineum is a devastating disease in sugarcane growing areas globally, which results in considerable loss of sugar yield [5]. Currently, control of sugarcane disease mainly relies on the breeding of resistant cultivars [6], which is constrained by long breeding processes, high cost, and availability of resistant parental lines. Rhizobacteria inhibit plant pathogens by numerous mechanisms related to: (i) secretion of metabolites like siderophores, which suppress pathogens by sequestering iron [7] (ii) hydrolytic enzymes, which degrade the cell wall of many pathogens [8]; (iii) antibiotics. Which induce systemic resistance in plants. Among the different diseases Sett rot or pineapple disease caused by Ceratocystis paradoxa (de Seynes) Moreau is both sett and soil borne disease of sugarcane affecting the sett germination at the early stages of planting. Three different biocontrol agents were evaluated in field condition for the management sett rot.

Introduction of wider row planting in sugarcane cultivation in Tamil Nadu has aimed to increasethe cane yield in unit area and same time it provides best tool for applying plant protection chemicals to the targeted sites in sugarcane. Under wider row condition, the fertilizers are being applied in heavy dose in multiple split till harvest which may alter the pests and disease occurrence and favour the pests and diseases population build up. As the wider row planting of sugarcane cultivation is being in advocation to the farming community, it now becomes imperative that the pest and disease pattern in the changed scenario has to be studied in detail as the moisture pattern is known to influence the pest and disease behavior significantly in many crops. Hence the detailed studies on pests and diseases occurrence pattern under wider row sugarcane cultivation are warranted. In the present study periodical pest and disease surveillance was conducted to assess the incidence of different pests and diseases of sugarcane along with natural enemies in New Cauvery Delta region of Thanjavur District.

2.**METHODOLOGY**

The popular and high sugar sugarcane variety viz Co 86032 was raised under wider row with row spacing of 120 cm in red loam soil condition at Agricultural college and Research institute, Eachangkottai. The crop was raised with single bud setts in paired /wider rows spacing of 120 cm between rows following the recommended wider row package of practices. The treatments were imposed as per the technical programme.

M_1.Single bud treated with *Trichoderma asperellum*(TNAU)@ 4 g l^{-1} + soil application @ 2.5 kg ha^{-1}

M_2.Single bud treated with *Bacillus subtilis* (TNAU)@ 10 g l^{-1} + soil application @ 2.5 kg ha^{-1}

M_3.Single bud treated with *Chaetomium globosum*(Cg6)@ 10 g l^{-1} + soil application @ 2.5 kg ha^{-1}

M_4.Single bud treated with Propiconazole @ 1 g l^{-1} + soil drenching @ 0.1 %

M_5 .Untreated control

Observations viz., Germination percent on 30^{th} day, Set rot incidence on 30^{th} day, tiller populations were recorded on 90 days after planting and economic shoot populations were recorded on 210 days after planting.

3. RESULT AND DISCUSSION

Fortnightly fixed plot observation was taken in cane crop planted under wider row planting in Orthanadu and Vallam block in New Cauvery delta area of Thanjavur district to assess the incidence ofdiseases *viz*., sett rot, red rot and smut. The Maximium and minimum temperature, RH and rainfall and rainy days also recorded daily and consolidated on monthly basis and weather parameters were correlated and presented in Table 1,2, 3 and 4

Table 1.Incidence of diseases of sugarcane in New Cauvery Delta of Thanjavur District .2019 – 2020.

S.No.	Month	Maximum temp.	Minimum temp.	Average	RH %	No. of rainy days	Rain fall (mm)	Sett rot Incidence (%)
1	Jun 19	32.00	21.50	27.00	79.00	3	60.0	-
2	July 19	33.00	23.50	2 8.00	85.60	11	300.0	-
3	Aug 19	33.40	23.50	29.00	85.00	8	154.0	-
4	Sep 19	33.60	25.00	28.00	88.00	11	116.0	-
5	Oct 19	33.50	22.70	28.80	83.00	5	150.0	5.80
6	Nov 19	33.53	23.00	28.50	89.00	10	160.0	5.90
7	Dec 19	31.50	21.00	26.50	81.00	10	620.5	7.25
8	Jan 20	31.70	21.50	26.00	82.00	14	501.0	7.25
9	Feb 20	31.00	22.50	27.00	82.00	1	0	-
10	Mar 20	32.00	23.60	28.00	84.00	0	0	-
11	April 20	31.00	23.50	27.50	84.00	0	7.0	-
12	May 20	35.50	23.50	29.50	79.00	1	8.0	-
Correlation Coefficient (*r*) with disease intensity				Max temp		-0.3146		
				Min temp		-0.6512		
				RH		-0.4611		
				No of rainy days		0.7412		
				Rain fall		0.6546		

Table 2.Incidence of diseases of sugarcane in New Cauvery Delta of Thanjavur District .2020 – 2021.

S.No.	Month	Maximum temp.	Minimum temp.	Average	RH %	No. of rainy days	Rain fall (mm)	Sett rot Incidence (%)

1	Mar 20	33.10	23.60	28.35	84.70	-	-	-
2	April 20	32.00	23.60	27.80	84.30	1	5.0	-
3	May 20	36.10	23.70	29.95	79.40	1	4.0	-
4	Jun 20	32.10	23.80	27.95	78.70	4	69.0	-
5	July 20	33.10	24.50	2 8.8	85.60	10	313.6	-
6	Aug 20	34.40	23.80	29.10	85.80	7	150.0	-
7	Sep 20	33.80	25.10	28.80	88.50	10	106.0	-
8	Oct 20	33.90	23.70	28.90	83.50	6	152.0	4.86
9	Nov 20	33.4	23.3	28.35	89.8	13	162.0	5.45
10	Dec 20	31.2	21.5	26.35	80.0	12	625.5	6.66
11	Jan 21	30.7	21.4	26.05	83.0	11	506.0	6.62
12	Feb 21	31.9	22.7	27.3	82.2	-	0	-
Correlation Coefficient (*r*) with disease intensity				Max temp	-0.4136			
				Min temp	-0.7105			
				RH	-0.5709			
				No of rainy days	0.7503			
				Rain fall	0.7523			

Table 3.Incidence of diseases of sugarcane in New Cauvery Delta of Thanjavur District .2021 – 2022.

S.No.	Month	Maximum temp.	Minimum temp.	Average	RH %	No. of rainy days	Rain fall (mm)	Sett rot incidence (%)
1	Mar 21	34.00	24.00	29.00	80.29	0	0	-
2	April 21	36.51	25.08	30.79	75.43	1	23	-
3	May 21	36.45	25.12	30.78	71.87	2	45	-
4	Jun 21	36.40	25.35	30.87	73.03	2	11	-
5	July 21	35.70	24.50	30.25	78.54	2	28.2	-
6	Aug 21	34.41	23.85	29.13	82.29	7	238.0	-
7	Sep 21	34.36	24.31	29.33	83.96	10	258.0	-
8	Oct 21	33.67	24.32	28.99	84.54	6	371.0	10.70
9	Nov 21	34.43	23.73	29.08	83.56	13	628.5	12.20
10	Dec 21	34.56	23.67	23.61	88.58	12	12.5	7.20

11	Jan 22	34.01	24.01	29.01	87.80	11	62	5.62
12	Feb 22	33.91	23.83	28.87	85.78	0	31	-
13	Mar 22	34.50	23.33	28.91	79.08	0	0	-
						Max temp	--0.0485	
						Min temp	-0.6912	
						RH	-0.5171	
						No of rainy days	0.7123	
						Rain fall	0.6425	

Table 4. Pooled mean analysis for Incidence of diseases of sugarcane in New Cauvery Delta region of Thanjavur District.

S.No.	Month	Maximum temp.	Minimum temp.	Average	RH %	No. of rainy days	Rain fall (mm)	Sett rot Incidence (%)
1	Jan	Jan	32.1	22.3	27.0	84.3	12.0	6.49
2	Feb	Feb	32.3	23.0	27.7	83.3	0.3	-
3	Mar	Mar	33.0	23.7	28.5	83.0	0.0	-
4	April	April	33.2	24.1	28.7	81.2	0.7	-
5	May	May	36.0	24.1	30.1	76.8	1.3	-
6	Jun	Jun	33.5	23.6	28.6	76.9	3.0	-
7	July	July	33.9	24.2	30.3	83.2	7.7	-
8	Aug	Aug	34.1	23.7	29.1	84.4	7.3	-
9	Sep	Sep	33.9	24.8	28.7	86.8	10.3	-
10	Oct	Oct	33.67	24.32	28.99	84.54	6.0	7.12
11	Nov	Nov	33.8	23.3	28.6	87.5	12.0	7.85
12	Dec	Dec	34.56	23.67	23.61	88.58	12	7.03
Correlation Coefficient (*r*) with disease intensity					Max temp	-0.0447		
					Min temp	-0.6843		
					RH	-0.5164		
					No of rainy days	0.7346		
					Rain fall	0.6831		

The minimum temperature and higher relative humidity prevailing during October to January might have favouredthe disease incidence which ultimately hindered the sett germination.Shanmugam et al., 2016.

Effect ofbiocontrol treatments on sett rot disease and yield characters.

The popular and high sugar sugarcane variety viz Co 86032 was raised under wider row at Agricultural college and Research institute, Eachangkottai during june 2019 and harvested during may 2020. The treatments were imposed and observations viz., Germination percent on 30th day, Set rot incidence on 30thday, Smut and red rot incidence at monthly intervals, Tillers population counts on 90th day, economic population counts on 210th day were recorded as per the technical programme. The observation *viz*., Set rot incidence, Smut and red rot incidence at monthly intervals were presented along with percent reduction and yield contributing characters in table 5 to 8

Table 5. Effects of Main treatment on disease and yield contributing parameters

S.No.	Treatments	Germination %	Set rot %	Percent reduction over control	Millable cane (000 /ha)	Yield (t/ha)	Percent increase over control	CCS (%)	Sugar Yield (t/ha)
1	**M_1**	83.12 (66.87)	3.0 (11.44)	66.70	**91.08**	**91.39**	**10.41**	**12.2**	**10.63**
2	**M_2**	75.62 (60.47)	4.5 (12.22)	50.00	87.10	86.40	5.24	12.2	10.36
3	**M_3**	77.19 (61.67)	4.5 (12.22)	50.00	88.03	87.74	7.16	12.3	10.52
4	**M_4**	71.00 (57.45)	4.0 (11.15)	55.55	85.99	86.09	4.09	12.3	10.32
5	**M_5**	64.47 (53.54)	9.0 (17.43)	-	83.19	81.87	-	12.2	9.82
CD (P=0.05)		1.67	1.28	-	**3.88**	**1.97**		**NS**	

Among treatments, highest millable cane (91,080/ha) and yield (91.39 tonnes / ha) and sugar yield (10.63 tonnes/ha) were recorded in **M1**- (Single bud treated with *Trichoderma asperellum*(TNAU)@ 4 g l^{-1} + soil application @ 2.5 kg ha^{-1}) followed by **M_3.** (Single bud treated with *Chaetomium globosum*(Cg6)@ 10 g l^{-1} + soil application @ 2.5 kg ha^{-1}) in which, the cane yield of 87.74 tonnes/ha and sugar yield of 10.52 tonnes/ha were recorded. There is no significant difference in CCS percent among the treatments.

Table .6. Effect of biocontrol on disease and yield character (**2020-2021)**

S.No.	Treatments	Germination %	Set rot %	Percent reduction over control	Millable cane (000 /ha)	Yield (t/ha)	Percent increase over control	CCS (%)	Sugar Yield (t/ha)
1	**M_1**	80.12 (63.52)	3.2 (10.30)	62.79	**92.70**	**92.86**	**10.70**	**12.31**	**10.74**
2	**M_2**	73.23 (58.84)	4.8 (12.65)	44.18	89.05	87.91	6.03	12.76	10.85
3	**M_3**	78.28 (62.22)	5.1 (13.05)	40.69	88.20	86.96	4.88	12.82	10.83
4	**M_4**	72.11 (58.12)	5.0 (12.92)	41.86	86.10	86.90	4.09	12.80	10.89
5	**M_5**	68.36 (55.77)	8.6 (17.05)	-	84.28	82.91	-	12.56	9.95

CD (P=0.05)	1.65	1.23	-	**3.78**	**1.95**		**NS**	

In Main treatment, highest millable cane (92,700 /ha) and yield (92.86 tonnes / ha) and sugar yield (10.70tonnes/ha) were recorded in **M1**- (Single bud treated with *Trichoderma asperellum*(TNAU)@ 4 g l^{-1} + soil application @ 2.5 kg ha^{-1}) followed by **M_2**. (Single bud treated with *Bacillus subtilis* (TNAU)@ 10 g l^{-1} + soil application @ 2.5 kg ha^{-1}) in which, the cane yield of 89.05tonnes/ha and sugar yield of 10.85tonnes/ha were recorded. The CCS percent among the treatment is also significantly different.

Table 7. Effects of Main treatment on disease and yield contributing parameters

S.No.	Treatments	Germination %	Set rot %	Percent reduction over control	Millable cane (000 /ha)	Yield (t/ha)	Percent increase over control	CCS (%)	Sugar Yield (t/ha)
1	**M_1**	85.12 (66.87)	6.5 (14.77)	**35**	**92.09**	**98.76**	**18.80**	**12.35 (20.58)**	**10.67**
2	**M_2**	83.62 (60.47)	7.0 (15.89)	30	89.23	96.53	16.70	12.33 (20.56)	10.23
3	**M_3**	81.19 (1.67)	8.0 (16.43)	20	87.19	88.64	9.43	12.18 (20.42)	9.66
4	**M_4**	81.00 (57.45)	7.2 (15.34)	28	85.71	86.09	5.90	12.20 (20.44)	9.85
5	**M_5**	74.47 (53.54)	10.0 (18.43)	-	84.19	81.70	-	12.17 (20.41)	9.61
CD (P=0.05)		2.15	2.09		1.91	1.75		2.07	0.19

In Main treatment, highest millable cane (92,090 /ha) and yield (98.76 tonnes / ha) and sugar yield (10.67 tonnes/ha) were recorded in **M1**- (Single bud treated with *Trichoderma asperellum*(TNAU)@ 4 g l^{-1} + soil application @ 2.5 kg ha^{-1}) followed by **M_2**. (Single bud treated with *Bacillus subtilis* (TNAU)@ 10 g l^{-1} + soil application @ 2.5 kg ha^{-1}) in which, the cane yield of 89.23 tonnes/ha and sugar yield of 10.23 tonnes/ha were recorded. The CCS percent among the treatment is also significantly different.

Poolled mean analysis

Table. 8. Effect of main treatments on disease incidence and yield characters

S.No.	Treatments	Germination %	Set rot %	Percent reduction over control	Millable cane (000 /ha)	Yield (t/ha)	Percent increase over control	CCS (%)	Sugar Yield (t/ha)
1	**M_1**	81.62 (65.19)	3.1 (10.85)	64.74	**91.89**	**92.125**	**10.555**	**12.295**	**10.685**
2	**M_2**	77.42 (59.65)	4.65 (12.43)	47.09	88.54	87.155	5.635	12.515	10.685
3	**M_3**	77.73 (61.94)	4.8 (12.6)	45.34	87.65	87.35	6.02	12.565	10.595
4	**M_4**	71.55 (57.78)	4.5 (12.03)	48.70	86.045	86.495	4.09	12.55	10.605
5	**M_5**	66.41 (54.65)	8.8 (17.24	-	83.735	82.39	-	12.415	9.885
CD (P=0.05)		1.66	1.25	-	**3.83**	**1.96**		**NS**	

In pooled mean analysis, highest millable cane (91089/ha) and yield (92.12tonnes / ha) and sugar yield (10.67 tonnes/ha) were recorded in **M1**- (Single bud treated with *Trichoderma asperellum*(TNAU)@ 4 g l^{-1} + soil application @ 2.5 kg ha^{-1}) followed by **M_2**- (Single bud treated with *Bacillus subtilis* (TNAU)@ 10 g l^{-1} + soil application @ 2.5 kg ha^{-1}) in which, the cane yield of 88.54 tonnes/ha and sugar yield of 10.68 tonnes/ha were recorded. The CCS percent among the treatment is also significantly different.

Among the biocontrol agents *P. fluorescens*, *Bacillus subtilis* and*Chaetomium globosum* are highly potential antagonists[9]. Antagonistic strains of the genus *Bacillus* are advantageous over other biocontrol agents in numerous ways, as they are ubiquitous in soils, sporulate excessively, have prolonged shelf life and enhance plant nutrition[10]. Their efficacy in controlling many plant diseases has repeatedly been proven. Three strains of the genus *Bacillus* reduced disease incidence by 45-49% in sugarcane plants challenged by pathogen inoculation in the stem and by 48-56% in the plants inoculated in the soil near the roots. *Bacillus* strains significantly controlled red rot disease on sugarcane varieties Co-1148 and SPF-234 under field conditions[11]. The antagonistic strains suppressed the pri-mary infection (Soil inoculation) as well as secondary infection (Challenge inoculation) of red rot which is caused by certain vectors like the sugarcane borer (*Diatraeasaccharalis*) and tools used in various cultural operations. These *Bacillus* strains also produced the broad-spectrum antifungal metabolite surfactin [12] which further characterize them as systemic resistance inducers, since surfactin is a good inducer of systemic resistance in [13,14].

4. CONCLUSION

This study provides a technology capsule for the management of Sett rot of sugarcane. Weather parameter studies provide an theoritical and practical knowledge about the correlation between sett rot,

maximium temperature, minimum temperature, RH, rainfall and rainy day which is helpful for the development of disease forecasting model.

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