Original Research Article

EFFECTIVENESS OF DIFFERENT FUNGICIDES IN COMBATING TOMATO POWDERY MILDEWIN INDIA

ABSTRACT

A field study was conducted to evaluate the efficacy of various fungicides against powdery mildew of tomato. Add synthesis of the metodology…..in two seasons of the year (……..)….in Bengaluru, India…….The results indicated that combination fungicides were significantly ($p<0.05$?)more effective than solo fungicides. Picoxystrobin 6.78% + Tricyclazole 20.33% SC applied at 2 ml/l achieved the owest percent disease index (PDI) of 14% in the first season, with a 74.77% reduction over the control (55.50% PDI). This was closely followed by Azoxystrobin 18.2% + Difenoconazole 11.4% SC at 1.2 ml/l, which recorded a PDI of 14.50% and a 73.87% reduction. In the second season, similar trends were observed with Picoxystrobin 6.78% + Tricyclazole 20.33% SC achieving a PDI of 13.50% and a 74.53% reduction, followed by Azoxystrobin 18.2% + Difenoconazole 11.4% SC with a PDI of 14% and a 73.58% reduction. Pooled data from both seasons confirmed these findings, showing Picoxystrobin 6.78% + Tricyclazole 20.33% SC with a PDI of 13.75% and a 74.65% reduction, and Azoxystrobin 18.2% + Difenoconazole 11.4% SC with a PDI of 14.25% and a 73.73% reduction. The highest PDIs were noted in the Carbendazim 50% WP and Hexaconazole 5% SC treatments. The study highlights the inefficacy of relying on a single fungicide due to resistance development, suggesting combination fungicides as a more effective strategy for managing powdery mildew in tomatoes.It is possible advancing with broader integrated disease sustainable management strategies to protection of environment, crop protection and yield.

Keywords: Tomato, *Oidium neolycopersici*, powdery mildew, Tebuconazole, Trifloxystrobin

INTRODUCTION

One of the most widely grown horticulture crops in the world is the tomato (*Solanum lycopersicum*), which is native to the Andes of South America. It may be grown in a variety of regions, from tropical to temperate, and it can also be grown indoors when the weather outside is unfavourable. After potatoes, tomatoes are the vegetable that people consume the most globally [1]. Tomatoes are used in a wide range of applications and are essential to a nutritious diet, which has led to a surge in the production of both processed and fresh types globally in recent years [2]. There are 161.7 million metric tonnes of tomatoes produced worldwide, with a market value of $59 billion. The production of tomatoes in the USA adds 13.2 million metric tonnes, worth $5 billion, to global output. After China and India, the USA comes in third place in terms of tomato output globally [3].add the importance in the country of the study

Powdery mildew of tomato caused by *Oidium neolycopersici* has become an important disease problem worldwide in both field and greenhouse production since outbreaks of this disease reported in Europe, North and South America and Asia in the early 1990. The disease mainly affects leaves, causing yellowing, drying, necrosis and defoliation. The powdery mildew is a dangerous pathogen, which spread through temperate areas of the world and the disease can cause up to 50 per cent yield losses in tomato [4].In India…..

Numerous bacterial, viral, fungal, and nematode illnesses have made it difficult to produce tomatoes for commercial purposes. Among fungal diseases, such as powdery mildew, have hampered tomato production. Due to severe selection and inbreeding during evolution and domestication, the cultivated tomato has a limited genetic diversity [5] making it more susceptible to disease epidemics. In contrast, wild tomato species are more disease resistant than tomato species that are grown in a greenhouse. Many systemic and non-systemic fungicides were reported to manage the powdery mildew of tomato.Add some studies on the effectiveness of using combined fungicides…. The information on the efficacy of new combi- fungicides against powdery mildew of tomato is insufficientin India. Hence, there is a need to evaluate new fungicides against powdery mildew of tomato. By considering the seriousness of diseases and the economic damage caused by the diseases, the present investigation was carried out by using new formulation of chemicals for its efficacy against powdery mildew of tomato.

MATERIALS AND METHODto complete…..

Study site….. locality, environmental conditions, plots etc.The experiments were conducted in two seasons (   ) to evaluate different fungicides against powdery mildew of tomato. The experiment was laid out in Randomized Block Design with three replications and seven treatments. Sprayings were done three times. It is necessary to explain and perform statistical analysis to see significative differences between treatments. Observations on disease were recorded 10 days after each spray. The PDI (Per cent Disease Index) was assessed based on visual observation and graded in 0-5 scale (Table 1) [6]

and PDI was calculated as per the standard formula given by [7]. The treatment details have been provided in **table 2**.

$$\text{Per cent disease index} = \frac{\text{Sum of all disease ratings}}{\text{Total No. of leaves observed}} \times \frac{100}{\text{Maximum disease rating}}$$

RESULTS

A field study was conducted to evaluate different fungicides against powdery mildew of tomato. Combi fungicides were more effective than solo fungicides in controlling the disease. Picoxystrobin 6.78% + Tricyclazole 20.33% SC @ 2 ml/lrecorded least PDI of 14% compared to control 55.50% with 74.77% reduction over control followed by Azoxystrobin 18.2% + Difenoconazole 11.4% SC @ 1.2 ml/l(14.50%) with 73.87% of reduction over control. Highest PDI was recorded in the treatment Carbendazim 50% WP @ 1 gm/l with 30.33% of PDI followed by Hexaconazole 5% SC @ 1 ml/l (24.50 %). Control recorded 55.50 % of PDI **(Table 3)**.In 2nd season Picoxystrobin 6.78% + Tricyclazole 20.33% SC @ 2 ml/lrecorded least PDI of 13.50 % compared to control 53.00 % with 74.53 % reduction over control followed by Azoxystrobin 18.2% + Difenoconazole 11.4% SC @ 1.2 ml/l(14.00 %) with 73.58 % of reduction over control. Highest PDI was recorded in the treatment Carbendazim 50% WP @ 1 gm/l with 28.33 % of PDI followed by Hexaconazole 5% SC 1 ml/l (23.00 %). Control recorded 53.00 % of PDI **(Table 4).**

In the pooled data of two seasons Picoxystrobin 6.78% + Tricyclazole 20.33% SC @ 2 ml/lrecorded least PDI of 13.75 % compared to control 54.25 % with 74.65 % reduction over control of the disease which is followed by Azoxystrobin 18.2% + Difenoconazole 11.4% SC @ 1.2 ml/l(14.25 %) with 73.73 % of reduction over control. Highest PDI was recorded in the treatment Carbendazim 50% WP @ 1 gm/l with 29.33 % of PDI followed by Hexaconazole 5% SC 1 ml/l (23.75 %). Control recorded 54.25 % of PDI **(Table 5).**

DISCUSSIONupdate with recent scientific literature

The results of the efficacy study indicate that combination fungicides, or combo fungicides, are substantially more successful than solo fungicides at controlling tomato powdery mildew. The lowest percent disease index (PDI) was recorded with Picoxystrobin 6.78% + Tricyclazole 20.33% SC at 2 ml/l, which achieved a PDI of 14% in the first season and 13.50% in the second season, with overall reductions of 74.77% and 74.53% over control, respectively. Similarly, Azoxystrobin 18.2% + Difenoconazole 11.4% SC at 1.2 ml/l showed comparable efficacy, with PDIs of 14.50% and 14.00%, resulting in reductions of 73.87% and 73.58% over control in the respective seasons.

The efficacy of these combi fungicides may be attributed to their ability to target multiple sites within the pathogen, thus reducing the risk of resistance development [8]. This is particularly important as continuous usage of a single fungicide can lead to the development of resistant strains, diminishing the fungicide's effectiveness over time. [8] insights into fungicide resistance highlight the necessity for integrated use of fungicides to manage disease effectively. The pooled data across two seasons confirmed the superior performance of combi fungicides. Picoxystrobin 6.78% + Tricyclazole 20.33% SC recorded a PDI of 13.75%, with a 74.65% reduction over control, while Azoxystrobin 18.2% + Difenoconazole 11.4% SC achieved a PDI of 14.25% and a 73.73% reduction. These results are consistent with previous studies that emphasize the enhanced efficacy of combi fungicides in managing various plant diseases [9-10]. In contrast, solo fungicides such as Carbendazim 50% WP and Hexaconazole 5% SC were less effective, with PDIs of 30.33% and 24.50%, respectively, in the first season, and 28.33% and 23.00% in the second season. This lower efficacy may be due to the development of resistance in the pathogen populations, as suggested by several researchers [11- 14]. The continuous use of these fungicides has likely led to a selection pressure favoring resistant strains of the pathogen, thereby reducing the fungicides' overall effectiveness.

The findings of this study align with previous research indicating that combi fungicides are more efficient in disease management due to their multi-site action, which minimizes the likelihood of resistance development [8]. Additionally, the results corroborate the observations of [15], who reported the superior performance of combi fungicides in managing powdery mildew in mango and other crops. This study demonstrates the enhanced efficacy of combination fungicides in controlling powdery mildew of tomato, underscoring the importance of integrating multiple modes of action to manage fungicide resistance.Add new option with biocontrol you can see the paper: Fighting Tomato Fungal Diseases with a Biocontrol Product Based on Amoeba Lysate,and its references.

CONCLUSION

The field study demonstrated that combination fungicides are significantly more effective in controlling powdery mildew of tomato compared to solo fungicides. Picoxystrobin 6.78% + Tricyclazole 20.33% SC and Azoxystrobin 18.2% + Difenoconazole 11.4% SC consistently achieved the lowest percent disease index (PDI) and highest reduction over control across two seasons. These findings underscore the importance of using combination fungicides to target multiple sites within the pathogen, thereby minimizing the risk of resistance development and improving disease management efficacy. Future research should explore the long-term sustainability and environmental impacts of combi fungicides, as well as their integration into broader integrated disease management strategies to crop protection and yield.

ETHICAL STATEMENT

All the experimental procedures involving only on plant species were conducted following the University of Agricultural Science, Bangalore institutional guidelines. There are no human and animal subjects/trials conducted in this article and informed consent is not applicable.

DISCLOSURE STATEMENT

The authors declare that there are no financial/commercial conflicts of interest.

REFERENCES add some references from recent years

1. Foolad, M.R. Genome mapping and molecular breeding of tomato. Int. J. Plant Genomics, 2007; 64358.
2. Rajeev, K.V. and Roberto, T. Translational Genomics for Crop Breeding, Volume I: Biotic Stress, First Edition. John Wiley & Sons, Inc., 2013.
3. FAOSTAT Database. Available online: http://faostat.fao.org/site/339/default.aspx (accessed on 19 September 2017).

4. Cerkauskas, R.F., Ferguson, G., and Banik, M. Powdery mildew (Leveillula taurica) on greenhouse and field peppers in Ontario-host range, cultivar response and disease management strategies. Can. J. Plant Pathol., 2011; 33: 485-498.
5. Zhang, L.P., Khan, A., Nino-Liu, D. and Foolad, M.R. A molecular linkage map of tomato displaying chromosomal locations of resistance gene analogs based on a Lycopersicon esculentum × Lycopersicon hirsutum cross. Genome, 2002; 45: 133–146.
6. Correll, J.C., Thomas, R.G. and Vern, J.E. The epidemiology of powdery mildew on tomatoes. California Agriculture, March-April, 1988; pp: 8-10.
7. Wheeler, B.E.J. An introduction to plant disease. John Wiley and Sons Ltd., London, 1969; 301.
8. Staub, T. Fungicide resistance: practical experience and anti-resistance strategies and the role of integrated use. Annu. Rev. Phytopathol., 1991; 29: 421-442.
9. Kumar, A. and Solanki, S.C. Management of blossom blight and leaf anthracnose of mango using fungicides. Int. J. Plant Prot., 2014; 7(2): 453-455.
10. Sharma, H., Kalaria, G.B., Ghoghari, P.D. and Khandelwal, V. Bioefficacy of different chemical fungicides for the management of mango powdery mildew in south Gujarat. J Mycol. Pl. Pathol., 2012; 42(4): 494-496.
11. Palti, J., Pinkas, Y. and Chorin, M. Powdery mildew of mango. Plant Dis. Reptr., 1974; 58: 45-49.
12. Prakash, O. and Singh, U.N. Evaluation of various fungicides for the control of powdery mildew of mango caused by Oidium mangiferae. Pesticides, 1982; 16: 17-18.
13. Rawal, R.D. and Ullasa, B.A. Control of powdery mildew (Oidium mangiferae Berth.) of mango by fungicides. Proc. Second International Symposium held at Bangalore in 1985 (India), 1989; pp. 534-536.
14. Ray, S.K. Efficacy of different fungicides for management of powdery mildew of mango in West Bengal. 2003.
15. Tahir, H.A.S., Sahi, S.T., Iqbal, M., Sahi, G.M. and Atif, M. Evaluation of new fungicides against powdery mildew of mango (Mangifera indica). 2009.

Table 1. Powdery mildew of tomato disease rating scale

Score	Description
0	No visible symptoms and no apparent defoliation
1	<10% Leaves with lesions and minimal defoliation
2	Approximately 25% of leaves with lesions and 10% defoliation
3	Approximately 50% of leaves with lesions and 25% defoliation
4	Approximately 75% of leaves with lesions and 50% defoliation
5	Most leaves (>90%) with lesions and extensive defoliation (75%)

Table 2. Treatment details

Sl. No.	Treatments	Dosage/L (g/ml)
1	Tebuconazole 50% + Trifloxystrobin 25% WG	0.4
2	Azoxystrobin 18.2% + Tebuconazole 18.3% SC	1.0
3	Azoxystrobin 18.2% + Difenoconazole 11.4% SC	1.2
4	Picoxystrobin 6.78% + Tricyclazole 20.33% SC	2.0
5	Hexaconazole 5% SC	1.0
6	Carbendazim 50% WP	1.0
7	Control	-

Table 3. Bio-efficacy of novel fungicides on Powdery mildew of tomato (first season)

Sl. No	Chemical treatments	Dosage/L (g/ml)	PDI at different intervals (Days)							Reduction over control (%)
			Before First spray	10 days after first spray	Before second spray	10 days after second spray	Before third spray	10 days after third spray	A week before harvest	
1	Tebuconazole 50% + Trifloxystrobin 25% WG	0.4	11.50 (3.46)	13.20 (3.70)	14.11 (3.82)	16.50 (4.12)	17.50 (4.24)	19.30 (4.45)	21.50 (4.69)	61.26
2	Azoxystrobin 18.2% + Tebuconazole 18.3% SC	1.0	11.00 (3.39)	13.33 (3.72)	14.20 (3.83)	13.50 (3.74)	16.20 (4.09)	14.75 (3.91)	16.00 (4.06)	71.17
3	Azoxystrobin 18.2% + Difenoconazole 11.4% SC	1.2	13.50 (3.74)	15.00 (3.94)	15.50 (4.00)	12.00 (3.54)	13.50 (3.74)	11.50 (3.46)	14.50 (3.87)	73.87
4	Picoxystrobin 6.78% + Tricyclazole 20.33% SC	2.0	13.00 (3.67)	12.50 (3.61)	13.00 (3.67)	11.50 (3.46)	12.50 (3.61)	13.00 (3.67)	14.00 (3.81)	74.77
5	Hexaconazole 5% SC	1.0	13.00 (3.67)	14.00 (3.81)	16.00 (4.06)	21.50 (4.69)	22.00 (4.74)	23.00 (4.85)	24.50 (5.00)	55.85
6	Carbendazim 50% WP	1.0	12.75 (3.64)	13.50 (3.74)	16.20 (4.09)	21.50 (4.69)	24.50 (5.00)	26.00 (5.15)	30.33 (5.55)	49.84
7	Control	-	21.00 (4.64)	33.00 (5.79)	35.00 (5.96)	41.00 (6.44)	50.05 (7.11)	53.00 (7.31)	55.50 (7.48)	-
	Sem ±		0.03	0.04	0.05	0.03	0.05	0.02	0.02	
	CD (5%)		0.09	0.11	0.14	0.09	0.17	0.07	0.06	

Note: PDI - Per cent Disease Index

Table 4. Bio-efficacy of novel fungicides on Powdery mildew of tomato (second season)

Sl. No	Chemical treatments	Dosage/L (g/ml)	PDI at different intervals (Days)							Reduction over control (%)
			Before First spray	10days after first spray	Before second spray	10days after second spray	Before third spray	10days after third spray	A week before harvest	
1	Tebuconazole 50% + Trifloxystrobin 25% WG	0.4	11.00 (3.39)	12.20 (3.56)	13.11 (3.69)	15.50 (4.00)	16.50 (4.12)	18.30 (4.33)	20.50 (4.58)	61.32
2	Azoxystrobin 18.2% + Tebuconazole 18.3% SC	1.0	10.50 (3.32)	12.33 (3.58)	13.20 (3.70)	12.50 (3.61)	15.20 (3.96)	13.75 (3.77)	15.50 (4.00)	70.75
3	Azoxystrobin 18.2% + Difenoconazole 11.4% SC	1.2	13.00 (3.67)	14.00 (3.80)	14.50 (3.87)	11.00 (3.39)	12.50 (3.61)	10.50 (3.32)	14.00 (3.81)	73.58
4	Picoxystrobin 6.78% + Tricyclazole 20.33% SC	2.0	12.50 (3.61)	11.50 (3.46)	12.00 (3.53)	10.50 (3.32)	11.50 (3.46)	12.00 (3.53)	13.50 (3.74)	74.53
5	Hexaconazole 5% SC	1.0	12.50 (3.61)	13.00 (3.67)	15.00 (3.93)	20.50 (4.58)	21.00 (4.63)	22.00 (4.74)	23.00 (4.85)	56.60
6	Carbendazim 50% WP	1.0	12.00 (3.53)	12.50 (3.61)	15.20 (3.96)	20.50 (4.58)	23.50 (4.90)	25.00 (5.05)	28.33 (5.37)	46.55
7	Control	-	20.00 (4.52)	32.00 (5.70)	33.00 (5.79)	39.00 (6.28)	48.05 (6.97)	51.00 (7.18)	53.00 (7.31)	-
	Sem ±		0.04	0.04	0.04	0.04	0.03	0.03	0.03	
	CD (5%)		0.12	0.13	0.14	0.13	0.10	0.09	0.08	

Note: PDI - Per cent Disease Index

Table 5. Bio-efficacy of novel fungicides on Powdery mildew of tomato (pooled data)

Sl. No	Chemical treatments	Dosage/L (g/ml)	PDI at different intervals (Days)							Reduction over control (%)
			Before First spray	10 days after first spray	Before second spray	10 days after second spray	Before third spray	10 days after third spray	A week before harvest	
1	Tebuconazole 50% + Trifloxystrobin 25% WG	0.4	11.25 (3.43)	12.70 (3.63)	13.61 (3.76)	16.00 (4.06)	17.00 (4.18)	18.80 (4.39)	21.00 (4.64)	61.29
2	Azoxystrobin 18.2% + Tebuconazole 18.3% SC	1.0	10.75 (3.35)	12.83 (3.65)	13.70 (3.77)	13.00 (3.67)	15.70 (4.02)	14.25 (3.84)	15.75 (4.03)	70.97
3	Azoxystrobin 18.2% + Difenoconazole 11.4% SC	1.2	13.25 (3.71)	14.50 (3.87)	15.00 (3.94)	11.50 (3.46)	13.00 (3.67)	11.00 (3.39)	14.25 (3.84)	73.73
4	Picoxystrobin 6.78% + Tricyclazole 20.33% SC	2.0	12.75 (3.64)	12.00 (3.54)	12.50 (3.61)	11.00 (3.39)	12.00 (3.54)	12.50 (3.61)	13.75 (3.77)	74.65
5	Hexaconazole 5% SC	1.0	12.75 (3.64)	13.50 (3.74)	15.50 (4.00)	21.00 (4.64)	21.50 (4.69)	22.50 (4.80)	23.75 (4.92)	56.22
6	Carbendazim 50% WP	1.0	12.38 (3.59)	13.00 (3.67)	15.70 (4.02)	21.00 (4.64)	24.00 (4.95)	25.50 (5.10)	29.33 (5.46)	45.94
7	Control	-	20.50 (4.58)	32.50 (5.74)	34.00 (5.87)	40.00 (6.36)	49.05 (7.04)	52.00 (7.25)	54.25 (7.40)	-
	Sem ±		0.04	0.04	0.05	0.04	0.04	0.03	0.03	
	CD (5%)		0.11	0.12	0.14	0.11	0.14	0.08	0.07	

Note: PDI - Per cent Disease Index