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Efficacy of fungicides for entomosporium leaf and fruit spot disease of pear (*Pyrus communis* L.)

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Abstract
Field studies were conducted at SKUAST-K to evaluate the comparative efficacy of nine systemic and four non-systemic fungicides against the leaf and fruit spot disease of pear caused by *Entomosporium maculatum* Lev. Four foliar sprays at 15 days interval with thiophanate methyl @0.05% produced the lowest leaf (PDI 2.26%) and fruit (PDI 1.53) disease with 95.86 and 96.12 percent disease reduction over control on leaves and fruits, respectively. Propiconazole 25 EC and triadimefon 25 WP both @ 0.05 % were next effective treatments with leaf disease intensity reduction of 94.15 and 93.78 per cent and fruit disease intensity reduction of 94.42 and 94.59 per cent over control, respectively. The other fungicides in decreasing order of their efficacy were Carbendazim 50WP (PDI 3.82 % on leaves & 1.70% on fruits), metiram + pyraclostrobin 60 WG (PDI 3.93% on leaves & 2.53% on fruits), difenoconazole 25 EC (PDI 4.13% on leaves & 2.60% on fruits) and flusilazole 40 EC (PDI 5.20 % on leaves & 3.06% on frits). Amongst the non-systemic fungicides chlorothalonil 70 WP was the most effective treatment with minimum disease intensities of 5.16 and 3.74 per cent on leaves and fruits followed by captan 50 WP with leaf and fruit disease intensities of 6.38 and 3.66 per cent, respectively. Hence, four foliar sprays of thiophanate methyl @ 0.05% or propiconazole 25 EC@ 0.05% or triadimefon 25 WP@ 0.05% at 15 days interval has been advocated for the effective management of Entomosporium leaf and fruit spot disease of pear.

Keywords: *Entomosporium maculatum,* fungicide, management

Introduction
Pear (*Pyrus communis* L.) is one of the important pome fruits crop with great economic significance in Kashmir valley after apple. The total area under Jammu And Kashmir State is 14475 ha with 106936 MT production (Anonymous, 2015) [1]. The cultivation of pear is decreasing consistently over the years in Jammu and Kashmir due to various factors (Anonymous, 2015) [1]. Entomosporium Leaf and fruit spot (*Entomosporium maculatum* Lev.) disease is one of the major factor responsible for declining cultivation of pear in the state. The disease has resulted in huge economic losses through pre-mature mid-summer defoliation besides reducing the tree vigour, fruit quality and fruit yield (Zargar, 1995) [11]. The disease occurs sporadically in most of the temperate areas, where pear is grown. In New Zealand, Mendoza and Ortiz (1984) [5] observed 100% foliage infection in June - July and 30 per cent fruit infection in November, besides pre-mature defoliation, bloom decrease in following year and fruit cracking which increased with fruit development. Considerable losses in pear yield due to the disease have also been observed in central black sea region by Ishchenko *et al.* (1983) [6]. Many workers have worked on the fungicidal management of the Entomosporium leaf and fruit disease on different crops. In Canada, Bowen *et al.* (1994) [3] reported reduced disease incidence of Entomosporium disease of photinia by spraying chlorothalonil, benzimidazoles, myclobutanil and tebuconazole fungicides. Entomosporium leaf and berry spot of saskatoon was managed by triforine (0.24-0.48 g a.i/L) or thiophanate-methyl + zinc + maneb (1.35g a.i/L) or chlorothalonil (1.35 g a.i/L) or vinclozolin 18 (0.90g a.i./L) (Lange *et al.*,1998) [7].
Although, Zargar (1995) [11] evaluated some fungicides against the disease and reported chlorothalonil @ 0.25 per cent and carbendazim at 0.1 per cent effective treatments in controlling the disease on pear in Kashmir valley. However, since then frequent epiphytotics of the diseases in the valley witnessed regularly and the extent of damage inflicted by it has necessitated to find out the effective fungicides among the new generation chemicals available in the market, which are generally being used against apple diseases. The present study was carried out to explore these newer generation fungicides for the management of Entomosporium leaf and fruit spot disease of pear under natural conditions of disease development.

Methods and Materials

The present investigation was carried out at – SKUAST-K situated in the Temperate zone with 34º0837' N latitude and 74º7973' E and Altitude of 1585 meters above sea level. Thirteen fungicides both systemic and non-systemic each at their recommended concentrations were evaluated for their comparative effectiveness in combating the disease under natural condition of disease development. The evaluation of the fungicides was carried out on susceptible pear cultivar; Chinese sandy pear. The experiment was laid out in Randomized block design (RBD) with three replications. First spray was given immediately at disease appearance i.e. 2nd week of June, followed by another three sprays at an interval of 15 days, except the control trees where only water was sprayed. The observations on disease intensity both on leaves as well as on fruits was recorded 20 days after the last spray i.e 3rd week of August.

The per cent disease intensity on leaves and fruits was calculated after rating the level of disease on 0-5 scale of Horsfall and Hueberger (1942) [5] modified by Zargar (1995) [11] as described below:

Category	Numerical value	Criterion
I	0	Disease free
II	1	1-5 spots on leaf/fruit
III	2	6-10 spots on leaf/fruit
IV	3	11-25 spots on leaf/fruit
V	4	26-50 spots with or without coalescing
VI	5	Above 50 spots with or without coalescing

Per cent disease intensity was calculated using the formula (Zargar, 1995) [11].

$$\text{Per cent disease intensity} = \frac{\Sigma (n \times v)}{N \times G} \times 100$$

Where,

Σ = Summation

n = Number of diseased leaves/fruits in each category;

v = Numerical value of each category;

N = Total number of leaves/fruits examined; and

G = Maximum numerical value

Results and Discussion

Field studies revealed that all the fungicides evaluated against the Entomosporium leaf and fruit spot disease of pear were significantly superior over control in reducing the percent disease intensity. The foliar sprays with thiophanate methyl 70WP @ 0.05% initiated at the appearance of the disease and then three more sprays at 15 days interval produced the lowest leaf (PDI 2.26%) and fruit (PDI 1.53) disease with 95.86 and 96.12 percent disease reduction on leaves and fruits respectively, over control (Table 1). This treatment is closely followed by foliar sprays of Propiconazole 25EC @0.05% and triadimefon 25 WP @ 0.05% which recorded leaf disease control of 94.15 and 93.78 per cent and fruit disease control of 94.42 and 94.59 per cent, respectively. The other fungicides in decreasing order of their efficacy were carbendazim 50WP (PDI 3.82 % on leaves& 1.70% on fruits), metiram + pyraclostrobin 60 WG (PDI 3.93% on leaves & 2.53% on fruits), difenoconazole 25 EC (PDI 4.13% on leaves& 2.60% on fruits) and flusilazole 40 EC (PDI 5.20 % on leaves & 3.06% on frits). Tebuconazole 50%+ trifloxystrobin 25% 75 WG and dithionone +pyraclostrobin 16 WG were comparatively less effective treatments among the systemic fungicides, however, the treatments recorded fruit disease reduction of 90.54 and 89.55 per cent over control, respectively. The findings are supported by the observations made by Cobbs *et al.,* (1985) who also reported the effectiveness of thiophanate methyl, Propiconazole and triadimefon in managing the Entomosporium leaf spot disease of Photinia. The effectiveness of triadimefon (0.30 g a.i./L) and propiconazole (0.28g a.i/L) in controlling the Entomosporium leaf spot of pear has been also reported by Lange *et al* (1998) [7]. The potential ability of systemic fungicides to eradicate any progressing infection in the system of the plants gives them advantage over non-systemic fungicides. The better efficacy of systemic fungicides over contact fungicides (non-sytemic fungicides) was observed by many authors (Prakash and Puri, 2012 [9], Bhaliya and Jadeja, 2014) [2].

Amongst the non-systemic fungicides chlorothalonil 70 WP was the most effective treatment with minimum disease intensities of 5.16 and 3.74 per cent, on leaves and fruits respectively, followed by captan 50 WP with leaf and fruit disease intensities of 6.38 and 3.66 per cent respectively, and both the fungicides were statistically at par with each other. These two treatments recorded 90.51 and 90.72 percent fruit disease reduction over control, respectively. Propineb and mancozeb were comparatively less effective treatments, however, they also reduced 89.70 and 82.25 per cent fruit disease intensity over control, respectively. These findings are also in consonance with the result of Walker (1992) [10], who also reported the effectiveness of Chlorothalonil in managing the Entomosporium leaf spot disease of photinia when applied on weekly basis. The effectiveness of Chlorothalonil @ 0.25 % was also reported by Zargar (1995) [11] in controlling the Entomosporium leaf and fruit spot disease of pear in Kashmir valley.

From the above discussion it may be concluded that among the tested fungicides, thiophanate methyl 70 WP, propiconazole 25 EC, triadimefon 25 WP, chlorothalonil 70 WP and captan 50WP may be recommended for effective management of this important disease of pear the alternate application of these chemicals may reduce the risk of resistance development in pathogen.

Table 1: Effect of various systemic fungicides on intensity of Entomosporium leaf and fruit spot disease (*Entomosporium maculatum*)of pearcv. Chinese sandy pear under field condition

Fungicides	Conc.(Product) (%)	Per cent disease Intensity *		Per cent disease control *	
		Leaf	Fruit	Leaf	Fruit
Flusilazole 40 EC	0.02	05.20(2.48) e	03.06(2.01)cd	90.49	92.24
Difenoconazole 25 EC	0.03	04.13(2.26) cd	02.60(1.88)c	92.45	93.40
Tebuconazole 50% + trifloxystrobin 25% 75 WG	0.04	06.40(2.71) f	03.73(2.17)de	88.30	90.54
Metiram 55% + pyraclostrobin 5% 60 WG	0.10	03.93(2.21) cd	02.53(1.87)bc	92.81	93.58
Propiconazole 25 EC	0.05	03.20(2.04) b	02.20(1.78) abc	94.15	94.42
Thiophanate methyl 70 WP	0. 05	02.26(1.80) a	01.53(1.58)a	95.86	96.12
Triadimefon 25 WP	0.05	03.40(2.09) bc	2.13(1.76)abc	93.78	94.59

Carbendazim 50 WP	0.05	03.82(2.32) de	01.70(1.62)ab	93.01	95.68
Dithionone 12% + pyraclostrobin 4% 16 WG	0.08	07.73(3.27) g	04.12(2.32)e	85.87	89.55
Control		54.72(7.46) h	39.44(6.35)f		
C.D(p≤0.05)		0.19	0.26	0.19	0.26

Figures in parenthesis are the square root transformed values;
Figures with same letter(s) are statistically at par

Table 2: Effect of various non-systemic fungicides on intensity of Entomosporium leaf and fruit spot disease (*Entomosporium maculatum*) of pear cv. Chinese sandy pear under field condition

Fungicides	Conc. (%)	Per cent disease intensity*		Per cent disease control *	
		Leaf	Fruit	Leaf	Fruit
Mancozeb 75 WP	0.3	13.60 (3.81)c	7.00 (2.82)c	75.14	82.25
Propineb 70 WP	0.3	8.31 (2.77)b	4.06 (2.49)bc	84.81	89.70
Chlorothalonil 70 WP	0.3	5.16 (2.21)a	3.74 (1.87)a	90.57	90.51
Captan 50 WP	0.3	6.38 (2.43)a	3.66 (2.15)ab	88.34	90.72
Control		54.72 (7.46)d	39.44 (6.35)d		
C.D(p≤0.05)		0.30	0.42	0.25	0.36
SE(m)		0.10	0.13	0.08	0.11

Figures in parenthesis are square root transformed values

Fig 1: Coalescing of lesions and fruit cracking

Fig 2: Irregular to circular disease spots

Fig 3: Circular, black, sunken lesions with acervuli

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