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Pre-harvest application of azoxystrobin minimised anthracnose of mango (cv. 'Alphonso') both at field and postharvest level enhancing yield and quality of fruits

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Abstract
In the present investigation a new strobulurin fungicide azoxystrbin was compared with widely used carbendazim and other previously used fungicides on its efficacy in managing anthracnose disease of mango. Also as a need of an hour performance of non-pollutive bioagents and botanicals against the disease were also tested. Pre-harvest sprays of azoxystrobin at 0.1 % significantly minimised the field inocula (24.54 %) on mango leaves and thereby reduced the latent infection and manifestation of the anthracnose disease (3.3 %) on fruits at postharvest stage. Bioagents were slightly effective in combating the disease. The botanical *Eupatorium odoratum* performed in significance to control, though non-comparable to azoxystrobin. Suppression of the disease by Azoxystrobin lead to high fruit yield (70.56 kg/tree) and enhanced fruit quality in terms of weights of fruit, pulp, peel and stone, pulp recovery and fruit volume. Fruits in this treatment had ideal specific gravity (1.02 g/cc) at harvest.

Keywords: mango, *Colletotrichum gloeosporioides*, anthracnose, azoxystrobin, *Eupatorium odoratum*

Introduction
Alphonso is one of the commercial cultivar of mango grown mainly in west coast of India and accounts nearly 60 per cent of the mango export (Ravindra and Shivashankar, 2004) [22]. The fruit has a rich aromatic flavour, perfect sugar acid blend taste and is an excellent source of vitamins A and C. Owing to its outstanding fruit qualities it is admired as the tastiest fruit of India and aptly called as 'King of mango cultivars'. However, Alphonso like other cultivars of mango is prone to most serious field and postharvest disease called anthracnose caused by *Colletotrichum gloeosporioides* Penz. In the field, anthracnose generally appears first as small, irregular yellow or brown necrotic spots on leaves (leaf spot), flowers, twigs and developing fruits. These spots coalesce eventually leading to defoliation, drying of twigs (twig blight), blackening of flower panicles (blossom blight) and hampered fruit set. The developing fruits rot and fall off in large numbers. But, the most damaging phase of the disease is after harvest where the latent infection manifests in ripening fruits causing an economical loss to a tune of 15-20 per cent (Litz, 1997) [18]. Pre-harvest field application of fungicides is considered to be the best way to approach this disease both at pre and postharvest levels. Such applications have been reported to reduce pre-harvest inoculum load and subsequent postharvest decay in the fruits (Blackarski *et al.*, 2001) [9]. Many workers have proposed the use of fungicides like zineb, carbendazim, thiophanate methyl, tricyclazole etc in managing anthracnose disease in mango and other crops (Agrios, 2005; Kapse *et al*., 2009; Zhang and Timmer, 2007; Kumar *et al.*, 2006) [2, 16, 35, 17]. However, fungicidal resistance to benomyl (0.1 %) in the pathogen causing anthracnose in mango (Akhtar *et al.*, 1998) lead to exploration of new fungicides to combat mango anthracnose. Azoxystrobin, a new promising group of strobilurins fungicide was effective against wide range of pathogens belonging to Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes (Anand *et al.*, 2008) [5]. As opined by Anand *et al*., 2010 [6] azoxystrobin with unique and elevated intensity on disease spectrum at fewer rates was unmatchable to the available commercial fungicides. This fungicide was effective against pathogens that have developed resistance to other fungicides (Hewitt, 1998) [14] due to its novel mode of action of hampering the mitochondrial respiration of pathogen causing its death (Harrison and Tedford, 2002) [13]. However, fungicides when used regularly causes toxicity, residual upshot and resistance development by the pathogens. Hence considerable attention has been drawn towards the potentiality of pollution free biological control agents (Bioagents) and botanicals (Plant extracts) to lessen the postharvest diseases of fruits (Pang *et al.*, 2002) [20].

Bioagents colonize the surface of fruit before the colonization of pathogens. Later, they compete with the pathogens for the space and nutrients, produce antibiotics, either parasite them or induce resistance to the crop (Ippolito and Nigro, 2000; Zhang *et al*., 2009) [15, 34]. *Trichoderma spp*. was found to be effective antagonist anthracnose of pomegranate (Mandhare *et al.*, 1996) [19]. Botanicals are antimicrobial in nature as they synthesize secondary metabolites like phenols, phenolic acids, quinones, flavones, flavonoids, flavonols, tannins and coumarins that were greatly active against the pathogen (Das *et al*., 2010) [10]. Plant extracts like *Eupatorium cannabinum* Linn. (Dubey *et al.*, 2007) [11] and *Cymbopogon* spp. (Salomone *et al.*, 2008) have reported to minimise postharvest anthracnose. Though ample studies have been performed using different fungicides on mangoes, research work performed on ‘Alphonso’, a leading cultivar of mango is sparse. Further, botanicals and bio-agents posses a ray of hope in disease management offering reduced toxicity and residue. Considering these points in view, it was attempted to evaluate the efficacy of new molecule like azoxystrobin with other formerly used fungicides, in addition to bioagents and botanicals to study the behaviour of Alphonso mangoes for anthracnose.

Materials and methods

Orchard selection, treatment imposition and collection of mango fruits

Uniformly grown, Alphonso mango trees aged 12 years, raised by approach grafting and spaced at 10m x10m spacing were selected for the experiment. For imposing the treatments three replications per treatment was considered and two trees per replication were allocated. Non-sprayed trees served control. A manually operated high volume foot sprayer with a spray pressure potential of 20 kg/cm^{-2} was used for spraying remaining trees. Trees were sprayed thrice with fungicides like Carbendazim, Tricyclazole, Azoxystrobin, Thiophanate methyl at 0.1 % each and Zineb at 0.2 %; botanicals like *Eupatorium odoratum* and *Nerium oleander* each at 5 % and bioagents like *Trichoderma viride* and *Trichoderma harzianum* each at 0.5 % prior to harvest each at different growth stages of mango fruit *viz.*, pre-flowering (Dec), peanut (Feb) and marble (March) stages of fruits during 2012-13 (year I). The experiment was repeated in 2013-14 (year II). Regular cultural practices for the crop were followed without affecting their routine. In the fortnight of May during both the years (2013 and 2014) mango fruits with uniform maturity and size were brought to the laboratory, Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, India.

Preparation of fungicides

Fungicides as detailed in table 1 were obtained from Karnataka Agro Chemicals, Dharwad. Fungicides namely, Thiophanate methyl, Carbendazim, Tricyclazole at 0.1 per cent were prepared by dissolving 1 g of each fungicide in 100 ml of water and making up the volume to 1000 ml. For Azoxystobin of 0.1 %, 1 ml of it was dissolved in water and made up to 1000ml. Zineb of 0.2 % was prepared by dissolving 2 g of zineb in 100 ml of water and then making up the volume up to 1000 ml.

Preparation of bioagents

Bioagents like *Trichoderma viride and Trichoderma harzianum* culture were obtained from the Department of plant pathology, University of Agricultural Sciences, Dharwad. Each was prepared with 0.5 % concentration by dissolving 5 g of respective culture in 100 ml of water and then making up the volume to 1000 ml.

Preparation of botanicals

Botanicals like *Eupatorium odoratum* and *Nerium oleander* commonly called as Siam weed and Oleander respectively, that were grown as weed in and around Dharwad were randomly collected and brought to the laboratory. The fresh leaves of botanicals free from damage or disease were collected from the plant. The leaves (200 g) of respective plants were rinsed in tap water for 3-4 times, juice was extracted in a blender without the addition of water and sieved through a muslin cloth to get the clear extract. The juice thus obtained from 200g leaf sample was made up to 1000 ml volume with distilled water.

For the complete coverage of the canopy, 6 litres of spray solution each with fungicides, bioagents and botanicals was prepared as per the concentration adopted in the treatment.

Leaf spot of mango

Four branches per mango tree in different directions and 25 leaves per branch were selected randomly and leaf spot was recorded after 15 days of every spray. Based on presence of number of small circular golden spots surrounded by a yellow hollow on the affected leaves, the degree of disease intensity was assessed using 0-5 scale, where 0= absence of disease, 1=1-5% disease affected area, 2= 6-25% disease affected area, 3= 26-50% disease affected area, 4 = 51-75% disease affected area, and 5 = 75-100% disease affected area. Leaf spot index was calculated by using the formula given below (Wheeler, 1969) [13].

$$\text{Leaf spot index(\%)} = \frac{\text{Total score}}{\text{Number of fruits observed x maximum score}} \times 100$$

Yield, weight, length, breadth, volume and specific gravity of the mango fruits at harvest

The fruits harvested from two trees of each replication were weighed, averaged and expressed in kilograms of fruit per tree. Immediately after harvest, stalk was removed from the fruit leaving 1 inch and the weight of fruit was recorded in grams (g) on five randomly selected fruits in each replication and was averaged. Length of the fruit from stalk end to the apex of fruit and the breadth as the maximum linear distance between two cheeks of the fruit was determined with the help of verniercalipers and expressed in centimetres (cm). Fruit volume was determined by the conventional water displacement method. The fruit was weighed and slid into the beaker containing known volume (ml) of water. Volume of the fruit was measured in a measuring cylinder as the quantity of water spilled out of the beaker and the mean was computed and expressed as cubic centimetres (cc). Specific gravity of the fruit was computed as the ratio of fresh weight of fruit to its volume and expressed as gram per cubic centimetres (g/cc).

Weights of ripe, pulp weight, peel, stone and pulp recovery of the mango fruits at ripening

The fruits were ripened at room temperature and the mean ripe fruit weight was recorded in grams. Pulp, peel and stones after separation from the ripe fruits were weighed separately and the mean weight was expressed in grams. The pulp recovery from the ripe fruits was determined by the following formula.

$$\text{Pulp recovery (\%)} = \frac{\text{Pulp weight (g)}}{\text{Ripe fruit weight (g)}} \times 100$$

Postharvest anthracnose disease incidence

Number of fruits infected with anthracnose disease in a lot per treatment was recorded and expressed in percentage as follows

$$\text{Anthracnose disease incidence(\%)} = \frac{\text{Number of fruits infected}}{\text{Total number of fruits}} \times 100$$

Statistical analysis

Statistical analysis was performed for both the years separately and then pooled. All data were collected and analysed by randomized block design (RBD). Significant differences among means at $P \leq 0.05$ were determined by post hoc tests using Duncan's multiple range test (Duncan, 1955) [12].

Results and Discussion

Effects of pre-harvest treatments on leaf spot disease of mango leaves

Initial symptoms of leaf spot disease index in all the mango trees irrespective of the treatments and the years were non-significant and the mean value ranged from 18.92 per cent to 20.13 per cent. In general, the disease progressed in all the treatments over the growth period. However, the results confirmed the existence of significant differences in the effectiveness among fungicidal sprays in reducing the disease spread (Table 2). Chemical sprays were more effective than bioagents or botanicals on disease suppression. Significant and consistent reduction in the leaf spot index noticed in the mango leaves treated with azoxystrobin at 0.1 % after first (20.71 %), second (22.33 %) and third sprays (24.54 %) assured greater protection to this fungicide to the mango fruits in the field from anthracnose. Efficacy of pre-harvest sprays of azoxystrobin in minimising foliage anthracnose in mango has also been observed by Sundravadana *et al*. (2006) [30] and Adhikary *et al*. (2013) [1]. Control of black sigataka leaf spot of banana (Perez *et al*., 2002) [21]; mildew diseases of grapevine and sweet cherry (Schwartz and Gent, 2005) [25] were obtained with this fungicide. Azoxystrobin, has an excellent translaminar and systemic movement inside the foliar leaf tissues that helps controlling the disease spread (Vincelli, 2002) [31]. In the pathogen cell, it inhibits the electron transfer of mitochondria by binding at a specific site on *cytochrome b*, hindering the ATP production and thereby cell death. The pathogen suffers from spore death, disintegration of mycelia and other developmental problems (Harrison and Tedford, 2002) [31]. In cucumber plants, this fungicide was found to increase the activity of defense enzymes like peroxidase, polyphenol oxidase phenylalanine ammonia lyase and chitinase (Anand *et al.*, 2007) [4]. All these evidences corroborate the effectiveness of azoxistrobin fungicide in controlling leaf spot disease of mango in this study. In contrast, control leaves revealed maximum leaf spot disease index (29.17 %; 38.00 % and 45.96 % respectively) after first, second and third sprays. Bioagents *Trichoderma* spp were slightly effective or sometimes ineffective in performance than control in managing the disease. In most of the crops, foliar disease control by bioagents was less successful as compared to their influence on soil borne diseases. Their poor survivability in the field conditions and lack of consistent efficacy on pathogens questions the commercial achievability of their application as pre harvest sprays (Andrews, 1992; Sharma *et al*., 2009)) [7, 26]. Anyway, the botanical *Eupatorium* significantly lessened the disease with minimum leaf spot index of 35.25 per cent in comparison to control though non-comparable to azoxystrobin. The efficiency of this botanical was found similar to fungicides zineb and thiophanate methyl. Dubey *et al.* (2007) [11] proposed fungitoxicity of *Eupatorium cannabinum* Linn oil applied as fumigant on *Collectotrichum gleosporioides*. Unlike synthetic pesticides, most of the botanicals are ecofriendly with no pesticide residues as they usually degrade within a few days or a few hours and less likely to kill beneficial pests (Siddiqui and Gulzar, 2003) [27].

Effects of pre-harvest treatments on fruit yield and fruit parameters at harvest of mango

In this study, it is conspicuous to note that the trees treated with Azoxystrobin at 0.1 % obtained nearly two-third higher fruit yield (70.56 kg/tree) than control (22.01 kg/tree) (Table 4). Increased yield by suppression of leaf anthracnose in mango by pre-harvest sprays of azoxystrobin had been reported by Sundravadana *et al*. (2006) and Adhikary *et al*. (2013) [1]. It had also been confirmed in other crops like grapes (Wedge *et al.*, 2007) [32], chilli (Srinivasan *et al.*, 2014) [29] and cucumber (Anand *et al.*, 2008) [5]. Increase in the number of fruits per tree observed in this investigation (data not shown) due to the reduction in anthracnose disease development by pre-harvest sprays of azoxystrobin might have resulted in the enhanced yield of mango fruits. On contrary, control fruits showing increased foliage anthracnose disease index with lower fruit yield indicated the inverse relationship of anthracnose with number of fruits produced per tree. Augmentation of yield in fruits of trees treated with botanical *Eupatorium* over control can be attributed to its suppression of disease in the first place. Fruit parameters at harvest *viz.*, weight, length and breadth were found to be non-significant among the treatments in the entire study period aptly proving them as inherent factors (Table 3). Anthracnose disease in the field appears to affect the fruit number per tree rather the fruit weight or size in this study. This finding is in agreement with Smith (2013) [28] who found no variations in the berry size of grape either treated with fungicides or untreated. However, there was a positive influence of azoxystrobin in increasing fruit volume (235.22 ml) (Table 3) and keeping ideal specific gravity (1.02 g/cc) of the fruits (Table 4).

Effect of pre-harvest treatments on postharvest anthracnose disease incidence, ripe weight, pulp weight, pulp recovery, peel weight and stone weight of fruits

Upon ripening, the mango fruits were studied for postharvest anthracnose and fruit quality. The least and similar level of postharvest anthracnose disease incidence was noticed in the fruits of the mango trees sprayed with azoxystrobin at 0.1 % as shown in fig 1 during both the years (3.33 %). However, pooled analysis of two years showed statistical significance of azoxystrobin at 0.1 % over rest of the treatments. Pre-harvest application of azoxystrobin showed high level of protection against the development of latent infection in the fruits during storage in this experiment. Efficacy of this chemical has been reported against many postharvest diseases like mold rot of apple, leather rot of strawberry (Rebollar-Alviter *et al.*, 2005) [23] and black spot of citrus (Anesiadis *et al.*, 2003) [8]. The maximum disease incidence was recorded in control (35.00 %) followed by *Trichoderma spp.* The efficiency of azoxystrobin on postharvest anthracnose disease suppression enhanced the postharvest quality of mango in terms of ripe fruit weight (217.09 g), pulp weight (162.20 g), peel weight (30.63 g) and stone weight (28.73 g). Infected fruit loses weight more rapidly than a non-infected fruit. This confirms the poor performance of severely infected control fruits having lower weights of ripe fruit, pulp, peel and stone (184.22 g, 133.23 g, 12.96 g and 23.83 g) of the mango fruits (Table 4 and 5). Though, pulp recovery did not vary among the treatments, fruits of azoxystrobin contained numerically higher percentage of pulp (74.76 %). Biogents or botanicals did not have any influence on ripening quality of fruits.

Table 1: Fungicide details

Sl. no	Chemical name	Trade name	Chemical type	Distribution in plant	Application dose
1	Azoxystrobin	Amistar, 250 SC	Strobilurin	Systemic	0.1 %
2	Carbendazim	Bavistin, 50 DF	Benzimidazole	Systemic	0.1 %
3	Thiophanate methyl	Topsin-M, 70 WP	Benzimidazole	Systemic	0.1 %
4	Tricyclazole	Beam, 75 WP	Triazole	Systemic	0.1 %
5	Zineb	Dithane Z-78	Dithio-carbamates	Contact	0.2 %

Table 2: Influence of pre-harvest sprays of fungicides, bioagents and botanicals on leaf spot (anthracnose) disease index of mango fruits cv. 'Alphonso'

Treatments	Leaf spot (anthracnose) disease index (%)											
	Before spray			After first spray (Dec)			After second spray (Feb)			After third spray (Mar)		
	Year I	Year II	Mean	Year I	Year II	Mean	Year I	Year II	Mean	Year I	Year II	Mean
Control	21.83	18	19.92	30.67a	27.67a	29.17a	39.75a	36.25a	38.00a	47.67a	44.25a	45.96a
Carbendazim at 0.1%	21.92	17.25	19.96	25.33d	21.25d	23.29f	29.83d	25.42e	27.63f	33.08d	30.17d	31.63d
Tricyclazole at 0.1%	20.92	19	19.46	29.17ab	26.25ab	27.72bc	37.92b	33.17b	35.55c	43.67b	41.25b	42.46b
Azoxystrobin at 01%	21.25	17.67	19.04	22.67e	18.75e	20.71g	24.00e	20.67f	22.33g	26.92e	22.17e	24.54e
Thiophanate methyl at 0.1%	20.75	17.33	19.92	26.42cd	23.67c	25.04e	30.92d	27.33d	29.13e	36.58c	32.50c	34.54c
Zineb at 0.1%	20.83	19	18.92	27.00cd	25.33bc	26.17de	33.75c	32.17bc	32.96d	37.67c	34.33c	36.00c
Eupatorium odoratum at 5 %	20.42	17.42	19.42	28.00bc	26.17ab	27.09cd	33.33c	31.42c	32.38d	36.08c	34.42c	35.25c
Nerium oleander at 5 %	21.92	16.92	19.59	30.33a	27.17a	28.75ab	38.67ab	35.25a	36.96ab	44.42b	42.92ab	43.67b
Trichoderma viride at 0.5 %	20.42	18.75	20.13	30.08ab	26.92ab	28.50abc	37.42b	34.83a	36.13bc	44.67b	41.33b	43.00b
Trichoderma harzianum at 0.5 %	21.75	18.5	19.58	30.50a	27.08a	28.79ab	38.50ab	35.67a	37.09ab	45.17b	42.50ab	43.84b

Note: Values within the column without letter or with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

Table 3: Influence of pre-harvest sprays of fungicides, bioagents and botanicals on fruit weight, fruit length, fruit breadth and fruit volume of mango fruits cv. Alphonso'

Treatments	Fruit weight (g)			Fruit length (cm)			Fruit breadth (cm)			Fruit volume (ml)		
	Year I	Year II	Mean	Year I	Year II	Mean	Year I	Year II	Mean	Year I	Year II	Mean
Control	242.64	226.38	234.51	8.88	8.17	8.52	7.29	6.23	6.76	185.90g	172.44e	179.17f
Carbendazim at 0.1%	244.3	226.63	235.47	9.09	8.2	8.65	7.3	6.3	6.8	227.33b	215.54ab	221.44b
Tricyclazole at 0.1%	241.97	226.67	234.32	9.24	8.3	8.77	7.42	6.27	6.84	209.78de	194.67cd	202.23cd
Azoxystrobin at 01%	250.79	227.2	238.99	8.94	8.42	8.68	7.49	6.33	6.91	247.18a	223.26a	235.22a
Thiophanate methyl at 0.1%	244.78	222.1	233.44	9.53	8.08	8.81	7.6	6.34	6.97	224.93bc	205.11bc	215.03b
Zineb at 0.1%	242.3	223.49	232.89	8.98	8.04	8.51	7.32	6.33	6.83	211.97cd	194.08cd	203.03c
Eupatorium odoratum at 5 %	244.71	220.33	232.52	9.17	8.17	8.67	7.4	6.41	6.91	211.88cd	191.75cd	201.82cd
Nerium oleander at 5 %	239.71	234.77	237.24	9.03	8.15	8.59	7.26	6.53	6.89	189.81fg	179.25de	184.53ef
Trichoderma viride at 0.5 %	236.04	224.19	230.12	9.34	8.17	8.76	7.17	6.33	6.75	200.73def	185.63de	193.19cde
Trichoderma harzianum at 0.5 %	243.75	224.84	234.3	9.42	8.11	8.76	7.42	6.3	6.86	196.77efg	186.78de	191.78de

Note: Values within the column without letter or with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

Table 4: Influence of pre-harvest sprays of fungicides, bioagents and botanicals on fruit yield, specific gravity, ripe fruit weight and pulp weight of mango fruits cv. 'Alphonso'

Treatments	Fruit yield (kg/tree)			Specific gravity (g/cc)			Ripe fruit weight (g)			Pulp weight (g)		
	Year I	Year II	Mean	Year I	Year II	Mean	Year I	Year II	Mean	Year I	Year II	Mean
Control	25.24f	18.78f	22.01f	1.31a	1.32a	1.31a	188.47e	179.96	184.22e	136.39e	130.07c	133.23e
Carbendazim at 0.1%	61.63b	56.46b	59.04b	1.08de	1.05e	1.06fg	211.43b	197.9	204.67b	154.59b	143.51b	149.05b
Tricyclazole at 0.1%	42.21cd	37.04de	39.62cd	1.12bcd	1.16c	1.16cd	196.63cde	186.93	191.78cde	144.84bcde	136.19bc	140.52cde
Azoxystrobin at 01%	73.39a	67.73a	70.56a	1.02e	1.02f	1.02g	227.026a	207.14	217.09a	168.44a	155.95a	162.20a
Thiophanate methyl at 0.1%	59.60b	54.66bc	57.12b	1.09de	1.08d	1.09ef	210.24bc	190.53	200.38bc	150.62bc	140.54bc	145.58bc
Zineb at 0.1%	48.277c	44.59cd	46.43c	1.15bcd	1.15c	1.15de	202.71bcde	188.78	195.74bcd	146.56bcde	135.01bc	140.79bcde
Eupatorium odoratum at 5 %	46.19cd	45.27cd	45.73c	1.15bcd	1.15c	1.15d	203.90bcd	186.18	195.04bcde	147.62bcd	136.47bc	142.05bcd
Nerium oleander at 5 %	28.19ef	21.90f	25.04ef	1.26ab	1.31a	1.28ab	190.09de	186.94	188.51de	138.62de	137.84bc	138.23cde
Trichoderma viride at 0. %	36.06de	27.82ef	31.94de	1.18bcd	1.21b	1.20cd	189.87de	182.55	186.21de	140.57cde	134.35bc	137.47cde
Trichoderma harzianum at 0.1 %	27.66ef	22.52f	25.09ef	1.25abc	1.20b	1.22bc	193.77de	179.64	186.70de	141.76cde	131.58c	136.68de

Note: Values within the column with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

Table 5: Influence of pre-harvest sprays of fungicides, bioagents and botanicals on pulp recovery, peel weight and stone weight of mango fruits cv. 'Alphonso'

Treatments	Pulp recovery (%)			Peel weight (g)			Stone weight (g)		
	Year I	Year II	Mean	Year I	Year II	Mean	Year I	Year II	Mean
Control	72.38	72.27	72.33	14.14f	11.77f	12.96g	24.63c	23.04c	23.83e
Carbendazim at 0.1%	73.11	72.6	72.86	24.16b	22.42b	23.29b	27.76b	25.85ab	26.81b
Tricyclazole at 0.1%	73.65	72.85	73.25	20.84c	16.64d	18.74d	25.63c	23.98bc	24.80de
Azoxystrobin at 01%	74.19	75.33	74.76	31.78a	29.47a	30.63a	29.89a	27.58a	28.73a
Thiophanate methyl at 0.1%	71.66	73.77	72.72	23.83b	20.43c	22.13b	27.54b	25.03bc	26.29bc
Zineb at 0.1%	72.29	71.59	71.95	21.51c	19.60c	20.56c	26.42bc	24.54bc	25.48bcd
Eupatorium odoratum at 5 %	72.39	73.32	72.85	21.24c	19.28c	20.26c	26.30bc	24.21bc	25.25cde
Nerium oleander at 5 %	72.94	73.79	73.37	16.53de	12.69ef	14.61f	24.65c	23.87bc	24.26de
Trichoderma viride at 0.5 %	74.11	73.62	73.87	18.56d	15.68d	17.12e	24.87c	23.85bc	24.36de
Trichoderma harzianum at 0.5 %	73.17	73.27	73.22	16.26ef	13.62e	14.94f	25.06c	23.41c	24.23de

Note: Values within the column without letter or with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$

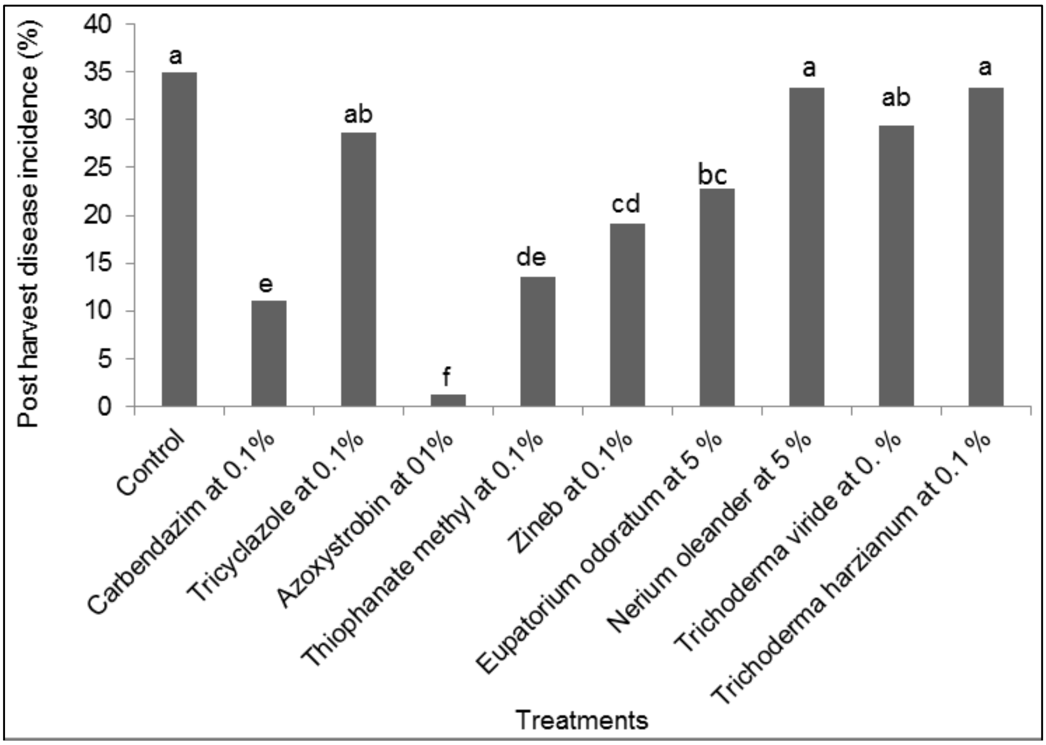

Fig 1: Influence of pre-harvest sprays of fungicides, bioagents and botanicals on postharvest anthracnose disease incidence (%) of mango fruits cv. 'Alphonso'. Figure represents the pooled analysis of two year's data. Bars with the same letter are not significantly different by Duncan Multiple Range Test at $P \leq 0.05$.

Conclusion

In conclusion, pre-harvest sprays of azoxystrobin protected mango from anthracnose disease both at pre (field) and post (storage) level. Superiority of azoxystrobin in disease suppression over carbendazim and other potential fungicides that has been widely used by most of the farmers for range of diseases and pathogens, directs to its use as an alternative chemical in the future. Exploitation of the new botanical *Eupatorium odoratum* introduced in this study for its efficacy and possible mechanism on pathogen control is required to have a holistic and integrated approach for disease management.

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