Field evaluation of Indofil Z-78 against Fruit rot (*Colletotrichum* sp.) and Leaf spot (*Alternaria and Cercospora*) disease of Pomegranate

Abstract:

The pomegranate (*Punica granatum* L.), is one of the ancient and highly praised favorite fruit belongs family Lythraceae of Myrtales order which is mainly grown in tropical and subtropical regions of the world. In recent years for successful cultivation of pomegranate, faced by many constraints, among them, pest and diseases are the major ones. Common pathogens of pomegranate leaf and fruits include Anthracnose and Cercospora and Alternaria leaf spot and these pathogens cause severe loss to pomegranate crop. Therefore, a field experiment was carried out on the effect of Indofil Z-78 against leaf spots and fruit rot of pomegranate during 2018-19 and 2019-2020 at College of Horticulture, Hiriyur. Experimental results revealed that all the treatments significantly reduced the leaf spots and fruit rot disease severity over untreated control. Amongst all the treatments in both seasons. Indofil Z-78 @ 4 gm/liter was most effective in management leaf spots (15.18 and 12.33 PDI), anthracnose (10.55 and 15.13 PDI) with a yield of 4.00 tons/ha and 3.82 tons/ ha respectively followed by the same fungicides at 3.00gm/liter.

Key Words: Pomegranate, Anthracnose, Cercospora and Alternaria leaf spot and Indofil Z-78

Introduction:

Pomegranate (*Punica granatum* L.) is an ancient be loved plant with edible fruits. It is regarded as "Fruit of Paradise" and is one of the most adaptable tropical and subtropical fruit crops. In India, it is regarded as a "vital cash crop", grown in an area of 131,000 ha with a production of 1.346 million tons (Anon., 2013). Among the different Indian States growing pomegranate, Maharashtra is the largest producer occupying two thirds of the total area in the country, followed by Karnataka, Andhra Pradesh, Gujarat and Rajasthan. Pomegranate in Karnataka State is cultivated under tropical conditions, occupying an area of 15,100 ha with a production of 150,500 t. Since last two decades, its cultivation has popularized in arid and semi-arid regions of India, not only because of its sweet acidic taste, precocious bearing and better shelf-life but as a remunerative crop as well (Anon., 2004). Among these leaf/fruit spot caused by various organisms such as, *Colletotrichum gloeosporioides, Cercospora punicae, Alternaria alternata, Sphaceloma punicae, Drechslera* sp., and *Phomopsis* sp., take a heavy toll on the crop (Jamadar and Patil, 2007). This results in drastic reduction in the yield as well as ultimate marketability by way of severe spotting of the produce. There are several conventional fungicides being used by the farmers with no avail. Hence there is a need to explore chemical formulations with higher doses, which are highly efficient in managing these diseases effectively. Hence an attempt was made to identify the performance of the higher dose molecules against the leaf spots and fruit rot of pomegranate.

Material and methods:

Field experiment was conducted in two *Kharif* cropping seasons of 2018-19 and 2019-20 on the management of anthracnose (*Colletotrichum gloeosporioides*), Cercospora and Alternaria leaf spot (*Cercospora punicae* and (*Alternaria* spp.) on pomegranate crop at College of Horticulture, Hiriyur, UAHS, Shivamogga, Karnataka. The soil of the experimental field was red sandy loam which was acidic to neutral in reaction. The experiment was laid out with Randomized Block Design (RBD). The experiment consists of 5 treatments including control and were laid out in plots with size 8m X 6 m (48 m^2) with spacing 12 ft X 10 ft and the variety used was Super Bhagwa. The treatment fungicides were applied to the Pomegranate field at beginning of the disease appearance. Spray schedule was repeated at 15 days interval. The observation of incidence of Leaf spots, Fruit spots and Anthracnose diseases was assessed by using the 1-9 score chart and the per cent disease index (PDI) was calculated for each spray as under.

The per cent disease index (PDI)was calculated by the following formula which was given by Wheeler, 1969 and Fruit yield per plant wise were recorded

$$\text{Per cent disease index (PDI)} = \frac{\text{Sum of the individual disease ratings}}{\text{Number of leaves/fruits observed}} \times \frac{100}{\text{Maximum disease grade}}$$

Chart 1: Treatment details along with checks:

	Treatments	Formulation (ml or g/litre)
1	Indofil Z-78	2.0
2	Indofil Z-78	3.0
3	Indofil Z-78	4.0
4	Propineb 70% WP	3.0
5	Untreated check	NA

Chart 2: Phytotoxicity

Sl. No	Treatments	Formulation (ml/g/Litre)
1	Indofil Z-78	2.0g
2	Indofil Z-78	3.0g
3	Indofil Z-78	4.0 g
4	Untreated check	NA
5	Indofil Z-78	8.0 g
6	Indofil Z-78	16.0 g

Phytotoxicity on Pomegranate crop

Phytotoxicity observations were recorded at 0, 1, 3, 5, 7 & 10 days after each spray of different treatments as per phytotoxicity parameters

Chart : Scores for Phytotoxicity

Sr.	Phytotoxicity (%)	Score
1	No phytotoxicity	0
2	0-10	1
3	11-20	2
4	21-30	3
5	31-40	4
6	41-50	5
7	51-60	6
8	61-70	7
9	71-80	8
10	81-90	9
11	91-100	10

Statistical Analysis:

The experimental data collected were analyzed statistically for its significance of difference by the normal statistical procedure adopted for randomized block design. Data from the percent disease index and yield were analyzed by ANOVA. Percent data were transformed arcsine where necessary. Differences within the means were compared by using Fisher's LSD (Least Significant Difference) test (Walter, 1997. The level of significance used in 'F' and 'T'

test was P = 0.05 and P = 0.01. Critical differences were calculated wherever 'F' test was significant. The values percent disease index was subjected to angular transformation according to the table given by Sundarraj *et al*. (1974).

Result and Discussion:

Efficacy of Indofil Z-78 against Fruit rot (*Colletotrichum* sp.) disease of Pomegranate during 2018-19 and 2019-2020

The efficacy of the different treatment during three sprays against fruit rot (*Colletotrichum* sp.) in Pomegranate during 2018-19 is presented in Table-1.

Before the spray, the infestation of Fruit rot (*Colletotrichum* sp.) was uniform in all the treatments and ranged PDI between 0.82 and 1.0. At 10 days after first application, Indofil Z-78, the @ 4.0 gm/liter was found superior in reducing the fruit rot incidence (4.03 PDI) of Pomegranate followed by Propineb 70% WP at 3.0 gm/lt (4.63 PDI). These were superior over rest of the treatments and these followed by Indofil Z-78 @ 3.0 gm/liter recorded 6.90 PDI and Indofil Z-78 @ 2.0 gm/liter recorded PDI 7.10 PDI. However, the untreated check recorded highest fruit rot incidence by showing 12.50 PDI.

After second spray the treatment with Indofil Z-78) @ 4gm/liter recorded PDI 8.65 and Propineb @ 3.0 gm/lt recorded 9.43 PDI and were superior over rest of the treatments. However, the untreated check recorded highest fruit rot incidence by showing 24.25 PDI.

After the third spray schedule similar trend in the efficacy of treatments was recorded, wherein, Indofil Z-78 @ 4 gm/liter was recorded lowest fruit rot disease incidence caused by *Colletotrichum* sp. with 10.55 PDI and this plot recorded 72.97 per cent reduction of disease over control plot which was followed by Propineb 70% WP which recorded PDI of 16.00 and Indofil Z-78 @ 3 gm/liter and 2 gm/liter recorded PDI of 21.05 and 21.78 respectively and both these treatments were on par with each other . However, highest disease incidence was recorded in the untreated check (39.03 PDI).

The efficacy of the different treatment during three sprays against fruit rot (*Colletotrichum* sp.) in Pomegranate during 2019-20 is presented in Table-2.

Before the spray, the infestation of Fruit rot (*Colletotrichum* Sp.) was uniform in all the treatments and ranged PDI between 0.57 and 0.82. At 10 days after first application, Indofil Z-78, the @ 4.0 gm/liter was found superior in reducing the fruit rot incidence (3.58 PDI) of Pomegranate followed by Propineb 70% WP at 3.0 gm/lt (4.60 PDI). These were superior over

rest of the treatments and these followed by Indofil Z-78 @ 3.0 gm/liter recorded 6.13 PDI and Indofil Z-78 @ 2.0 gm/liter recorded PDI 6.54 PDI. However, the untreated check recorded highest fruit rot incidence by showing 12.25 PDI.

After second spray the treatment Indofil Z-78 @ 4gm/liter recorded PDI 8.59 and Propineb @ 3.0 gm/lt recorded 8.84 PDI and were superior over rest of the treatments. However, the untreated check recorded highest fruit rot incidence by showing 22.25 PDI.

After the third spray schedule similar trend in the efficacy of treatments was recorded, wherein, Indofil Z-78 @ 4 gm/liter was recorded lowest fruit rot disease incidence caused by *Colletotrichum* sp. with 15.13 PDI and this plot recorded 65.46 per cent reduction of disease over control plot which was followed by Propineb 70% WP which recorded PDI of 16.13 and Indofil Z-78 @ 3 gm/liter and 2 gm/liter recorded PDI of 22.87 and 23.48 respectively and both these treatments were on par with each other . However, highest disease incidence was recorded in the untreated check (43.80 PDI).

Efficacy of Indofil Z-78 against Leaf spot (*Alternaria and Cercospora*) disease of Pomegranate during 2018-19.

The efficacy of the different treatment during three sprays against Leaf spot (*Alternaria* and *Cercospora*) in Pomegranate during 2018-19 is presented in Table-3

Before the spray, the infestation of Leaf spot (*Alternaria* and *Cercospora*) was uniform in all the treatments and ranged PDI between 0.82 and 1.00. At 10 days after first application, Indofil Z-78 @ 4.0 gm/liter and 3.0 gm/liter were found superior in reducing the leaf spot incidence (3.78 and 3.93 PDI) of Pomegranate which were superior over other treatments which was followed by Propineb 70% WP at 3.0 gm/lt (4.58 PDI). Then Indofil Z-78 @ 2.0 gm/liter recorded 5.83 PDI. However, the untreated check recorded highest fruit rot incidence by showing 12.25 PDI.

After second spray the treatment with Indofil Z-78 @ 4gm/liter and 3 gm/liter recorded PDI of 8.28 and 8.35 respectively and these two treatments were on par with each other and was followed by Propineb @ 3.0 gm/lt recorded 9.00 PDI and were superior over rest of the treatments. However, the untreated check recorded highest fruit rot incidence by showing 23.88 PDI.

After third spray schedule similar trend in the efficacy of treatments was recorded wherein, Indofil Z-78 @ 4gm/liter and 3gm/liter were recorded lowest leaf spot disease

incidence caused by *Alternaria* and *Cercospora* with 15.18 and 15.38 PDI respectively where these two treatments were on par with each other and which was followed by Propineb 70% WP @3 gm/liter which recorded PDI of 17.53 and Indofil Z-78 @ 2 gm/liter recorded PDI of 21.95. However, highest disease incidence was recorded in the untreated check (46.28 PDI) and in the plot treated with Indofil Z-78 @ 4gm/liter recorded 67.20 per cent disease reduction over control.

The efficacy of the different treatment during three sprays against Leaf spot (*Alternaria* and *Cercospora*) in Pomegranate during 2019-20 is presented in Table-4.

Before the spray, the infestation of Leaf spot (*Alternaria* and *Cercospora*) was uniform in all the treatments and ranged PDI between 0.82 and 1.00. At 10 days after first application, Indofil Z-78 @ 4.0 gm/liter and 3.0 gm/liter were found superior in reducing the leaf spot incidence (3.25 and 3.48 PDI) of Pomegranate which were superior over other treatments which was followed by Propineb 70% WP at 3.0 gm/lt (4.83 PDI). Then Indofil Z-78 @ 2.0 gm/liter recorded 5.80 PDI. However, the untreated check recorded highest fruit rot incidence by showing 11.88 PDI.

After second spray the treatment with Indofil Z-78 @ 4gm/liter and 3 gm/liter recorded PDI of 8.22 and 8.33 respectively and these two treatments were on par with each other and were superior over rest of the treatments and was followed by Propineb @ 3.0 gm/lt which recorded 10.18 PDI. However, the untreated check recorded highest fruit rot incidence by showing 22.08 PDI.

After third spray schedule similar trend in the efficacy of treatments was recorded wherein, Indofil Z-78 @ 4gm/liter and 3gm/liter were recorded lowest leaf spot disease incidence caused by *Alternaria* and *Cercospora* with 12.33 and 12.65 PDI respectively where these two treatments were on par with each other and which was followed by Propineb 70% WP which recorded PDI of 14.18 and Indofil Z-78 @ 2 gm/liter recorded PDI of 21.95. However, highest disease incidence was recorded in the untreated check (43.55 PDI) and in the plot treated with Indofil Z-78 @ 4gm/liter recorded 71.39 per cent disease reduction over control.

Fruit yield

The efficacy of the different treatment during three applications were found difference in Pomegranate yield per plant during 2018-19 is presented in Table-1.

Application of Indofil Z-78, the @ 4.0 ml/liter recorded higher pomegranate fruit yield of 4.00 tons/ha and this treatment remained statistically superior over all the treatment. Propineb 70% WP @ 3g/liter which has given yield of 3.35 tons/ha and Indofil Z-78 @ 3 gm/liter recorded fruit yield of 3.24 tons/ha where these two treatments were on par with each other. These were followed by application of Indofil Z-78 @ 2 gm/liter (2.82 tons/ha). However, lowest yield was recorded in the untreated check (2.23 tons/ha).

The efficacy of the different treatment during three applications were found difference in Pomegranate yield per hectare during 2019-2020 is presented in Table-3.

Application of Indofil Z-78, the @ 4.0 ml/liter recorded higher pomegranate fruit yield of 3.82 tons/ha and this treatment remained statistically superior over all the treatment. Propineb 70% WP @ 3g/liter which has given yield of 3.53 tons/ha and Indofil Z-78 @ 3 ml/liter recorded fruit yield of 2.88 tons/ha. This was followed by application of Indofil Z-78 @2 ml/liter (2.04 tons/ha). However, lowest yield was recorded in the untreated check (1.94 tons/ha).

Phytotoxic effect of Indofil Z-78 for Phytotoxicity on Pomegranate crop during 2018-19 and 2019-2020

Application of Indofil Z-78 @ 16.0gm/liter, 8.0gm/ liter, 4 gm/liter,3gm/liter and 2gm/liter dose rates and other tested chemicals for its phytotoxicity studies did not shown any phytotoxic symptoms like leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty at any days after treatments on pomegranate crop (Table 5).

Navale *et al*. (1998) found that Zineb, Mancozeb, Copper oxy chloride, Ziram and Captan as the best fungicides for controlling leaf spot and fruit spots of pomegranate in mrigbahar caused by *Alternaria alternata, Cercospora* sp., *Colletotrichum gloeosporioides.* The present findings were also in agreement with the work of Gowder *et al.* (2017). Zineb is a broad-spectrum fungicide with protective action. The product is fungitoxic exposed to air. It is converted an isothicyanate, which inactivates the sulphahydral (SH) groups in enzymes of fungi. Sometimes the metals are exchanged between zineb and enzymes of fungi, thus causing disturbance in fungal enzyme functioning.

Table.1: Bio-efficacy evaluation of Indofil Z-78 against Fruit rot (*Colletotrichum* sp.) disease of Pomegranate during 2018-19

Tr. No.	Treatments	Dose Formulation (gm or ml/liter)	Before spray	PDI 10 days after			% Reduction over control after 3rd spray	Yield tons/ha
				First spray	Second spray	Third spray		
T1	Indofil Z-78	2.0	0.82 (4.93)	7.10 (15.46)	13.90 (21.89)	21.78 (27.81)	44.20	2.82 (9.67)
T2	Indofil Z-78	3.0	0.82 (4.93)	6.90 (15.23)	13.53 (21.57)	21.05 (27.30)	46.06	3.24 (10.28)
T3	Indofil Z-78	4.0	1.00 (5.97)	4.03 (11.56)	8.65 (17.10)	10.55 (18.96)	72.97	4.00 (11.29)
T4	Propineb 70% WP	3.0	0.98 (5.61)	4.63 (12.40)	9.43 (17.84)	16.00 (23.56)	59.00	3.35 (10.57)
T5	Untreated check	NA	0.94 (5.74)	12.50 (20.69)	24.25 (29.50)	39.03 (38.24)	0.00	2.23 (8.72)
	CD@5%		NS	1.21	1.51	6.52	-	0.64
	SEM		NS	0.39	0.49	2.11	-	0.21

Table.2: Bio-efficacy of Indofil Z-78 against Fruit rot (*Colletotrichum* sp.) disease of Pomegranate during 2019-20

Tr. No.	Treatments	Dose Formulation (gm or ml/liter)	Before spray	PDI 10 days after			% Reduction over control after 3rd spray	Yield tons/ha
				First spray	Second spray	Third spray		
T1	Indofil Z-78	2.0	0.82 (4.93)	6.54 (14.81)	13.00 (21.10)	23.48 (28.97)	46.40	2.04 (8.06)
T2	Indofil Z-78	3.0	0.57 (4.62)	6.13 (14.32)	12.73 (20.86)	22.87 (28.57)	47.80	2.88 (9.84)
T3	Indofil Z-78	4.0	0.63 (4.22)	3.58 (10.85)	8.59 (17.04)	15.13 (22.88)	65.46	3.82 (11.17)
T4	Propineb 70% WP	3.0	0.63 (4.62)	4.60 (12.39)	8.84 (17.29)	16.13 (23.66)	63.18	3.53 (10.57)
T5	Untreated check	NA	0.75 (4.62)	12.25 (20.46)	22.45 (28.28)	43.80 (41.41)	0.00	1.94 (7.78)
	CD@5%		NS	1.59	1.45	2.99	-	1.26
	SEM		NS	0.91	0.47	0.97	-	0.41

Table.3: Bio-efficacy evaluation of Indofil Z-78 against Leaf spot (*Alternaria and Cercospora*) disease of Pomegranate during 2018-19

Tr. No.	Treatments	Dose Formulation (gm or ml/liter)	Before spray	PDI 10 days after			% Reduction over control after 3rd spray	Yield tons/ha
				First spray	Second spray	Third spray		
T1	Indofil Z-78	2.0	0.82 (4.93)	5.83 (13.94)	11.35 (19.63)	21.95 (27.92)	52.56	2.82 (9.67)
T2	Indofil Z-78	3.0	0.82 (4.93)	3.93 (11.43)	8.35 (16.80)	15.38 (23.09)	66.77	3.24 (10.28)
T3	Indofil Z-78	4.0	1.00 (5.97)	3.78 (11.21)	8.28 (16.72)	15.18 (22.93)	67.20	4.00 (11.29)

Tr. No.	Treatments	Dose Formulation (gm or ml/liter)	PBDI Before spray	PBDI 10 days after First spray	PBDI 10 days after Second spray	PBDI 10 days after Third spray	% Reduction over control after 3rd spray	Yield tons/ha
T4	Propineb 70% WP	3.0	0.98 (5.61)	4.58 (12.34)	9.00 (17.45)	17.53 (24.75)	62.12	3.35 (10.57)
T5	Untreated check	NA	0.94 (5.74)	12.25 (20.46)	23.88 (29.25)	46.28 (42.87)	0.00	2.23 (8.72)
	CD@5%		NS	1.36	1.58	1.50	-	0.64
	SEM		NS	0.34	0.50	0.49	-	0.21

Table.4: Bio-efficacy of IFC018 (Indofil Z-78) against Leaf spot (*Alternaria and Cercospora*) disease of Pomegranate during 2019-2020

T1	Indofil Z-78	2.0	0.82 (4.93)	5.80 (13.92)	10.48 (18.81)	19.50 (26.17)	55.22	2.04 (8.06)
T2	Indofil Z-78	3.0	0.57 (4.62)	3.48 (10.74)	8.33 (16.77)	12.65 (20.83)	70.95	2.88 (9.84)
T3	Indofil Z-78	4.0	0.63 (4.22)	3.25 (10.38)	8.22 (16.66)	12.33 (20.55)	71.69	3.82 (11.17)
T4	Propineb 70% WP	3.0	0.63 (4.62)	4.83 (12.65)	10.18 (18.60)	14.18 (22.11)	67.45	3.53 (10.57)
T5	Untreated check	NA	0.75 (4.62)	11.88 (20.14)	22.08 (28.02)	43.55 (41.27)	0.00	1.94 (7.78)
	CD@5%		NS	1.48	1.76	3.14	-	1.26
	SEM		NS	0.48	0.57	1.01	-	0.41

Sl.No.	**Treatments**	**Dosage (gm /lt)**	**Phytotoxicity observations at 0, 1, 3, 5, 7 & 10 days after application (Scale: 0-9)**																				
			Leaf tip injury			**Wilting**			**Vein clearing**			**Necrosis**			**Epinasty**			**Yellowing**			**Hyponasty**		
			R_1	**R_2**	**R 3**	**R_1**	**R 2**	**R 3**	**R 1**	**R_2**	**R 3**	**R 1**	**R 2**	**R_3**	**R 1**	**R 2**	**R 3**	**R_1**	**R_2**	**R_3**	**R_1**	**R_2**	**R_3**
T1	Indofil Z-78	2.0g	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

T2	Indofil Z-78	3.0g	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
T3	Indofil Z-78	4.0 g	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
T5	Untreated check	NA	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
T6	Indofil Z-78	8.0 g	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
T7	Indofil Z-78	16.0 g	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Table.5: Evaluation of Indofil Z-78 for Phytotoxicity of Pomegranate during 2018-19 and 2019-2020

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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