

Original Research Article

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Bio Efficacy of Fungicides and Bio Agents against *Colletotrichum gloeosporioides* causing Anthracnose in Pomegranate

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ABSTRACT

Pomegranate (*Punica granatum* L.) of Lythraceae family, called “fruit of paradise” is one of the major fruit crops of arid region. At present, the known fungal disease agents of pomegranate are *Colletotrichum gloeosporioides*, *Alternaria* spp., *Botrytis cinerea*, *Aspergillus niger*, *Pestalotiopsis versicolor*, *Penicillium* spp. and *Rhizopus* spp. Among the various fungal diseases, anthracnose caused by *Colletotrichum gloeosporioides* is the most important post harvest diseases in pomegranate. In this study, several fungicides and bio agents were evaluated against this pathogen. Among systemic fungicides, propiconazole 25% EC, hexaconazole 5% EC, iprobenfos 48% EC and kresoxim methyl 44.3% EC recorded cent per cent mycelial inhibition of *Colletotrichum gloeosporioides*. Among six contact and seven combi products (1000, 1500, 2000 and 3000 ppm), mancozeb 75% WP, zineb 75% WP, tricyclazole 18 % + mancozeb 62 %, carbendazim 12% + mancozeb 63% and carboxin 37.5% + thiram 37.5% completely inhibited the growth of *Colletotrichum gloeosporioide*. Among different bio agents tested, *Trichoderma harzianum*, UAS, Dharwad isolate recorded significantly higher per cent mean inhibition followed by *Trichoderma harzianum*, UHS, Bagalkot isolate. Fungicides and bio agents found effective were tested in field condition for the management of pomegranate leaf spot and fruit rot. The results showed that mancozeb 75% WP, carbendazim 12% + mancozeb 63% and propiconazole 25% EC @ 0.1% were effective in controlling the leaf spot and fruit rot incidence as compared to other treatments.

Keywords

Pomegranate, anthracnose, *Colletotrichum gloeosporioides*, bio agents, fungicides, per cent disease index

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Introduction

Pomegranate (*Punica granatum* L.) is an ancient fruit of arid regions of the world. It belongs to the family Lythraceae. Pomegranate is native from Iran to Himalayas in northern India. It is mainly liked for its refreshing juice. Pomegranates are also used

in cooking, juice blends, meal garnishes and alcoholic beverages. It is having potential to counteract free radicals and provide antioxidants, tannins and anthocyanins. It has been used to treat sore throats, coughs, skin disorders and digestive disorders. (Bhowmik *et al.*, 2013). India is world’s largest producer of the pomegranate fruit followed by Iran,

China, Turkey and United States. Maharashtra is the leading producer of pomegranate followed by Karnataka, Gujarat, Madhya Pradesh, Himachal Pradesh and Rajasthan. Area under pomegranate cultivation in India is 2, 34,000 ha with the production of 28, 45,000 MT during 2017-18. Karnataka accounts 25,970 ha area, 2, 68,230 MT production and 10.33 MT/ha productivity during 2017-18. It has spread across different districts of Karnataka viz., Chitradurga, Bellary, Tumkur, Vijayapur and Bagalkot (Anon., 2018).

Pomegranate is affected by several pathogens before and after harvest. This results in huge losses during harvest and storage. Fruit rot is one of the contributing factors for the low productivity. Fruit rot is wide spread in rainy season/ high moisture conditions. It is suspected to be caused by, *Colletotrichum sp.*, *Alternaria sp.*, *Cercospora sp.*, *Phytophthora sp.*, *Penicillium spp.*, *Aspergillus spp.*, *Coniella granati* and *Rhizopus spp.* (Munhuweya *et al.*, 2016). Among these pathogens, *Colletotrichm gloeosporioides* (Penz.) Penz. & Sacc. causing anthracnose important fruit rot (pre and post harvest) pathogen in pomegranate. In India, *Colletotrichm gloeosporioides* responsible for leaf spot disease was first time reported on coffee by Butler (1918) and anthracnose disease on mango by McRae (1924).

In India, Chandra and Tondon (1965) for the first time reported *C. gloeosporioides* causing pomegranate leaf spot and fruit rot. The pre harvest management of anthracnose is necessary as the pathogen is known to cause huge loss after harvest. But there are several fungicides available in the market and their bio efficacy need to evaluate under *in vitro* and field studies. Therefore, the efficacy of different contact, systemic and combination fungicides and bio agents were verified by *in vitro* and effective fungicides and bio agents were tested under field condition.

Materials and Methods

The experimental studies on pomegranate anthracnose were carried out at Department of Plant Pathology, College of Horticulture, Bagalkot. Pre harvest management study was carried out at farmer field at Tulasigeri village of Bagalkote taluk. The standard tissue isolation technique was followed for the isolation of the pathogens causing anthracnose. Pure culture was done by following single spore isolation technique. Isolated pathogen was identified through the cultural, morphological and molecular studies.

In vitro* evaluation of fungicides and bio agents against *Colletotrichum gloeosporioides

Twenty four fungicides evaluated against the *Colletotrichum gloeosporioides* to test their efficacy under the laboratory condition. The systemic fungicides were evaluated at the concentration of 250, 500, 1000 and 1500 ppm. The contact and combi products were evaluated at concentration of 1000, 2000, 2500 and 3000 ppm. The fungicides were evaluated using potato dextrose agar as the basal medium and by following Poison Food Technique. Antagonistic micro organisms like, *Bacillus subtilis*, *Trichoderma asperellum* and *Trichoderma harzianum* were evaluated for their antagonistic properties by dual plate culture technique.

Field evaluation of fungicides and bio control agents against fruit rot of pomegranate

The experiments on field evaluation of fungicides and bio control agents against fruit rot of pomegranate was conducted during July 2019 in natural epiphytic conditions on pomegranate at farmer field in Tulasigeri village of Bagalkote taluk. The fungicides and commercial formulation of biological agents

which were found effective *in vitro* were tested at recommended concentration. There were ten treatments for fruit rot disease with randomized completely blocked design (RCBD) and each treatment was replicated three times. Two sprays were taken at 40 and 60 days after fruit set. The treatment details were as follows.

Results and Discussion

***In vitro* evaluation of contact fungicides against *Colletotrichum gloeosporioides* (Fig.1 and Table.1)**

Mancozeb 75% WP and zineb 75% WP showed cent per cent inhibition of mean mycelial growth and were found to be most effective as compared to other four contact fungicides. The least mean per cent inhibition was recorded by copper oxy chloride 50% WP (33.33%) and propineb 70% WP (49.62%).

At 1000 ppm, mancozeb 75% WP and zineb 75% WP were found to be most effective with complete inhibition of mycelia growth followed by captan 50% WP (59.26%). Copper oxy chloride 50% WP was least effective (2.59%). The same trend continued at 2000 and 2500 ppm concentrations as all fungicides were slightly effective than lower concentrations. At 3000 ppm, mancozeb 75% WP, zineb 75% WP, propineb 70% WP and chlorothalonil 75% WP recorded complete (100.00%) fungal growth inhibition. Copper oxy chloride 50% WP showed least per cent inhibition of mycelia growth (47.41%).

***In vitro* evaluation of systemic fungicides against *Colletotrichum gloeosporioides* (Fig.2 and Table.2)**

Total eleven systemic fungicides were evaluated at four concentrations for their efficacy against *Colletotrichum gloeosporioides*. Four systemic fungicides

viz., hexaconazole 5% EC, propiconazole 25% EC, kresoxim methyl 44.3% EC and iprobenfos 48% EC showed cent per cent inhibition of mean mycelial growth and were found to be most effective as compared to other seven systemic fungicides. The next best chemicals were found to be tebuconazole 25% EC, difenconazole 25% EC and tricyclazole 75% WP with 97.47%, 89.75% and 89.02% mean per cent inhibition of mycelia growth. The least growth inhibition was recorded by thifluzamide 24% SC (9.93%) followed by azoxystrobin 25% EC (22.97%).

At 250 ppm, cent per cent inhibition of mycelia growth was recorded by hexaconazole 5% EC, propiconazole 25% EC, kresoxim methyl 44.3% EC and iprobenfos 48% EC and were found best chemicals followed by tebuconazole 25% EC (93.45%), difenconazole 25% EC (84.44%) and tricyclazole 75% WP (71.63%). Thifluzamide 24% SC and azoxystrobin 25% EC did not show inhibition at this concentration level. At 500 ppm the same trend continued. In addition to these 4 effective fungicides, showed cent per cent inhibition was recorded by tricyclazole 75% WP at 1000 and 1500 ppm, and by difencinazole at 1500 ppm. Carbendazim 50% WP could show inhibition of 88.63% at 1500 ppm. All other fungicides were ineffective.

***In vitro* evaluation of combi products against *Colletotrichum gloeosporioides* (Fig.3 and Table.3)**

Total seven combi products were evaluated for their efficacy against *Colletotrichum gloeosporioides* at 1000, 2000, 2500 and 3000 ppm.

Mean per cent inhibition of mycelia growth were recorded for all the different combi products, among which tricyclazole 18% + mancozeb 62%, carbendazim 12% +

mancozeb 63% and carboxin 37.5% + thiram 37.5% showed complete inhibition. The efficacy of captan 70% + hexaconazole 5% (79.07%) was much the same as tricyclazole 45% + hexaconazole 10% (77.40%). Hexaconazole 4% + zineb 68% were least effective, which recorded 70.45% mycelia growth inhibition.

At 1000 ppm, cent per cent inhibition was recorded by tricyclazole 18% + mancozeb 62%, carbendazim 12% + mancozeb 63% and carboxin 37.5% + thiram 37.5% and these were followed by captan 70% + hexaconazole 5% (74.81%). Least efficacy was observed for hexaconazole 4% + zineb 68% (59.25%). The same trend continued even at 2000 and 2500 ppm concentrations. At 3000 ppm, cent per cent inhibition was recorded by tricyclazole 18% + mancozeb 62%, carbendazim 12% + mancozeb 63% and carboxin 37.5% + thiram 37.5%. Tricyclazole 45% + hexaconazole 10% and hexaconazole 4% + zineb 68% were recorded next highest value of per cent mycelial inhibition (88.88%).

***In vitro* evaluation of bio agents against *Colletotrichum gloeosporioides* (Fig.4 and Table.4)**

Four different bio agents collected from UAS, Dharwad and UHS, Bagalkot were tested for their competitive ability against *Colletotrichum gloeosporioides*. *Trichoderma harzianum*, UAS, Dharwad isolate recorded significantly higher per cent mean inhibition (86.67%) followed by *Trichoderma harzianum*, UHA, Bagalkot isolate (75.19%). *Trichoderma asperellum*, UHS, Bagalkot isolate showed 69.63% growth inhibition. The per cent inhibition of *Colletotrichum gloeosporioides* by bacterial antagonists, *Pseudomonas fluorescens* (58.15%) and *Bacillus subtilis* (56.67%) isolates of UAS, Dharwad and *Pseudomonas fluorescens*, UHS, Bagalkot isolate (55.93%) was on par with

each other. The least per cent inhibition was recorded for UHS, Bagalkot isolate of *Bacillus subtilis* (54.44%).

Field management of leaf spot and fruit rot of pomegranate (Fig5, Table5 and Table6)

20 days after second spray, highest per cent disease reduction over control was recorded in carbendazim 12% + mancozeb 63% (56.52%) @ 0.1%, mancozeb 75% WP @ 0.1% (54.35%) and propiconazole 25% EC @ 0.025% (53.26%) with lowest leaf spot PDI values of 26.67%, 28.00% and 28.67% respectively. Significant PDI of fruit rot was recorded for propiconazole 25% EC @ 0.025% (36.00%), mancozeb 75% WP @ 0.1% (37.33%) and carbendazim 12% + mancozeb 63% @ 0.1% (37.33%) followed by iprobenfos 48% EC @ 0.025% (42.67%) and kresoxim methyl 44.3% EC @ 0.025% (42.67%). Highest PDI was recorded in control (57.33%), *T. harzianum* @ 1% (49.33%) and tricyclazole 18% + mancozeb 62% @ 0.1% (48.00%). These results showed that Mancozeb 75% WP, carbendazim 12% + mancozeb 63% and propiconazole 25% EC were effective in controlling the leaf spot and fruit rot incidence as compared to other treatments. Among systemic fungicides (250, 500, 1000 and 1500 ppm), propiconazole 25% EC, hexaconazole 5% EC, iprobenfos 48% EC and kresoxim methyl 44.3% EC recorded cent per cent mycelial inhibition at their lowest level of test concentration. Least per cent inhibition was recorded by thifluzamide 24% SC (9.93%) followed by azoxystrobin 25% EC (22.97%). Among six contact and seven combi products (1000, 1500, 2000 and 3000 ppm), mancozeb 75% WP, zineb 75% WP, tricyclazole 18% + mancozeb 62%, carbendazim 12% + mancozeb 63% and carboxin 37.5% + thiram 37.5% completely inhibited the growth of both the test pathogens at their lowest level of concentrations evaluated.

Table.1 *In vitro* efficacy of contact fungicides against *Colletotrichum gloeosporioides*

Sl. No.	Fungicide	Per cent inhibition of mycelial growth				
		Concentration (ppm)				
		1000	2000	2500	3000	Mean
1	Captan 75% WP	59.26 *(50.33)	62.59 (52.29)	64.44 (53.39)	67.41 (55.19)	63.42
2	Chlorothalonil 75% WP	12.96 (21.09)	38.15 (38.14)	78.15 (62.13)	100.00 (89.66)	57.31
3	Copper oxychloride 50% WP	2.59 (9.21)	38.15 (38.14)	45.19 (42.23)	47.41 (43.51)	33.33
4	Mancozeb 75% WP	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00
5	Propineb 50% WP	23.33 (28.87)	26.67 (31.08)	48.52 (44.15)	100.00 (89.66)	49.62
6	Zineb 75% WP	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00
Mean		49.68	60.92	72.71	85.80	
		F	C	F×C		
S.Em±		0.19	0.16	0.39		
CD @ 0.01		0.72	0.59	1.44		

*Arcsine Transformed Values

Table.2 *In vitro* efficacy of systemic fungicides against *Colletotrichum gloeosporioides*

Sl. No.	Fungicide	Per cent inhibition of mycelial growth				
		Concentration (ppm)				
		250	500	1000	1500	Mean
1	Azoxystrobin 25% EC	0.00 *(0.249)	7.43 (15.82)	33.22 (35.19)	51.26 (45.72)	22.97
2	Carbendazim 50% EC	62.67 (52.33)	71.33 (57.63)	72.41 (58.31)	88.63 (70.31)	73.76
3	Difenconazole 25% EC	84.44 (66.77)	86.71 (68.61)	87.88 (69.66)	100.00 (89.75)	89.75
4	Hexaconazole 5% EC	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00
5	Iprobenfos 48% EC	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00
6	Kresoxim methyl 44.3 %EC	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00
7	Propiconazole 25% EC	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00 (89.75)	100.00
8	Tebuconazole 25% EC	93.45 (75.21)	96.45 (79.33)	100.00 (89.75)	100.00 (89.75)	97.47
9	Thifluzamide 24% EC	0.00 (0.24)	4.61 (12.37)	12.11 (20.35)	23.03 (28.64)	9.93
10	Thiophonate methyl 70% WP	44.45 (41.81)	45.19 (42.24)	47.74 (43.66)	52.93 (46.67)	47.56
11	Tricyclazole 75% WP	71.63 (57.82)	84.48 (66.81)	100.00 (89.75)	100.00 (89.75)	89.02
Mean		68.78	72.38	77.57	83.26	
		F	C	F×C		
S.Em±		0.26	0.16	0.51		
CD @ 0.01		0.97	0.58	1.93		

*Arcsine Transformed Values

Table.3 *In vitro* efficacy of combi products against *Colletotrichum gloeosporioides*

Sl. No.	Fungicide	Per cent inhibition of mycelial growth				
		Concentration (ppm)				
		1000	2000	2500	3000	Mean
1	Captan 70 % + hexaconazole 5 %	74.81 *(59.87)	77.41 (61.63)	79.62 (63.17)	84.44 (66.77)	79.07
2	Carbendazim 12 % + mancozeb 63 %	100.00 (89.69)	100.00 (89.69)	100.00 (89.69)	100.00 (89.69)	100.00
3	Carboxin 37.5% +thiram 37.5%	100.00 (89.69)	100.00 (89.69)	100.00 (89.69)	100.00 (89.69)	100.00
4	Hexaconazole 4% + zineb 68%	59.25 (50.33)	61.85 (51.85)	71.85 (57.96)	88.88 (70.51)	70.45
5	Tebuconazole 50% + trifluoxystrobin 25%	69.26 (56.32)	71.48 (57.72)	75.55 (60.37)	78.51 (62.39)	73.70
6	Tricyclazole 18 % + mancozeb 62 %	100.00 (89.69)	100.00 (89.69)	100.00 (89.69)	100.00 (89.69)	100.00
7	Tricyclazole 45% + hexaconazole 10%	63.70 (52.95)	71.48 (57.72)	85.55 (67.67)	88.88 (70.54)	77.40
Mean		81.00	83.17	87.51	91.52	
		F	C	F×C		
S.Em±		0.27	0.20	0.54		
CD @ 0.01		0.99	0.75	1.98		

*Arcsine Transformed Values

Table.4 *In vitro* efficacy of bio agents against *Colletotrichum gloeosporioides*

Sl. No.	Bio agent	Per cent inhibition of mycelial growth
		<i>Colletotrichum gloeosporioides</i>
1	<i>T. harzianum</i> (UHS, Bagalkot)	75.19 *(60.10)
2	<i>T. harzianum</i> (UAS, Dharwad)	86.67 (68.57)
3	<i>T. asperellum</i> (UHS, Bagalkot)	69.63 (56.53)
4	<i>P. fluorescens</i> (UHS, Bagalkot)	55.93 (48.39)
5	<i>P. fluorescens</i> (UAS, Dharwad)	58.15 (49.67)
6	<i>B. subtilis</i> (UHS, Bagalkot)	54.44 (47.53)
7	<i>B. subtilis</i> (UAS, Dharwad)	56.67 (48.81)
S.Em±		0.67
CD @ 0.01		2.83

*Arcsine Transformed Values

Table.5 Efficacy of fungicides and bio control agent against leaf spot of pomegranate

Sl. No.	Treatments	PDI			Per cent reduction over control
		Before 1 st spray	20 days after 1 st spray	20 days after 2 nd spray	
1	Mancozeb 75% WP @ 0.1%	49.33 *(44.60)	40.67 (39.60)	28.00 (31.94)	54.35
2	Zineb 75% WP @ 0.1%	48.67 (44.22)	48.00 (43.84)	33.33 (35.25)	45.65
3	Carbendazim 12 % + mancozeb 63 % @ 0.1%	51.33 (45.77)	42.67 (40.77)	26.67 (31.08)	56.52
4	Tricyclazole 18 % + mancozeb 62 % @ 0.1%	50.00 (44.98)	50.00 (44.98)	42.67 (40.77)	30.43
5	Carboxin 37.5% +thiram 37.5% @ 0.1%	50.67 (45.36)	48.67 (44.22)	46.67 (43.07)	23.91
6	Propiconazole 25% EC @ 0.025%	47.33 (43.45)	39.33 (38.82)	28.67 (32.36)	53.26
7	Hexaconazole 5% EC @ 0.025%	52.67 (46.51)	48.67 (44.22)	36.67 (37.25)	40.21
8	Iprobenfos 48% EC @ 0.025%	49.33 (44.60)	48.67 (44.22)	34.67 (36.05)	43.48
9	Kresoxim methyl 44.3% EC @ 0.025%	48.67 (44.22)	47.33 (43.45)	32.67 (34.84)	46.74
10	<i>T. harzianum</i> @1%	48.67 (44.22)	50.67 (45.36)	41.33 (39.99)	32.61
11	Control	55.33 (48.04)	56.67 (48.81)	61.33 (51.53)	
S.Em±		0.7	0.60	2.11	
CD @ 0.05		2.11	1.82	6.46	

*Arcsine Transformed Values

Table.6 Efficacy of fungicides and bio control agent against fruit rot of pomegranate

Sl. No.	Treatments	PDI of fruit rot		PDI of fruit rot	Per cent reduction over control
		Before 1 st spray	20 days after 1 st spray	20 days after 2 nd spray	
1	Mancozeb 75% WP @ 0.1%	50.67 *(45.36)	46.67 (43.07)	37.33 (37.64)	34.88
2	Zineb 75% WP @ 0.1%	49.33 (44.60)	48.00 (43.83)	46.67 (43.07)	18.60
3	Carbendazim 12 % + mancozeb 63 % @ 0.1%	49.33 (44.60)	42.67 (40.76)	37.33 (37.64)	34.88
4	Tricyclazole 18 % + mancozeb 62 % @ 0.1%	49.33 (44.60)	46.67 (43.07)	48.00 (43.83)	16.27
5	Carboxin 37.5% +thiram 37.5% @ 0.1%	52.00 (46.13)	49.33 (44.60)	46.67 (43.07)	18.60
6	Propiconazole 25% EC @ 0.025%	52.00 (46.13)	45.33 (42.30)	36.00 (36.84)	37.21
7	Hexaconazole 5% EC @ 0.025%	52.00 (46.13)	49.33 (44.60)	45.33 (42.30)	20.93
8	Iprobenfos 48% EC @ 0.025%	50.67 (45.36)	46.67 (43.07)	42.67 (40.76)	25.58
9	Kresoxim methyl 44.3% EC @ 0.025%	48.00 (43.83)	45.33 (42.30)	42.67 (40.76)	25.58
10	<i>T. harzianum</i> @1%	50.67 (45.36)	50.67 (45.36)	49.33 (44.60)	13.95
11	Control	50.67 (45.36)	54.67 (47.66)	57.33 (49.20)	
S.Em±		1.60	1.91	1.78	
CD @ 0.05		4.91	5.83	5.37	

*Arcsine Transformed Values

Fig.1 *In vitro* efficacy of contact fungicides against *Colletotrichum gloeosporioides*

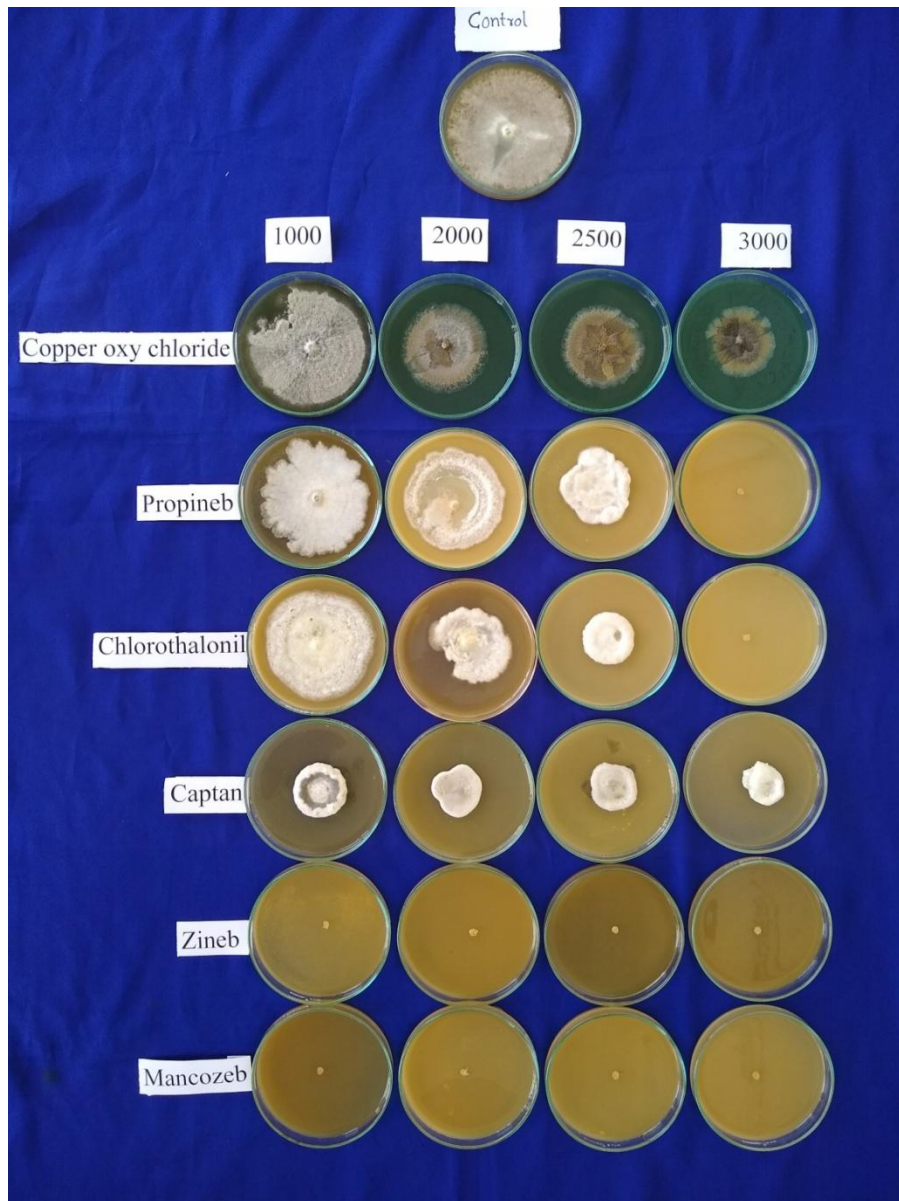


Fig.2 *In vitro* efficacy of systemic fungicides against *Colletotrichum gloeosporioides*

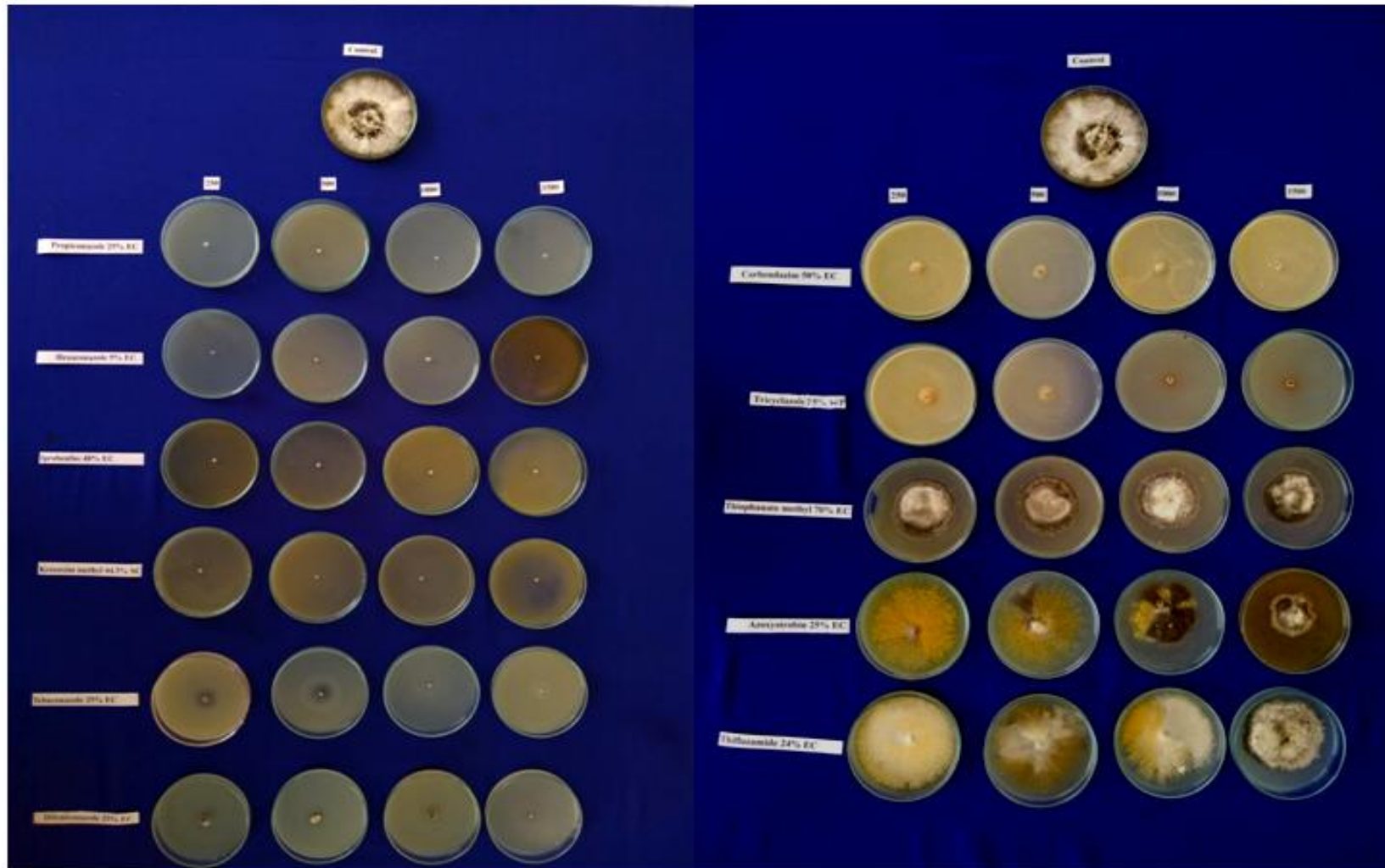


Fig.3 In vitro efficacy of combi products against *Colletotrichum gloeosporioides*

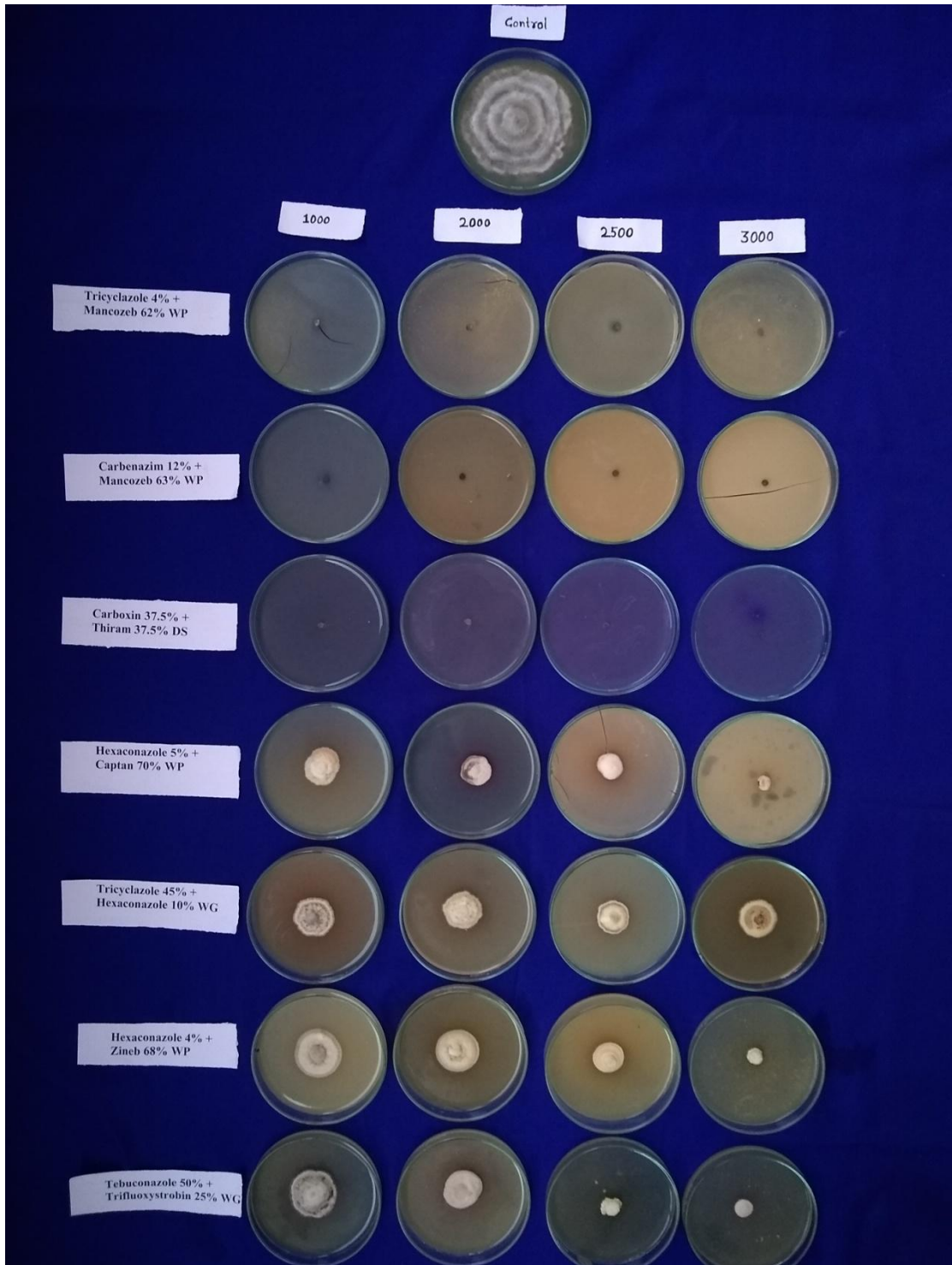
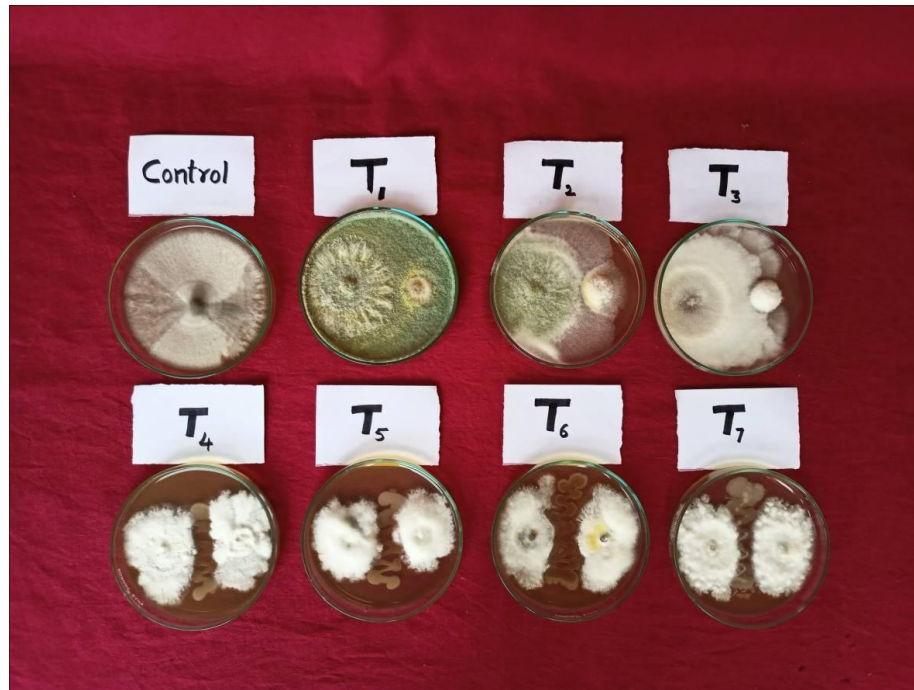


Fig.4 *In vitro* efficacy of bio agents against *Colletotrichum gloeosporioides* and *Alternaria alternata*



a. *Colletotrichum gloeosporioides*

- T1-** *T.harzianum* (UAS, Dharwad) **T2-** *T.harzianum* (UHS Bagalkot)
T3- *T. viride* (UHS, Bagalkot) **T4-** *P. fluorescens* (UHS, Bagalkot)
T5- *P. fluorescens* (UAS, Dharwad) **T6-** *B. Subtilis* (UHS, Baglkot)
T7- *B. Subtilis* (UAS, Dharwad)

Fig.5 Efficacy of different treatments in management of leaf spot and fruit rot of pomegranate

T1- Mancozeb 75% WP @ 0.1%

T3- Carbendazim 12 % + mancozeb 63 % @ 0.1%



T6- Propiconazole 25% EC @ 0.025%



Control



Least inhibition was observed by copper oxy chloride 50% WP (33.33%), propineb 70% WP (49.62%) hexaconazole 4% + zineb 68% (70.45%). The results recorded are in line with findings of Jayalkshmi *et al.*, (2013) who reported that carbendazim 12% + mancozeb 63% (0.3 per cent) and propiconazole 25% EC (0.1%) were most effective in reducing the mycelial growth of the fungus. Naragund *et al.*, (2012) recorded iprobenfos, propiconazole and carbendazim 12% + mancozeb 63% as effective chemicals against *Colletotrichum gloeosporioides*. Mahesh *et al.*, (2020) reported that SAAF (carbendazim 12% + mancozeb 63%) showed 88.40% inhibition of mycelia growth. Dev and Narendrappa (2016) reported that among systemic fungicides, Hexaconazole 5% EC, propiconazole 25% EC, penconazole 10% EC, tebuconazole 25.9% EC and carbendazim 50% EC showed cent per cent mycelial inhibition at 500, 1000 and 2000 ppm concentrations.

Parvathy and Girija (2016) revealed that among seven fungicides maximum inhibition was obtained with tebuconazole 25.9% EC (0.10%) and combination fungicide mancozeb 63% + carbendazim 12% (0.10%) which gave cent per cent growth inhibition over the

control. Propiconazole 25% EC, a triazole group fungicide blocks the action of 14- α -sterol demethylase, there by inhibiting the formation of fungal cell membrane ergosterols. Kresoxim methyl 44.3% EC, which belongs to strobilurin fungicide inhibit the fungal respiration by binding to the cytochrom b complex II and also disrupts the metabolism. Iprobenfos, belongs to organophosphate group interfere with the formation of new cells required for the growth and development of fungus. Mancozeb and zineb are the members of dothiocarbamate fungicide group. These two contact fungicides inactivates the sulfhydryl groups of amino acids and enzymes within fungal cells which results in disruption of respiration and lipid metabolism.

Among different bio agents tested, *Trichoderma harzianum*, UAS, Dharwad isolate recorded significantly higher per cent mean inhibition (86.67%) followed by *Trichoderma harzianum*, UHS, Bagalkot isolate (75.19%). *Trichoderma asperellum*, UHS, Bagalkot isolate showed 69.63% growth inhibition. But in the studies carried out by Sataraddi *et al.*, (2011), *Trichoderma asperellum* was found to be significant

followed by *Trichoderma harzianum* with per cent inhibition of 79.1% and 62.8% respectively. The least per cent inhibition was recorded for Bagalkote isolate of *Bacillus subtilis* (54.44%) and is in line with findings of Sataraddi *et al.*, (2011) who recorded least mycelia inhibition by *Bacillus subtilis* (34.9%). Naragund *et al.*, (2012) and Dev *et al.*, (2015) reported *T. asperellum* as the effective bio agents against pomegranate anthracnose causing pathogen, *Colletotrichum gloeosporioides*. Pavitra and Benagi (2017) reported that *Tichoderma asperellum* and *Pseudomonas fluorescens* showed maximum fungal inhibition.

The results showed that mancozeb 75% WP, carbendazim 12% + mancozeb 63% and propiconazole 25% EC @ 0.1% were effective in controlling the leaf spot and fruit rot incidence as compared to other treatments. *T. harzianum*, UHS, Dharwad showed least per cent disease reduction over control followed by kresoxim methyl 44.3% EC @ 0.025%. The results are supported by the findings of Jayalakshmi *et al.*, (2015) who reported that carbendazim 12% + mancozeb 63% @ 0.3% and propiconazole @ 0.1% reduced the anthracnose disease drastically with high yield. Nargund *et al.*, (2012) reported that propiconazole @ 0.1% concentration was significantly superior over other fungicides tested *in vivo*. By this it is clear that two alternate sprays with propiconazole 25% EC @ 0.025%, mancozeb 75% WP @ 0.1% or carbendazim 12% + mancozeb 63% @ 0.1% can reduce fruit rot/ anthracnose incidence in the field.

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