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Development of spray schedule for the integrated management of *Alternaria* leaf blight of safflower under field condition

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Abstract

A field experiment was conducted during the *rabi* 2023-24 at MARS, UAS, Dharwad, to evaluate various spray schedules for managing *Alternaria* leaf blight of safflower caused by *A. carthami* on the variety Annigeri 1. The study was designed as a randomized complete block with three replications with 11 treatments. Among the spray schedules evaluated, the treatment involving the first application of Mancozeb 75% WP (0.1%), followed by a second spray of (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG (0.1%) at a 15 days interval, resulted in the lowest PDI values of 20.71 and 23.16 respectively (T_9) and with an mean PDI of 21.26 percent which found significantly superior over all the treatments. The next most effective treatment was two sprays of Hexaconazole 5% EC (@ 0.1%) (T_{10}), which recorded PDI values of 23.26 and 27.39 after first and second sprays respectively, with a mean PDI of (23.69).

Keywords: Safflower, Integrated management, spray schedule, fungicides and bio agents

Introduction

Safflower an ancient and highly adaptable crop has been cultivated for over 4,000 years, originally valued for its vivid red and yellow florets. Historically, it played a significant role in textile dyeing, as evidenced by references in ancient Egyptian and Mesopotamian records. Today, the significance of safflower has evolved beyond the dye production to include diverse applications in agriculture, industry and health. Safflower oil derived from its seeds is rich in polyunsaturated fatty acids particularly linoleic (75%) and oleic acids which are potent antioxidants (Furuya, 1987) ^[4], making it a popular choice in culinary, cosmetic and industrial products. The oil's nutritional profile has also drawn attention for its potential health benefits such as reducing cardiovascular risks and managing cholesterol levels (Dajue and Mundel, 1996) ^[3].

Safflower is cultivated in over 60 countries worldwide ranging between latitudes 50°N and 23°S (Gilbert *et al.*, 2008) ^[7]. Mexico is the largest producer, followed by India. In India, the primary safflower producing states are Maharashtra and Karnataka, which together account for (86%) of the country's total production with Maharashtra contributing (55%) and Karnataka 31 percent. Globally, safflower is cultivated on 6.94 lakh hectares, producing 6.27 lakh tonnes annually, with an average yield of 903 kg per hectare (Anon., 2020) ^[1]. In India, safflower is grown on 0.79 lakh hectares, yielding 0.61 lakh tonnes annually, with an average yield of 777 kg per hectare. The crop is predominantly cultivated in the Indian states of Maharashtra, Karnataka, Andhra Pradesh, Telangana, and Madhya Pradesh. Karnataka alone accounts for 0.41 lakh hectares, producing 0.33 lakh tonnes, with an average yield of 810 kg per hectare. In Karnataka, safflower is primarily grown in the districts of Vijayapura, Kalaburagi, Bagalkot, Belagavi, Yadgiri, Raichur, Gadag and Dharwad (Anon., 2022) ^[2].

Safflower is known for its tolerance to cold and drought (Majidi *et al.*, 2011) ^[11] and its ability to extract soil water that is inaccessible to most other dryland crops (Weiss, 2000) ^[18]. Despite its significant potential and adaptability to a wide range of agro-ecological conditions, safflower remains underutilized by farmers. This is due to several challenges, including its extended rosette stage, spiny nature, relatively low seed oil content (30-38%), late maturity and susceptibility to various diseases and pests (Sujatha *et al.*, 2008) ^[16].

The major biotic stresses affecting safflower production include leaf spot diseases caused by *Alternaria carthami* Chowdhury, *Cercospora carthami* Sundararaman and Ramakrishnan and *Ramularia carthami* Zaprometov; wilts caused by *Fusarium oxysporum* Schlecht. f. sp. *carthami* and *Verticillium albo-atrum*, Powdery mildew by *Erysiphe cichoracearum* f. sp. *Carthami* Milovtsova, Phytophthora root rot and insect pests such as aphids and the safflower fly (Kalpana Sastry and Chattopadhyay, 2005; Singh and Prasad, 2005) [9, 15].

Among the various diseases affecting safflower, *Alternaria* leaf blight and *Fusarium* wilt are considered the most significant biotic constraints on production. *Alternaria* leaf blight caused by *Alternaria carthami* leads to annual yield losses of 25-60 percent (Singh and Prasad, 2005, Indi *et al.*, 1988) with substantial economic consequences for farmers in the Deccan Plateau of India (Rao *et al.*, 2014) [14]. The continuous practice of monocropping and the cultivation of susceptible conventional varieties are key factors contributing to the high incidence of these diseases with reduction in the seed size, seed volume as well as percent oil content (Kalpana Sastry *et al.*, 1993) [10].

Hence, an attempt was made to study the relative efficacy and economics of use of different newer fungicides, botanicals and bio agents for the management of *Alternaria* leaf blight of safflower under field conditions to minimize the losses caused by the disease.

Materials and Methods

A field experiment was conducted during rabi season during 2023-24 to study the efficacy of different fungicides, commercially available botanical and biocontrol agents in an integrated approach for the control of *Alternaria* leaf spot of safflower and also to study the economics of use of different fungicides for the disease control. The experiment was sown during 1st fortnight of September employing variety Annigeri-1 (A1) during all the year to have maximum infection and build-up of the disease and thereby rigorous screening of the fungicides, botanical and biocontrol agents against the disease. The crop was sown at 45 x 20 cm spacing with gross plot size of 2.7 x 5.0 m and net plot size of 1.8 x 4.6 m and 50:25 kg N and P2O5 were applied at the time of sowing as basal dose. There were 11 treatments as per the details given in Table 1. The first spray of the fungicides was applied immediately after the disease appearance at 500 lit ha⁻¹ and further need-based 2 sprays were given at 15 days interval thereafter. The disease intensity was recorded on ten randomly selected plants at 7 days after the last spray. The seed yield was recorded after harvest. The data were subjected to statistical analysis by employing standard methods of analysis of variance (Panse and Sukhatme, 1985).

Results & Discussion

Among the spray schedules evaluated, the treatment involving the first application of Mancozeb 75% WP (0.1%), followed by a second spray of (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG (0.1%) at a 15 days interval, resulted in the lowest PDI values of 20.71 and 23.16 respectively (T₉) and with an mean PDI of 21.26 percent which found significantly superior over all the treatments. The next most effective treatment was two sprays of Hexaconazole 5% EC (@ 0.1%) (T₁₀), which recorded PDI values of 23.26 and 27.39 after first and

second sprays respectively, with a mean PDI of (23.69).

The first spray of (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG followed by a second spray of *T. harzianum* (10 g/l) resulted in a mean disease severity of 25.07 percent (T₈), which was on par with the two sprays of (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG (@ 0.1%) (T₆) with mean severity of 26.74 percent followed by two sprays of Mancozeb 75% WP (@ 0.1%) with severity of 28.47 percent. Two sprays of Azadirachtin 0.15% (@ 0.5%) (T₃) resulted in the highest disease severity, with severity of (38.00%) after the first spray and (49.44%) after the second, leading to a mean severity of (36.16%). This was next only to the control, which recorded significantly highest mean severity of (45.36%) (Table 1).

The first spray of Mancozeb 75% WP (0.1%) followed by second spray of (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG (0.1%), resulted in the highest disease reduction over control (64.82%), which was significantly superior to other treatments (Table 1). This was followed by the treatment with (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG and *T. harzianum* (10 g/l), which achieved 58.40 percent disease reduction. The lowest disease reduction of (24.92%), was observed in the treatment with two sprays of Azadirachtin 0.15% at 0.5 percent (T₃). Wagh *et al.* (2017) [17] studied fungicides, biocontrol agents and botanicals under field conditions during 2013 and 2014 in safflower and found Hexaconazole at 0.1 percent recorded lowest PDI of 14.34 percent with seed yield increase of 54.56 percent and 3.22 B:C ratio. Hexaconazole acts by inhibiting fungal growth and reproduction by disrupting ergo-sterol biosynthesis, a key component of fungal cell wall.

Effect of different spray schedules on yield of safflower

There was considerable variation in yield across the treatments. Spray of Mancozeb 75% WP (0.1%) followed by (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG (0.1%) (T₉) resulted in the highest yield of 11.10 q/ha, outperforming other treatments. This was followed by two sprays of Hexaconazole 5% EC (@ 0.1%) (T₁₀) with a yield of 9.90 q/ha, and (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG followed by a second spray of *Trichoderma harzianum* (10 g/l), which produced a yield of 9.38 q/ha. The control treatment (T₁₁) had the lowest yield at 6.81 q/ha, followed by two sprays of Azadirachtin (0.15%) at (0.5%) (T₂) with a yield of 7.03 q/ha and two sprays *Trichoderma harzianum* @ 10 g/l (T₃) producing a yield of 7.22 q/ha. Results obtained in respect of efficacy of chemical and bioagent in effectively inhibiting these pathogens are in conformity with those reported earlier by Nzojiyobiri *et al.* (2003) [12], Gaurilčikienė *et al.* (2008) [6] and Gaurilčikienė *et al.* (2012) [5].

Economic analysis of integrated spray schedules on *Alternaria* leaf blight of safflower

The economic analysis and cost-benefit ratio for different treatments are presented in the (Table 2). The highest net income of Rs 17931/ha was achieved with the treatment Mancozeb 75% WP (0.1%) followed by (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG (0.1%), which had a significantly superior cost-benefit ratio of 1.52 compared to other treatments. The next best treatment was, two sprays of Hexaconazole 5% EC at (0.1%) (T₁₀), recorded a cost-benefit ratio of 1.46. The lowest cost-benefit ratio of less than 1 (0.93) was found in the treatment with two sprays of

Azadirachtin 0.15% at (0.5%). Wagh *et al.* (2017) [17] studied fungicides, biocontrol agents and botanicals under field conditions during 2013 and 2014 in safflower and found Hexaconazole at 0.1 percent recorded lowest PDI of

14.34 percent with seed yield increase of 54.56 percent and 3.22 B:C ratio. Hexaconazole acts by inhibiting fungal growth and reproduction by disrupting ergo-sterol biosynthesis, a key component of fungal cell wall.

Table 1: Development of integrated spray schedule for the management of *Alternaria* leaf blight of safflower under field condition

Treatments	Disease severity (%)			Mean PDI	Mean percent disease reduction over control	Yield q/ha
	Before spray	After 1 st spray	After 2 nd spray			
T ₁ : Mancozeb 75% WP @ 0.1% followed by Mancozeb 75% WP @ 0.1%	18.61 (25.56)*	28.85 (32.49)	37.95 (35.02)	28.47 (32.25)	42.33	8.29
T ₂ : Azadirachtin 0.15% @ 0.5% followed by Azadirachtin 0.15% @ 0.5%	21.04 (27.30)	38.00 (38.05)	49.44 (44.68)	36.16 (36.96)	24.92	7.03
T ₃ : <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l followed by <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l	20.02 (26.58)	31.67 (34.24)	45.73 (42.55)	32.47 (34.74)	30.55	7.22
T ₄ : Mancozeb 75% WP @ 0.1% followed by Azadirachtin 0.15% @ 0.5%	20.51 (26.93)	29.19 (32.70)	39.23 (38.78)	29.64 (32.99)	40.43	7.44
T ₅ : Mancozeb 75% WP @ 0.1% followed by <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l	21.30 (27.48)	30.25 (33.35)	38.39 (38.29)	29.97 (33.19)	41.70	7.72
T ₆ : (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1% followed by (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1%	20.07 (26.62)	27.54 (32.65)	32.62 (34.83)	26.74 (31.14)	50.47	9.02
T ₇ : (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1% followed by Azadirachtin 0.15% @ 0.5%	21.18 (27.40)	28.25 (32.11)	37.08 (37.51)	28.84 (32.48)	43.69	8.81
T ₈ : (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1% followed by <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l	19.85 (26.45)	26.32 (30.87)	29.04 (32.61)	25.07 (30.05)	55.90	9.38
T ₉ : Mancozeb 75% WP @ 0.1% followed by (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1%	19.91 (26.50)	20.71 (27.07)	23.16 (28.77)	21.26 (27.46)	64.82	11.10
T ₁₀ : Hexaconazole 5% EC @ 0.1% followed by Hexaconazole 5% EC @ 0.1%	20.44 (26.88)	23.26 (30.87)	27.39 (31.56)	23.69 (29.11)	58.40	9.90
T ₁₁ : Control (Untreated)	22.56 (28.36)	47.66 (43.66)	65.85 (54.24)	45.36 (42.34)	0.00	6.81
S. Em.±	NS	0.49	0.67			0.55
C.D. at 5%		1.46	1.98			1.62

NS-Non significant, *-Arcsine transformed value

Table 2: Economic analysis of integrated spray schedules on *Alternaria* leaf blight of safflower

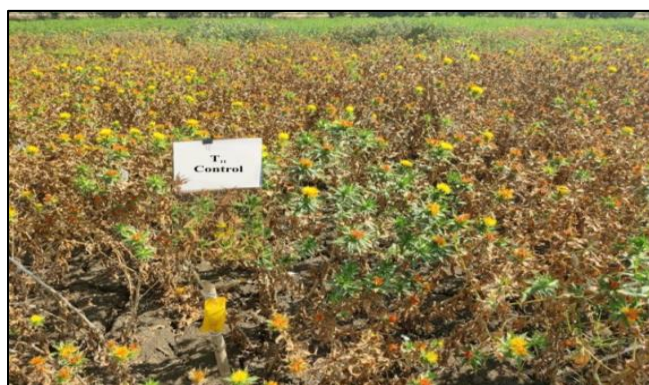
Treatments	Seed yield (q/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T ₁ : Mancozeb 75% WP @ 0.1% followed by Mancozeb 75% WP @ 0.1%	8.29	30624	38943	8319	1.29
T ₂ : Azadirachtin 0.15% @ 0.5% followed by Azadirachtin 0.15% @ 0.5%	7.03	35624	33041	2583	0.93
T ₃ : <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l followed by <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l	7.22	31200	33934	2734	1.07
T ₄ : Mancozeb 75% WP @ 0.1% followed by Azadirachtin 0.15% @ 0.5%	7.44	33124	34948	1824	1.03
T ₅ : Mancozeb 75% WP @ 0.1% followed by <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l	7.72	30912	36302	5390	1.17
T ₆ : (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1% followed by (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1%	9.02	37810	42394	4584	1.09
T ₇ : (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1% followed by Azadirachtin 0.15% @ 0.5%	8.81	36717	41405	4688	1.13
T ₈ : (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1% followed by <i>Trichoderma harzianum</i> (MH027645.1) IOF strain @ 10 g/l	9.38	34505	44086	9581	1.28
T ₉ : Mancozeb 75% WP @ 0.1% followed by (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1%	11.10	34217	52148	17931	1.52
T ₁₀ : Hexaconazole 5% EC @ 0.1% followed by Hexaconazole 5% EC @ 0.1%	9.90	31800	46552	14752	1.46
T ₁₁ : Control (Untreated)	6.81	30150	32054	1904	-
S. Em.±					
C.D. at 5%					



a. General view of experimental plot



b. T9: Mancozeb 75% WP @ 0.1% – (Tebuconazole 50% + Trifloxystrobin 25%) 75% WG @ 0.1%



c. T11: Control (untreated)

Plate 1: Evaluation of integrated spray schedule under field condition against *Alternaria* leaf blight of safflower.

References

1. Anonymous. Area, production and productivity of safflower. 2020. Available from: www.faostat.fao.org
2. Anonymous. Crop wise area, production and yield of oilseeds in India. 2022. Available from: www.eands.dacnet.nic.in
3. Dajue L, Mündel HH. Safflower, *Carthamus tinctorius* L. Rome: International Plant Genetic Resources Institute; 1996.
4. Furuya S. Growth diagnosis of rice plants by means of leaf color. Jpn Agric Res Q. 1987;20:147-153.
5. Gaurilčikienė I, Česnulevičienė R, Janušauskaitė D, Ronis A. Management of seed borne root and foot rot diseases of pea (*Pisum sativum* L.) with a fungicide seed treatment. Zemdirbyste Agric. 2012;99(1):77-84.
6. Gaurilčikienė I, Janušauskaitė D, Česnulevičienė R, Ramanauskienė J. The suppression of stem base and

7. Gilbert GS, Magarey PA, Suiter KA, O'Brien PT. Pathogen diversity and the effects of climate change on disease. J Plant Pathol. 2008;90(2):121-130.
8. Indi DV, Lukade GM, Patil PS, Shambharkar DA. Estimation of yield losses due to *Alternaria* leaf spot in safflower (caused by *Alternaria carthami* Chowdhary) under dryland conditions. Pesticides. 1988;22(1):41-43.
9. Kalpana Sastry R, Chattopadhyay C. Major biotic stresses affecting safflower production. J Mycol Plant Pathol. 2005;35(2):123-130.
10. Kalpana Sastry R, Chattopadhyay C, Varma A. Plant Pathology and Plant Diseases. New Delhi: Oxford and IBH Publishing Co.; 1993.
11. Majidi MM, Tavakoli V, Mirlohi A, Sabzaljan MR. Wild safflower species (*Carthamus oxyacanthus* Bieb.) a possible source of drought tolerance for arid environments. Aust J Crop Sci. 2011;5(8):1055-1063.
12. Nzojiyobiri JB, Xu T, Song-Feng M, Shen Y. Effect of *T. harzianum* strain NF9 against bacterial leaf blight of rice. Chin J Biol Control. 2003;19(3):111-114.
13. Panse VS, Sukhatme PV. Statistical Methods for Agricultural Workers. New Delhi: ICAR; 1985.
14. Rao VV, Ghosh SK, Patel RK. Economic impact of *Alternaria* leaf blight on safflower production in the Deccan Plateau. Agric Econ Res Rev. 2014;27(2):135-142.
15. Singh V, Prasad RD. Integrated Management of Pests and Diseases in Safflower. Hyderabad: Directorate of Oilseeds Research; 2005. p. 49.
16. Sujatha K, Singh P, Venkatesh B. Late maturity and susceptibility to diseases and pests in safflower. J Crop Improv. 2008;22(4):91-98.
17. Wagh SS, Suryawanshi AP, Pawar DV. Efficacy of fungicides, bioagents and phytoextracts against *Alternaria carthami* of safflower under *in vitro* conditions. J Pure Appl Microbiol. 2017;11(4):11-15.
18. Weiss EA. Oilseed Crops. 2nd ed. Oxford: Blackwell Science; 2000.