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Field evaluation of combination fungicides against *Alternaria* leaf spot and flower blight disease of marigold

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Leaf spot and flower blight in marigold incited by *Alternaria tagetica* is one of the major fungal diseasesin Chhotaudepur district of Gujarat. In recent years, it has become one of the major constraints in commercial cultivation of marigold.The field experiments were carried out for two consecutive years (2023 and 2024)during *kharif* season at the experimental field of College of Agriculture, A.A.U., Jabugam, Gujarat. The study was carried out to find out the most effective combination fungicides for the management of *Alternaria* leaf spot and flower blight disease of marigold. The experiment was laid out in a randomized block design with three replications and three concentrations of three combination fungicides, *e.g.* Metiram 55% + Pyraclostrobin 5% WG (Doses - 0.160, 0.210 and 0.260%), Tebuconazole 50% + Trifloxystrobin 25% WG (Doses - 0.0281, 0.0375 and 0.0460%) and Kresoxim-methyl 15% + Chlorothalonil 56% WG (Doses - 0.106. 0.142 and 0.177%), with untreated check comprising a total of ten treatments.Fungicides were sprayed two times at 15-days interval after initiation of disease. Results of the experiment showed that all the treatments were effective in reducing the disease intensity and good efficacies were obtained at higher concentrations. Among the treatments considered, Kresoxim-methyl 15% + Chlorothalonil 56% WG @ 0.177 % recorded the lowest leaf spot (22.86%) and flower blight disease intensity (21.97%), documented the highest flower yield (14.27t/ ha), caused 56.06% reduction of leaf spot, 58.78% reduction of flower blight disease intensity and 56.20% increment of flower yield over untreated check.

Keywords : *Alternaria,*flower blight,fungicides, leaf spot,Marigold,management

INTRODUCTION

Marigold (*Tagetesspp*.), native to Central and South America, is one of the most popular traditional flower crops grown commercially in different parts of India and Gujarat. In Gujarat, marigold is cultivated over an area of 9.23 thousand hectares with a production of 88.64 thousand tonnes (Anon., 2023).

The plant has economic importance due to its showy flowers, presence of phenolics, antioxidants, tagetes oil and anti-nematicidal properties (Khalil *et al.* 2007).

Inspite of insecticidal, nematicidal, larvicidal properties (Hooks *et al.,* 2010; Ravikumar, 2010), marigold is attacked by fungal, viral and bacterial diseases which resultsin yield losses. Important fungal diseases affecting marigold are *Alternaria* leaf spot (*Alternaria tagetica*), stem rot (*Phytophthora cryptogea*), damping off (*Pythium* sp.), *Fusarium* wilt (*Fusarium oxysporium*) and *Cercospora* leaf spot (*Cercospora megalo-potamica*). Among the fungal diseases, leaf spot and flower blight caused by *Alternaria tagetica* is one of the major destructive and economically important diseases and causes upto 50-60 % losses in flower yield (Shinde *et al.* 2018).

Many systemic fungicides with specific mode of action and non-systemic fungicides with multisite modes of action were used separately for managing the leaf spot and flower blight of marigold. From experiments conducted in past it

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was observed that non-systemic fungicide Mancozeb 75 WP (0.25%) was used in managing the disease (Barnal *et al*., 2002; Jash *et al*. 2004; Singh *et al.* 2010). Systemic fungicides like Carbendazim 50 WP (0.1%), Tebuconazole 25.9 EC (0.1%), Difenoconazole 25 EC (0.1%) and Propiconazole 25 EC (0.1%) were reported effective in reducing disease severity under field condition (Ram *et al.* 2002**;** Singh *et al*. 2006; Singh*et al.*2016).Combined application of systemic and non- systemic fungicides or systemic fungicides with different modes of action was not attempted on this disease of marigold crop. Combined application of systemic and non-systemic fungicides gives better results than their sole application (Karadimos and Karaoglanidis, 2007; Trivedi *et al.* 2021). But the sole and repeated use of systemic fungicide which has very specific mode of action may help in the rapid development of fungicide resistance (Fairchild *et al.* 2013), enhances the cost of management, the possibility of phytotoxicity and environmental concern over persistent residues, disrupts the activities of non-target beneficial micro-organisms and limit the usefulness against other pathogens except the target one. The application of combination fungicides prevents of resistance development in fungi, protects crop for longer duration (Wei *et al*. 2021), manages disease complex, reduces the number of sprays, is effective against broad spectrum of diseases and their successful control, has both protective and curative action in systemic + non-systemic fungicide combination or curative action in combination of systemic fungicide + systemic fungicide.To encounter the above -mentioned demerits of sole application of systemic fungicides and keeping the merits of application of combination fungicidesin mind, the experiments are being conducted for the management of various pathogensof vast array of crops. Chakraborty and Roy (2017) controlled both late and early blight of potato by using the combined formulation of Kresoxim-methyl 15% + Chlorothalonil 56% WG while Rathava *et al.* (2025) effectively managed the *Alternaria porri* causing purple blotch in onion by the application of same combination fungicides e.g. Kresoxim-methyl 15% + Chlorothalonil 56% WG.No research work for the management of leaf spot and flower blight disease of marigold and augmentation of its flower yield by using combination fungicides were done under the study location earlier. Keeping the above research gaps and merits of the combination fungicides in mind, the present study was conducted to evaluate the efficacy of different combination fungicides on the reduction *Alternaria* leaf spot and flower blight disease severities, incidence of flower blight and increment of flower yield of marigold.

MATERIALS AND METHODS

Field experimentswere conducted during the *kharif* season of 2023and 2024 at Agricultural Research Station, Anand Agricultural University, Jabugam, Gujarat. The experiment was laid out following randomized block design (RBD) comprising ten treatments and three replications (Fig.1). The area of each plot was measured 10.6 m^2 with a spacing of 60 × 60 cm.A gap of 2 meterswas given between replications for irrigation channels while 0.3 meters between treatments under each replication. The seeds of marigold cultivar Punjab Gainda-1were sown in nursery and 15 days old seedlings were transplanted in the experimental field. The concentration and quantity of formulation of the fungicides were determined utilizing 25 percent higher and 25 percent lower of standard doses(Table 1). Recommended agronomic practices were followed as and when necessary to raise the crop. Two foliar sprays of fungicides were given at 15 days interval. First spray was given just after initiation of disease symptoms in the experimental plots. Only water was sprayed for the untreated check.The disease intensities for leaf spot and flower blight as well as the incidences of flower blight were recorded at 15 day intervals after the first and second sprays from five selected plants under each treatment. Disease severity scoring was made on sixcompound leaves in accordance with the 0 – 5scale given by Hotchkiss and Baxter (1983). Similarly for flower blight severity, ten flowers from each plant were observed and scored based on 0-4 scale given by Dhiman and Arora (1990) (Table 2).The observations on flower blight incidence were recorded from 10 randomly selected plants of marigold and percent flower blight incidence was calculated by the following formula.

Table 1. Fungicides with concentrations and doses used against *Alternaria* leaf spot and flower blight disease

Tr. No.	Treatments	Conc. (%)	Quantity required (g or ml / 10 litre of water)	g.a.i./ha
T_1	Metiram 55% + Pyraclostrobin 5% WG	0.16	27.00	787.50
T_2	Metiram 55% + Pyraclostrobin 5% WG	0.21	35.00	1050.00
T_3	Metiram 55% + Pyraclostrobin 5% WG	0.26	44.00	1312.50
T_4	Tebuconazole 50% + Trifloxystrobin 25% WG	0.0281	3.75	140.62
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG	0.0375	5.00	187.50
T_6	Tebuconazole 50% + Trifloxystrobin 25% WG	0.046	6.25	234.37
T_7	Kresoxim-methyl 15% + Chlorothalonil 56% WG	0.106	15.00	532.50
T_8	Kresoxim-methyl 15% + Chlorothalonil 56% WG	0.142	20.00	710.00
T_9	Kresoxim-methyl 15% + Chlorothalonil 56% WG	0.177	25.00	887.50
T_{10}	Untreated check	-	-	-

Table 2. Disease rating scales used for recording leaf spot and flower blight severity

	Description of disease rating scale	
Scales	On leaves (Hotchkiss and Baxter, 1983)	On flowers (Dhiman and Arora, 1990)
0	No symptoms on leaf	Healthy
1	Up to 10% of leaf area covered by lesions	Up to 25 % flower area covered by the disease
2	11-20% of leaf area covered by lesions	26-50% flower area covered by the disease
3	21-30% of leaf area covered by lesions	51-75% flower area covered by the disease
4	31- 40% of leaf area covered by lesions	Whole of flower area covered by the disease symptom
5	More than 40% of leaf area covered by lesions	------

Flower Blight incidence (%) = No. of infected flowers ×100 Total no. of flowers per plant

The experimental data were analyzed following RBD design. Pooled analyses forleaf blight and flower blight disease intensity of first and second sprays were performed year-wise.The same were also performed year wise for leaf blight and flower blight disease severity, flower blight disease incidence and projected yield.

RESULTS AND DISCUSSION

-Symptoms on leaves and flowers of Marigold have been depicted in Fig. 2, A-C. The efficacy of combination fungicides with three doses each in 10 treatments including untreated check was examined against *Alternaria* leaf blight disease intensity during kharif 2023 and 2024 and the results of the experiment presented in Tables 3& 4.During 2023, all the treatments were effective

in reducing leaf spot disease intensity compared to untreated check. However, the lowest disease intensity of 24.11%, 26.67% and 25.39% was observed in treatment T_9 (Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177) after first, second and in pooled over sprays respectively**.**The same trendin lowest disease intensity was also recorded in T9 treatment at first (17.78%), second(22.89%) and pooled over sprays (20.33%) during 2024. When the leaf spot disease intensities were pooled for both the years, the same T9 treatment again exhibited the lowest disease intensity (22.86%) and highest reduction over control (56.06%) as compared to other treatments (Fig.2, D-E).

The effectiveness of three combination fungicides with three doses each was inspected during kharif 2023 and 2024 for *Alternaria* flower blight disease severity parameter and findings of the inspection were presented in Tables 5& 6.Inspectionson the efficacy of fungicides on *Alternaria* flower blight intensity after first spray during 2024 revealed that treatment T_6*i.e.*Tebuconazole 50% + Trifloxys-trobin 25% WG, 0.046, showed lower disease intensity (20.34%) which was *at par* with remaining treatments except untreated check. Data on flower blight disease intensity after second spray revealed that lowest disease intensity was observed in treatment T_9*i. e.*Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177 (20.83%) and was *at par* with T_3 (Metiram 55% + Pyraclostrobin 5% WG, 0.26), T_6 (Tebuconazole 50% + Trifloxystrobin 25% WG,0.046) and T_8 (Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.142). In pooled over spray, the same treatment *i.e.* T_9 (Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177) registered lowest flower blight disease intensity (20.97%) **.** The same trend lowest flower blight intensity was also recorded in T9 treatment after first (19.00%), secodn (26.97%) and Pooled over sprays (22.98%) during 2024. When the flower blight disease intensities were pooled for both the years, the same T9 treatment again documented the lowest disease intensity (21.97%) and highest reduction over control (58.78%) as compared to other treatments.

The efficacy of above mentioned 10 treatments on the incidence of flower blight incidence was tested duringkharif 2023 and 2024 and results of the efficacy testing were presented in Table 7.Among all the treatments, the lowest flower blight disease incidence (29.48%)was recorded in treatment T_9 *i. e.*Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177 not only during 2023 (29.48%) and 2024 (30.24%) but also in pooled over years (29.86%). During 2023, the flower blight disease incidence of treatment T9 was documented*at par* with all treatments except T1 (38.92%) and untreated check (70.09) When the flower blight disease incidences were pooled for both the years, the same T9 treatment again exhibited highest reduction over control (59.46%) compared to other treatments

The efficacy of the three combination fungicides with three doses in 10 treatments were also examined during kharif 2023 and 2024 and pooled over years on flower yield and its increment. The results of the experimental finding were presented in Table 8.The highest projected flower yield in kg/ ha, and percent yield increment over control during 2023, 2024 and pooled over years were recorded in treatment T_9*i. e.*Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177 as 14.17 t/ha and 53.91% in 2023, 14.38 t/ha and 58.48% in 2024 as well as 14.27 kg/ha and 56.20% in pooled over years.

Combine fungicides contain the mixture two or more active ingredients with different modes of action. They have the capacity to control broad spectrum of diseases, improve disease control efficiency through synergy (Wei *et al.* 2021), manage or delay disease resistance, may have curative or both protective and curative actions, can control disease complexes and reduce the number of sprays. Keeping the above advantages in mind, combination fungicides are being used for the various diseases in different crops. In the present experiment we used three combination fungicides with three different doses *e.g.* Metiram 55% + Pyraclostrobin 5% WG (Doses - 0.160, 0.210 and 0.260%), Tebuconazole 50% + Trifloxystrobin 25% WG (Doses - 0.0281, 0.0375 and 0.0460%) and Kresoxim-methyl 15% + Chlorothalonil 56% WG (Doses - 0.106. 0.142 and 0.177%). Out of nine treatments, Kresoxim-

Fig.1: Experimental Field set up of Marigold

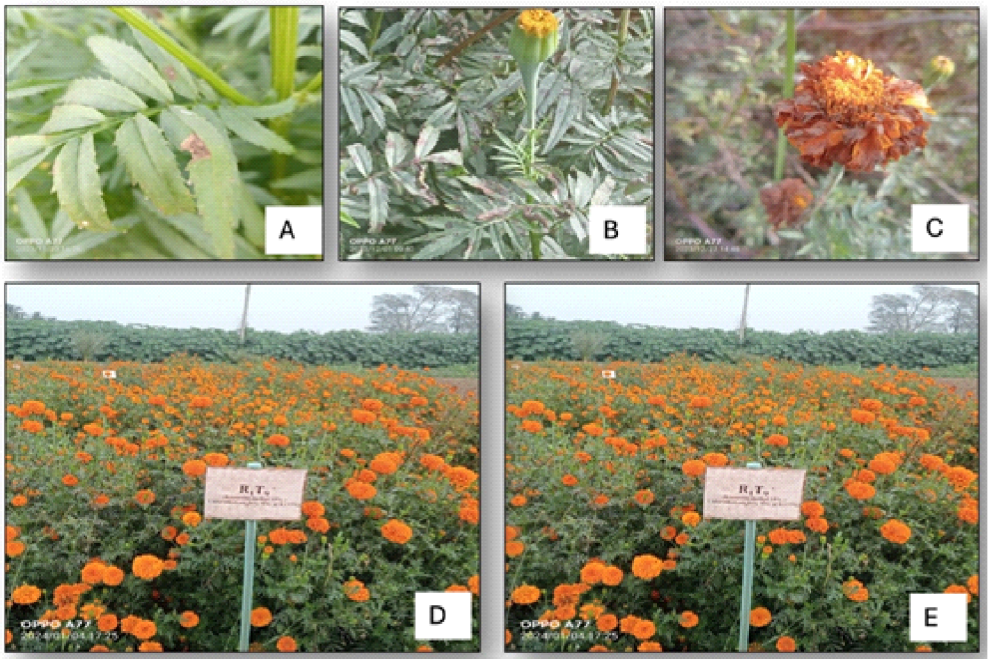

Fig.2: Symptoms on leaves (A,B) and flowers (C) of Marigold. Control (D) and treated (T-9) plants in field

Per cent disease index (PDI) was calculated by following formula described by Wheeler (1969).

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{No. of leaves observed} \times \text{Maximum rating scale}} \times 100$$

methyl 15% + Chlorothalonil 56% WG with dose of 0.177% was found best with lowest leaf blight and flower blight disease severity, lowest percent flower blight disease incidence and highest flower yield. The same treatment caused the highest percent reduction of disease severity and incidence parameters as well as caused the highest increment of flower yield over control. The efficacy of Kresoxim-methyl 15% + Chlorothalonil 56% WG as observed here was also observed by many workers who also found that combination treatments were effective in disease

Table3 : Efficacy of combination fungicides against *Alternaria* leaf spot disease intensity in marigold during *kharif,*2023and 2024.

Tr. No	Treatments	Disease intensity (%) 2023 Before spray	2023 1st spray	2023 2nd spray	2023 Pooled over sprays	2024 Before spray	2024 1st spray	2024 2nd spray	2024 Pooled over sprays
T_1	Metiram 55% + Pyraclostrobin 5% WG, 0.16	*15.41 (23.06)	30.44 (33.46)^{b}	37.56 (37.75)^{b}	34.00 (35.60)^{b}	13.09 (21.03)	28.22 (32.05)^{b}	41.33 (39.99)^{b}	34.77 (36.02)^{b}
T_2	Metiram 55% + Pyraclostrobin 5% WG, 0.21	14.22 (22.11)	29.66 (32.97)^{bc}	35.78 (36.70)^{b}	32.72 (34.84)^{bc}	11.56 (19.84)	23.83 (29.08)^{bcd}	38.00 (38.03)^{bc}	30.91 (33.55)^{bc}
T_3	Metiram 55% + Pyraclostrobin 5% WG, 0.26	16.22 (23.61)	26.67 (31.07)^{bc}	31.11 (33.83)^{bc}	28.89 (32.45)^{cd}	12.00 (20.26)	20.22 (26.64)^{cd}	30.00 (33.18)^{e}	25.11 (29.91)^{d}
T_4	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0281%	16.00 (23.42)	31.33 (33.94)^{b}	34.67 (36.04)^{bc}	33.00 (34.99)^{bc}	13.56 (21.57)	24.00 (29.28)^{bcd}	40.00 (39.20)^{bc}	32.00 (34.24)^{bc}
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0375	14.44 (22.25)	28.00 (31.92)^{bc}	34.97 (36.21)^{b}	31.48 (34.07)^{bc}	12.44 (20.61)	25.78 (30.47)^{bc}	36.89 (37.38)^{bcde}	31.33 (33.92)^{bc}
T_6	Tebuconazole 50% + Trifloxystrobin 25% WG, 0.046	13.78 (21.73)	28.67 (32.35)^{bc}	29.78 (32.99)^{bc}	29.22 (32.67)^{bcd}	12.22 (20.44)	20.89 (27.14)^{c}	33.11 (35.10)^{cde}	27.00 (31.12)^{cd}
T_7	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.106	16.44 (23.88)	27.78 (31.79)^{bc}	32.67 (34.79)^{bc}	30.22 (33.29)^{bc}	11.78 (20.04)	25.56 (30.320^{cd}	37.33 (37.64)^{bcd}	31.45 (33.98)^{bc}
T_8	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.142	15.78 (23.31)	26.89 (31.20)^{bc}	30.89 (33.74)^{bc}	28.89 (32.47)^{bcd}	14.00 (21.93)	22.90 (28.530^{bc}	32.66 (34.80)^{de}	27.78 (31.65)^{cd}
T_9	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177	14.89 (22.65)	24.11 (29.35)^{c}	26.67 (31.07)^{c}	25.39 (30.21)^{d}	11.78 (20.00)	17.78 (24.85)^{d}	22.89 (28.55)^{f}	20.33 (26.70)^{e}
T_{10}	Untreated check	16.22 (23.71)	38.44 (38.29)^{a}	64.44 (53.39)^{a}	51.44 (45.84)^{a}	13.33 (21.39)	35.34 (36.44)^{a}	70.00 (56.86)^{a}	52.67 (46.65)^{a}
S.Em.± Treatment (T)		1.31	1.12	1.50	0.94	0.97	1.54	1.42	1.01
	Spray (S)	-	-	-	0.42	-	-	-	0.45
	T X S	-	-	-	1.33	-	-	-	1.44
CD at 5%	Treatment (T)	NS	3.31	4.47	2.69	NS	4.57	4.21	2.91
	Spray (S)	-	-	-	1.20	-	-	-	1.30
	T X S	-	-	-	3.81	-	-	-	4.12
	C.V. (%)	9.86	5.92	7.11	6.55	8.11	9.04	6.45	7.39

Note: 1. *Figures in parentheses are arc sine transformed values and those outside are original values.
2. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. Ns: Non significant

Table 4. Efficacy of combination fungicides against *Alternaria* leaf blight in marigold during *kharif,* 2023 and 2024

Tr. No	Treatments		Leaf blight Intensity (%) 2023	2024	Pooled over years	Disease reduction over control (%)
T_1	Metiram 55% + Pyraclostrobin 5% WG, 0.16		34.00 (35.60)^{b}	34.77 (36.02)^{b}	34.38 (35.81)^{b}	33.94
T_2	Metiram 55% + Pyraclostrobin 5% WG, 0.21		32.72 (34.84)^{bc}	30.91 (33.55)^{bc}	31.81 (34.20)^{bc}	38.88
T_3	Metiram 55% + Pyraclostrobin 5% WG, 0.26		28.89 (32.45)^{cd}	25.11 (29.91)^{d}	27.00 (31.18)^{e}	48.12
T_4	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0281%		33.00 (34.99)^{bc}	32.00 (34.24)^{bc}	32.50 (34.61)^{b}	37.56
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0375		31.48 (34.07)^{bc}	31.33 (33.92)^{bc}	31.40 (33.99)^{bcd}	39.67
T_6	Tebuconazole 50% + Trifloxystrobin 25% WG, 0.046		29.22 (32.67)^{bcd}	27.00 (31.12)^{cd}	28.11 (31.89)^{de}	45.99
T_7	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.106		30.22 (33.29)^{bc}	31.45 (33.98)^{bc}	30.83 (33.63)^{bcd}	40.76
T_8	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.142		28.89 (32.47)^{bcd}	27.78 (31.65)^{cd}	28.33 (32.06)^{cde}	45.57
T_9	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177		25.39 (30.21)^{d}	20.33 (26.70)^{e}	22.86 (28.45)^{f}	56.06
T_{10}	Untreated check		51.44 (45.84)^{a}	52.67 (46.65)^{a}	52.05 (46.24)^{a}	-
	S.Em.±	Treatment (T)	0.94	1.01	0.69	
		Spray (S)	0.42	0.45	1.61	
		Year (Y)	-	-	0.31	
		T X S	1.33	1.44	0.98	
		T X Y	-	-	0.98	
		S X Y	-	-	0.43	
		T X S X Y	-	-	1.38	
	CD at 5%	Treatment (T)	2.69	2.91	1.95	
		Spray (S)	1.20	1.30	NS	
		Year (Y)	-	-	NS	
		T X S	3.81	4.12	2.76	
		T X Y	-	-	NS	
		S X Y	-	-	1.23	
		T X S X Y	-	-	NS	
		C.V. (%)	6.65	7.39	7.02	

Note: *Figures in parentheses are arc sine transformed values and those outside are original values.Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance **NS**: Non-significant

Table 7: Efficacy of combination fungicides against *Alternaria* flower blight incidence in marigold during *kharif,* 2023 and 2024

Tr. No	Treatments	Flower blight incidence (%)			Disease reduction over control (%)
		2023	2024	Pooled over years	
T_1	Metiram 55% + Pyraclostrobin 5% WG, 0.16	38.92 (38.58)^{b}	43.56 (41.28)^{b}	41.24 (39.93)^{b}	44.01
T_2	Metiram 55% + Pyraclostrobin 5% WG, 0.21	35.54 (36.57)^{bc}	40.71 (39.62)^{bc}	38.12 (38.10)^{bc}	48.24
T_3	Metiram 55% + Pyraclostrobin 5% WG, 0.26	32.45 (34.68)^{bc}	38.74 (38.45)^{bc}	35.59 (36.57)^{c}	51.68
T_4	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0281%	34.66 (36.04)^{bc}	40.04 (39.23)^{bc}	37.35 (37.63)^{bc}	49.29
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0375	36.77 (37.29)^{b}	38.41 (38.26)^{bc}	37.59 (37.78)^{bc}	48.96
T_6	Tebuconazole 50% + Trifloxystrobin 25% WG, 0.046	33.14 (35.07)^{bc}	35.49 (36.54)^{c}	34.31 (35.81)^{c}	53.42
T_7	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.106	35.19 (36.37)^{bc}	40.98 (39.77)^{bc}	38.08 (38.07)^{bc}	48.30
T_8	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.142	33.82 (35.54)^{bc}	36.68 (37.25)^{c}	35.25 (36.39)^{c}	52.14
T_9	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177	29.48 (32.82)^{c}	30.24 (33.34)^{d}	29.86 (33.08)^{d}	59.46
T_{10}	Untreated check	70.09 (56.85)^{a}	77.23 (61.51)^{a}	73.66 (59.18)^{a}	-
	S.Em.± Treatment (T)	1.22	0.99	0.76	
	Year (Y)	-	-	0.35	
	T X Y	-	-	1.10	
	CD at 5% Treatment (T)	3.62	2.95	2.17	
	Year (Y)	-	-	3.18	
	T X Y	-	-	NS	
	C.V. (%)	5.55	4.24	4.90	

Note: *Figures in parentheses are arc sine transformed values and those outside are original values . Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
NS: Non-significant

Table 8. Effect of combination fungicides on flower yield in marigold during *kharif,* 2023 and 2024

Tr. No	Treatments	Flower yield (t/ha)			Yield increase over control (%)
		2023	2024	Pooled	
T_1	Metiram 55% + Pyraclostrobin 5% WG, 0.16	10.03^{b}	9.43^{b}	9.73^{c}	35.76
T_2	Metiram 55% + Pyraclostrobin 5% WG, 0.21	10.91^{b}	10.05^{b}	10.48^{bc}	40.36
T_3	Metiram 55% + Pyraclostrobin 5% WG, 0.26	12.12^{ab}	12.00^{ab}	12.06^{b}	48.17
T_4	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0281%	10.24^{b}	10.02^{b}	10.13^{c}	38.30
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0375	10.85^{b}	10.70^{b}	10.87^{bc}	42.50
T_6	Tebuconazole 50% + Trifloxystrobin 25% WG, 0.046	10.94^{b}	11.27^{b}	11.10^{bc}	43.69
T_7	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.106	10.76^{b}	10.68^{b}	10.72^{bc}	41.69
T_8	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.142	11.40^{ab}	10.94^{b}	11.19^{bc}	44.14
T_9	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177	14.17^{a}	14.38^{a}	14.27^{a}	56.20
T_{10}	Untreated check	6.53^{c}	5.97^{c}	6.25^{d}	-
	S.Em.± Treatment (T)	0.89	0.82	0.54	
	Year (Y)	-	-	0.27	
	T X Y	-	-	0.85	
	CD at 5% Treatment (T)	2.64	2.43	1.56	
	Year (Y)	-	-	2.4	
	T X Y	-	-	NS	
	C.V. (%)	14.24	13.43	13.85	

Note: 1. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
2. NS: non-significant

Table 5 : Efficacy of combination fungicides against *Alternaria* flower blight in marigold during *kharif,* 2023 and 2024

Tr. No	Treatments	Disease intensity (%) 2023				2024			
		Before spray	1st spray	2nd spray	Pooled over sprays	Before spray	1st spray	2nd spray	Pooled over sprays
T_1	Metiram 55% + Pyraclostrobin 5% WG, 0.16	*13.06 (21.07)	25.83 (30.50)^{b}	32.22 (34.51)^{b}	29.02 (32.50)^{b}	10.33 (18.71)	27.50 (31.61)^{b}	36.33 (37.04)^{b}	31.91 (34.32)^{b}
T_2	Metiram 55% + Pyraclostrobin 5% WG, 0.21	13.61 (21.58)	22.22 (28.06)^{b}	31.39 (33.96)^{b}	26.80 (31.01)^{b}	8.67 (17.07)	25.00 (29.95)^{b}	34.50 (35.94)^{bc}	29.75 (32.94)^{bc}
T_3	Metiram 55% + Pyraclostrobin 5% WG, 0.26	13.65 (21.60)	24.05 (29.22)^{b}	26.95 (31.23)^{bc}	25.50 (30.22)^{bc}	11.00 (19.27)	22.33 (28.16)^{bc}	28.83 (32.41)^{cd}	25.58 (30.28)^{de}
T_4	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0281%	13.89 (21.72)	22.78 (28.43)^{b}	30.84 (33.67)^{b}	26.81 (31.05)^{b}	8.17 (16.49)	27.00 (31.28)^{b}	34.00 (35.64)^{bc}	30.50 (33.46)^{bc}
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0375	15.00 (22.69)	26.64 (31.01)^{b}	30.33 (33.40)^{b}	28.48 (32.20)^{b}	9.33 (17.74)	24.83 (29.86)^{b}	36.00 (36.84)^{b}	30.41 (33.35)^{bc}
T_6	Tebuconazole 50% + Trifloxystrobin 25% WG, 0.046	13.06 (21.14)	20.34 (26.79)^{b}	27.22 (31.37)^{bc}	23.78 (29.08)^{bc}	11.00 (19.22)	22.83 (28.45)^{bc}	31.00 (33.79)^{bcd}	26.91 (31.12)^{cd}
T_7	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.106	13.06 (21.14)	26.11 (30.69)^{b}	31.39 (34.02)^{b}	28.75 (32.36)^{b}	13.50 (21.52)	26.17 (30.74)^{b}	34.83 (36.14)^{bc}	30.50 (33.44)^{bc}
T_8	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.142	14.93 (22.65)	24.17 (29.41)^{b}	27.50 (31.58)^{bc}	25.83 (30.50)^{bc}	8.83 (17.19)	27.50 (31.58)^{b}	31.83 (34.31)^{bcd}	29.66 (32.95)^{bc}
T_9	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177	14.72 (22.44)	21.11 (27.31)^{b}	20.83 (27.11)^{c}	20.97 (27.21)^{c}	8.83 (17.25)	19.00 (25.83)^{c}	26.97 (31.25)^{d}	22.98 (28.54)^{e}
T_{10}	Untreated check	15.56 (23.16)	35.83 (36.71)^{a}	69.72 (56.60)^{a}	52.77 (46.65)^{a}	12.00 (20.18)	35.17 (36.33)^{a}	72.50 (58.35)^{a}	53.83 (47.34)^{a}
S.Em.± Treatment (T)		1.50	1.59	1.65	1.11	1.19	1.09	1.13	0.76
	Spray (S)	-	-	-	0.49	-	-	-	0.34
	T X S	-	-	-	1.57	-	-	-	1.08
CD at 5% Treatment (T)		NS	4.73	4.89	3.19	NS	3.23	3.35	2.19
	Spray (S)	-	-	-	1.42	-	-	-	0.98
	T X S	-	-	-	4.51	-	-	-	3.11
	C.V. (%)	11.88	9.25	8.21	8.47	11.88	6.20	5.26	5.57

1. *Figures in parentheses are arc sine transformed values and those outside are original values.
2. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
Ns: Non significant

control (Karadimos and Karaoglanidis, 2007**;** Chakraborty and Roy, 2017; Anand, 2021; Disha and Patel, 2022). Karadimos and Karaoglanidis (2007**)** evaluated the effectivity of strobilurin fungicides against *Cercospora* leaf spot. Azoxystrobin provided a modest to poor control efficacy whereas Kresoxim-methyl provided only poor disease control efficacy but the Azoxystrobin-containing mixtures provided significantly better control compared with that obtained by single applications of each mixture component. Chakraborty and Roy (2017) studied the efficacy of Kresoxim-methyl 15% + Chlorothalonil 56% WG against early and late blight pathogens and observed that the fungicide pre-mixture was highly effective in controlling both late and early blight disease of potato in terms of per cent intensity of the disease and tuber yield. Ishieze *et al.* (2023) after conducting an*in vitro* experiment came into conclusion that the combination of Mancozeb 63% + Carbendazim 12% exhibited higher mycelial growth inhibition of *A. brassicola*, causing black rot of cabbage, indicating the superiority of the combination fungicide over systemic fungicide alone. The fungicides were also found to control the disease under field condition. Rathava *et al.* (2025) evaluated different fungicides against *Alternaria porri* causing purple blotch in onion and found Kresoxim-methyl 15% + Chlorothalonil 56% WG @ 0.177 was most effective in managing the disease.

Considering overall efficacy of the fungicides, it may be concluded that two foliar sprays of Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177 % (25 g per 10 litre of water), first at the appearance of disease and second spray at 15 days after first spray can be used for effective management of *Alternaria* leaf spot and flower blight in marigold.

Table 6. Efficacy of combination fungicides against *Alternaria*flower blight in marigold during *kharif,* 2023 and 2024

Tr. No	Treatments		Flower blight intensity (%)			Disease reduction over control (%)
			2023	2024	Pooled over years	
T_1	Metiram 55% + Pyraclostrobin 5% WG, 0.16		29.02 (32.50)^{b}	31.91 (34.32)^{b}	30.46 (33.41)^{b}	42.85
T_2	Metiram 55% + Pyraclostrobin 5% WG, 0.21		26.80 (31.01)^{b}	29.75 (32.94)^{bc}	28.27 (31.98)^{bcd}	46.96
T_3	Metiram 55% + Pyraclostrobin 5% WG, 0.26		25.50 (30.22)^{bc}	25.58 (30.28)^{de}	25.54 (30.25)^{cd}	52.08
T_4	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0281%		26.81 (31.05)^{b}	30.50 (33.46)^{bc}	28.65 (32.25)^{bc}	46.24
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG,0.0375		28.48 (32.20)^{b}	30.41 (33.35)^{bc}	29.44 (32.78)^{b}	44.76
T_6	Tebuconazole 50% + Trifloxystrobin 25% WG, 0.046		23.78 (29.08)^{bc}	26.91 (31.12)^{cd}	25.34 (30.10)^{d}	52.45
T_7	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.106		28.75 (32.36)^{b}	30.50 (33.44)^{bc}	29.62 (32.90)^{b}	44.42
T_8	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.142		25.83 (30.50)^{bc}	29.66 (32.95)^{bc}	27.74 (31.72)^{bcd}	47.95
T_9	Kresoxim-methyl 15% + Chlorothalonil 56% WG, 0.177		20.97 (27.21)^{c}	22.98 (28.54)^{e}	21.97 (27.87)^{e}	58.78
T_{10}	Untreated check		52.77 (46.65)^{a}	53.83 (47.34)^{a}	53.30 (47.00)^{a}	-
	S.Em.±	Treatment (T)	1.11	0.76	0.67	
		Spray (S)	0.49	0.34	0.65	
		Year (Y)	-	-	0.30	
		T X S	1.57	1.08	0.95	
		T X Y	-	-	0.95	
		S X Y	-	-	0.42	
		T X S X Y	-	-	1.35	
	CD at 5%	Treatment (T)	3.19	2.19	1.91	
		Spray (S)	1.42	0.98	NS	
		Year (Y)	-	-	0.85	
		T X S	4.51	3.11	2.70	
		T X Y	-	-	NS	
		S X Y	-	-	1.20	
		T X S X Y	-	-	NS	
		C.V. (%)	8.47	5.57	7.10	

Note: *Figures in parentheses are arc sine transformed values and those outside are original values.Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

NS: Non-significant

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