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Laxmi Rawat

Plant Pathology Division,
College of Forestry, Rancihauri,
V.C.S.G. Uttarakhand
University of Horticulture and
Forestry, Bharsar, Uttarakhand,
India

TS Bisht

Department of Horticulture,
School of Agriculture and Allied
Sciences, HNB Garhwal
University, Srinagar Garhwal A
Central University,
Uttarakhand, India

Akshit Kukreti

Plant Pathology Division,
College of Forestry, Rancihauri,
V.C.S.G. Uttarakhand
University of Horticulture and
Forestry, Bharsar, Uttarakhand,
India

Efficacy of Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) in combating apple disease complex in Uttarakhand

Laxmi Rawat, TS Bisht and Akshit Kukreti

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Abstract

The present investigation was carried out to evaluate the bio-efficacy of Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) at different doses along with standard checks *viz.*, Pydiflumetofen 20% SC, Difenconazole 25% EC, Metiram 55% + Pyraclostrobin 5% WG, Mencozeb 75% WP at recommended doses and untreated check (Control) against apple scab, premature leaf fall and powdery mildew diseases of apple at Harsil and Jhala fruit belt (District- Uttarkashi) locations over two consecutive growing seasons. The field experiment was arranged in randomized complete block design with three replications and nine treatments. Data on different apple diseases for two crop seasons (2017 and 2018) revealed that all the fungicides tested were found effective for the management of scab, premature leaf fall and powdery mildew diseases of apple as compared to untreated check (Control). However, the treatment T₄ [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600 ml/ha] was found most effective followed by T₃ [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 500ml/ha] for all the diseases studied under Harshil and Jhala locations during both the studied years under present materials and conditions. However, the highest disease intensity for all the studied diseases was recorded in untreated control. The data of two consecutive crop seasons indicated maximum yield (96.07 q/ha & 93.69 q/ha in 2017 and 2018, respectively from Harshil location and 100.37 q/ha & 98.13 q/ha in 2017 and 2018, respectively from Jhala location) when the crop was sprayed with Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600 ml/ha followed by when sprayed with the same treatment @ 500 ml/ha (92.25 q/ha in 2017 and 89.82 q/ha in 2018 from Harshil location and 97.64 q/ha in 2017 and 95.41 q/ha in 2018 from Jhala location). Whereas, minimum yield (66.70 q/ha in 2017 and 56.17 q/ha in 2018 from Harshil location and 74.25 q/ha in 2017 and 63.01 q/ha in 2018 from Jhala location) was recorded when trees were left unsprayed (Control) from both the locations during both the studied years.

Keywords: Bio-efficacy, Difenconazole, Pydiflumetofen, Premature leaf fall, Powdery mildew, Scab

Introduction

Apples are grown in many countries and consumed worldwide. Because of their high content in bioactive molecules (e.g., antioxidants and vitamins), such fruit can exert beneficial effects in a balanced diet (Boyer and Liu, 2004; Gallus *et al.*, 2005) [2, 3]. Apple is a deciduous fruit mainly grown in the North Western mountainous states like Jammu & Kashmir, Himachal Pradesh and Uttarakhand. Jammu & Kashmir and Himachal Pradesh are the two leading apple producing states while Uttarakhand is at third rank in the apple production in India (Indian Horticulture Database, 2008, 2011 and 2013) [4]. Apple has gained much popularity over the past few decades and different cultivars of apples imported from different countries have now been spread all over apple growing areas in Uttarakhand but the production has not increased proportionally. The productivity is quite lower in comparison to advanced apple growing countries of the world. The reasons for low apple productivity could be many but one of the reasons is the incidence of a variety of fungal diseases. Fungal diseases are of utmost economic importance and are responsible for causing huge losses to the apple growers. Apple scab disease, caused by the pathogen *Venturia inaequalis*, is a non-stop issue to the apple growers (Rexhepi *et al.*, 2018) [14]. Apple scab affects both leaves and fruits in which scattered, circular brown or olive-green spots appear on the undersurface of leaves borne on fruit spurs. Initially, the lesions are small and gradually cover a large portion of the leaf

Corresponding Author:**Laxmi Rawat**

Plant Pathology Division,
College of Forestry, Rancihauri,
V.C.S.G. Uttarakhand
University of Horticulture and
Forestry, Bharsar, Uttarakhand,
India

leading to premature yellowing of leaves, defoliation and fruit drop. Early in the season, these spots often develop around blossom end (calyx end) of the fruit and later they are found anywhere on the fruit surface. Cracks often develop in the scabbed areas, which allow the entry of other pathogens, causing rot of fruit either in the field, or in storage (NHB, 2019) [11]. Powdery mildew (*Podosphaera leucotricha*) disease of apple is another serious disease affecting buds, new shoots and leaves. The disease appears in the dry climatic conditions. The nursery plants are more prone to this disease. The diseases appears as white powdery (ash like) coating in patches on both the sides of leaves, and young shoots. The affected leaves turn pale and curl up and shoots remain weak and immature. In case of severe infection, leaf fall and premature fruit drop may also occur. Sometimes, the young infected fruit shows signs of russetting (NHB, 2019) [11]. Marssonina blotch/pre-mature leaf fall disease, caused by *Marssonina coronaria* (Ellis & J.J. Davis) J.J. Davis, is another one most devastating disease of apple in India and in other apple producing countries (Lee *et al.*, 2011) [8]. Marssonina blotch occurs every year wherever apples are grown in India. The fungus infects leaves and fruits of apple. Dark brown patches develop on upper surface of leaves. Area around these spots become pale, the entire leaf soon turns yellow, drops off prematurely. The yellowing advances towards petiole end and induces mid season defoliation. In excessive humid conditions, the lower portion of the tree is defoliated within few weeks and only fruits are seen hanging on the naked branches (Singh *et al.*, 2012) [21]. Keeping in view the importance of the crop and severe economic losses caused by these diseases, present study was, therefore, conducted to evaluate the bio-efficacy of different fungicides

against apple disease complex (apple scab, premature leaf fall and powdery mildew) at two locations of Uttarakhand Hills (Harsil and Jhala fruit belt in Uttarkashi district) during 2017 and 2018 to find out the best method against the apple disease complex.

Materials and Methods

A field trial was laid out at two worst affected orchard sites of Harsil and Jhala fruit belt (District Uttarakashi), Uttarakhand, over two consecutive crop seasons (2017 and 2018). Apple leaf & fruit scab, premature leaf fall and powdery mildew control experiments consisted of two sprays schedules (June 11 and June 26) using different fungicides in the farmer's orchards were carried out. The farmer's orchards were selected such that they comprised of royal delicious trees in the age group of 10-12 years. The experiment was laid out in Randomized Block Design with nine treatments including untreated check (Control) and each treatment was replicated thrice with three trees per replicate. The list of different bio-efficacy treatments along with dosages are presented in Table 1. First spray of fungicides as per treatments was taken up after initial appearance of disease in crop and the time interval was maintained 15 days as second spray was given with foot sprayer for thorough coverage of foliage with spray fluid after 15 days period of first spray. Untreated check (Control) treatment was sprayed with the same volume of water only. Disease severity data of different diseases on apple were recorded four times for each treatment with one before application of fungicides. Final observation on disease severity was recorded 30 days after second spray and observation on yield was taken after harvest.

Table 1: List of different bio-efficacy treatments used in the present study

Symbol for Treatment	Treatment	Formulation dosage (g ai/ha)	Dose, Product (ml or gm/ha)
T ₁	Untreated check (Control)	-	-
T ₂	Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC)	80 (30+50)	400
T ₃	Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC)	100 (37.5+62.50)	500
T ₄	Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC)	120 (45+75)	600
T ₅	Pydiflumetofen 20% SC	45	225
T ₆	Difenoconazole 25% EC	40	160
T ₇	Difenoconazole 25% EC	75	300
T ₈	Metiram 55% + Pyraclostrobin 5% WG	1050	1750
T ₉	Mencozeb 75% WP	2250	3000

The observations on apple scab, premature leaf fall and powdery mildew diseases were recorded as mentioned below:-

On apple scab

Rating of disease intensity on leaves and fruits of apple was categorized as per the rating scale mentioned in Table 2.

Table 2: Rating scale of scab disease of apple

Scale	Observations
0	No scab observed
1	Less than 5% of leaves/fruits affected and no aesthetic impact
2	5 to 20% of leaves/fruits affected, with some yellowing but little or no defoliation, moderate aesthetic impact
3	20 to 50% of leaves/fruits affected, significant defoliation and/or leaf yellowing, substantial aesthetic impact
4	50 to 80% of leaves/fruits affected, severe foliar discoloration and defoliation, severe aesthetic impact
5	80 to 100% of foliage/fruits affected, with 90% to 100% defoliation.

The per cent disease index (PDI) for apple scab was calculated according to the following formula, given by

Vincent (1947) [23], as follows-

$$\text{PDI (\%)} = \frac{\sum \text{Disease Score}}{\text{Number of leaf or fruit assessed} \times \text{Maximum disease score}} \times 100$$

On premature leaf fall

The disease severity for premature leaf fall was recorded by

using the scale given by James (1974) ^[6], the details of the scale is mentioned in Table 3.

Table 3: Scale of disease severity for premature leaf fall of apple

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	51.1-75.0	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 per cent disease index (PDI) for Marssonina blotch was calculated according to the following formula, given by McKinney (1923) ^[9], as follows-

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

On powdery mildew

To record powdery mildew incidence, four scaffold branches from four sides of tree canopy were marked. Five terminals randomly selected from each marked branch were assessed for per cent disease incidence and intensity. The per cent disease incidence was calculated by the formula given by

Mirza (1999) ^[10], the details of the criteria is mentioned in Table 4.

$$\text{Disease incidence (\%)} = \frac{\text{Number of mildewed terminals}}{\text{Total number of terminals observed}} \times 100$$

Table 4: Categories of per cent disease intensity of powdery mildew disease of apple

Category	Numerical value	Criteria
I	0	Disease free
II	1	1 to 25% of annual extension growth mildewed
III	2	26 to 50% of annual extension growth mildewed
IV	3	51 to 75% of annual extension growth mildewed and bud necrosis
V	4	Above 75% of annual extension growth mildewed and bud necrosis

Percent disease intensity was calculated by the formula given by Mirza (1999) ^[10].

$$\text{PDI (\%)} = \frac{\sum(n \times v)}{N \times S} \times 100$$

Where,
 $\sum$ = summation

n = number of terminals in each category
 v = numerical value of each category
 N = Total number of terminals examined
 S = the maximum numerical value

Per cent disease control was calculated by the following formula:-

$$\% \text{ Disease control} = \frac{\% \text{ disease incidence in control} - \% \text{ disease incidence in treatment}}{\% \text{ disease incidence in control}} \times 100$$

Per cent yield increase was calculated by the following formula:-

$$\% \text{ Yield increase} = \frac{\% \text{ yield in treatment} - \% \text{ yield in control}}{\% \text{ yield in treatment}} \times 100$$

Results and Discussion

The average of four observations recorded for disease severity data during 2017 and 2018 crop seasons (Table 5 to 8) revealed that, the incidence of leaf scab, fruit scab, pre-mature leaf fall and powdery mildew diseases in apple was higher in

trees left unsprayed (Control) from both the fruit belts. However, disease severity was found higher in Harsil fruit belt when compared to Jhala fruit belt during both the studied years.

Table 5: Bio-efficacy evaluation of different fungicides against leaf scab of apple under field conditions

S. No.	Treatment	Harsil				Jhala			
		2017		2018		2017		2018	
		M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)
1.	T ₁	64.44	-	43.22	-	59.55	-	38.77	-
2.	T ₂	27.77	56.90	24.77	42.68	23.44	60.63	21.77	43.84
3.	T ₃	22.55	65.00	19.77	54.25	18.55	68.84	17.44	55.01
4.	T ₄	19.44	69.83	18.55	57.08	15.77	73.51	15.77	59.32
5.	T ₅	33.55	47.93	33.22	23.13	32.11	46.07	29.77	23.21
6.	T ₆	29.44	54.31	28.11	34.96	27.88	53.18	23.77	38.68
7.	T ₇	22.22	65.51	21.77	49.62	19.55	67.17	18.88	51.30
8.	T ₈	31.55	51.03	30.22	30.07	29.77	50.00	26.44	31.80

9.	T ₉	34.88	45.87	33.44	22.62	34.11	42.72	30.11	22.33
	Grand Mean	31.76	-	28.12	-	28.97	-	24.75	-
	S.E.m.	1.39	-	0.56	-	1.35	-	0.81	-
	CD at 1%	5.75	-	2.30	-	5.58	-	3.36	-
	CD at 5%	4.17	-	1.67	-	4.05	-	2.44	-
	CV	7.59	-	3.43	-	8.07	-	5.69	-

M.D.I. - Mean Disease Index, P.R.O.C. - Percent Reduction over Control

Bio-efficacy of fungicides against leaf scab and fruit scab diseases of apple under field conditions

All the tested fungicides were found effective against leaf scab disease of apple and also found significant at both the locations (Harsil and Jhala fruit belt) during 2017 and 2018 study period over untreated control. Mean per cent disease index was recorded maximum in T₁ (untreated check) at both the locations during 2017 and 2018 experimentation period as depicted in Table 5. Among all the fungicidal treatments, the minimum mean per cent disease index (19.44% & 18.55% from Harsil during 2017 and 2018, respectively and at the same time 15.77% and again 15.77% from Jhala during 2017 and 2018, respectively) was recorded in T₄ [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600 ml/ha] treatment, followed by T₃ [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 500 ml/ha] treatment. With respect to the percent reduction of leaf scab disease over control, the maximum per cent reduction over control (69.83% and 57.08% from Harsil in 2017 and 2018, respectively and 73.51% & 59.32% from Jhala during 2017 and 2018, respectively) was observed in T₄ [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600 ml/ha] followed by T₃ [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 500 ml/ha] treatment during both the years of experimentation.

The results of the two seasons trial clearly indicated that all the fungicides were found to be significantly superior over

untreated check (Control) in management of apple fruit scab disease at both the locations as depicted in Table 6. The disease management was better with increase in concentration of Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) fungicide. The minimum mean per cent disease index (20.11% & 15.77% from Harsil in 2017 and 2018, respectively and 17.77% & 14.00% from Jhala during 2017 and 2018, respectively) was observed in T₄ treatment [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600 ml/ha] followed by T₃ treatment [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 500 ml/ha] during both the years of experimentation. However, the maximum mean per cent disease index (60.88% & 45.44% from Harsil in 2017 and 2018, respectively and 56.22% & 39.11% from Jhala during 2017 and 2018, respectively) was recorded under untreated check (Control) treatment. The per cent reduction over control was again found maximum in T₄ treatment followed by T₃ treatment. Bisht *et al.* (2020)^[1], evaluated bio-efficacy of different fungicides against apple diseases in Harsil valley of district Uttarkashi, Uttarakhand and found that Chlorothalonil 40% + Difenconazole 4% w/w/ SC @ 900 ml/ha most effective and promising with minimum percent disease severity and maximum percent reduction over control with respect to leaf and fruit scab during the experimental years.

Table 6: Bio-efficacy evaluation of different fungicides against fruit scab of apple under field conditions

S. No.	Treatment	Harsil				Jhala			
		2017		2018		2017		2018	
		M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)
1.	T ₁	60.88	-	45.44	-	56.22	-	39.11	-
2.	T ₂	26.11	57.11	21.77	52.09	23.44	58.30	19.44	50.29
3.	T ₃	23.11	62.04	17.44	61.61	20.88	62.86	16.44	57.96
4.	T ₄	20.11	66.96	15.77	65.29	17.77	68.39	14.00	64.20
5.	T ₅	34.22	43.79	29.77	34.48	33.55	40.32	27.88	28.71
6.	T ₆	27.77	54.38	25.44	44.01	26.44	52.97	22.44	42.62
7.	T ₇	23.44	61.49	18.44	59.41	21.55	61.66	15.11	61.36
8.	T ₈	30.77	49.45	27.44	39.61	29.55	47.43	25.44	34.95
9.	T ₉	33.88	44.34	30.44	33.01	31.88	43.29	28.11	28.12
	Grand Mean	31.14	-	25.77	-	29.03	-	23.11	-
	S.E.m.	0.83	-	1.37	-	1.11	-	0.73	-
	CD at 1%	3.41	-	5.67	-	4.59	-	3.02	-
	CD at 5%	2.48	-	4.11	-	3.33	-	2.19	-
	CV	4.59	-	9.22	-	6.62	-	5.48	-

M.D.I. - Mean Disease Index, P.R.O.C. - Percent Reduction Over Control

Bio-efficacy of fungicides against Marssonina blotch/premature leaf fall disease of apple under field conditions

The results on per cent disease index along with per cent disease reduction over control after the application of different fungicides on premature leaf fall disease of apple is presented in Table 7. Analysis of data for two crop seasons (2017 and 2018) of two locations viz., Harsil and Jhala revealed that all fungicides were found effective in controlling premature leaf fall disease in apple. Application of fungicides

showed significant percent disease reduction over control with maximum reduction (66.74% & 68.14% from Harsil in 2017 and 2018, respectively and 67.12% and 70.12% from Jhala during 2017 and 2018, respectively) in T₄ treatment [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600ml/ha] followed by T₃ treatment [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 500 ml/ha] during both the years of experimentation. The maximum mean per cent disease index (45.44% & 47.44% from Harsil during 2017 and 2018, respectively and 40.88% & 43.11% from

Jhala during 2017 and 2018, respectively) was observed under untreated check (Control) treatment during both the years of evaluation. Verma and Khosla (2018) [22] conducted an experiment on chemical management of Marssonina leaf blotch of apple in Himachal Pradesh and found Fluopyram 200 + Tebuconazole 200 SC @ 0.0625% concentration as a promising fungicide against Marssonina blotch disease of apple.

Earlier also many fungicides have been recommended for the management of Marssonina blotch/Premature leaf fall disease of apple, viz., Bordeaux mixture, ferbam, zineb, folpet, captan, fuzet (Kwang and Chong, 1962) [7], mancozeb propineb, carbendazim (Sharma and Kaul, 1997) [19], dodine (Sharma, 1999) [18], dithiocarbamate, benzimidazole and dithianon groups (Sharma and Bhardwaj, 2003, Sharma *et al.*, 2004) [17, 20].

Table 7: Bio-efficacy evaluation of different fungicides against pre-mature leaf fall disease under field conditions

S. No.	Treatment	Harsil				Jhala			
		2017		2018		2017		2018	
		M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)
1.	T ₁	45.44	-	47.44	-	40.88	-	43.11	-
2.	T ₂	21.11	53.54	21.77	54.11	21.22	48.09	19.44	54.90
3.	T ₃	18.11	60.14	18.44	61.12	16.88	58.70	15.44	64.18
4.	T ₄	15.11	66.74	15.11	68.14	13.44	67.12	12.88	70.12
5.	T ₅	31.66	30.32	28.77	39.35	31.77	22.28	26.44	38.66
6.	T ₆	23.77	47.68	23.77	49.89	24.11	41.02	21.44	50.26
7.	T ₇	19.11	57.94	17.11	63.93	17.77	56.53	16.88	60.84
8.	T ₈	27.11	40.33	25.77	45.67	27.11	33.68	23.44	45.62
9.	T ₉	32.55	28.36	27.11	42.85	30.55	25.26	28.11	34.79
	Grand Mean	26.00	-	25.03	-	24.86	-	23.02	-
	S.Em.	0.99	-	0.70	-	0.92	-	0.85	-
	CD at 1%	4.07	-	2.89	-	3.78	-	3.49	-
	CD at 5%	2.96	-	2.10	-	2.74	-	2.54	-
	CV	6.57	-	4.85	-	6.38	-	6.37	-

M.D.I. - Mean Disease Index, P.R.O.C. - Percent Reduction over Control

Bio-efficacy of fungicides against powdery mildew disease in apple under field conditions

Values of powdery mildew disease index and percent reduction over control in apple orchards, evaluated during both the seasons (2017 and 2018) at both the locations (Harsil and Jhala) are presented in Table 8. All the tested fungicides were found effective against powdery mildew disease and also found significant over untreated check (Control). Of all the fungicidal treatments, T₄ treatment [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600 ml/ha] was again found as most effective by registering minimum mean per cent disease index (47.77% & 32.44% from Harsil during 2017 and 2018, respectively and 43.44% and 27.77% from Jhala during 2017 and 2018, respectively) followed by T₃

treatment [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 500 ml/ha] as evident in Table 8. The maximum mean per cent disease index (75.44% & 56.11% from Harsil during 2017 and 2018, respectively and 73.77% & 55.44% from Jhala during 2017 and 2018, respectively) was recorded under untreated check (control). Rather *et al.*, (2015) [12] reported efficacy of Trademifon 25 WP @ 0.05%, Myclobutanil 10 WP @ 0.03%, Dinocap 48% EC @ 0.05% and Sulphur 80% WP @ 0.2% in controlling powdery mildew disease of Ambri apple in Kashmir Valley. The effectiveness of Difenconazole, Dinocap, Sulphur and Bitertanol has been reported by various workers in previous reports (Gupta & Sharma, 2009) [5].

Table 8: Bio-efficacy evaluation of different fungicides against powdery mildew disease under field conditions

S. No.	Treatment	Harsil				Jhala			
		2017		2018		2017		2018	
		M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)	M.D.I. (%)	P.R.O.C. (%)
1.	T ₁	75.44	-	56.11	-	73.77	-	55.44	-
2.	T ₂	52.44	30.48	37.11	33.86	49.77	32.53	33.22	40.07
3.	T ₃	49.44	34.46	35.11	37.42	46.66	36.74	30.44	45.09
4.	T ₄	47.77	36.67	32.44	42.18	43.44	41.11	27.77	49.90
5.	T ₅	61.55	18.41	45.11	19.60	60.22	18.36	41.77	24.65
6.	T ₆	54.44	27.83	40.44	27.92	52.55	28.76	36.22	34.66
7.	T ₇	50.11	33.57	34.11	39.20	46.77	36.60	29.77	46.30
8.	T ₈	58.11	22.97	43.77	21.99	54.55	26.05	38.22	31.06
9.	T ₉	60.44	19.88	46.22	17.62	59.44	19.42	42.66	23.05
	Grand Mean	56.64	-	41.16	-	54.13	-	37.28	-
	S.Em.	1.17	-	0.86	-	0.87	-	1.45	-
	CD at 1%	4.85	-	3.56	-	3.61	-	5.97	-
	CD at 5%	3.52	-	2.58	-	2.62	-	4.34	-
	CV	3.59	-	3.63	-	2.80	-	6.72	-

M.D.I. - Mean Disease Index, P.R.O.C. - Percent Reduction over Control

Fruit yield after application of fungicides against diseases of apple under field conditions

Estimation of percent increase in yield over control after application of different fungicides provided us the information regarding the efficacy of individual fungicide in reducing the incidence of apple diseases at both the locations (Harsil and Jhala). The data of two crop seasons presented in Figure 1 and Figure 2 showed that maximum fruit yield (96.07 qtl/ha & 93.69 qtl/ha from Harsil during 2017 and 2018, respectively and 100.37 qtl/ha & 98.13 qtl/ha from Jhala during 2017 and 2018, respectively) and maximum per cent increase over control (30.57% & 40.04% from Harsil during 2017 and 2018, respectively and 26.02% & 35.78% from Jhala during 2017 and 2018, respectively) was recorded when the crop was sprayed with Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600ml/ha followed by T₃ treatment [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 500ml/ha] during both the years of experimentation. Data on yield losses due to the incidence of different apple diseases indicated that maximum yield losses occurred when crop was left unsprayed (Control) during both the years. In fruit crops like apple, fungicidal treatments may largely influence quality of the fruits and can be effective in increasing fruit bud initiation and fruit set in apples (Rich

1957, Ross and Longley 1963) [15, 16]. However, by keeping the photosynthetic area of leaves free from diseased spots, fungicides can increase the yields of the fruit crops also, apart from improving the quality of the fruit (Rather *et al.*, 2018) [13].

Pydiflumetofen is a newest member of succinate dehydrogenase inhibition (SDHI) family of fungicides that disrupts the energy production by inhibiting the functioning of succinate dehydrogenase, an enzyme involved in both the citric acid cycle and mitochondrial electron transport chain. Difenconazole is a broad spectrum systemic fungicide and acts as a sterol demethylation inhibitor that prevents the development of the fungus by inhibiting membrane ergosterol biosynthesis. Based on the two consecutive years (2017 and 2018) experimentation period at two locations of Uttarkashi district (Harsil and Jhala), it has been found that the combination treatment i.e. T₄ [Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200 SC) @ 600 ml/ha] was most effective against the diseases of apple and at the same time improved apple crop yield under studied materials and environmental conditions which was followed by the same fungicide @ 500 ml/ha when compared to the other treatments.

Fig 1: Effect of different fungicides on fruit yield of apple at Harsil location (a) and Jhala location (b) in 2017 and 2018

Fig 2: Effect of different fungicides on P.I.O.C. (Per cent increase over control) at Harsil location (a) and Jhala location (b) in 2017 and 2018

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