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ND Mehta
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

PR Patel
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

HV Pandya
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

SD Patel
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Correspondence
ND Mehta
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Evaluation of various fungicides and bio-agents against the powdery mildew of mango (*in vivo*) under south Gujarat condition

ND Mehta, PR Patel, HV Pandya and SD Patel

Abstract
Among all diseases, Powdery mildew (***Oidium*** *mangiferae* Berthet) of mango is emerging as one of the most common, wide spread and serious disease throughout the world and causes significant yield losses. The most serious losses occur when flowering and growth flushes are infected during cool and dry conditions. The management studies against powdery mildew of mango in field condition showed hexaconazole @ 0.01% recorded highest per cent disease control of powdery mildew and also significantly inhibited growth of the pathogen and proved strongly fungi toxic at the given concentrations. Wettable sulphur @ 0.3% significantly inhibited disease incidence and at par with the best one. The next best in order of merit was *Pseudomonas fluorescence* @ 5% inhibited the disease incidence.

Keywords: fungicides, powdery mildew

Introduction
The mango (*Mangifera indica* L.) belongs to the dicotyledenous family Anacardiaceae. This tree is indigenous to India and southern Asia and originated from the Indian Burmese border region where it has been cultivated for many centuries (Kwee & Chang, 1985). Today, mangoes are cultivated in most tropical and subtropical parts of the world where they are commonly eaten fruits (Prakash & Srivastava, 1987; Schroeder, 1990) [11, 15].

Mango described as the "king of fruits", known for its strong aroma, delicious taste, and high nutritive value is a prominent horticultural crop of India. Mango is a tropical and subtropical fruit crop grown in India over an area of 2.31 million hectares with production of 15.03 million tons (2009-10). India stands first in global mango production (53%). However, the productivity of mango is affected by various diseases. The fungal, bacterial, viral diseases play major role in the decline of mango fruit yield and fruit quality (Prakash, 1996; Misra, 2002) [13, 7].

Among these diseases, Powdery mildew (*Oidium mangiferae* Berthet) of mango is emerging as one of the most common, wide spread and serious disease throughout the world and causes significant yield losses. The most serious losses occur when flowering and growth flushes are infected during cool and dry conditions. A minimum temperature range of 11-14 °C and maximum of 27-31°C along with 64-72% RH are the most conducive for disease development (Nasir *et al*., 2014) [8]. The fungus produces the symptoms of white superficial powdery masses on inflorescence, leaves and young fruits. The disease mainly attack on inflorescence resulting in premature shedding of flowers and young fruits, thus causing heavy monetary losses to the mango growers (Prakash, 1996; Misra, 2002) [13, 7]. Application of dinocap and sulphur are the widely adopted practices but it becomes difficult to manage the disease particularly when the disease pressure is high at the time of flowering (Sharma, 1992; Verma and Deepraj, 1998; Prakash and Raoof, 1985) [16, 19, 12].

Materials and Methods
Powdery mildew of Mango causes considerable loss to crop. Therefore, to find out the most suitable bio-agent or/and fungicides for the disease, a field trial was conducted during 2014-2015 and 2015-2016. This trial was conducted at Regional Horticultural Research Station Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University., Navsari, and laboratory trial was also conducted at Pathology Laboratory in A.C.H.F., N.A.U., Navsari with susceptible variety Kesar. Treatments: T_1 Wettable sulfur (0.3), T_2 Tridemefon (0.01), T_3

Myclobutanil (0.1), T_4 Carbendazim (0.1), T_5 Azoxystrobin (0.1), T_6 Hexaconazole (0.01), T_7 Penconazole (0.05), T_8 *Pseudomonas fluorescence* (5%), T_9 *Bacillus subtilis* (5%), T_{10} Control.

Three sprays were given, first at the initiation of disease and second and third spray at 15 days of interval. Disease severity of powdery mildew was recorded on flower bunch area damaged. Ten inflorescences were randomly selected from each plant and labeled for subsequent evaluations.

Observation recorded:

A field experiment was conducted at RHRS farm, NAU, in a 15-20 year old mango orchard. (Each with three replications) foot Sprayer fitted with hollow cone nozzle. First spray was given at the time of initiation of disease and second and third spray at 15 days interval. Disease intensity assessments were calculated regularly at 7 and 15 days intervals based on a scale of Percent Disease Index (PDI).

- Per cent disease index (PDI) was calculated by using following formula

$$PDI = \frac{\text{Sum of numerical values}}{\text{Number of inflorescence observed x Maximum disease ratin}} \times 10$$

Disease scoring scale 0-4 for powdery mildew was used

a) 0: Inflorescence free from infection.

b) 1: Less than 25% of the inflorescence covered by powderymildew

c) 2: 26-50 % of the inflorescence covered by powdery mildew

d) 3: 51-75% of the Inflorescence covered by powdery mildew

e) 4: More than 75 % of the inflorescence covered by powdery Mildew

Results and discussion

To know the field performance of selected fungicides and bio-agent against powdery mildew disease the field experiment was conducted at R.H.R.S ASPEE College, NAU, Navsari in the year 2014-15 and 2015-16. It is universal truth that chemical play an important role in plant disease management. Each chemical has its own unique chemical properties due to which they can effectively use against the different plant disease management. They manage the pathogen by two ways systemically or non systemically. There has been greater emphasis on development of chemicals means fungicides. Besides fungicides application, different biocontrol agents also play a major role in controlling the plant disease. Hence for considering the necessity of this present study tries to found out the effectiveness of chemicals and bio agents against powdery mildew disease. Seven fungicides from systemic and non-systemic groups and two bio agents were evaluated at mentioned concentrations

The results recorded about per cent disease intensity and fruit yield are presented in Table 1, 2 and 3, respectively. The year wise results were discussed as under:

2014-15

The powdery mildew intensity (PDI) recorded at disease initial stage (before spraying) was ranged from 29.43 to 32.11 per cent. Three sprays of different fungicides and bio agents were under taken at initiation of disease and rest of all are at 15 days interval. The per cent disease intensity was recorded before first spray, 15 days after first spray (before second spray), 15 days after second spray (before third spray) and 15 days after third spray at maturity stage. The perusal of data presented in table 4.23 revealed that before spray, all the treatment showed non significant differences with PDI *i.e.* the disease appearance was more or less similar.

It is clear from the data that all the treatments were found significantly superior over control for the per cent disease intensity after 15 days of first spray (before second spray). The minimum per cent disease intensity (19.15 %) was observed in the plots treated with hexaconazole @ 0.01% followed by wettable sulphur @ 0.3% (19.84 %) which was at par with bio agent *Pseudomonas fluorescence* @ 5% (20.54 %). Whereas, Penconazole @ 0.05%, *Bacillus subtilis* @ 5%, Myclobutanil @ 0.1%, Azoxystrobin @ 0.1%, Carbendazim @ 0.1% and tridemefon @ 0.01% were found to reduced the disease and at par with each other but these were shown significant difference with fungicides.

Similarly, 15 days after second spraying, the per cent disease intensity was found to be reduced significantly by all the treatments over respective un-sprayed control. Minimum disease intensity (17.24 %) was recorded by hexaconazole @ 0.01% which was at par with wettable sulphur @ 0.3% (17.58 %) and *Pseudomonas fluorescence* @ 5% (18.67). These three treatments were more effective compare to the others.

At the third spray (pea size fruit stage), all the treatments found significantly superior by reducing per cent disease intensity over respective un-sprayed control. Significantly lowest disease intensity (13.42 %) was observed in hexaconazole @ 0.01% followed by treatment of wettable sulphur @ 0.3% (16.9 %) was at par with of *Pseudomonas fluorescence* @ 5% (17.2%). Whereas, penconazole @ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% were found comparatively less effective.

2015-16

The data presented in Table 2 revealed that Per cent disease intensity was significantly reduced by all the treatments over control at first spray and second and third spray at 15 days interval. The disease intensity before first spray was found non-significant among the treatment.

After first spray, among the treatments, the lowest disease intensity (19.45 %) was noted in the plots treated with hexaconazole @ 0.01% followed by wettable sulphur @ 0.3% (19.64%) which was at par with *Pseudomonas fluorescence* @ 5% (20.29%). Whereas, penconazole @ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% were found comparatively less effective.

Before 3rd spray, all the treatments were found significantly superior over control by reducing per cent disease intensity. Significantly minimum disease intensity (16.73 %) was recorded by hexaconazole @ 0.01% followed by wettable sulphur @ 0.3% (18.32 %) and *Pseudomonas fluorescence* @ 5% (18.78%). The penconazole @ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% were also found at pat with each other and less effective as compared to fungicides and bio-agent.

After third spray significantly minimum disease intensity (13.52 %) was recorded by hexaconazole @ 0.01% at par with the treatment wettable sulphur @ 0.3% (16.29 %) and *Pseudomonas fluorescence* @ 5% (17.12%). The penconazole

@ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% were found at par with each other and showed fungicidal effects on disease but comparatively less effective than fungicides and bio agent.

Pooled

The pooled data of 2014-15 and 2015-16 indicated that all the treatments were found significantly superior over control for the per cent disease intensity at before first spray, 15 days after first spray and second spray. The disease intensity before first spray was found nonsignificant among the treatment.

Before second spray *i.e.* 15 days after first spray, among the nine treatments, lowest disease intensity (19.3%) was observed in hexaconazole @ 0.01% which was at par with the wettable sulphur @ 0.3% (19.74%) and *Pseudomonas fluorescence* @ 5% (20.42%). Whereas, the penconazole @ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% were found at par with each other and showed fungicidal effects on disease but comparatively less effective than fungicides and bio agent.

At 15 days after 2nd spray, significantly minimum disease intensity (16.99%) was observed in hexaconazole @ 0.01% in comparison to wettable sulphur @ 0.3% (17.95 %) and *Pseudomonas fluorescence* @ 5% (19.3%).Whereas, the penconazole @ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% were inhibited comparatively least growth of the pathogen.

At pea size fruit stage, all the treatments were found significantly superior over control. The minimum disease intensity (13.47%) was exhibited by hexaconazole @ 0.01%. The next best treatment was wettable sulphur @ 0.3% with 16.59 per cent disease intensity. The *Pseudomonas fluorescence* @ 5% (17.16%) was found at par with other fungicides. Whereas, the penconazole @ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% were revealed nonsignificant differences with each other. The per cent disease intensity was found to be minimized but comparatively less effective than fungicides and triazophos.

The result in terms of per cent disease control revealed that hexaconazole @ 0.01% recorded highest per cent disease control of powdery mildew followed by wettable sulphur @ 0.3%, *Pseudomonas fluorescence* @ 5% and penconazole @ 0.05%, *Bacillus subtilis* @ 5%, myclobutanil @ 0.1%, azoxystrobin @ 0.1%, carbendazim @ 0.1% and tridemefon @ 0.01% gave less disease control as compared to other treatment.

Nasir *et al.* (2014) [8] reported that hexaconazole and penconazole were found effective against the powdery mildew disease in mango. Mandradia *et al.* (2014) [6] conducted a field experiment during rainy season of 2009 and 2010 and observed that hexaconazole and penconazole recorded less incidence of powdery mildew of mango in *cv*. Dashari. Joubert *et al.* (2014) Observed that three spray of benomyle or sulphur dust was effectively control powdery mildew disease in mango. The results are conformity with the work of Prakash and Srivastava (1980), Prakash and Singh (1982) [10] and Ahmed *et al.* (1999) [1, 3]. Thus, it may be concluded from the present study that hexaconazole @ 0.1% is the most effective fungicide in controlling powdery mildew of mango in low hills zone of Himachal Pradesh. The use of the foliar fungicides in the management of powdery mildew of mango is not uncommon (Akhtar *et al.*, 1999.). Earlier Saleem *et al.* (1991) [14] reported Afugan, Rubigan, Topsin-M, Tilt, and Bayfidon to be effective fungicides for the control of this disease. Later Haq *et al.* (1994) reported that Topas, Topsin-M, Benlate and Bayleton could effectively be used in the management of powdery mildew of mango. Ihsan and his associates (1999), in their effort for the protective and curative control of the disease, determined that Bayleton, Calixin, and Bafidan were statistically equally effective fungicides and these cured powdery mildew infection by reducing 88.33, 88.16, and 88.16 % disease respectively, over that of control. Effectiveness of Anpower, Bayleton, Score, and Spotless fungicides in controlling powdery mildew disease has also been reported (Iqbal and Ihsan, 2001) [4]. The effectiveness of two non-systemics namely Dinocap, Wettable sulphar, and three systemics namely Carbendzim, Thiophanatemethyl, Tridemorph, in controlling powdery mildew of mango on *cv* "Dusehri", has also been reported earlier (Nofal and Haggag, 2006; Sinha and Verma, 2002; Sinha *et al.* 2001) [9, 17, 18].

The management studies against powdery mildew of mango in field condition showed hexaconazole @ 0.01% recorded highest per cent disease control of powdery mildew and also significantly inhibited growth of the pathogen and proved strongly fungi toxic at the given concentrations. Wettable sulphur @ 0.3% significantly inhibited disease incidence and at par with the best one. The next best in order of merit was *Pseudomonas fluorescence* @ 5% inhibited the disease incidence.

Table 1: Evaluation of fungicides and bio agent against powdery mildew of mango cv. Kesar in Navsari during the year 2014-15 *(In vivo)*

	Per cent Disease Intensity			
Treatment	**Before spray**	**1st spray**	**2nd spray**	**3rd spray**
T_1 Wettable sulphur	29.99 (24.13)*	27.07 (19.84)	25.47 (17.58)	24.95 (16.9)
T_2 Tridemefon	31.99 (27.17)	31.3 (26.06)	29.38 (23.12)	27.33 (20.14)
T_3 Myclobutanil	31.24 (26.01)	28.97 (22.56)	27.38 (20.21)	25.24 (17.27)
T_4 Carbendazim	31.9 (27.05)	30.7 (25.15)	28.5 (21.84)	26.65 (19.2)
T_5 Azoxystrobin	31.53 (26.47)	29.1 (22.76)	27.57 (20.5)	26.12 (18.48)
T_6 Hexaconazole	29.43 (23.3)	26.58 (19.15)	25.21 (17.24)	22.2 (13.42)
T_7 Penconazole	31.61 (26.58)	29.14 (22.8)	27.66 (20.61)	26.28 (18.68)
T_8 *Pseudomonas fluorescence*	30.11 (24.32)	27.57 (20.54)	26.27 (18.67)	25.18 (17.2)
T_9 *Bacillus subtilis*	30.89 (25.5)	28.24 (21.5)	26.85 (19.48)	25.24 (17.27)
T_{10} Control	32.11 (27.35)	44.77 (48.59)	46.62 (51.81)	48.64 (55.33)
S. Em	2.15	1.79	1.44	1.54
CD	NS	5.32	4.27	4.59
CV %	11.98	10.22	8.55	9.62

*****Figure in the parenthesis are original value.
Those outside are arcsine transformed value.

Table 2: Evaluation of fungicides and bio agent against powdery mildew of mango cv. Kesar in Navsari during the year 2015-16 (*In vivo*)

	Per cent Disease Intensity			
Treatment	**Before spray**	**1st spray**	**2nd spray**	**3rd spray**
T_1 Wettable sulphur	29.61 (23.52)*	26.93 (19.64)	25.98(18.32)	24.51(16.29)
T_2 Tridemefon	32.29 (27.61)	31.08 (25.71)	29.22 (22.91)	27.14 (19.86)
T_3 Myclobutanil	31.27 (26.02)	28.55 (21.92)	27.07 (19.81)	25.33 (17.38)
T_4 Carbendazim	32.09 (27.31)	31.05 (25.69)	28.16 (21.37)	26.51 (18.99)
T_5 Azoxystrobin	31.7 (26.69)	28.59 (22.01)	27.07 (19.82)	25.8 (18.01)
T_6 Hexaconazole	29.13 (22.81)	26.8 (19.45)	24.8 (16.73)	22.31 (13.52)
T_7 Penconazole	32.08 (27.29)	28.88 (22.41)	27.41 (20.29)	25.85 (18.07)
T_8 *Pseudomonas fluorescence*	30.77 (25.27)	27.4 (20.29)	26.32 (18.78)	25.14 (17.12)
T_9 *Bacillus subtilis*	30.81 (25.33)	28.47 (21.83)	26.57 (19.12)	25.31 (17.35)
T_{10} Control	32.17 (27.43)	44.87 (48.77)	46.8 (52.13)	48.77 (55.55)
S. Em	1.80	1.72	1.76	1.36
CD	NS	5.10	5.23	4.04
CV %	10.00	9.83	10.54	8.50

*****Figure in the parenthesis are original value.
Those outside are arcsine transformed value.

Table 3: Evaluation of fungicides and bio agent against powdery mildew of mango cv. Kesar in Navsari during the year 2015 and 2016 (pooled) (*In vivo*)

	Per cent Disease Intensity			
Treatment	**Before spray**	**1st spray**	**2nd spray**	**3rd spray**
T_1 Wettable sulphur	29.8(23.82)*	27 (19.74)	25.73(17.95)	24.73(16.59)
T_2 Tridemefon	32.14 (27.39)	31.19 (25.89)	29.3 (23.01)	27.23 (20)
T_3 Myclobutanil	31.26 (26.02)	28.76 (22.24)	27.22 (20.01)	25.29 (17.33)
T_4 Carbendazim	32 (27.18)	30.88 (25.42)	28.33 (21.6)	26.58 (19.09)
T_5 Azoxystrobin	31.61 (26.58)	28.85 (22.38)	27.32 (20.16)	25.96 (18.24)
T_6 Hexaconazole	29.28 (23.05)	26.69 (19.3)	25.01 (16.99)	22.26 (13.47)
T_7 Penconazole	31.85 (26.94)	29.01 (22.61)	27.53 (20.45)	26.06 (18.38)
T_8 *Pseudomonas fluorescence*	30.44 (24.79)	27.48 (20.42)	26.29 (18.72)	25.16 (17.16)
T_9 *Bacillus subtilis*	30.85 (25.42)	28.36 (21.67)	26.71 (19.3)	25.27 (17.31)
T_{10} Control	32.14 (27.39)	44.82 (48.68)	46.71 (51.97)	48.71 (55.44)
S. Em	1.97	1.75	1.60	1.45
CD	NS	5.21	4.75	4.31
CV %	10.99	10.02	9.54	9.06

*****Figure in the parenthesis are original value.
Those outside are arcsine transformed value.

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