The influence of various fungicides, bioagents and eco-friendly substances on anthracnose disease of banana

Comment [SM1]: Assessment of various fungicides, bioagents and natural substances on anthracnose disease of banana

ABSTRACT

The study compared fungicides and bio agents for fruit dip treatment. The most effective treatment was carbendazim 12% + mancozeb 63% WP, showing the least disease intensity (20.26%) and the highest reduction in banana anthracnose (52.56%). Carbendazim and propiconazole also demonstrated significant disease reduction. Among non-hazardous chemicals, chitosan was the most effective (31.11% disease intensity, 34.24% reduction), followed by edible paraffin wax and yeast. Hot water treatment showed the highest disease intensity (44.49%) and the least disease control (20.86%).

Comment [SM2]: Mention whether the work has done in in vitro or in vivo

Keywords: *Musa paradisica*, comparative study, hot water treatment, chitosan, management

1. INTRODUCTION

Banana (*Musa paradisica* L.) is an important fruit crop in tropical and sub-tropical regions. The term banana was introduced from the Guinea Coast of West Africa by the Portuguese while; the term 'Plantain' (for cooking bananas) was derived from 'Plantano' of the Spaniards. The banana, which is a member of the Musaceae family, is India's and the world's most significant fruit crop. It is renowned for its age and has a long history that dates back to the beginning of civilization in India. Due to its socioeconomic importance and variety of uses, the banana crop is known as "Kalpataru" (Plant of Heaven) and defines the socioeconomic standing of the farmers. It is known as "Poor man's apple" and is inexpensive and nutrient-rich. Unripe fruit is consumed as a starchy food. Banana is cultivated in nearly 120 countries in the world. Banana is the fourth largest fruit crop of the world. Major banana producing countries are India, China, Indonesia, Brazil, Ecuador, Philippines, Guatemala, Angola, United Republic of Tanzania, Colombia, Costa Rica. In world, 5.6 million ha of land are dedicated to banana with production of 119.8 million metric tons [1]. India being the largest producer at 30.5 million metric tons on 866,000 ha. China comes second with 12 million metric tons per year on 358,924 ha. with 7.2 million metric tons of production per year, Indonesia is the third largest producer of banana [1].

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In terms of production among fruits, bananas top the list in India. After mango and citrus, it is the third largest in terms of area. India produces 324.54 lacs MT of bananas annually from an area of 8.84 lac ha. Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka, Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal, Assam, Chhattisgarh are the top banana producing states of India. The production of Andhra Pradesh is 58.38 lakh MT and share is 17.99% Maharashtra ranks second with production of 46.28 lakh MT and share of 14.26%. Gujarat being third on position with production of 39.07 lakh MT and share of 12.04 % of India's total production [21]. In addition to being a great source of potassium, vitamin A, vitamin C, vitamin B-6, and fiber, bananas are also low in fat, cholesterol-free, and salt. Certain blood pressure drugs reduce the body's potassium reserves. The potassium balance is restored by consuming one banana each day. At least five servings of fruits or vegetables per day are advised in order to maintain a healthy diet and reduce the risk of cancer. According to a recent study, consuming nine or ten servings of fruits and vegetables per day, together with three portions of low-fat dairy products, can significantly lower blood pressure. The ripe banana fruits are edible, delicious and very nutritious. Banana is a rich source of vitamin A and fair source of vitamin C, B and B1. The fruits are also rich in carbohydrates, magnesium, sodium, potassium and phosphorus. It contains 17 mg calcium, 36 mg phosphorus, 27 g carbohydrates and 1 g protein in 100 g fruit. From the nutritional point of view banana has a calorific value of 116 calories per 100 g fruit. The food value is about three times that of wheat. It makes healthy and salt free balanced diet than many of the fruits [12]. The lack of proper storage and transportation infrastructure makes post-harvest losses more common in underdeveloped nations [25].

For many years, mycologists have focused their attention on the microbes responsible for fruit rotting after harvest. Fruit deterioration after harvest results in enormous losses. According to [11, 14] infections cause 20 to 25 percent of harvested fruits to rot during post-harvest handling. Banana fruits are extremely prone to spoilage. At room temperature, bananas have a limited shelf life as climacteric fruit. Without any restrictions on the use of ripening agents, banana fruits are professionally ripened and kept by fruit merchants. Due to inappropriate handling, inadequate storage, and post-harvest infections, there is a 25 to 30 % post-harvest loss of bananas. Fruits like bananas suffer significant post-harvest losses in tropical nations like India. The cultivated banana is prone to a wide range of diseases, mostly fungi that affect the plant numerous parts from the root to the fruit. During storage, banana fruits deteriorate through the activity of microorganisms and their activity is favored by the changing physiological state of the fruit. Banana fruit suffers from many serious diseases such as anthracnose, crown rot, finger rot, white rot, cigar end rot etc. Due to all these diseases storage of banana is difficult. The two primary postharvest rots of banana fruits are anthracnose and crown rot. The fungus *Colletotrichum musae* can cause both crown rot and anthracnose; in addition, crown rot diseases may also be caused by fungal pathogens in the genera *Fusarium*, *Acremonium*, *Verticillium* and *Curvularia*. The fungus *Colletotrichum* has been the most notorious fungal pathogen, which causes severe rots which rapidly deteriorating fruit quality and rendering the fruit completely to a rotten with sticky mass tickling from the infected pulpy banana. One of the most significant postharvest diseases of bananas is anthracnose, which is typically brought on by the fungus *Colletotrichum musae* (Berk. & Curt.), which affects both mature and damaged green fruits. Additionally, banana tip rot, crown rot, and blossom end rot have all been caused by *C. musae*. The disease typically develops during extended periods of storage and transit that are characterized by low temperatures and high humidity. Banana anthracnose is characterized by brown patches that develop into depressed lesions with acervuli that are orange or pink in color. The disease won't be seen until the fruit ripens. The following objectives guided the planning and execution of the current investigations on post-harvest fruit rot of bananas in light of the disease's significance.

2. MATERIAL AND METHODOLOGY

2.1 Effect of different fungicides and bioagents on anthracnose disease of banana fruits

On the basis of results of *in vitro* experiments, a study was carried out on banana fruits against post-harvest disease of anthracnose (*C. musae*). The two treatments that have been gave best inhibition of test pathogen, were taken for fruit dip treatments. Six different fungicides namely, mancozeb 75% WP, chlorothalonil 75%, carbendazim 50% WP, propiconazole 25% EC, carbendazim 12% + mancozeb 63% WP and carboxin 37.5% + thiram 37.5% DS at 0.05% concentrations and *T. harzianum* (10^6 cfu/ml) and *P. fluorescens* (10^6 cfu/ml), including of a control were carried out in experiment. Healthy banana fruits were washed and surface sterilized in 1% sodium hypochlorite solution for 2 minutes. Semi-ripe healthy banana fruits were artificially inoculated by dipping in spore suspension (2×10^5 spores/ml) of test fungus, which were previously prepared in sterile distilled water with pure culture of *C. musae*. One hour after inoculation these banana fruits were treated with various fungicides and biocontrol agents. Four banana fruits were taken in each treatment which was repeated three times in complete randomized design. Treated fruits were air dried and kept in well aerated room in laboratory, Plant Pathology Section, College of Agriculture, Dhule. Observations were recorded. The estimation of anthracnose was taken by using 0-5 scale as mentioned earlier and calculated the per cent disease intensity in each treatment. The experimental details were as follows: Design: Completely Randomized Design (CRD), Replications: Three, Treatments: Nine. The per cent disease intensity (PDI) were calculated according to the formula suggested by Datar and Mayee [8] given as below.

$$PDI = \frac{\text{Sum of rating of infected fruits}}{\text{Total no. of fruits observed X Maximum disease score}} \times 100$$

Per cent disease intensity decrease over control (PDIDOC) was calculated using following formula suggested by Kapadiya [13].

$$PDIDOC = \frac{\text{PDI in control – PDI in treatment}}{\text{PDI in control}} \times 100$$

2.2 Effect of different nonhazardous chemicals on anthracnose of banana fruits

Banana is a staple food for millions of people and daily used by human being. Anthracnose is the most important post-harvest disease of banana fruits. To provide safe banana fruits from hazardous effect of chemicals, nonhazardous chemicals were used for control the anthracnose disease. These chemicals are also easily available in markets and cheaper than fungicides.

Therefore, an effort was made, to study the efficacy of various six non-hazardous chemicals *viz*., yeast, chitosan, hot water treatment, edible paraffin wax, sulphur, etc. for controlling anthracnose of banana fruits. Semi-ripen banana fruits were washed and surface sterilized in 1% sodium hypochlorite solution for 2 minutes. A spore suspension (2×10^5 spores/ml) was prepared from pure culture of *C. musae*. Healthy banana fruits were inoculated with above spore suspension. One hour after inoculation these banana fruits were treated with non-hazardous chemicals. Four banana fruits were taken in each treatment which was repeated three times in complete randomized design. Treated fruits were air dried and kept in well aerated room at laboratory plant pathology section, college of agriculture, Dhule. Observations were recorded. The estimation of anthracnose was taken by using 0-5 scale as mentioned earlier and calculated the per cent disease intensity in each treatment. The experimental details were as follows: Design: Completely Randomized Design (CRD), Replications: Four, Treatments: Six

3. RESULT AND DISCUSSION

3.1 Effect of different fungicides and bioagents on anthracnose disease of banana fruits

The perusal of data presented in the Table 1 and Fig, 1 showed that all fungicides and biocontrol agents were capable of controlling per cent disease intensity (PDI) at all concentrations tried in the present investigation. Their mean PDI after 3 days was ranged from 20.13 to 59.70 per cent. Results revealed that all the treatments tested against anthracnose disease were significantly reduced disease as compared to the control. Minimum disease intensity (20.13%) was recorded in carbendazim 12 % + mancozeb 63 % WP tested at 0.05% concentration and it was significantly superior over control and remaining other treatments. Carbendazim 50 % WP (27.10 %) was remained better in reduction of anthracnose diseases of banana. Propiconazole 25% EC and mancozeb 75% WP noted 35.63 and 36.90 per cent disease intensity, respectively and were also good, they remain at par. Bio agent *T. harzianum* (45.83%) also performed considerable reduction in anthracnose disease as compared to chemical fungicide. However, other treatments namely, carboxin 37.5% + thiram 37.5% DS, *Pseudomonas fluorescens* and chlorothalonil were showed inferior in reduction with 53.96, 57.76 and 59.70 per cent disease intensity, respectively. Control treatment recorded maximum disease (100 %).

Comment [SM4]: Spacing after digits (should be in same format)

Table 1: Effect of different fungicides and bioagents on anthracnose disease of banana fruits

Tr. No.	Treatments	Conc.	PDI (after 3 days)	PDI (after 5 days)	Average of PDI	PDI over Control
T_1	Mancozeb	0.15 %	36.90[#] (37.41)[*]	40.40 (39.47)	38.65	34.17
T_2	Chlorothalonil	0.15 %	59.70 (50.59)	62.06 (51.98)	60.88	11.94
T_3	Carbendazim	0.05 %	27.10 (31.37)	25.30 (30.20)	26.20	46.62

T_4	Propiconazole	0.05 %	35.63 (36.65)	36.03 (36.89)	35.83	36.99
T_5	Carbendazim 12% + Mancozeb 63%	0.05 %	20.13 (26.66)	20.40 (26.85)	20.26	52.56
T_6	Carboxin 37.5% + Thiram 37.5%	0.05 %	53.96 (47.28)	50.86 (45.50)	52.41	20.41
T_7	*Trichodema harzianum*	10^6 cfu/m	45.83 (42.61)	46.16 (42.80)	45.99	26.83
T_8	*Pseudomonas fluorescens*	10^6 cfu/m	57.76 (49.47)	57.96 (49.58)	57.86	14.96
T_9	Control (Untreated)	--	70.44 (57.06)	75.20 (60.13)	72.82	00.00
	S.E.± (m)	--	0.31	0.26	-	
	C.D at 1%	--	0.93	0.78	-	

#Average of three replications. *Figures in parenthesis are arc sine transformation values.

PDI - Percent disease intensity

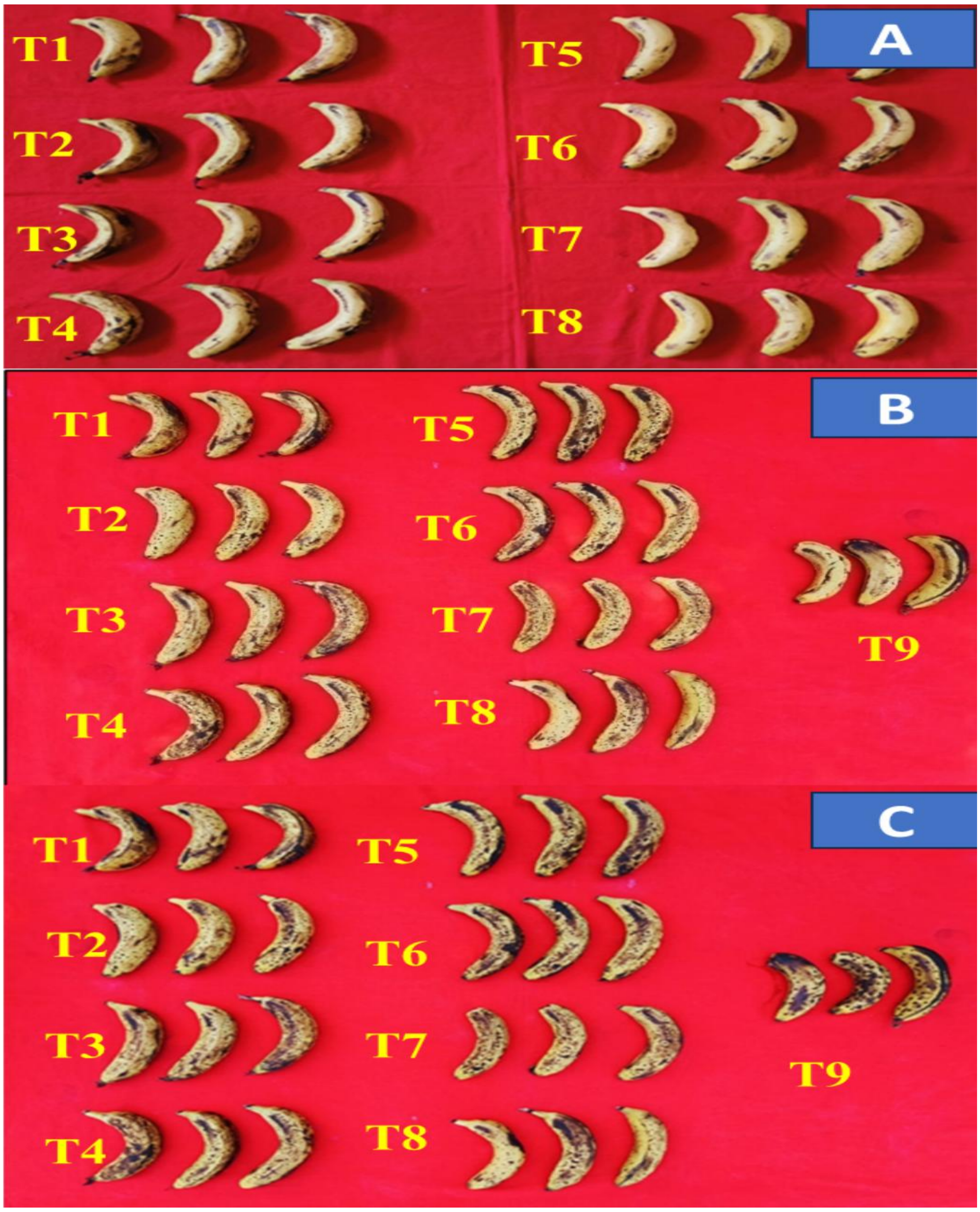

Fig 1: Effect of different fungicides and bioagents on anthracnose disease of banana A) Healthy fruits B) After 3 and C) 5 days of application

Their mean PDI after 5 days was ranged from 20.40 to 62.06 per cent. Results revealed that all the treatments tested against anthracnose disease were significantly reduced disease as compared to the control. Minimum disease intensity (20.40 %) was recorded in carbendazim 12 % + mancozeb 63 % WP tested at 0.05 % concentration and it was significantly superior over control and remaining other treatments. Carbendazim 50 % WP (25.30 %) was remained better in reduction of anthracnose diseases of banana. Propiconazole 25 % EC and mancozeb 75 % WP noted 36.03 and 40.40 per cent disease intensity, respectively and were also good. Bioagent *T. harzianum* (46.16 %) also performed considerable reduction in anthracnose disease as compared to chemical fungicide. However, other treatments namely, carboxin 37.5 % + thiram 37.5 % DS, *P. fluorescens* and chlorothalonil were showed inferior in reduction with 50.86, 57.96 and 62.06 per cent disease intensity, respectively. Control treatment recorded maximum disease (100 %). Average per cent disease intensity recorded with all the treatments was ranged from 20.26 to 60.88 per cent as against untreated control; as well as reduction in average disease intensity with the treatment was ranged from 11.94 (T_2) to 52.56 (T_5) per cent. However, comparatively least average disease intensity was observed in treatment carbendazim 12 % + mancozeb 63 % WP (20.26 %) and its highest reduction of anthracnose diseases of banana (69.74 %), followed by carbendazim treatment (Av. PDI: 26.20 %, Av. PDC: 46.62 %), Propiconazole (Av. PDI: 35.83 %, Av. PDC: 36.99 %) & Mancozeb (Av. PDI: 38.65 %, Av. PDC: 34.17 %). The highest average percent disease & less per cent disease control recorded in chlorothalonil treatment (Av. PDI: 60.88 %, Av. PDC: 11.94 %), followed by *P. fluorescens* (Av. PDI: 57.86 %, Av. PDC: 14.96 %), carboxin 37.5 % + thiram 37.5 % DS (Av. PDI: 52.41 %, Av. PDC: 20.41 %) and *T. harzianum* (Av. PDI: 45.99 %, Av. PDC: 26.83 %). Similar result was found by [7] who studied that pathogens associated with fruit rot of banana can be effectively controlled by dipping the fruits in carbendazim (1000 ppm) for 10 min. Nath *et al*. [19] and Nath *et al*. [20] who showed that minimum PDI was observed in propiconazole and carbendazim 12% + mancozeb 63% WP (1 %) treated fruits with 25 maximum reduction of fruit rot disease (98.76 %) followed by carbendazim (2.50 %) with 96.79 % reduced fruit rot disease. Mevada and Kapadiya [18] revealed that among the all twelve different treatments minimum (11.54%) per cent disease intensity was recorded in fruits treated with carbendazim 12% + mancozeb 63 % WP at 0.05 % concentration. For obtaining residue free organic banana fruits cinnamon oil at 0.1% and *T. harzianum* (10^6 cfu/ml) were found best which minimized 36.87 and 52.89 per cent disease, respectively.

3.2 Effect of various non-hazardous chemicals on anthracnose disease of banana fruits

The efficacy of different non-hazardous chemicals *viz*., yeast, chitosan, hot water treatment, edible paraffin wax and sulphur (fumigant) were tested by fruit dip method of spore suspension. The observations regarding per cent inhibition of linear growth are presented in Table 2, Fig 2. All the treatments tested against *C. musae* were significantly differing from each other. Among all five non-hazardous chemicals significantly minimum mean PDI after 3 days was recorded in treatment with chitosan (30.12 %) followed by treatment with yeast (36.20 %). The treatments hot water treatment (39.97 %), edible paraffin wax (42.17%) and sulphur (43.87 %) were found inferior in reducing anthracnose disease of banana. All the treatments tested against *C. musae* were significantly differing from each other. Among all five non-hazardous chemicals significantly minimum mean PDI after 5 days was recorded in treatment with chitosan (32.10 %) followed by treatment with edible paraffin wax (36.20%) and yeast (39.97%). The treatments Sulphur (42.17%) and hot water treatment (43.87 %) were found inferior in reducing anthracnose disease of banana. Average per cent disease intensity recorded with all the treatments was ranged from 31.11 to 44.49 per cent as against untreated control; as well as reduction in average disease intensity with the treatment was ranged from 22.68 (T_5) to 34.24 (T_2) per cent. However, comparatively least average disease intensity was observed in chitosan treatment (31.11 %) and its highest reduction of anthracnose diseases of banana (34.24 %), followed by edible paraffin wax treatment (Av. PDI: 37.16 %, Av. PDC: 28.19 %), yeast (Av. PDI: 39.97 %, Av. PDC: 24.86 %) and sulphur (fumigant) (Av. PDI: 42.67 %, Av. PDC: 22.68 %). The highest average percent disease & less per cent disease control was recorded in hot water treatment (Av. PDI: 44.49 %, Av. PDC: 20.86 %).

Table 2: Effect of different non-hazardous chemicals on anthracnose disease of banana fruits

Tr. No.	Treatments	PDI (after 3 days)	PDI (after 5 days)	Average PDI	PDI over Control
T_1	Yeast	39.97 (39.58)	41.02 (39.83)	40.49	24.86
T_2	Chitosan	30.12 (33.29)	32.10 (34.82)	31.11	34.24
T_3	Hot water treatment	43.87 (41.48)	45.12 (42.20)	44.49	20.86
T_4	Edible paraffin wax	36.20# (36.99)*	38.12 (38.13)	37.16	28.19
T_5	Sulphur (fumigant)	42.17 (40.50)	43.17 (41.08)	42.67	22.68
T_6	Control (Untreated)	60.20 (50.89)	70.50 (57.10)	65.35	00.00
	S.E.±(m)	0.27	0.21		
	C.D at 1%	0.84	0.63		

#Average of three replications, PDI - Percent disease intensity
*Figures in parenthesis are arc sine transformation values.

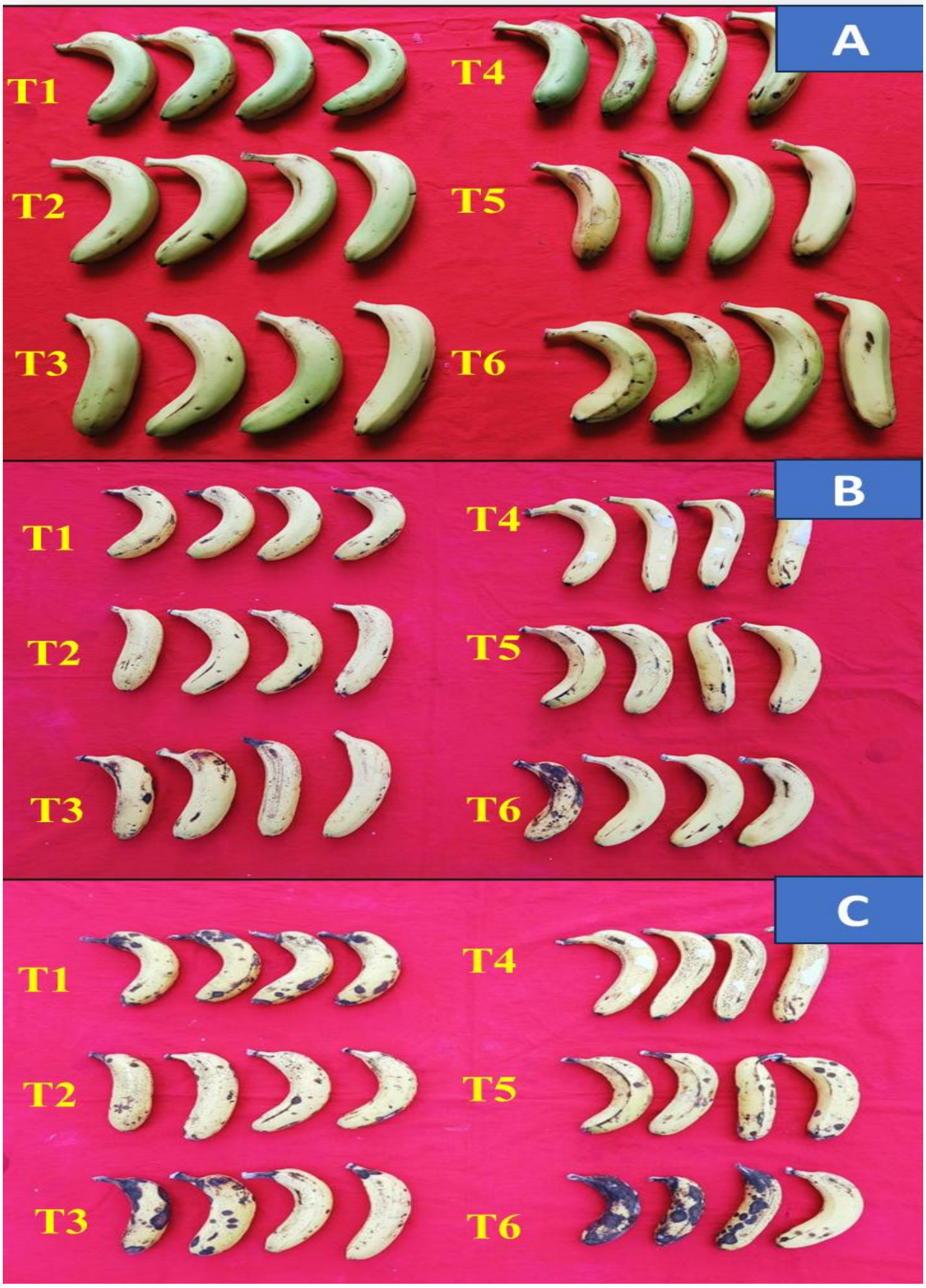

Fig 2: Effect of different non-hazardous chemicals on anthracnose disease of banana A) Healthy fruits B) After 3 and C) 5 days of application

Maqbool *et al*. [17] reported the complete inhibition of mycelia growth of *C. musae* by chitosan at 1% concentration during 7 days of incubation period. Also, Wattanakorn [32] discussed that chitosan has been believed to have antifungal effects against several fungi, including *C. musae*. Chitosan acted as a barrier for the penetration of germ tube of *C. musae* into tissues [4]. Xiangchun *et al.* [33] reported that dipping of banana fruits in chitosan reduced the anthracnose lesion diameter.

Conclusion

The present investigation concluded that, among the different fungicides and bio agents tested against the *C. musae*, the minimum percent disease intensity was shown by carbendazim 12% + mancozeb 63% 20.13% and 20.40% after 3 and 5 days respectively. Where as in testing of non-hazardous chemicals in fruit dip method the minimum percent disease intensity was recorded by chitosan 30.12% and 32.10% after 3 and 5 days respectively.

References

1. Anonymous (2022). FAOSTAT Agriculture data. Available at accessed on July 2022.
2. Asalkar UA, Hingole DG, Khaire PB, Mete VS. Effect of Different Solid Media on the Growth and Sporulation of *Colletotrichum gloeosporioides* Penz. and Sacc. causing Fruit Rot of Aonla. Int.J.Curr.Microbiol.App.Sci. (2019) 8(10): 610-616.
   doi: https://doi.org/10.20546/ijcmas.2019.810.069
3. Azad CS, Srivastava JN, Chand G. Evaluation of bio-agents for controlling anthracnose of banana caused by *Colletotrichum musae in-vitro* condition. *The Bioscan.,* (2013) 8 (4): 1221-1224.
4. Bautista-Banos S, Hernandez-Lopez M, Bosquez-Molina E, Wilson CL. Effects of chitosan and plant extracts on growth of *Colletotrichum gloeosporioides*, anthracnose levels and quality of papaya fruit. *Crop Prot.,* (2003) 22: 1087-1092.
5. Bhuvaneswari V, Rao MS. Evaluation of *Trichoderma viride* antagonistic to post harvest pathogens on mango. *Indian Phytopathol*., (2001) 54 (4): 493-494.
6. Costa DM De, Subasinghe SSNS. Antagonistic bacteria associated with the fruit skin of banana in controlling its post-harvest diseases. *Trop. Sci.,* (1998) 38 (4): 206-212.
7. Datar VV, Ghule KK. Investigations on some aspects of control of fruit rot of banana (*Musa cavendishii* L.) *Indian J. Pharm. Bio. Sci.,* (1998) 6(2): 133-138.
8. Datar VV, Maye CD. Assessment losses in tomato yield due to early blight. *Indian Phytopath.,* (1981) 34 (2): 191-195.
9. Dennis KL, Webster J. Antagonistic properties of species group of Trichoderma and hyphal interaction. British Mycol. Soc., (1971) 57: 363396.
10. Deshmukh PP, Raut JG. Antagonism by *Trichoderma* spp. on five plant pathogenic fungi. *New Agriculturist.,* (1992) 3: 127-130.
11. Droby S, Zhu. Improving quality and safety of fresh fruits and vegetables after harvest and the use of biological control and natural materials. *Acta Hortic.,* (2006) 709: 45-51.

12. Gopalan C, Rama Sastri BV, Balasubramania SC. Nutritive value of Indian foods, National Institute of Nutrition, ICMR, Hyderabad (2004).
13. Kapadiya HJ. Post-harvest management of Black mold of Onion (*Allium cepa* L.) caused by *Aspergillus niger* V. Tiegh. Ph.D. Thesis, Junagadh Agricultural University, Junagadh, India (2006).
14. Khaire PB, Hake LG. Some Important Post Harvest Diseases of Tomato and Their Management. Popular Kheti. (2018) Volume -6, Issue-3, 80-86.
15. Kolase, SV, Kamble TM, Musmade NA. Efficacy of different fungicides and botanicals against blossom blight of Mango caused by *Colletotrichum gloeosporioides*. *Int. J. Plant Prot.,* (2014) 7 (2): 444-447.
16. Lokhande RD, Tiwari S, Patil RV. Eco-friendly management of anthracnose of Chilli (*Capsicum annuum* L.) caused by *Colletotrichum capsici* (Syd.) Butler and Bisby. *Int. J. Curr. Microbiol. App. Sci* 8(2): (2019) 1045-1052.
17. Maqbool M, Ali A, Alderson PG. Effect of cinnamon oil on incidence of anthracnose disease and post-harvest quality of bananas during storage. *Int. J. Agric. Biol.,* (2010) 12 (4): 516–520.
18. Mevada RR, Kapadiya HJ. Effect of various fungicides, biocontrol agents, phytoextracts and essential oils on post-harvest management of banana anthracnose (*Colletotrichum musae* Berk. & Curt.). *International Journal of Chemical Studies.,* (2019) 7 (6): 387-391.
19. Nath K, Solanky KU, Bala M. Management of banana (*Musa paradisiaca* L.) fruit rot diseases using fungicides. (2015) *J. Plant Pathol. Microb*., 6(8): 298.
20. Nath K, Solanky KU, Bala M, Kumawat GL. Post harvest deterioration of banana fruits and its control using fungicides. *Internat. J. Plant Protec*., (2014) 7(2): 345-348.
21. National Horticultural Board, (NHB, 2022, 1st Advance Estimate), agriexchange.apeda.gov.in.
22. Patil PP. Studies on leaf blight of sapota caused by *Colletotrichum gloeosporioides* Penz. M.Sc. (Agri.) Thesis submitted to B.S.K.K.V., Dapoli, Maharashtra, India (2009).
23. Pawar SV, Khaire PB Mane SS. Management Strategies Used against Fungal Diseases of Capsicum. AgriCos e-Newsletter. (2020) Vol 1(5). 22-26.
24. Ranathunge NP, Rajapaksha RJ, Yogarajah K, Preethikumara M. Isolation, screening and *in vitro* evaluation of bacterial antagonist from spent mushroom substrate against *Colletotrichum musae*. *Trop. Agric. Res. & Ext.,* (2014) 17 (2): 115-120.
25. Rashad RA, Al-Najada AR, Saleh AM. Isolation and identification of some fruit spoilage fungi: Screening of plant cell wall degrading enzymes. *Afri. J. Microbiol. Res.,* (2011) 5 (4): 443-448.
26. Rathva AA, Mehta BP, Chauhan R, Ganvit MR. *In vitro* evaluation of fungicides against *Colletotrichum gloeosporioides* Penz. and Sacc. causing anthracnose in pointed gourd. *Int. J. Chemical Studies.,* (2017) 5 (6): 1870-1872.
27. Sangeetha G, Usharani S, Muthukumar A. Biocontrol with *Trichoderma* species for the management of postharvest crown rot of banana. *Phytopathol. Mediterr.,* (2009) 48 (2): 214–225.
28. Shrishikar GS. Studies on fruit rots of mango (*Mangifera indica* L.) caused by *Botryodiplodia theobromae* and *Colletotrichum gloeosporioides* and their management. M. Sc. (Agri.) Thesis, B.S.K.K.V, Dapoli, Maharashtra (2002).
29. Singh N. Biocontrol of red rot disease of sugarcane. *Indian Phytopath.,* (1992) 43: 64.

30. Somasekhara YM, Prasannakumar MK, Dev D. Cultural characterization of *Colletotrichum gloeosporioides* causing anthracnose of pomegranate. *Indian Phytopathological Society* (2018).
31. Vincent JM. Distoration of fungal hyphae in the presence of certaion inhibitors. Nature, (1947) 159: 159-850.
32. Wattanakorn C. Effect of Konjac Gum Coatings on Storage Time of Banana cv. Kluai Hom Thong. M.Sc Thesis. King Mongkut's University of Technology Thonburi, Bangkok, Thailand (2003).
33. Xiangchun M, Yanxia T, Aiyu Z, Xuemei H, Zhaoqi Z. Effect of oligochitosan on development of *Colletotrichum musae in vitro* and *in situ* and its role in protection of banana fruits. *Fruits.,* (2011) 67 (3): 147-155.