

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 IJABR 2024; 8(8): 755-759
www.biochemjournal.com
 Received: 15-05-2024
 Accepted: 20-06-2024

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Bio-efficacy of ready mix fungicides against powdery mildew of fenugreek

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DOI: <https://doi.org/10.33545/26174693.2024.v8.i8j.1862>

Abstract

Fenugreek (*Trigonella foenum-graecum* L.) is a valuable leguminous crop widely cultivated for its medicinal, culinary and nutritional properties. However, powdery mildew, caused by the fungus *Erysiphe polygoni* poses a significant threat to fenugreek production leading to considerable yield losses and reduced quality of the harvested product. Considering the efficacy of different fungicide against powdery mildew of fenugreek, Tebuconazole 10% + sulphur 65% WG @ 0.234 found most effective which was at par with Tebuconazole 10% + sulphur 65% WG @ 0.187 than the rest of treatments. These treatments also reflected on yield of seed yield of fenugreek.

Keywords: Fenugreek, powdery mildew, ready mix fungicides

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is herbaceous annual plant in the family *Fabaceae*. There are two cultivated species of genus *Trigonella* viz. *foenuni-graecum* (common fenugreek) and *corniculata* (Kasuri type fenugreek). The major fenugreek producing countries are India, Argentina, Egypt, Southern France, Morocco, Spain, Turkey and China. Native to the Mediterranean region, southern Europe and western Asia, it has been widely cultivated for its culinary and medicinal applications. This plant is valued for its seeds and leaves, which have been used in traditional medicine and cooking for centuries. Fenugreek seeds are rich in fiber, protein, iron, magnesium, and manganese. They contain various beneficial compounds, including saponins, flavonoids, and alkaloids (Mehrafarin *et al.*, 2010) [4]. Seeds have a bitter taste and a strong aroma, often likened to maple syrup or burnt sugar (Srinivasan, 2006) [8]. Leaves are used fresh or dried to flavour curries, stews, and soups (Basch *et al.*, 2003) [1]. The plant possesses anti-inflammatory properties, making it useful in alleviating pain and swelling (Khare, 2007) [2].

Fenugreek can be grown in almost all type of soils having good drainage but grow best on well drained loamy soils. Organic matter rich clay-loam soil may also be used if adequate drainage facilities are available. However, it can be grown on sandy or gravelly soils with slightly compromising yield. For rainfed cultivation, black cotton soils are best suited for its successful cultivation. Although the crop is sensitive to salinity except very low yet it can tolerate the pH up to 8.5, but in neutral soils having a pH range from 6.0 to 7.0 it always gives higher yield with better quality of leaves.

Fenugreek can be susceptible to various diseases that can affect yield and quality. Here are some common diseases that affect fenugreek: Damping off (*Pythium aphanidermatum*) Powdery Mildew (*Leveillula taurica*), Downy Mildew (*Peronospora trigonellae*), Root Rot (*Rhizoctonia solani* and *Fusarium* spp.), Anthracnose (*Colletotrichum* spp.) and Leaf Spot (*Cercospora* spp.) The disease, powdery caused by *Erysiphe polygoni* is serious diseases resulting 15 to 50 percent seed yield losses (Kumawat and Shekhawat, 2015) [3]. Fenugreek yield loss of 27 to 33 per cent due to powdery mildew caused (Prakash and Saharan, 2002) [5]. The symptoms of powdery mildew appeared in month of February. White floury patches were found on leaves, stems and pods (Prakash and Saharan, 2002) [5] Symptoms start with white powdery growth on leaves which may coalesce and cover the white leaf with the white powdery growth of the fungus (Roba and Simion, 2022) [6]. Hence, this experiment was initiated with the objective of determining of the effects fungicides on powdery mildew on seed yield.

Materials and Methodology

A field trial was conducted during *rabi* 2021-22 and *rabi* 2022-23 at Horticulture Farm, College of Horticulture, Anand Agricultural University, Anand to test the efficacy of three ready mix fungicides efficacy at different doses against powdery mildew of fenugreek. Fenugreek (Gujarat Fenugreek 2) was raised during *rabi* season in Randomized block design with three replications. A spacing of 30 (between rows) was adopted in plots (Gross: 4.0x 2.4 m Net: 3.8x 1.8 m).

Foliar application of fungicide was made just after disease initiation in the field and second spray was done after 15 days of first spray. The fungicides were than concentrated

and used after proper dilution in water. The spray was given using manually operated knapsack sprayer. The per cent disease severity was recorded after 10 days of first spray and second spray by examining 20 randomly selected plants per plot. Disease intensity was recorded by observing powdery mildew on leaf, stem and pods using 0-4 grade (Sekhavat *et al.*, 2016) [7], where, 0=healthy, 1= whitish small spots on leaves, 2 = whitish growth covering the entire leaf, 3 = growth on leaf and stem and 4 = growth on leaf, stem and pods. Seed yield of fenugreek per plot was recorded and converted in to hectare for each treatment. The data on disease intensity and seed yield were subjected to ANOVA.

Treatment details

| Tr. No. | Fungicides | Conc. (%) | g.a.i./ha | Quantity required ml or g/10 litre of water |
|-----------------|---|-----------|-----------|---|
| T ₁ | Boscalid 25.2% + pyraclostrobin 12.8% WG | 0.029 | 171 | 8 |
| T ₂ | | 0.038 | 228 | 10 |
| T ₃ | | 0.048 | 285 | 13 |
| T ₄ | Tebuconazole 10% + sulphur 65% WG | 0.140 | 703.12 | 19 |
| T ₅ | | 0.187 | 937.50 | 25 |
| T ₆ | | 0.234 | 1171.75 | 31 |
| T ₇ | Tebuconazole 50% + trifloxistrobin 25% WG | 0.029 | 140.63 | 4 |
| T ₈ | | 0.038 | 187.50 | 5 |
| T ₉ | | 0.048 | 234.37 | 6 |
| T ₁₀ | Control (Water spray) | - | - | - |
| T ₁₁ | Control | - | - | - |

Observations recorded

1. Per cent disease intensity
2. Seed yield (kg/plot)

Results and Discussion

First year (2021-22) (Table-1)

Ten days after first spray

The result of first year revealed that significantly minimum diseases intensity of powdery mildew has been observed in treatment T₆, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with 12.48% disease intensity after 10 days of first spray which was at par with treatment T₅, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 13.55 PDI. The next best treatment in order of merit was treatment T₉, i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (15.59 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (17.33 PDI).

Ten days after second spray

After 10 days of second spray, all the treatment found significantly reduces the disease intensity as compared to control. The significantly minimum diseases intensity of powdery mildew has been observed in treatment T₆, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with (4.65% DI) after 10 days of first spray which was at par with treatment T₅, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 6.34% DI. The next best treatment in order of merit was treatment T₉, i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (8.43 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (10.18 PDI).

Pooled

The pooled data of powdery mildew disease intensity show that the significantly lowest disease intensity found in T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with

(8.13% DI) after 10 days of first spray which was at par with treatment T₅, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 9.64% DI. The next best treatment in order of merit was treatment T₉, i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (11.78 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (13.55 PDI).

Second year (2022-23) (Table-1)

Ten days after first spray

The result of first year revealed that significantly minimum diseases intensity of powdery mildew has been observed in treatment T₆, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with 14.47% disease intensity after 10 days of first spray which was at par with treatment T₅, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 16.62 PDI. The next best treatment in order of merit was treatment T₉, i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (18.16 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (19.42 PDI).

Ten days after second spray

After 10 days of second spray, all the treatment found significantly reduces the disease intensity as compared to control. The significantly minimum diseases intensity of powdery mildew has been observed in treatment T₆, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with (6.53% DI) after 10 days of first spray which was at par with treatment T₅, i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 8.33% DI. The next best treatment in order of merit was treatment T₉, i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (11.00 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (13.96 PDI).

Pooled

The pooled data of powdery mildew disease intensity show that the significantly lowest disease intensity found in T₅ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with (11.08% DI) after 10 days of first spray which was at par with treatment T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with 11.22% DI. The next best treatment in order of merit was treatment T₉ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (14.39 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (16.61 PDI).

Pooled (2021-22 & 2022-23) (Table-2)**Ten days after first spray**

The result of first year revealed that significantly minimum diseases intensity of powdery mildew has been observed in treatment T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with 13.46% disease intensity after 10 days of first spray which was at par with treatment T₅ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 15.05 PDI. The next best treatment in order of merit was treatment T₉ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (16.86 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (18.38 PDI).

Ten days after second spray

After 10 days of second spray, all the treatment found significantly reduces the disease intensity as compared to control. The significantly minimum diseases intensity of powdery mildew has been observed in treatment T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with (6.37% DI) after 10 days of first spray which was at par with treatment T₅ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 6.43% DI. The next best treatment in order of merit was treatment T₉ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (9.67 PDI) which was at

par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (12.00 PDI).

Pooled

The pooled data of powdery mildew disease intensity show that the significantly lowest disease intensity found in T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with (9.62% DI) after 10 days of first spray which was at par with treatment T₅ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 10.34% DI. The next best treatment in order of merit was treatment T₉ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.048% (13.05 PDI) which was at par with treatment T₈ i.e. Tebuconazole 50% + trifloxistrobin 25% WG @ 0.038% (15.04 PDI).

Seed Yield (Table-3)**First Year (2021-22)**

Among all evaluated treatments against powdery mildew of fenugreek, the significantly highest seed yield was found in treatment T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with 1440.9 kg/ha which was at par with T₅ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% having 1427.0 kg/ha.

Second year (2022-23)

Among all evaluated treatments against powdery mildew of fenugreek, the significantly highest seed yield was found in treatment T₅ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% with 2043.9 kg/ha which was at par with T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% having 2240.0 kg/ha.

Pooled (2021-22 & 2022-23)

The seed yield data of pooled result suggested that maximum yield was found in T₆ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.234% with 1840 kg/ha which was at par with T₅ i.e. Tebuconazole 10% + sulphur 65% WG @ 0.187% having 1735.0 kg/ha.

Table 1: Effect of ready-mix fungicide against on powdery mildew of fenugreek (2021-22 & 2022-23)

| Treatment No. | Disease Intensity (%) | | | | | | | |
|-----------------------|--|-----------------------------|------------------------------|------------------------------|---------------|-----------------------------|-----------------------------|------------------------------|
| | 2021-22 | | | | 2022-23 | | | |
| | Before spray | 10 DAFS | 10 DASS | Pooled over period and spray | Before spray | 10 DAFS | 10 DASS | Pooled over period and spray |
| T ₁ | 32.45 (28.79) | 27.59 ^c (21.45) | 25.59 ^f (18.66) | 26.59 ^f (20.03) | 27.57 (21.42) | 31.00 ^e (26.53) | 27.58 ^c (21.44) | 29.29 ^d (23.93) |
| T ₂ | 32.47 (28.82) | 25.86 ^{bc} (19.02) | 22.90 ^{ef} (15.14) | 24.38 ^{ef} (17.04) | 26.57 (20.01) | 28.86 ^{de} (23.3) | 26.44 ^{de} (19.83) | 27.65 ^{cd} (21.54) |
| T ₃ | 31.56 (27.39) | 25.48 ^{bc} (18.51) | 19.94 ^{cde} (11.63) | 22.71 ^{de} (14.9) | 27.49 (21.31) | 26.61 ^{cd} (20.06) | 24.46 ^d (17.14) | 25.53 ^{bcd} (18.57) |
| T ₄ | 33.34 (30.21) | 25.21 ^{bc} (18.14) | 19.43 ^{cde} (11.07) | 22.32 ^{de} (14.42) | 26.33 (19.67) | 27.47 ^{cd} (21.28) | 25.13 ^{de} (18.03) | 26.30 ^{bcd} (19.63) |
| T ₅ | 33.49 (30.45) | 21.60 ^a (13.55) | 14.58 ^{ab} (6.34) | 18.09 ^{ab} (9.64) | 27.70 (21.61) | 24.06 ^{ab} (16.62) | 14.81 ^a (6.53) | 19.44 ^a (11.08) |
| T ₆ | 33.13 (29.87) | 20.69 ^a (12.48) | 12.45 ^a (4.65) | 16.57 ^a (8.13) | 25.99 (19.20) | 22.36 ^a (14.47) | 16.78 ^a (8.33) | 19.57 ^a (11.22) |
| T ₇ | 32.92 (29.54) | 27.52 ^c (21.35) | 21.50 ^{de} (13.43) | 24.51 ^{ef} (17.21) | 27.07 (20.71) | 30.13 ^c (25.2) | 27.42 ^c (21.21) | 28.78 ^d (23.18) |
| T ₈ | 33.67 (30.74) | 24.60 ^{bc} (17.33) | 18.61 ^{cd} (10.18) | 21.60 ^{cd} (13.55) | 27.20 (20.89) | 26.15 ^{bc} (19.42) | 21.94 ^c (13.96) | 24.05 ^{bc} (16.61) |
| T ₉ | 34.21 (31.61) | 23.26 ^{ab} (15.59) | 16.88 ^{bc} (8.43) | 20.07 ^{bc} (11.78) | 28.06 (22.13) | 25.22 ^{bc} (18.16) | 19.37 ^b (11.00) | 22.29 ^{ab} (14.39) |
| T ₁₀ | 32.56 (28.96) | 39.23 ^d (40.00) | 48.89 ^e (56.77) | 44.06 ^g (48.36) | 27.75 (21.68) | 42.49 ^f (45.62) | 51.67 ^f (61.54) | 47.08 ^e (53.63) |
| T ₁₁ | 33.46 (30.40) | 43.51 ^e (47.40) | 56.57 ^h (69.65) | 50.04 ^h (58.75) | 27.84 (21.81) | 46.71 ^g (52.98) | 58.63 ^g (72.90) | 52.67 ^f (63.23) |
| S. Em.± Treatment (T) | 1.25 | 0.90 | 1.06 | 0.71 | 0.81 | 0.78 | 0.75 | 1.25 |
| Spray (S) | - | - | - | 0.30 | - | - | - | 0.53 |
| T x S | - | - | - | 1.00 | - | - | - | 1.77 |
| C.D. at 5% (T) | NS | Sig. | Sig. | Sig. | NS | Sig. | Sig. | Sig. |
| C. V. % | 7.30 | 5.60 | 7.30 | 6.58 | 5.15 | 4.51 | 4.53 | 4.44 |
| Note: | DAFS: Days After First Spray; DASS: Days after Second Spray; NS: Non-significant Figures in the parentheses are retransformed values; those outside arc sign transformed values Treatments means with the letter(s) in common are not significant by DNMRT at 5% level of significance | | | | | | | |

Table 2: Effect of ready-mix fungicide against on powdery mildew of fenugreek (Pooled)

| Treatments | Disease Intensity (%) | | | |
|---|---|-----------------------------|-----------------------------|------------------------------|
| | Before spray | 2021-22 | 2022-23 | Pooled over period and spray |
| Boscalid 25.2% + pyraclostrobin 12.8% WG @ 0.029% | 30.01 (25.02) | 29.30 ^g (23.95) | 26.58 ^e (20.02) | 27.94 ^f (21.95) |
| Boscalid 25.2% + pyraclostrobin 12.8% WG @ 0.038% | 29.51 (24.26) | 27.36 ^{ef} (21.12) | 24.67 ^e (17.42) | 26.01 ^e (19.23) |
| Boscalid 25.2% + pyraclostrobin 12.8% WG @ 0.048% | 29.52 (24.28) | 26.05 ^{de} (19.29) | 22.20 ^e (14.28) | 24.12 ^{cd} (16.7) |
| Tebuconazole 10% + sulphur 65% WG @ 0.140% | 29.83 (24.74) | 26.34 ^{de} (19.69) | 22.28 ^{cd} (14.37) | 24.31 ^d (16.95) |
| Tebuconazole 10% + sulphur 65% WG @ 0.187% | 30.58 (25.88) | 22.83 ^{ab} (15.05) | 14.69 ^a (6.43) | 18.76 ^a (10.34) |
| Tebuconazole 10% + sulphur 65% WG @ 0.234% | 29.55 (24.32) | 21.52 ^a (13.46) | 14.62 ^a (6.37) | 18.07 ^a (9.62) |
| Tebuconazole 50% + trifloxistrobin 25% WG@0.029% | 29.98 (24.97) | 28.83 ^{fg} (23.25) | 24.46 ^{de} (17.14) | 26.64 ^{ef} (20.1) |
| Tebuconazole 50% + trifloxistrobin 25% WG@0.038% | 30.43 (25.65) | 25.38 ^{cd} (18.37) | 20.27 ^e (12.00) | 22.82 ^c (15.04) |
| Tebuconazole 50% + trifloxistrobin 25% WG@0.048% | 31.12 (26.71) | 24.24 ^{bc} (16.86) | 18.12 ^b (9.67) | 21.18 ^b (13.05) |
| Control (Water spray) | 30.14 (25.21) | 40.86 ^h (42.8) | 50.28 ^f (59.16) | 45.57 ^g (50.99) |
| Control | 30.64 (25.97) | 45.11 ⁱ (50.19) | 57.60 ^g (71.29) | 51.35 ^h (60.99) |
| S. Em. ± Treatment (T) | 0.54 | 0.56 | 0.69 | 0.45 |
| Spray (S) | - | - | - | 0.19 |
| Year (Y) | 0.24 | 0.25 | 0.27 | 0.19 |
| T x S | - | - | - | 0.63 |
| T x Y | 0.80 | 0.84 | 0.92 | 0.63 |
| S x Y | - | - | - | 0.27 |
| T x S x Y | - | - | - | 0.90 |
| C.D. at 5% (T) | NS | Sig. | Sig. | Sig. |
| C. V.% | 4.60 | 5.04 | 5.92 | 5.60 |
| Note: | Figures in the parentheses are retransformed values; those outside arc sign transformed values Treatments means with the letter(s) in common are not significant by DNMR at 5% level of significance Significant parameters and interactions: S and S x T | | | |

Table 3: Effect of ready-mix fungicide on seed yield in fenugreek

| Treatment No. | Seed yield (kg/ha) | | |
|---|---|---------------------|---------------------|
| | 2021-22 | 2022-23 | Pooled |
| Boscalid 25.2% + pyraclostrobin 12.8% WG @ 0.029% | 916 ^{cb} | 1629 ^{bcd} | 1272 ^{de} |
| Boscalid 25.2% + pyraclostrobin 12.8% WG @ 0.038% | 1118 ^b | 1512 ^{cd} | 1315 ^{cde} |
| Boscalid 25.2% + pyraclostrobin 12.8% WG @ 0.048% | 1198 ^b | 1512 ^{cd} | 1355 ^{cde} |
| Tebuconazole 10% + sulphur 65% WG @ 0.140% | 1198 ^b | 1765 ^{bc} | 1481 ^{bcd} |
| Tebuconazole 10% + sulphur 65% WG @ 0.187% | 1427 ^a | 2043 ^{ab} | 1735 ^{ab} |
| Tebuconazole 10% + sulphur 65% WG @ 0.234% | 1441 ^a | 2240 ^a | 1840 ^a |
| Tebuconazole 50% + trifloxistrobin 25% WG@0.029% | 958 ^{cb} | 1296 ^{de} | 1127 ^e |
| Tebuconazole 50% + trifloxistrobin 25% WG@0.038% | 1249 ^a | 1666 ^{bcd} | 1457 ^{cd} |
| Tebuconazole 50% + trifloxistrobin 25% WG@0.048% | 1278 ^a | 1820 ^{abc} | 1549 ^{bc} |
| Control (Water spray) | 635 ^c | 1018 ^{ef} | 826 ^f |
| Control | 597 ^c | 858 ^f | 727 ^f |
| S. Em.± Treatment (T) | 80.33 | 130.02 | 78.64 |
| Year (Y) | - | - | 32.58 |
| T x Y | - | - | 108.07 |
| C.D. at 5% (T) | Sig. | Sig. | Sig. |
| C. V.% | 12.73 | 14.26 | 14.01 |
| Note: | Treatments means with the letter(s) in common are not significant by DNMR at 5% level of significance | | |

Conclusion

Considering the efficacy of different fungicide against powdery mildew of fenugreek, Tebuconazole 10% + sulphur 65% WG @ 0.234 found most effective which was at par with Tebuconazole 10% + sulphur 65% WG @ 0.187 than the rest of treatments. These treatments also reflected on yield of seed yield of fenugreek.

Recommendation

Application of Tebuconazole 10% + sulphur 65% WG @ 0.187 @ 25 g / 10 lit of water, first at initiation of powdery mildew and second at 15 days after first spray was found effective against powdery mildew of fenugreek.

Competing interests

Authors have declared that no competing interests exist.

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