International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(4): 3316-3319

Received: 09-05-2018
Accepted: 17-06-2018

Shalini Verma
Department of Plant Pathology, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Kishore Khosla
Regional Horticultural Research and Training Station, Dr. YS Parmar University of Horticulture and Forestry, Seobag-Kullu, Himachal Pradesh, India

Correspondence
Shalini Verma
Department of Plant Pathology, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Chemical management of marssonina leaf blotch and alternaria leaf spot diseases of apple in Himachal Pradesh

Shalini Verma and Kishore Khosla

Abstract
A number of leaf spot diseases attack apple, the most important temperate fruit crop in Himachal Pradesh. After the scab caused by *Venturia inaequalis* (Cooke) G. Winter, apple plantations in the state are under attack by relatively less known fungal pathogens *Marssonina coronaria* (Ellis & J.J. Davis) J.J. Davis (Syn. *Marssonina mali* (P. Henn) Ito) and *Alternaria alternata* (Fr.) Keissler by causing mid-season defoliation. Hence, to manage these diseases, fluopyram 200 + tebuconazole 200 SC along with standard checks were evaluated for bio-efficacy against Marssonina blotch and Alternaria leaf spot during 2015 and 2016. The pooled analysis of two crop seasons showed that all the treatments differed significantly with regard to per cent disease index and per cent disease control for both the diseases. For Marssonina blotch, maximum per cent disease control was observed when the crop was sprayed with fluopyram 200 + tebuconazole 200 SC at a concentration of 0.0625 per cent (94.35%) followed by fluopyram 200 + tebuconazole 200 SC at a concentration of 0.05 per cent (89.85%) and 0.0375 per cent (87.72%), respectively. For Alternaria leaf spot, maximum per cent disease control occurred when the crop was sprayed with fluopyram 200 + tebuconazole 200 SC at a concentration of 0.0625 per cent (94.55 %) followed by fluopyram 200 + tebuconazole 200 SC at its concentration 0.05 per cent (89.42%) and 0.0375 per cent (86.55 %), respectively.

Keywords: apple, fluopyram, tebuconazole, *Marssonina* leaf blotch, *Alternaria* leaf spot

Introduction
Apple is the most important temperate fruit crop in Himachal Pradesh, India. Apple production occupies first place among all the fruits grown in the state having total area of 1, 10,680 hectares with a production of 4, 92,100 metric tonnes (Anonymous, 2017) [1]. The area under apple cultivation has increased manifold during the last few decades but the production has not increased proportionately due to low productivity of 4.45 metric tonnes per hectare (Anonymous, 2017) [1] in comparison to advanced apple growing countries of the world. The reasons for low productivity are many but fungal, bacterial and viral diseases play a significant role in hampering apple production. Among these, fungal diseases are of utmost economic importance and are responsible for widespread economic losses to the growers. During the last few years, leaf spot diseases have emerged as a major constraint in successful apple cultivation. After the scourge of scab caused by *Venturia inaequalis* (Cooke) G. Winter in the nineties, apple plantations in Himachal Pradesh are under severe attack by relatively less known fungal pathogens like *Marssonina coronaria* (Ellis & J.J. Davis) J.J. Davis [Syn. *Marssonina mali;* Perfect state: *Diplocarpon mali*)] and *Alternaria alternata* (Fr.) Keissler. These pathogens are a major cause of midseason defoliation in apple crop.

Marssonina blotch of apple is responsible for widespread premature defoliation in apple and was observed in 1992 in some orchards in Kotkhai area of Himachal Pradesh, India (Sharma and Bhardwaj, 2003 [14]). It appeared in epidemic proportions during 1995 and several subsequent years in as many as 90 per cent apple orchards of the state covering more than 70,000 hectares. Since then the disease is causing huge losses every year by considerably lowering the yield and quality of fruits (Sharma and Bhardwaj, 2003 [14]). Disease symptoms are visible invariably after the rains in spring and early summer months as 5-10 mm diameter dark brown spots on the mature whorl of leaves, which turn yellow and drop within a few weeks. Small dot-like structures (acervuli) are also visible in such lesions. The fungus also attacks the fruits by causing circular dark brown spots of varying size (3-5 mm diameter) on all the commercial apple cultivars, thereby reducing the quality of marketable produce.

The unusual leaf drop starts in late summer months after the onset of rains and apple fruits nearing maturity were commonly seen hanging from the defoliated branches (Sharma, 2003 [13]). The disease first appears in the second fortnight of June and spreads rapidly during the month of July-August with the average temperature ranging between 23.5-25.4 degrees Celsius and frequent rains (3-6 rainy days per week) of moderate to high intensity. The development of the disease has a positive correlation with relative humidity and rainfall (Sharma, 2003) [13]. The perfect state of the pathogen *Diplocarpon mali* was observed in overwintering leaves, though less frequently. The pathogenic fungus was found to perennate in the overwintering leaf litter in the form of conidia, which showed up to 20 per cent viability in the next season (Sharma *et. al*., 2005) [19].

Alternaria leaf spot initially appears as small, oval to irregular, dark brown 1-3 mm diameter reddish brown necrotic spots on leaves in late spring or early summer which later on fuse and form bigger blotches on young leaves giving blighted appearance followed by defoliation of apple trees. Dark brown to black elongated lesions also appear on the petioles and mid-ribs leading to yellowing of leaves and severe defoliation. Sometimes round, blackish brown and sunken spots form on growing twigs and fruits. Severe infection kills the affected twigs. Lenticels on shoots also occasionally appear swollen as a result of infection (Verma *et al*., 2012) [22]. The optimum temperature for infection, mycelial growth, sporulation and germination of spores ranges between 25-30 degrees Celsius. The increase in wetness (2-48 hours) and temperature range of 12-28 degrees Celsius also increases the infection.

Therefore, keeping in view the economic importance of the crop and losses caused by these diseases, the present investigation evaluated the bio-efficacy of different fungicides against Marssonina blotch and Alternaria leaf spot.

Materials and Methods

The present studies for evaluation of effective fungicides against Marssonina blotch and Alternaria leaf spot were undertaken at the Regional Horticultural Research and Training Station, Seobag- Kullu, Himachal Pradesh, India during the years 2015 and 2016 under natural epiphytotic conditions. The field experiments were laid out in Randomized Block Design with seven treatments including control (water spray) and each treatment was replicated thrice. The fungicides used were fluopyram 200 + tebuconazole 200 SC (0.0375, 0.05 and 0.0625 %), fluopyram 500 SC (0.025 %), tebuconazole 250 EC (0.05 %), difenoconazole 25% EC (0.015 %), and mancozeb 75% WP (0.3 %). The first spray of different fungicides was given in the last week of May on apple trees and the remaining three sprays were given at 15 days interval. The observations on the disease severity on apple leaves were recorded at 15 days after the last spray on hundred leaves collected at random from all the four sides of the trees.

The disease severity for Marssonina blotch was recorded by using the scale given by James (1974) [6], the details of the scale are as follows:

Grade	Per cent disease on leaves	Description of symptoms
0	0.0	Leaves completely healthy with no blotch symptoms
1	0.1-25.0	Leaves show light infection, disease mainly on the lower portion of the plant
2	25.1-50.0	Up to 50% portion of the leaves infected
3	50.1-75.0	About 75% portion of the leaves infected and the leaves appear to be blotched
4	75.1-100.0	Almost the whole of the leaves infected

The disease severity for Alternaria leaf spot in apple was recorded by adopting the 0-9 disease rating scale as given below:

0 = No leaf fall; all leaves healthy

1 = No leaf fall; 10-15 leaves showing 1-2 spots with or without yellowing in the lower canopy of the tree

2 = Leaf fall initiated but less than 10 %; and up to 25 % of the remaining leaves showing disease symptoms

3 = Leaf fall up to 25 %, rest showing leaf spotting and/or yellowing

4 = Leaf fall up to 33% and the remaining >50 per cent leaves showing disease symptoms i.e. leaf spotting and/or yellowing

5 = Leaf fall up to 50 % and remaining 25% of the leaves showing symptoms

6 = Leaf fall up to 66 % and remaining 25 % of the leaves showing symptoms

7 = Leaf fall up to 75 % and most of the remaining leaves showing symptoms

8 = Leaf fall up to 90 % and most of the remaining leaves showing symptoms

9 = Leaf fall more than 90 % and most of the remaining leaves showing symptoms

The per cent disease index (PDI) for both the diseases was calculated according to the following formula, given by McKinney (1923) [9] as follows:

$$\text{Disease index (\%)} = \frac{\text{Sum of all the disease ratings}}{\text{Total number of ratings X Maximum disease grade}} \text{ X } 100$$

The per cent disease control was calculated by adopting the below mentioned formula:

$$\text{Disease control (\%)} = \frac{\text{Disease index in control treatment} - \text{Disease index in treatment}}{\text{Disease index in control (unsprayed) treatment}} \text{ X } 100$$

The data was analysed to calculate the critical differences amongst the treatments as per Gomez and Gomez (1983) [5] for randomised complete block design.

Results and Discussion

Bio-efficacy of different fungicides against Marssonina blotch

The pooled analysis of 2015 and 2016 crop seasons of data (Table 1) showed that all the treatments differed significantly with regard to per cent disease index and per cent disease control. Minimum per cent disease index occurred when the apple crop was sprayed with fluopyram 200 + tebuconazole 200 SC at a concentration of 0.0625 per cent (3.58 %). It was followed by fluopyram 200 + tebuconazole 200 SC at concentrations of 0.05 and 0.0375 per cent which provided 5.98 and 7.39 per cent control, respectively. The standard check fungicides viz., tebuconazole, fluopyram, difenoconazole and mancozeb when sprayed showed less per cent disease index of 7.34, 8.03, 8.51 and 8.53 per cent but was significantly less in comparison to control (64.43%).

Correspondingly, per cent disease control was maximum when the apple crop was sprayed with fluopyram 200 + tebuconazole 200 SC at a concentration of 0.0625 per cent (94.35 %) followed by fluopyram 200 + tebuconazole 200 SC at its concentration 0.05 and 0.0375 per cent which provided control of 89.85 and 87.72 per cent, respectively.

The standard check fungicides viz., tebuconazole, mancozeb, difenoconazole and fluopyram when sprayed showed per cent disease control of 90.70, 90.16, 88.68 and 86.88 per cent, respectively. Therefore, it is evident that all the sprays of different fungicides tested during 2015 and 2016 crop seasons were effective in controlling *Marssonina* blotch over control (water spray) but a new fungicide combination viz., fluopyram 200 + tebuconazole 200 SC at a concentration of 0.0625 per cent was more effective in field trials against the pathogen.

Table 1: Bio-efficacy evaluation of different fungicides against Marssonina blotch of apple during 2015 and 2016

Treatment	Conc. (%)	Percent Disease Index			Per cent Disease Control		
		2015	2016	pooled	2015	2016	pooled
Fluopyram 200 + tebuconazole 200 SC	0.0375	5.93	8.87	7.39 (15.75)	85.54	89.89	87.72 (9.42)
Fluopyram 200 + tebuconazole 200 SC	0.050	5.13	6.82	5.98 (14.11)	87.46	92.23	89.85 (9.53)
Fluopyram 200 + tebuconazole 200 SC	0.0625	2.4	4.78	3.58 (10.85)	94.13	94.56	94.35 (9.77)
Fluopyram 500 SC	0.025	6.12	9.94	8.03 (16.45)	85.08	88.68	86.88 (9.37)
Tebuconazole 250 EC	0.050	1.42	13.25	7.34 (15.71)	96.51	84.89	90.70 (9.58)
Difenoconazole 25% EC	0.015	2.5	14.52	8.51 (16.95)	93.90	83.46	88.68 (9.47)
Mancozeb 75% WP	0.3	0.19	16.87	8.53 (16.98)	99.54	80.78	90.16 (9.55)
Control (water spray)		41.09	87.78	64.43 (53.37)	-	-	-
$C.D._{0.05}$				(1.31)			(0.02)

Figures in parentheses are angular transformed and square root transformed

Bio-efficacy of different fungicides against alternaria leaf spot

The pooled analysis of 2015 and 2016 crop seasons of data (Table 2) showed that all the treatments differed significantly with regard to per cent disease index and per cent disease control. Minimum per cent disease index occurred when the apple crop was sprayed with fluopyram 200 + tebuconazole 200 SC at the concentration 0.0625 per cent (3.41%) followed by fluopyram 200 + tebuconazole 200 SC at its concentration 0.05 and 0.0375 per cent provided 5.71 and 7.46 per cent, respectively. The standard check fungicides viz., tebuconazole, fluopyram, difenoconazole and mancozeb when sprayed showed less per cent disease index of 8.24, 8.79, 11.84 and 17.75 per cent but was significantly less in comparison to control (57.97%). Similarly, maximum per cent disease control was observed when sprayed with fluopyram 200 + tebuconazole 200 SC at its concentration 0.0625 per cent (94.55 %). It was followed by fluopyram 200 + tebuconazole 200 SC at its concentration 0.05 and 0.0375 per cent at 89.42 and 86.55 per cent, respectively.

The standard check fungicides viz., tebuconazole, difenoconazole, fluopyram and mancozeb, when sprayed showed per cent disease control of 86.56, 84.86, 83.47 and 76.17 per cent, respectively. Therefore, it is evident that even though all the sprays of different fungicides tested during 2015 and 2016 crop seasons were effective in controlling *Alternaria* leaf spot over control (water spray) but a new fungicide combination viz., fluopyram 200 + tebuconazole 200 SC at a concentration of 0.0625 per cent was more effective in field trials against the pathogen.

Table 2: Bio-efficacy evaluation of different fungicides against *Alternaria* leaf spot of apple during 2015 and 2016

Treatment	Conc. (%)	Per cent Disease Index			Per cent Disease Control		
		2015	2016	pooled	2015	2016	pooled
Fluopyram 200 + tebuconazole 200 SC	0.0375	4.99	9.92	7.46 (15.83)	85.21	87.89	86.55 (9.36)
Fluopyram 200 + tebuconazole 200 SC	0.050	4.15	7.26	5.71 (13.80)	87.71	91.12	89.42 (9.51)
Fluopyram 200 + tebuconazole 200 SC	0.0625	1.46	5.37	3.41 (10.64)	95.65	93.45	55 (9.78)
Fluopyram 500 SC	0.025	6.69	10.88	8.79 (17.23)	80.18	86.76	47 (9.19)
Tebuconazole 250 EC	0.050	3.87	12.6	8.24 (16.67)	88.47	84.64	56 (9.36)
Difenoconazole 25% EC	0.015	0.79	22.89	11.84 (20.12)	97.64	72.08	86 (9.27)
Mancozeb 75% WP	0.3	2.55	32.94	17.75 (24.90)	92.45	59.89	76.17 (8.79)
Control (water spray)		33.81	82.12	57.97 (49.56)	-	-	-
$C.D._{0.05}$				(0.85)			(0.07)

Figures in parentheses are angular transformed and square root transformed

Earlier also many fungicides have been recommended for the management of leaf blotch of apple (*M. coronaria*), viz., Bordeaux mixture (2-12-100) + $ZnSo_4$ (40g/20L), ferbam, zineb, folpet, captan, fuzet (Kwang and Chong, 1962) [8]; mancozeb, propineb, carbendazim (Sharma and Kaul, 1997) [16]; dodine (Sharma, 1999) [15]; dithiocarbamate, benzimidazole, and dithianon groups (Sharma and Bhardwaj, 2003 [14], Sharma *et. al*., 2004 [17]). Even the **c**hemical control of *A. mali* has been achieved through use of fungicides such as iprodione, mancozeb, captan (Asari and Takahashi, 1988 [2]); polyoxin, captafol (Filajdac and Sutton, 1992) [4]; dodine, zineb, mancozeb + hexaconazole (Sharma *et al*., 2005) [19]; hexaconazole, copper oxychloride, ziram (Shahzad, 2009) [12]; and penconazole (Sofi *et al*., 2013) [20].

However, fluopyram acts on the mitochondrial respiration chain and is a potent source of broad-spectrum inhibition of fungal development. The fluopyram belongs to succinate dehydrogenase inhibitors (SDHIs) group of fungicides and has a systemic activity. It has excellent foliar activity against a wide range of significant pathogens. Resistance is an issue for the SDHIs and so the products are normally sold in mixtures (Oliver and Hewitt, 2014) [10]. Tebuconazole belongs to chemical group of triazoles and acts on the sterol biosynthesis in membrane [sterol biosynthesis inhibitor (SBI)

Class I]. It is systemic and provides protectant, curative and eradicant control (Oliver and Hewitt, 2014) [10].

Since the new combination of fluopyram 200 + tebuconazole 200 SC exhibits systemic activity and has different modes of action, therefore, such a new combination can delay or prevent the build-up of resistance in the pathogen and can be effectively utilized as a promising preventive fungicide for the control of both the leaf spot diseases of apple.

Conclusion

The results of our studies reveal that fluopyram 200 +tebuconazole 200 SC is a promising fungicide against the Marssonina blotch and Alternaria leaf spot diseases of apple in Himachal Pradesh. This combination at a concentration of 0.0625 per cent was highly effective and gave maximum per cent disease control in Marssonina blotch (94.35%) and Alternaria leaf spot (94.55%) in apple.

References

1. Anonymous, 2017. https://www.faostat.fao.org. (Accessed 8:00PM, 27 July 2018).
2. Asari M, Takahashi S. Occurrence of iprodione-resistant strains of *Alternaria mali* Roberts on apple. Bulletin of the Akita Fruit tree Experiment Station, Japan. 1988; 19:13-24.
3. Chang JP, Li ZQ, Guo LM, Chang GH, Qiao CF, Lu CJ. Experiment for controlling apple leaf brown spot disease with Zhonqshenqjunsu fungicide. China fruits 1998; 1:37.
4. Filajdac N, Sutton TB. Chemical control of Alternaria blotch of apples caused by *Alternaria mali*. Plant Disease. 1992; 76:126-130.
5. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Wiley and Sons, New York, 1984, 680.
6. James WC. Assessment of plant diseases and losses. Annual Review of Phytopathology. 1974; 2:27-48.
7. Jiang RD, Lu SJ, Wang PS, Wang JQ, Li Q. Control of apple leaf spot disease by spraying. China Fruits. 1997; 2:51.
8. Kwang YL, Chong CK. Fungicidal control of apple blotch, *Marssonina mali* (P. Henn.) Ito, in South Korea. Plant Disease Reporter. 1962; 46(6):435-437.
9. McKinney. Influence of soil temperature and moisture on the influence of wheat seedlings by *Helminthosporium sativa*. Journal of Agricultural Research. 1923; 26:196-217.
10. Moshe Reuveni, Dimitri Sheglov. Effects of azoxystrobin, difenoconazole, polyoxin B (polar) and trifloxystrobin on germination and growth of Alternaria alternata and decay in Red Delicious apple fruits. Crop Protection. 2002; 21(10):951-955.
11. Oliver R, Hewitt HG. Fungicide Performance. In*:* Fungicides in crop protection. CABI, USA. 2014; 75-91, 190.
12. Shahzad A. Management of Alternaria blotch of apple using fungicides. Indian Journal of Plant Protection. 2009; 37(1/2):134-138.
13. Sharma IM. Influence of environmental factors on the development of pre-mature defoliation disease caused by *Marssonina coronaria* in apple and its management. Journal of Mycology and Plant Pathology. 2003; 33(1):89-95.
14. Sharma IM, Bhardwaj SS. Efficacy and economics of different fungicide spray schedules in controlling premature defoliation disease in apple. Plant Disease Research. 2003; 18(1):21-24.
15. Sharma JN. Marssonina blotch- a new disease causing premature leaf fall in apple. Indian Phytopathology. 1999; 52:101-2.
16. Sharma JN, Kaul JL. Marssonina blotch- a new disease hits apple crop in Himachal Pradesh. *In:* International Conference on Integrated Plant Disease Management for Sustainable Agriculture. Indian Phytopathological Society 10-15 November, IARI, New Delhi. (No. P10B-029(Abstr.), 1997.
17. Sharma JN, Sharma Anita, Sharma Pankaj. Out-break of *Marssonina* blotch in warmer climates causing premature leaf fall problem of apple and its management. Acta Horticulturae. 2004; 662:405-409.
18. Sharma JN, Sharma PK, Sharma Anita. Studies on epidemiology and management of *Marssonina* blotch, the cause of premature leaf fall in apple. *In*: Integrated plant disease management-Challenging problems in horticultural and forest pathology, Solan, India, 14 to 15 November, Scientific Publishers, Jodhpur. 2003, 2005; 1-7, xiii + 362.
19. Sharma JN, Gupta Dharmesh, Bhardwaj LN, Kumar Ravinder. Occurrence of Alternaria leaf spot (*Alternaria alternata*) on apple and its management. *In*: Integrated plant disease management-Challenging problems in horticultural and forest pathology, Solan, India. Scientific Publishers, Jodhpur. 2003. 2005; 25-31, xiii + 362.
20. Sofi TA, Beig MA, Dar GH, Ahangar FA, Aflaq-Hamid. Virulence variation in *Alternaria mali* (Roberts) and evaluation of systemic acquired resistance (SAR) activators for the management of Alternaria leaf blotch of apple. Emirates Journal of Food and Agriculture. 2013; 25(3):196-204.
21. Verma Shalini, Sharma JN, Gupta Dharmesh, Sharma NC. Occurrence of Alternaria blight on apple in Himachal Pradesh and its management. In: Annual Meeting IPS (NZ) & National Symposium on "Emerging issues in Plant Health Management at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan on. 2012, 63(070).