



## ISAH Indian Journal of Arid Horticulture Year 2026, Volume-8, Issue-1 (January-June)

### Field evaluation of fungicides against leaf and fruit spot diseases of pomegranate (*Punica granatum* L.)

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#### ARTICLE INFO

Received: 08 May 2026

Accepted: 21 April 2026

**Keywords:** *Alternaria alternata*,  
*Colletotrichum gloeosporioides*, fungicides,  
leaf spot, fruit spot, pomegranate

DOI: <https://doi.org/10.56093/IJAH.v39i1.10>

#### ABSTRACT

A two-year field experiment was conducted during Mrig Bahar to evaluate the efficacy of different fungicides against Anthracnose and Alternaria leaf and fruit spot diseases of pomegranate (*Punica granatum* L.). Three sprays were applied at 15-day intervals and disease observations on leaves and fruits were recorded 15 days after the final spray. Results revealed that the ready-mix fungicide Tebuconazole 50% + Trifloxystrobin 25% WG was found significantly effective treatment, recording the lowest PDI of 14.03% on leaves and 13.96% on fruits. Plants treated with Tebuconazole 50% + Trifloxystrobin 25% WG showed minimum yield loss.

#### Introduction

Pomegranate (*Punica granatum* L.) is one of India's fastest-growing commercially important fruit crops, valued for its export potential, drought tolerance and high nutritional quality. Globally, India ranks first in pomegranate cultivation with an area of 0.224 million hectares and production of 2.842 million metric tonnes during 2023-24 (Anonymous, 2024a). During the financial year 2023-24, India exported 72,011 metric tonnes of pomegranate valued at USD 69.08 million to countries such as the United Arab Emirates, Bangladesh, Nepal, Netherlands, Saudi Arabia, Sri Lanka, Thailand, Bahrain, and Oman (Anonymous, 2024b). The crop is cultivated widely in Maharashtra, Karnataka, Andhra Pradesh, Gujarat, Rajasthan and Tamil Nadu. Maharashtra is considered the pomegranate basket of India, contributing nearly two-thirds of the country's cultivated area (Anonymous,

2009). In Gujarat, pomegranate occupies an area of 43.53 thousand hectares with an annual production of 0.629 million tonnes and productivity of 14.45 tonnes per hectare (Anonymous, 2024b). It is intensively grown in northern districts such as Kutch, Banaskantha, Morbi, and Mehsana, and is now expanding rapidly in the Saurashtra region.

The increasing popularity of pomegranate cultivation in Gujarat is mainly due to the high economic returns from the crop. Despite its expanding cultivation, productivity in Gujarat has not increased proportionately because of severe damage caused by insect pests and diseases. Among fungal diseases, anthracnose caused by *Colletotrichum gloeosporioides* and leaf spot caused by *Alternaria alternata* are the most destructive (Berbegal *et al.*, 2014). These diseases affect leaves and fruits, reducing yield, market quality and causing considerable economic losses to growers (Dev *et al.*,

2017). Therefore, systematic studies on the in vivo effectiveness of suitable chemical fungicides are urgently needed to develop efficient management strategies for controlling Anthracnose and Alternaria diseases in pomegranate under Gujarat conditions.

**Material and Methods**

The study was conducted at the Department of Plant Pathology, College of Agriculture, Junagadh Agricultural University (JAU), Junagadh, Gujarat (latitude: 21.49519°N and longitude: 70.42207°E) during 2018-19 and 2019-20. Field experiments were undertaken during Mrig Bahar (November-December) in a seven-year-old pomegranate cv. Bhagwa. Seven fungicidal treatments along with an untreated control were evaluated against anthracnose and Alternaria diseases. The trial was laid out in a Randomized Block Design (RBD) with three replications, keeping one plant per replication. Sprays were initiated at the onset of disease symptoms. A total of three sprays were applied at an interval of 15 days using a manually operated high-volume knapsack sprayer. Disease intensity was recorded on 40 leaves per plant (10 leaves from each direction) and 20 fruits per plant (5 fruits from each direction) using a 0-5 disease rating scale. The per cent disease index (PDI) was calculated according to Wheeler (1969) and the data obtained was transformed into angular transformations and analyzed statistically.

$$PDI = \frac{\sum \text{Numerical ratings observed}}{\text{No. of units observed} \times \text{maximum grade or rating}} \times 100$$

Where, Units = leaves/ fruits

Per cent disease control (PDI) was also computed based on reduction in PDI over untreated control. The recorded data were subjected to angular transformation before statistical analysis. Recoded the rating/ per cent incidence reaction (Table 1) as described by Archana, 2012 and Jagtap et al., 2015.

**Table 1.** Disease rating/ per cent incidence reaction

Disease rating (Grade)	Per cent area of infection	
	On fruits	On leaf
0	No infection	No infection
1	1-10	1-5% leaf area covered
2	11-25	6-10% leaf areas covered
3	26-50	11-25% leaf areas covered
4	51-75	26-50% leaf areas covered
5	> 75	> 50% leaf areas covered

Yield losses due to Anthracnose and Alternaria were estimated simultaneously with fungicide evaluation. The treatment found most effective in disease suppression was considered as disease-free check. Fruit yield of each plant under all treatments was recorded and compared with the check treatment. Per cent yield loss was calculated using the formula suggested by Colpauzos et al. (1976):

$$\text{Yield loss (\%)} = \frac{\text{Yield of check} - \text{Yield of treatment}}{\text{Yield of check}} \times 100$$

**Table 2.** List of treatments used for field evaluation

S.No.	Treatments	Concentration (%)	Qty. per 10 liter water
1.	Propineb 70% WP	0.2	28.57 g
2.	Mancozeb 75% WP	0.2	26.66 g
3.	Iprobenfos 48% EC	0.02	4.16 ml
4.	Picoxystrobin 22.52% SC	0.02	8.88 ml
5.	Difenoconazole 250 EC	0.02	8 ml
6.	Epoxiconazole 50 g/ l + Pyraclostrobin 133 g/ l	0.01	5.81 ml
7.	Tebuconazole 50% + Trifloxystrobin 25% WG	0.025	3.33 g
8.	Control	-	-

**Results and Discussion**

A two-year field study was conducted during Mrig Bahar season to evaluate the comparative efficacy of different fungicides against Anthracnose and Alternaria diseases of pomegranate. Seven fungicidal treatments along with an untreated control were tested.

**Effect of fungicides on leaf spot disease**

The analyzed data indicated that all fungicidal treatments significantly reduced leaf spot severity over untreated control during both years of experimentation. Among the treatments, the ready-mix fungicide Tebuconazole 50%+ Trifloxystrobin 25% WG at 0.025 per cent proved most effective, recording the lowest pooled PDI of 14.03 per cent. This treatment was statistically at par with Epoxiconazole 50 g/ l + Pyraclostrobin 133 g/ l at 0.01 per cent, which recorded 16.01 per cent. PDI.

These were followed by Picoxystrobin 22.52% SC at 0.02 per cent with 19.06 per cent PDI (Table 3).

Moderate disease reduction was observed with Difenoconazole 25 EC (21.50%), Iprobenfos 48 EC (24.06%) and Propineb 70 WP (27.50%). Mancozeb 75 WP at 0.2 per cent was found least effective among the tested fungicides, though still superior to the untreated control. In terms of disease control over untreated control, Tebuconazole + Trifloxystrobin registered the highest reduction (56.62%), followed by Epoxiconazole + Pyraclostrobin (50.49%).

Mancozeb recorded the lowest disease reduction (7.47%).

These findings are in agreement with earlier reports of Jayalakshmi (2015) and Archana and Jamadar (2014), who also observed lower efficacy of Mancozeb against leaf and fruit spot diseases of pomegranate. However, Shreeshail *et al.* (2016) reported Mancozeb (0.2%) as effective against *Colletotrichum gloeosporioides*, indicating possible variation due to environmental conditions, pathogen virulence, or spray schedules. effect of fungicides on fruit spot disease

**Table 3.** Effect of different fungicides on leaf spots of pomegranate

S.No.	Treatment	Conc. (%)	2018-19	2019-20	Pooled	PDI (%)
1.	Propineb 70% WP	0.2	32.66 (29.17)*	32.57 (25.83)	32.61 (27.50)	14.95
2.	Mancozeb 75% WP	0.2	34.23 (31.67)	34.55 (28.17)	34.39 (29.92)	7.47
3.	Iprobenfos 48% EC	0.02	31.32 (27.08)	29.45 (21.04)	30.39 (24.06)	25.58
4.	Picoxystrobin 22.52% SC	0.02	28.55 (22.92)	26.20 (15.21)	27.38 (19.06)	41.04
5.	Difenoconazole 250 EC	0.02	29.72 (24.67)	25.61 (18.33)	27.67 (21.50)	33.51
6.	Epoxiconazole 50 g/ l + Pyraclostrobin 133 g/l	0.01	26.37 (19.79)	22.88 (12.22)	24.62 (16.01)	50.49
7.	Tebuconazole 50% + Trifloxystrobin 25% WG	0.025	24.39 (17.22)	23.63 (10.83)	24.01 (14.03)	56.62
8.	Control	-	35.83 (34.33)	34.86 (30.33)	35.34 (32.33)	0.00
SEm±			1.36	1.04	0.86	
CD at 5%			4.14	3.16	2.49	
CV (%)			7.78	6.28	7.11	
Y						
SEm±					0.43	
CD at 5 %					1.24	
Y x T						
SEm±					1.21	
CD at 5 %					NS	

\*Data outside the parentheses are arcsine transformed, whereas inside are re-transformed values

### **Effect of fungicides on fruit spot disease**

The data revealed (Table 4) that all fungicidal treatments significantly reduced fruit spot severity compared with untreated control. The lowest pooled PDI of 13.96 per cent was recorded with Tebuconazole 50% + Trifloxystrobin 25% WG at 0.025 per cent, followed by Epoxiconazole 50 g/ l + Pyraclostrobin 133 g/ l at 0.01 per cent (17.22%) and Picoxystrobin 22.52% SC at 0.02 per cent (21.11%). Difenoconazole 25 EC, Iprobenfos 48 EC and Mancozeb 75 WP recorded 24.69, 27.61 and 30.75

per cent PDI, respectively, Propineb 70 WP was found least effective in reducing fruit spot severity among all tested fungicides. The highest fruit spot incidence was observed in untreated control plants with 33.17 per cent PDI. Maximum disease control over untreated control was obtained with Tebuconazole + Trifloxystrobin (57.91%), followed by Epoxiconazole + Pyraclostrobin (48.08%), Propineb showed minimum disease control.

The superior performance of Tebuconazole + Trifloxystrobin may be attributed to the combined

systemic and protective action of triazole and strobilurin groups, which inhibit fungal growth and sporulation effectively. However, under the present field conditions, these fungicides were comparatively less effective than the newer combination fungicides. Among all treatments, Tebuconazole 50% + Trifloxystrobin 25% WG consistently recorded the lowest disease intensity on leaves and fruits and provided maximum disease control, followed by Epoxiconazole + Pyraclostrobin. Therefore, these fungicides can be recommended as effective options for integrated

disease management of pomegranate under field conditions.

Similar results were earlier reported by Ekabote and Narayanswarthy (2019) against anthracnose of pomegranate, Ann et al. (2017) against anthracnose of black pepper caused by *C. gloeosporioides*, and Ginoya and Gohel (2015) against *Alternaria alternata* causing chilli fruit rot. Tziros et al. (2017) also reported Iprobenfos (Kitazin) as effective against pomegranate anthracnose, while Jamadar and Patil (2007) found Difenoconazole 25 EC highly effective.

**Table 4.** Effect of different fungicides on fruit spots of pomegranate

S.No.	Treatment	Conc. (%)	2018-19	2019-20	Pooled	PDI (%)
1.	Propineb 70% WP	0.2	35.15 (33.17)	32.36 (29.83)	33.75 (31.50)	5.03
2.	Mancozeb 75% WP	0.2	33.41 (30.33)	32.46 (31.17)	32.93 (30.75)	7.29
3.	Iprobenfos 48% EC	0.02	31.39 (27.17)	33.57 (28.13)	32.48 (27.61)	16.76
4.	Picoxystrobin 22.52% SC	0.02	26.54 (20.00)	30.02 (22.22)	28.28 (21.11)	36.35
5.	Difenoconazole 250 EC	0.02	29.42 (24.17)	32.31 (25.21)	30.86 (24.69)	25.55
6.	Epoxiconazole 50 g/ l + Pyraclostrobin 133 g/ l	0.01	24.42 (17.22)	27.38 (17.22)	25.90 (17.22)	48.08
7.	Tebuconazole 50% + Trifloxystrobin 25% WG	0.025	22.04 (14.17)	23.53 (13.75)	22.79 (13.96)	57.91
8.	Control	-	35.76 (34.17)	34.59 (32.17)	35.18 (33.17)	0.00
SEm±			1.28	1.11	0.85	
CD at 5%			3.88	3.36	2.45	
CV (%)			7.44	6.22	6.84	
Y						
SEm±					0.42	
CD at 5%					NS	
Y x T						
SEm±					1.20	
CD at 5%					NS	

\*Data outside the parentheses are arcsine transformed, whereas inside are re-transformed values

#### **Assessment of yield losses in pomegranate due to Anthracnose and Alternaria**

Amongst fungal diseases, fruit spot caused by *Colletotrichum gloeosporioides* results in rotting of pomegranate fruits within a week of infection, causes drastic reduction in the yield as well as marketability of the produce. This study was undertaken to evaluate the relative efficacy of different fungicides for

management of anthracnose of pomegranate and affect fruit yield. The fungicide which found effective in suppression of diseases effectively in field (Tebuconazole 50% + Trifloxystrobin 25% WG) was used to maintain disease free condition (control). The fruit yield of each plant was recorded in each treatment and compare with the control. Per plant production recorded for different treatment and yield loss was calculated as described in materials and methods. Among all tested fungicides highest fruit

yield was recorded in Tebuconazole 50% + Trifloxystrobin 25% WG (15.75 kg/ plant) followed by Epoxiconazole 50 g/ l + Pyraclostrobin 133 g/ l with 13.12 kg/ plant which was at par with Picoxystrobin 22.52% SC with 12.25 kg/ plant fruit yield (Table 5). The next on par yield levels were obtained in Difenconazole 250 EC, Iprobenfos 48 % EC and Propineb 70% WP with 11.22, 10.36 and 9.65 kg/plant fruit yield.

Maximum yield loss was recorded in untreated control (47.74%) which was followed by Mancozeb 75% WP (44.55%) followed by Propineb 70% WP

**Table 5.** Effect of different fungicides on fruit yield of pomegranate

S.No.	Treatment	Conc. (%)	2018-19 (kg/ plant) <sup>#</sup>	2019-20 (kg/ plant) <sup>#</sup>	Pooled	Yield loss (%)
1.	Propineb 70% WP	0.2	17.34 (8.99)*	18.72 (10.32)*	18.03 (9.65)	38.72
2.	Mancozeb 75% WP	0.2	16.66 (8.29)	17.60 (9.18)	17.13 (8.74)	44.55
3.	Iprobenfos 48 % EC	0.02	18.06 (9.69)	19.34 (11.02)	18.70 (10.36)	34.26
4.	Picoxystrobin 22.52% SC	0.02	20.08 (11.79)	20.85 (12.71)	20.46 (12.25)	22.24
5.	Difenoconazole 250 EC	0.02	18.94 (10.60)	20.07 (11.83)	19.50 (11.22)	28.80
6.	Epoxiconazole 50 g/ l + Pyraclostrobin 133 g/ l	0.01	20.82 (12.67)	21.60 (13.57)	21.21 (13.12)	16.74
7.	Tebuconazole 50% + Trifloxystrobin 25% WG	0.025	23.16 (15.49)	23.59 (16.02)	23.37 (15.75)	0.00
8.	Control	-	16.24 (7.89)	16.99 (8.58)	16.62 (8.23)	47.74
SEm±			0.93	0.91	0.65	
CD at 5%			2.82	2.76	1.88	
CV (%)			8.51	7.95	8.23	
Y						
SEm±					0.33	
CD at 5%					NS	
Y x T						
SEm±					0.92	
CD at 5%					NS	

\*Data outside the parentheses are arcsine transformed, whereas inside are re-transformed values

<sup>#</sup>Mean of three replications

## Conclusion

In conclusion, the two-year study showed that fungicidal sprays effectively managed Anthracnose and Alternaria diseases in pomegranate during Mrig Bahar and improved yield. Tebuconazole 50% + Trifloxystrobin 25% WG at 0.025% was the most effective, reducing disease intensity and increasing fruit yield (15.75 kg/ plant). Its superior performance

(38.72). yield loss recorded in iprobenfos 48 % EC, Difenconazole 250 EC and Picoxystrobin 22.52% SC were 34.26%, 8.80% and 22.24%, respectively. Minimum yield loss was recorded in Epoxiconazole 50 g/ l + Pyraclostrobin 133 g /l (16.74%). Jayalakshmi (2015) recorded the effect of fungicides against *Colletotrichum gloeosporioides* causing anthracnose of pomegranate and found iprobenfos (0.2%), carbendazim (0.2%), Difenconazole (0.1%), Captan (0.3%) and Mancozeb (0.3%) were at par in yield of pomegranate. Effectiveness of Difenconazole was recorded by Jamadar and Patil (2007).

highlights the benefit of combining systemic and protective fungicides. Therefore, Tebuconazole + Trifloxystrobin followed by Epoxiconazole + Pyraclostrobin is recommended for effective disease management under field conditions.

## Acknowledgements

Authors express sincere gratitude to the authorities of College of Agriculture, Junagadh Agricultural

University, for providing the resources and facilities necessary for conducting this research. Special thanks are extended to Goradhanbhai, who gave me full freedom and support to carry out the experiment in his orchard.

### Conflict of Interest

The authors declare no conflict of interest.

### Data Sharing

All relevant data are within the manuscript.

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