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Biomanagement and survey of Postharvest Anthracnose of Banana

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Banana (*Musa paradisiaca* L.) is a tropical fruit and holds first position under production and productivity in India. The naturally infected banana fruits showing typical characteristics symptoms of anthracnose was collected from famers field of Bharuch district and pathogenicity was proved by pin prick method. Survey of post harvest disease incidence of various banana fruit rots was conducted in Bharuch and Surat fruit market and maximum incidence of anthracnose banana fruit rots was recorded at Tulsidham Market, Bharuch.Total eleven isolated microbes were evaluated *in vitro* against *Colletotrichum musae*and among that,*Bacillussubtilis* recorded maximum mycelial growth inhibition than others microbes(72.73%). The fructoplane and rhizopspheric microbes were tested against anthracnose of banana by pre and post inoculation method under*in vivo* conditions.Banana fruit dipping in Carbendazim (0.05%) dipping for 2 minutes found the most effective to reduce anthracnose fruit rot in banana under *in vivo* condition.

Keywords : Anthracnose, *Bacillus*, banana, beneficial microbes, fruit rot, survey

INTRODUCTION

Banana (*Musa paradisiaca* L.) is a tropical fruit grown in India and also known as the “poor man’s apple” and “apple of paradise”. It originated in south-east Asia and is likely to have been first domesticated in Papua New Guinea. It is oldest crop in the world and considered as “dollar earning” crop. India contributes 27 percent of global banana production (Anon., 2018).Banana exports by different countries worth of around 11.8 billion dollars with the volume of 18.1 million tons. In India, banana as an enterprise is generating around7 billion dollar and providing livelihood to millions of farmers. Banana alone contributes 2.8 per cent to the agricultural GDP (Anon., 2020).

Bananas are rich in nutritional values and have a calorific value of 67 to 137 calories per 100 grams. It is rich source of carbohydrate (27%), calcium (80 ppm) and phosphorus (290 ppm) and also in magnesium, sodium, potassium and phosphorus (Rao, 2005). Banana is susceptible to many diseases, mostly fungal pathogen which attacks various part of the plant from root to fruit. Bananas are highly perishable commodities with post-harvest losses estimated to the tune of 25-30 per cent. The injudicious applications of chemicals in pest-disease management result into soil, air, water and food contamination that ultimately affect consumers (Waghunde and Patil, 2009; Waghunde *et al*. 2016).

The present investigation was done to screen out the rhizopsheric and fructoplane bacteria for the management of anthracnose of banana fruit under south Gujarat condition.

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MATERIALS AND METHODS

Isolation, purification and pathogenicity

The soil samples and fruits were collected from the banana growing farmers of shukaltirth, sajod, nikora and tavra village of Bharuch district. The G-9 banana variety was mostly cultivated in south Gujarat, hence selected for the isolation of fructoplane bacteria. The soil samples and fruits were suspended in sterile distilled water and rhizopsheric/fructoplanebacteria were isolated by serial dilution technique and purified microbes were coded as M1 to M11.These bacteria were further identified based on their biochemical characterization. The pure culture of *Colleto-trichum musae*inciting anthracnose fruit rot of banana brought from the Department of Plant Pathology, CoA, NAU, Bharuch for research work. The pathogenicity was proved by pin-prick method. The antifungal efficacy of isolated rhizopsheric and fructoplanemicrobes were tested *in vitro* by dual culture technique against pathogen causing anthracnose. The seven microbes (M1 to M7) were selected based on per cent growth inhibition efficacy against *C. musae* under *in vitro* condition and further used for*in vivo* assay.The healthy banana fruits were brought and they were washed in tap water, sterilized by dipping in 0.1 per cent NaOCl solution for one minute followed by three successive washings with sterile water and then it was inoculated with*C. musae*. The inoculated fruits were observed regularly and re-isolation of pathogens from the diseased fruits was done for confirmation.

Survey: The survey of banana fruit rots was carried out at Sardar Patel, APMC market, Surat and Tulsidham Market, Bharuch during first week of October to fourth week of January (2018-19,2019-20 and 2020-21). Five vendors were selected randomly from each market each containing 100 fruits from both the locations were collected and examined for the anthracnose fruit rotsincidence. The per cent fruit rot incidence was calculated by following standard formula as mentioned below

$$\text{Percent Incidence} = \frac{\text{Number of infected fruits}}{\text{Total Number of fruits}} \times 100$$

Dual culture

Antagonistic effect of isolated fructoplane/ rhizopsheric microbes were tested *in vitro*by dual culture technique (Dennis and Webster, 1971) for evaluation of their antagonism against *C. musae* causing anthracnose fruit rot of banana.

Total eleven (11) rhizopsheric/fructoplane bacteria were isolated and evaluated under *in vitro* condition. Seven days old culture of the pathogen and four days old bacterial bioagent were employed for dual culture method. The mycelial disc of 5 mm diameter of cut from the periphery of pathogen was placed in front of each bacterial bioagents where half portion of plates streaked by it. In control, only test pathogen was kept in the centre of Petri plate. Each treatment was repeated 3 times. The Petri plates were incubated at 25 ± 1^0C in B.O.D. incubator. The observation on mycelial growth (mm) was recorded and Per cent Growth Inhibition (PGI) of pathogen in each treatment was calculated by following formula.

$$\text{PGI (\%)} = \frac{C - T}{C} \times 100$$

Where C- Control and T- Treatment

In vivo

The seven microbes (M1 to M7) were selected based on per cent growth inhibition was used in dual culture technique for *in vivo* study to manage anthracnose disease of banana fruit rot following both pre-inoculation and post-inoculation methods. Hot water treatment 50-^{0}C for 5 min. and Carbendazim (0.05%) dipping for 2 min. treatments were also evaluated along with bioagents.

Pre-inoculation

Thehealthy fruits of banana were collected from farmer's field and brought to the laboratory in the paper bags. The fruits were washed with tap water and sterilized by dipping in 0.1 per cent NaOCl solution for one minute followed by three successive washings with sterilized water. The experiment was conducted in Completely Randomized Design (CRD). The healthy uniform

size fruits were pin pricked and inoculated by fructoplane/rhizospheric microbes along with solution (10^6 CFU/ml) for *T. viride* and (2 X 10^8 CFU/ml) for bacterial bioagents of seven days old culture separately and after 12 hrs the fruits were inoculated at the same site with spore suspension (10^6 spores/ml) of seven days old culture of pathogen. The control maintained separately with pathogen. Each treatment was repeated 3 times.

The inoculated as well as non-inoculated fruits were placed in sterilized and loosely tied polythene bags. A piece of sterilized wet absorbent cotton was placed inside each bag and the bag was kept at 25 ± 1^0 C in B.O.D. incubator for seven days. After development of symptoms, inoculated fruits were observed regularly. The observation on disease incidence was recorded on 4th and 7th day with the help of assessment key as per (Baria, 2021) (Table 1). The severity was calculated with the help of following formula

$$\text{Fruit rot Severity (\%)} = \frac{\text{Area of infected fruits}}{\text{Total area of fruit tissue}} \text{x100}$$

Table1: Disease Assessment Key

Scale	Description
0	Fruit completely healthy
1	Disease present near the crown or tip with a little Browning of pericarp portion and fruit completely healthy
2	<10 per cent pulp rot with browning of pericarp
3	10-25 per cent pulp rot with browning of pericarp
4	25-50 per cent pulp rot with browning of pericarp
5	>50 per cent pulp rot with browning of pericarp

Post-inoculation

The procedure mentioned in pre- inoculation was followed except that the fruits first inoculated with pathogens and then with antagonists while rest of the procedure was the same.

RESULTS AND DISCUSSION

Isolation and purification

The various rhizhosphreic soil samples and fruits were collected from the different farmer's field subjected for serial dilution method. The suspension was spread on nutrient agar plate. The fluorescent, milky white and opaque colony were picked and purified for further study. The eleven bacterial bioagents were isolated from rhizosphere and fructoplane of banana. The pure culture of pathogen inciting banana anthracnose was brought from Department of Plant Pathology, CoA, NAU, Bharuch and was used to prove pathogenicity which further purified for another study.

Identification and Pathogenicity

The effective seven fructoplane and rhizopheric isolated bacteria were identified by biochemical characterization of bacteria. On the basis of characterization, they were identified as *P. aureofaciens*, *P. chlororaphis*, *Bacillus megaterium*, *B. licheniformis*, *B. subtilis*, *B. mucilaginous* and *B. pumilus*. The healthy banana fruit was brought from fruit market to prove the pathogenicity by following Koch's postulates. The fruits were washed in tap water and sterilized by dipping in 0.1 per cent NaOCl solution for one minute followed by three successive washings with sterile water and then was inoculated with isolated pathogen. The fruits were pin pricked at pericarp region with sterilized pins. The fruits were dipped in spore suspension (10^6 spores/ml) of pathogens for 3 minutes and air dried for 15 minutes. An inoculated fruit was placed in polythene bags and bag was kept at 25 ± 1^0C in B.O.D. incubator for seven days and regularly observed the symptoms. Re-isolation was carried out from these inoculated fruits and same pathogens matched with the original isolated pathogen.

Table 2: Incidence of banana fruit rots at Tulsidham Market, Bharuch (2018-19 to 2020-21)

Sr. No.	Fruit rots	Average Per cent Disease Incidence																Mean (%)
		October				November				December				January				
		Week				Week				Week				week				
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	
1	Aspergillus Rot	0.23	0.53	0.87	1.22	1.48	1.71	2.01	2.14	3.59	4.76	6.42	8.11	9.30	8.98	7.23	4.83	3.96
2	Anthracnose Fruit Rot	9.75	11.02	11.98	13.38	15.28	16.52	18.27	19.60	17.35	15.67	15.13	13.75	11.20	9.60	6.08	4.33	13.06
3	Crown Rot	7.07	8.88	10.47	11.01	12.18	13.35	13.69	14.24	14.59	13.12	12.35	10.37	8.52	6.45	5.52	3.57	10.34
4	Blossom End Rot	0.28	0.53	0.77	0.98	1.28	1.53	1.63	1.96	2.18	2.53	3.15	3.77	3.17	2.22	1.83	1.18	1.81
5	Rhizopus Rot	0.42	0.83	1.23	1.45	1.67	1.94	2.35	2.79	3.31	3.84	5.13	6.13	7.53	5.82	3.92	2.52	3.18
6	Curvularia Rot	0.09	0.28	0.38	0.58	0.79	1.04	1.39	1.68	1.93	2.29	2.64	3.08	3.57	2.04	1.63	1.03	1.53
7	Other	0.00	0.25	0.49	0.85	1.15	1.40	1.64	1.97	2.09	2.38	2.98	3.50	3.92	3.78	3.32	2.65	2.02
	Weekly Av. Incidence (%)	2.55	3.19	3.74	4.21	4.83	5.36	5.85	6.34	6.44	6.37	6.83	6.96	6.74	5.56	4.22	2.87	

Table 3: Incidence of banana fruit rots at Sardar Patel, APMC Market, Surat (2018-19 to 2020-21)

Sr. No.	Fruit rots	Average Per cent Disease Incidence																Mean (%)
		October				November				December				January				
		Week				Week				Week				week				
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	
1	Aspergillus Rot	0.36	0.66	0.68	1.08	1.54	1.84	2.16	3.17	4.34	5.21	6.92	9.21	9.65	10.45	8.98	6.95	4.58
2	Anthracnose Fruit Rot	9.27	11.47	13.17	15.07	16.29	17.00	16.53	13.90	13.69	11.45	9.65	8.28	7.23	6.28	4.63	3.40	11.08
3	Crown Rot	7.35	8.91	10.23	10.88	11.65	12.58	12.23	12.91	13.10	9.65	8.65	7.53	6.83	5.99	4.82	3.69	9.19
4	Blossom End Rot	0.38	0.58	0.78	0.98	1.13	1.29	1.69	2.37	2.50	3.53	4.46	5.64	5.52	4.63	2.78	1.95	2.51
5	Rhizopus Rot	0.46	0.66	0.82	1.13	1.35	1.63	1.99	2.75	3.44	3.98	5.58	7.82	8.82	9.70	6.58	5.41	3.88
6	Curvularia Rot	0.03	0.19	0.33	0.53	0.75	0.99	1.19	1.35	1.63	1.83	2.03	2.35	2.59	2.33	2.14	1.45	1.36
7	Other	0.19	0.35	0.59	0.75	0.83	1.19	1.47	1.71	1.99	2.47	2.99	3.47	4.35	4.08	2.12	1.72	1.89
	Weekly Av. Incidence (%)	2.58	3.26	3.80	4.34	4.79	5.22	5.32	5.45	5.81	5.45	5.76	6.33	6.43	6.21	4.58	3.51	

Survey:

Average incidence (2018-19 to 2020-21)

During the post-harvest survey of banana fruit various fruit rot i.e. *Aspergillus*, anthracnose, crown, blossom end rot, *Rhizopus, Curvularia* and others were observed in the market. The maximum (13.06%) anthracnose mean fruit rot incidence was observed followed by crown rot (10.34%), Aspergillus (3.96%) and Rhizopus rot (3.18%) in Tulsidham Market, GNFC Road, Bharuch and minimum (1.53%) incidence of Curvularia rot was recorded during survey (Table 2)while in Surat, maximum (11.08%) anthracnose fruit rot mean incidence of was observed followed by crown rot (9.19%), Aspergillus (4.58%) and Rhizopus rot (3.88%), respectively rot in Sardar Patel, APMC market, Surat and minimum (1.36%) incidence of Curvularia rot was recorded during survey mentioned in (Table 3).

Table 4 : Evaluation of rhizospheric and fructoplane bacteria against anthracnose of banana fruit rot in *in vitro* condition

Sr. No.	Rhizospheric and fructoplane bacteria	Mycelial growth (cm)	PGI (%)
1	M_1	3.6	59.09
2	M_2	3.5	60.23
3	M_3	2.9	67.05
4	M_4	2.6	70.45
5	M_5	2.4	72.73
6	M_6	3.7	57.95
7	M_7	3.8	56.82
8	M_8	3.3	62.50
9	M_9	3.0	65.91
10	M_{10}	2.9	67.05
11	M_{11}	3.4	61.36
	CD at 1%		2.24
	S.Em. (±)		0.78
	C.V. (%)		5.44

Dual culture

The eleven pure cultures of rhizopsheric/ fructoplane bacteriawere tested *in vitro* against *Colletotrichum musae* by dual culture technique. The radial growth of pathogen was recorded on 7days after incubation and PGI was calculated and mentioned in (Table 4).Among eleven bacterial bioagents, *B. subtilis*recorded the highest (72.73%) per cent growth inhibition followed by *B.licheniformis* i.e. 70.45 per cent. *Bacillus pumilus*recorded the lowest per cent growth inhibition i.e. 56.82 per cent among the tested bioagent (Table 4).

***In vivo*:** The rhizospheric and fructoplane bacteria isolated from the banana were evaluated *in vivo* along with *Trichoderma viride* and *Pseudomonas*

Table 5 : Effect of rhizospheric and fructoplane bacteria on the anthracnose severity of banana under *in vivo* condition (2018-19 to 2021-22)

Sr. No.	Treatment	Severity (%) 2018				Severity (%) 2019				Severity (%) 2020				Severity (2021)			
		Pre-inoculation		Post-inoculation		Pre-inoculation		Post-inoculation		Pre-inoculation		Post-inoculation		Pre-inoculation		Post-inoculation	
		4th	7th	4th	7th	4th	7th	4th	7th	4th	7th	4th	7th	4th	7th	4th	7th
1	T_1	(5.00)* 12.90	(15.75) 18.89	(7.33) 15.70	(13.67) 21.67	(2.10) 8.32	(5.89) 14.02	(2.42) 8.91	(6.11) 14.31	(2.47) 9.02	(5.80) 13.92	(3.83) 11.28	(7.07) 15.40	(9.68) 18.13	(6.30) 14.54	(11.66) 19.07	(15.86) 23.47
2	T_2	(6.87) 15.18	(15.50) 18.73	(8.80) 17.24	(8.80) 17.24	(2.50) 9.06	(5.75) 13.86	(3.12) 10.05	(5.76) 13.88	(2.90) 9.80	(6.53) 14.80	(4.05) 11.55	(6.10) 14.26	(10.14) 18.57	(6.80) 15.12	(11.92) 20.20	(14.75) 22.59
3	T_3	(7.90) 16.31	(17.95) 20.22	(10.67) 19.05	(16.67) 24.07	(2.83) 9.63	(6.00) 14.16	(3.90) 11.33	(6.50) 14.76	(2.90) 9.80	(6.17) 14.36	(5.03) 12.93	(5.50) 13.54	(10.14) 18.57	(5.80) 14.42	(13.26) 21.35	(14.05) 22.01
4	T_4	(4.00) 9.38	(15.75) 18.89	(4.40) 9.85	(15.50) 18.73	(3.17) 10.24	(5.06) 13.00	(1.80) 7.63	(5.55) 13.60	(2.68) 9.42	(6.73) 15.01	(3.03) 9.99	(6.43) 14.68	(9.77) 18.21	(6.20) 14.77	(10.41) 18.82	(15.15) 22.91
5	T_5	(3.95) 9.32	(14.93) 22.71	(4.25) 9.68	(11.07) 19.41	(1.38) 6.73	(5.23) 13.20	(2.00) 8.13	(6.58) 14.82	(3.10) 10.14	(5.87) 14.00	(3.27) 10.40	(5.85) 13.96	(10.47) 18.88	(6.50) 17.66	(12.72) 20.89	(14.46) 23.35
6	T_6	(8.67) 17.10	(19.03) 25.85	(10.93) 19.29	(22.33) 28.18	(3.22) 10.23	(6.67) 14.94	(3.93) 11.24	(7.25) 15.96	(3.12) 10.16	(8.90) 17.35	(5.10) 12.91	(6.70) 14.98	(10.49) 18.90	(9.20) 15.12	(11.32) 19.66	(15.45) 23.12
7	T_7	(5.20) 13.16	(19.50) 21.12	(7.37) 15.73	(14.70) 18.23	(1.20) 6.28	(6.58) 14.85	(2.77) 9.54	(6.83) 15.12	(3.80) 11.23	(6.80) 15.10	(3.67) 10.99	(7.53) 15.86	(11.53) 19.85	(6.80) 15.62	(11.52) 19.84	(16.36) 24.86
8	T_8	(4.05) 9.44	(16.35) 19.26	(4.75) 10.23	(20.35) 21.60	(1.55) 7.10	(5.71) 13.79	(2.37) 8.81	(8.07) 16.47	(4.43) 12.15	(7.17) 15.52	(3.53) 10.82	(8.90) 17.34	(12.43) 20.64	(7.25) 14.83	(11.36) 19.70	(17.80) 24.41
9	T_9	(4.25) 9.68	(18.95) 20.81	(4.70) 10.18	(23.35) 23.22	(1.71) 7.47	(6.42) 14.66	(1.98) 8.09	(8.07) 16.47	(3.87) 11.33	(6.77) 15.06	(3.00) 9.96	(8.73) 17.17	(11.63) 19.44	(6.55) 15.84	(10.54) 18.94	(17.63) 24.83
10	T_{10}	(7.45) 12.86	(24.70) 23.92	(8.45) 13.70	(34.66) 32.35	(2.71) 9.46	(8.53) 16.97	(3.47) 10.71	(9.58) 18.00	(3.50) 10.76	(7.00) 15.33	(4.20) 11.82	(9.08) 17.52	(11.08) 19.54	(7.45) 14.12	(12.31) 20.54	(17.98) 25.09
11	T_{11}	(7.50) 12.51	(19.10) 10.71	(10.40) 15.25	(33.16) 29.92	(2.13) 8.39	(5.28) 13.23	(2.06) 8.26	(3.83) 11.25	(1.83) 7.78	(5.43) 13.47	(2.20) 8.51	(4.77) 12.58	(8.19) 16.63	(5.95) 14.12	(9.18) 17.64	(13.18) 21.29
12	Control	(19.23) 25.99	(43.47) 41.22	(20.53) 26.92	(44.07) 41.57	(5.75) 13.83	(14.07) 22.00	(6.33) 14.55	(13.03) 21.15	(5.17) 13.13	(12.50) 20.69	(7.37) 15.73	(7.07) 15.40	(13.39) 21.46	(12.35) 20.57	(16.12) 23.67	(22.23) 28.13
S.Em. ±		0.33	0.32	0.47	0.31	0.57	0.53	0.72	0.58	0.22	0.29	0.61	0.48	0.13	0.29	0.66	0.47
C.D. at 5 %		1.01	0.97	1.43	0.94	1.67	1.56	2.09	1.70	0.67	0.85	1.79	1.42	0.38	0.84	1.93	1.37
C.V. %		3.50	2.28	3.15	2.89	11.11	6.22	12.67	6.53	3.82	3.30	9.30	5.32	6.36	3.15	9.67	5.02

***** Values in parenthesis are original value, outside parenthesis are arcsine transformed

fluorescens and recorded the disease severity on 4th and 7th days after inoculation of pathogen under pre and post inoculation method.

2018-19: The bioagent, *B. subtilis* recorded significantly minimum (3.95% & 14.93%) disease severity of anthracnose of banana after 4th and 7th days after inoculation in pre inoculation method while maximum (8.67% & 24.70%) disease severity was recorded in T_6 and $T_{10,}$ respectively 4th and 7th days after inoculation (Table 5).Same trend was observed in post inoculation method, significantly minimum (4.25% & 11.07%) disease severity of anthracnose of banana fruit rot after 4th and 7th days inoculation, respectively and maximum (10.93% & 34.66%) disease severity was recorded in T_6 and $T_{10,}$ respectively 4th and 7th days after inoculation (Table 5).

2019-20: The treatment T_7 andT_4 recorded significantly minimum (1.20% &5.06%) disease severity of anthracnose of banana fruit rot after 4th and 7th after inoculation in pre inoculation method, respectively as per (Table 5). The treatment T_6andT_{10}recorded significantly maximum (3.22% &8.53%) disease severity of anthracnose of banana after 4th and 7th days, respectively in pre inoculation method. The minimum (1.80% & 5.55%) disease severity of anthracnose was recorded in T_4 while the maximum (3.93% &9.58%) disease severity was recorded in T_6 and $T_{10,}$ respectively 4th and 7th days after inoculation in post inoculation method (Table 5).

2020-21: The treatment T_{11} recorded significantly minimum (1.83% & 5.43%) disease severity of anthracnose of banana fruit rot after 4th and 7th days. The treatment T_8 andT_6 recorded significantly maximum (4.43% & 8.90%) disease severity of anthracnose of banana after 4th and 7th days, respectively in pre inoculation method (Table-4). The treatment T_{11} recorded significantly minimum (2.20% & 4.71%) disease

Table 6: Effect of rhizospheric and fructoplane bacteria on the anthracnose severity of banana under *in vivo* condition (2018-19 to 2021-22).

Sr. No.	Treatment	Mean severity (%)			
		Pre-inoculation		Post-inoculation	
		4th	7th	4th	7th
1	*Trichoderma viride* (Navsari isolate) 20g/lit	9.54 (2.75)*	14.29 (6.09)	14.67 (6.41)	14.29 (6.09)
2	*Pseudomonas fluorescens* (Navsari isolate) 5ml/lit (2 X 10^8 CFU/ml)	10.27 (3.18)	14.45 (6.23)	15.11 (6.80)	14.58 (6.34)
3	M_1 (5ml/lit) (*P. aureofaciens*) (2 X 10^8 CFU/ml)	10.76 (3.49)	15.29 (6.95)	14.54 (6.30)	15.21 (6.88)
4	M_2 (5ml/lit) (*P. chlororaphis*) (2 X 10^8 CFU/ml)	10.10 (3.08)	14.59 (6.35)	15.82 (7.43)	15.08 (6.77)
5	M_3 (5ml/lit) (*Bacillus megaterium*) (2 X 10^8 CFU/ml)	10.23 (3.15)	15.09 (6.78)	15.25 (6.92)	13.19 (5.21)
6	M_4 (5ml/lit) (*B.licheniformis*) (2 X 10^8 CFU/ml)	11.45 (3.94)	14.88 (6.59)	16.51 (8.08)	14.88 (6.59)
7	M_5 (5ml/lit) (*B. subtilis*) (2 X 10^8 CFU/ml)	9.36 (2.65)	13.11 (5.14)	14.53 (6.25)	12.71 (4.84)
8	M_6 (5ml/lit) (*B. mucilaginous*) (2 X 10^8 CFU/ml)	10.20 (3.14)	13.30 (5.29)	15.45 (7.10)	15.34 (7.00)
9	M_7 (5ml/lit) (*B. pumilus*) (2 X 10^8 CFU/ml)	9.76 (2.87)	15.51 (7.15)	15.15 (6.83)	15.03 (6.72)
10	Hot water treatment 50^{0}C for 5 min.	10.57 (3.36)	15.06 (6.75)	16.05 (7.64)	15.41 (7.06)
11	Carbendazim (0.05%) dipping for 2 min.	9.21 (2.56)	12.65 (4.80)	13.34 (5.32)	12.65 (4.80)
12	Control	13.37 (5.34)	21.08 (12.94)	16.58 (8.14)	21.42 (13.34)
	S.Em. ± (Y x T)	0.15	0.18	0.20	0.18
	C.D. at 5%(T)	0.42	0.52	0.62	0.52
	C.D. at 5%(Y x T)	NS	NS	NS	NS
	C.V. %	4.92	4.26	4.06	4.36

* Values in parenthesis are retransformed values

severity of anthracnose of banana after 4th and 7th days after inoculation in post inoculation method. The treatment T_6 and T_{10} recorded significantly maximum (5.10% & 9.08%) disease severity of anthracnose of banana after 4th and 7th days, respectively in post inoculation method (Table 5).

2021-22: The treatment T_{11} recorded significantly minimum (8.19% & 5.95%, 9.18% & 13.18%) disease severity of anthracnose of banana after 4th and 7th days after inoculation in pre and post inoculation method. The maximum(12.43% & 9.20%)and (12.72% & 17.98%) fruit rot severity was recorded after 4th and 7th days after inoculation in pre and post inoculation method, respectively as mentioned in (Table 5).

Pooled: In pooledanalysis, pre and post-inoculation method treatment T_{11} i.e. Carbendazim (0.05%) dipping for 2 min. found most effective (9.21% & 12.65%) to reduce anthracnose fruit rot severity 4th and 7th days after inoculation in pre-inoculation method, respectively followed by T_7 (9.36 & 13.11%)(Table 6).The maximum (11.45%) was recorded in T_6 which was at par with T_3 (10.76%) 4th days after inoculation The maximum (15.51%) was recorded in T_9 which was at par

with T_3 (15.29%) and T_4 (15.09%) 7th days after inoculation as mentioned in (Table 6).

The treatment T_{11} was found the most (13.34%& 12.65%) significant to reduce disease severity followed by on 4thand 7thdays after inoculation in post-inoculation method as compare to rest of the treatments. The maximum (16.51%) was recorded in T_6which was at par with T_{10} (16.05%) 4th days after inoculation.The similartrend was observed in post- inoculation 7th days also, treatment T_{11} was found most significant (12.65%) to reduce disease severity but it was at par with T_7(12.71%). The maximum (15.41%) was recorded in T_{10} which was at par with T_3 (15.21%), T_4 (15.08%) T_7 (15.34%)and T_9 (15.03%) 7th days after inoculation as mentioned in (Table 6).

Similar result also found by Baria *et al.* (2021) who surveyed Fusarium rot incidence of banana at Navsari and Surat market and maximum incidence was recorded in Navsari.Jagana (2017) also carried out post harvest disease prevalence on banana in Dharwad and Hubballi marketsand recorded anthracnose, crown rot, finger rot and cigar end rotalso byZoier*et al*. (2021).There areseveral factors affecting post-harvest disease incidence mode of transportation, handling of fruits, packaging material and stage of harvesting. The lower the quality of handling, packaging material and transportation increase fruit rot incidence. The higher efficacy of *Bacillus subtilis* is may be due to variant mode of action i.e. antibiosis production of lytic enzymes, competence by nutrients and space, or the induction of resistance mechanisms. Bio-agents have different mode of action, i.e., competition (pseudobactin, pyoverdins), lysis (chitinase, â-1-3 glucanase), antibiosis (gliotoxin, viridin, trichodermin and phenazine-l- carboxylic acid) and mycoparasitism (proteases, endochitinases, exochitinases) and which directly affects the growth of the pathogen. These findings are conformities by Yadav and Majumdar (2004), Waghunde and Patil (2009) and Chauhan *et al*. (2021) who found *B. subtilis* and*T. viride* reduced maximum fruit rot than other bioagents.

CONCLUSION

The maximum incidence of banana fruit rots was recorded at Tulsidham Market, Bharuch as compared to APMC, Surat. The banana fruit dipping in Carbendazim (0.05%) for 2 minutes was found the most effective to reduce anthracnose fruit rot severity however fruit dipping in *B. subtilis* (5ml/lit) 10^8cfu/ml for 5 minutes also found effective to reduce the fruit rot severity in both i.e. pre and post inoculation method.

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DECLARATION

Conflict of Interest. Authors declare no conflict of interest

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