International Journal on Emerging Technologies **12**(1): 80-86(2021)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Fungicide efficacy for control of Mango Powdery Mildew caused by *Oidium mangiferae*

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(Received 26 September 2020, Revised 23 December 2020, Accepted 20 January 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Mango is vulnerable to numerous diseases at all stages of development. Among these diseases, powdery mildew caused by *Oidium mangiferae* is one of the most serious and widespread disease. The purpose of this study was to investigate the efficacy of different fungicides on Mango powdery mildew. The experiment was conducted on four different varieties, viz. Sindhri (V1), Siroli (V2), Dasehri (V3), and Chunsa (V4) grown in four different mango orchards located in Tando Allah Yar, Pakistan. A total of four fungicides, i.e., Cabriotop at Ghaffar Bachani Agriculture Farm (Farm 1), Correct at Shah Agriculture Farm (Farm 2), Nativo at Hyder Shah Fruit Farm (Farm 3) and Topas at Anwar Bachani Agriculture & Fruit Farm (Farm 4) were applied to evaluate their performance by determining disease incidence percent (DI %) and disease severity index (DSI) for susceptibility/resistance of different varieties in order to study the efficacy of different fungicides on Mango powdery mildew caused by *Oidium mangiferae*. Therefore, the response of Correct, Nativo and Topas applied fungicides to the treatment was approximately the same when they were applied to Farms 2, 3 and 4, which were less than the control as 62.57 reduction percent, followed by Cabriotop (25.1 percent) with 62.113 reduction percent over control when they were applied at Farm 1. Compared with the control, all the fungicides showed good control effect, the incidence rate was between 51.7 and 84.6 percent. Before and after spraying results were recorded. After spraying all fungicides on four common varieties and farms, the (DI %) of the control was the lowest (24.9) and the highest (65.49 percent), it was 61.866 reduction percent less than the control. Mango crops are seriously affected by mango powdery mildew. At the same time, due to poor management and ignorance of orchardists, the disease often enters the epidemic state.

Keywords: Efficacy of fungicides, Powdery mildew, Mango varieties, *Oidium mangiferae,* Chemical control, Disease management

I. INTRODUCTION

The mango, *Mangifera indica* L. is one of the most famous members of the family Anacardiaceae [1]. It has been considered as one of the most commercialized fruit of the tropical and sub-tropical countries [2-4]. Mangoes in Pakistan are popular for their unique characteristics and taste. It is Pakistan's second-largest fruit crop in terms of production. Average mango production in Pakistan during Fiscal Year 2001-2017 was nearly 1.6 million tons, with an average area covered of 147 thousand hectares and an average yield of 10 tons per hectare. Pakistan's mango exports increased from $45.37 million in 2016-17 to $73.16 million in 2017-18, which constitute almost a 2.66 % share of global mango exports in 2018 [5].

Mango has a variety of infectious diseases caused by plant pathogens all over the world. There are 83 and 27 different mango plant and fruit diseases recognized in the world and Pakistan respectively [6]. Common fungal diseases of Mango include root rot [7], powdery mildew [8], gummosis [6], decline complex [9], anthracnose [10], malformation [11], some post-harvest problems [12] and a few diseases caused by nematodes [13] and bacteria [14] have also been studied [11]. Every year, several kinds of pests cause considerable damage to mango [15]. Nowadays, powdery mildew is a known devastating disease affecting almost all mango varieties regardless of geographical and ecological differences [8; 16; 17]. Powdery mildew caused by *Oidium mangiferae* is one of the most serious and widespread diseases of Mango. The most serious losses occurred during flowering and growing stages and are infected under cool and dry conditions [18]. According to [19] Mango powdery mildew in Pakistan was found to perpetuate through older infected mango leaves and inflorescence in the form of mycelium and conidia or dormant mycelium. The maximum infection in the host occurred at the temperature between 15-30℃ and relative humidity ranging from 60-85%. It is estimated that 20% to 90% of mango in Pakistan is due to the losses caused by powdery mildew. The highest (DI %) of powdery mildew was observed at temperature of 28.2℃ and humidity of 49% for variety 'Siroli'. (DSI) recorded at 34.4℃ and 47% humidity was relatively low, while variety 'Sindhri' at 40℃ and 42% humidity was the lowest (DI %). Because varieties, i.e., Dasehri and Sindhri are a late, lowest possible infestation of powdery

mildew takes place on them. Mango is highly sensitive to fungal diseases that damage the main parts of products in the process of grading, packaging, transportation, storage, sales and other post-harvest operations until they reach consumers [20].

Raut *et al.,* [21] reported that in India, among the number of infections of Mango powdery mildew, leaf, flower, and fruit infections are most serious resulting in yield loss up to 80%. According to El-Meslamany *et al.,* [22] in Egypt, (DI %) of Mango's powdery mildew increased from February through May in the various districts of Sharqia and Ismailia Governorates but with higher values especially during the growing seasons of March and April in Ismailia in 2016 and 2017. The highest value of the disease was obtained in May, ranging from 43% to 73% when the average temperature was 26.8℃ and relative humidity was 43.04%. In season 2016 Lengara cultivar proved to be the pathogen's least affected mango cultivar. Balady cultivar was highly susceptible however, and the remaining cultivars appeared to be moderately susceptible. Low temperature at night (below 20℃) and daytime temperature above 30℃, joint with humidity over 90%, are highly correlated with the severity of the disease [23].

A. Effects of fungicides in Powdery mildew

In Egypt, El-Meslamany *et al.,* [22] investigated all tested fungicides significantly reduced Mango powdery mildew disease incidence and consequently increased the efficiency rather than the control. The highest disease incidence (13.78) was obtained when the fungicide Sopulo, was applied. However, Nasr Zool and Apache revealed the least nonsignificant values of disease incidence being 4.60 and 5.00%, respectively. The highest efficiencies were also obtained with Nasr Zool and Apache being 82.32% and 80.92% without significant differences between them. It could be concluded that the application of such fungicide significantly reduced the disease incidence percent and in consequence improved efficiency. The great reduction in disease incidence thus could be obtained through rotational application materials rather than repeating spraying from season to another in order to reduce the risk of intensive use of synthetic fungicides *in-vivo* conditions.

In Bangladesh, according to Pérez-Rodríguez *et al.,* [24] in the case of powdery mildew, on the basis of collecting the data of each stage (flowering stage, pinheaded and marble stage), the control group had the highest degree of powdery mildew (1.51%) and the lowest level of Indofil (0.32%) with the foliar spraying concentration of 2g /L. Compared with other treatments, Indofil M-45 and BAU-Biofungicide could reduce the powdery mildew of leaves and inflorescences to the greatest extent.

Therefore, in the current study, different fungicides are used to control the Mango powdery mildew, to reduce the occurrence of disease, and evaluate the incidence rate of different varieties of mango. Mango powdery mildew exists for a long time in the form of mycelium, conidia, or resting mycelium through the old leaves and inflorescences. The maximum infection occurred in the range of temperature (15-30℃) and relative humidity (60-85%) [19] and the purpose of this study is to evaluate the performance of different mango varieties through the determination of (DI %), to determine the (DSI) for susceptibility/ resistance of different mango varieties and to study the efficacy of different fungicides on powdery mildew disease caused by *Oidium mangiferae* on different mango varieties.

II. MATERIAL AND METHODS

The present study was conducted in mango orchards of different 4 varieties *viz*. Sindhri, Siroli, Dasehri, and Chunsa at four different farms of Tando Allah Yar District. Four fungicides *viz*: Nativo, Topas, Correct, and Cabriotop were applied to evaluate their efficacy.

The inflorescence of mango affected due to powdery mildew disease caused by *Oidium mangiferae* was observed in 13 mango varieties and the random ages of plants were carried out. For powdery mildew disease and to know the effect of fungicides four common mango varieties were selected in which two plants were selected for each variety of mango one as for fungicidal evaluation and the second was served as control (without fungicide). The mango inflorescence was treated with fungicide and the same four common varieties were treated in each farm with one fungicide per recommended doses, with 15 days interval between each spraying. Further details are given in (Table 1). Ten inflorescences of each variety were observed before and after each spraying. The same method was used for the response of the fungicidal effect, but only 4 varieties were common for powdery mildew disease, four farms were observed every 15 days. Naqvi *et al.,* [25] reported that, the white superficial powdery mycelial growth on inflorescence, leaves and young fruits were the utmost clear signs of Mango powdery mildew. The infection of powdery mildew was assessed to define the disease severity index and disease incidence percent for the field investigation by adjusting the scale for disease on the inflorescence.

Table 1: Details of fungicides used in experiments.

Tradename	Activeingredient	Applied dose	Manufacturer	Farms
Cabriotop	*Pyraclostrobin*	125/100l H_2O	Farma medicalcompany	Farm 1
Correct	*Thiophinate methyle*	100g/100l H_2O	Dada Jeecorporation	Farm 2
Nativo	*Kevaconazol*	65g/acre	Bayer crop science	Farm 3
Topas	*Panaconazol*	50cc/100l H_2O	Syngenta	Farm 4

For data collection, (DI %) was obtained using Equation 1 and (DSI) was collected by using Equation 2 [25; 26]. as:

$$DI\ \% = \frac{n}{N} \times 100 \quad (1)$$

where, n refers to number of infected inflorescence and N refers to total number of inflorescences.

$$DSI = \frac{\sum S_i}{N} \times \frac{100}{S_m} \quad (2)$$

Where $\sum S_i$ refers to the sum of all the score of individual inflorescence and S_m refers maximum scale evaluated, a visual scale of powdery mildew was used for evaluation: 1 –visible symptoms in 0 to 25% of the inflorescence; 2 – 25-50%; 3 – 50-75%; and 4 – more than 75%. [25; 26]

The reduction percent (RP) of the powdery mildew over the control was calculated by using the following formula:

$$RP = \frac{DI_{ct} - DI_{fst}}{DI_{ct}} \times 100$$

Where;

DI_{ct} = Powdery mildew disease incidence in control trees.

DI_{fst} = Powdery mildew disease incidence in fungicide sprayed trees.

A. Statistical Analysis

All the data collected during fieldwork was then analyzed using statistical analysis software (version 8.1). ANOVA and the mean were separated by statistical analysis software (version 8.1). The difference obtained at the P ≤ 0.05 level is considered significant.

III. RESULTS

The results showed that the highest incidence rate of Mango powdery mildew was ranged (98.33%) in Beganpali, Langro, Sindhri, Siroli, and Sonaro variety, followed by Chunsa and Desi variety (89.00%), Totapari (69.00%), and Sufaida variety (59.00%). The lowest (DI %) ranged (9.00%) in Fajri, Dasehri, and Anwar ratol variety followed by Lalbadshah (39.00%) mango variety (Figure 1).The highest disease severity percent of Mango powdery mildew ranged in Sufaida Variety (57.00%) followed by Chunsa variety (55.70%), Fajri variety (53.00%), Dasehri variety (49.00%), Desi variety (48.00%), Siroli variety (35.50%), Sindhri and Anwar ratol variety (34.00%). The lowest disease severity index percent was ranged in Lalbadshah variety (4.00%) followed by Sonaro variety (8.00%), Beganpali variety (19.00%), Totapari, and Langro variety (20.00%), respectively (Fig. 1).

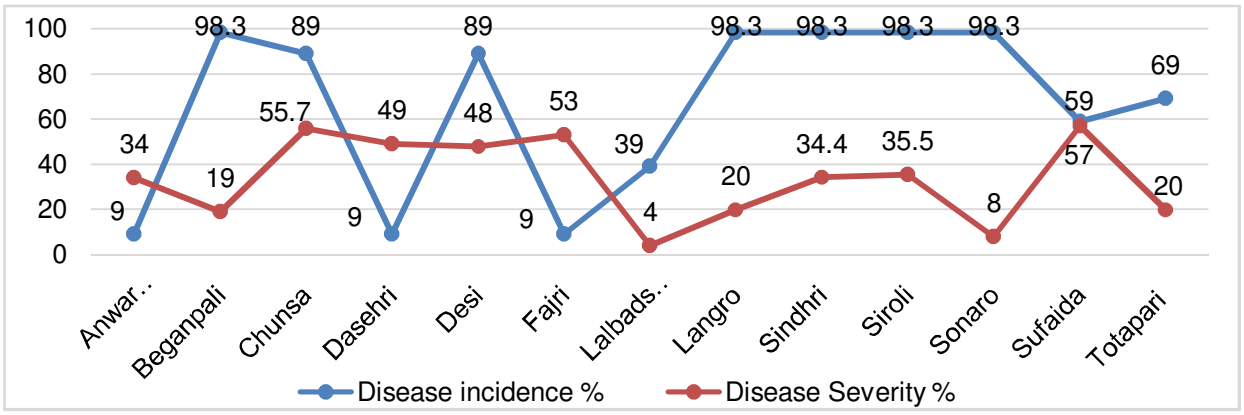

Fig. 1. Performance of different mango varieties concerning powdery mildew disease Incidence and disease severity.

Initially, powdery mildew (DI %) were ranged from (61 to 64.6%) on Siroli mango variety at all four observed farms; however, it was highest at Farm 3 compared to other farms. The range of (DI %) for Dasehri (51.4 to 55.6%), Chunsa (40.7 to 43.0%), and Sindhri (42.1 to 44.6%) was comparatively lower than Siroli variety (Figure 2). Whereas, the minimum disease incidence was ranged from (40.7 to 43.0%) on Chunsa variety was comparatively lower than Sindhri variety (42.1 to 44.6%) before spray in selected trees in the experimental area. The minimum (DI %) ranged from on Chunsa variety (14.5 to 17.4%) was comparatively lower than Sindhri variety (20.7 to 24.8%), while the maximum (DI %) was ranged from on Siroli variety (30.7 to 32.5%) was comparatively lower than Dasehri variety (28.7 to 31.2%) in case of using fungicides.

The response of Correct, Nativo and Topas fungicides to the treatment was approximately the same when they were applied to Farms 2, 3 and 4, while the incidence was ranged between 24.9, 24.925 and 24.975%, with 61.765, 60.986 and 62.57 reduction percent over control respectively followed by Cabriotop (25.1%) with 62.113 reduction percent over control when applied at Ghaffar Bachani Agriculture Farm (Fig. 3 and 4). All the fungicides gave a good response as compared to control, in which the disease incidence remains between 51.7 to 84.6%.

The observations were also recorded before spray and after spray as control. The minimum (DI %) was recorded after all fungicide sprays in four common varieties and farms (24.9%) and the maximum (DI %) was observed in control (65.49%), whereas 61.866% reduction over control was recorded after spray in four common varieties and farms of all four fungicides (Fig. 3 and 4). The results also show that it is not enough for mango growers to use one spray, so further analysis is needed.

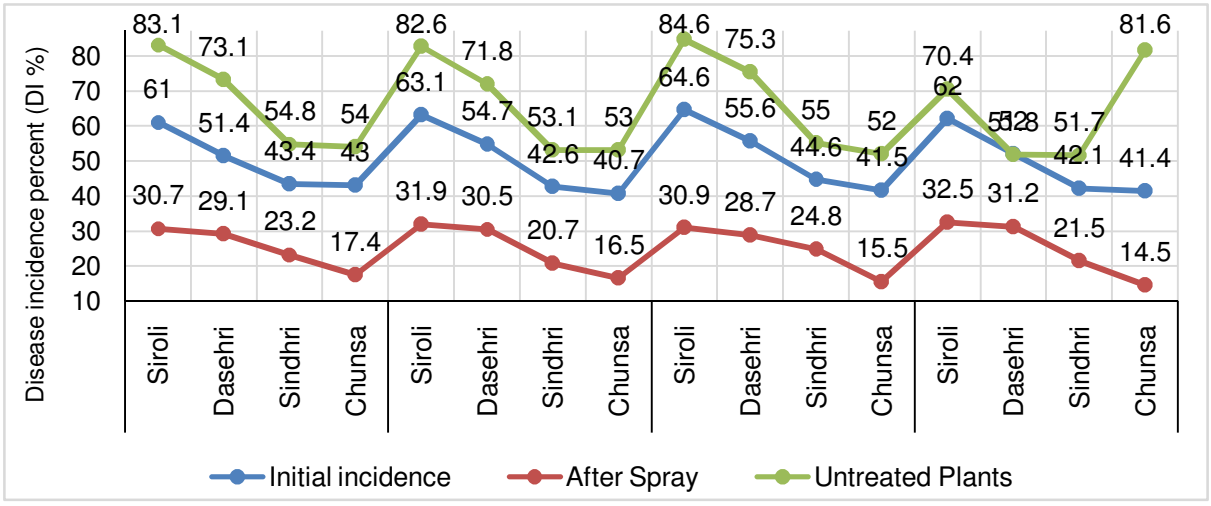

Fig. 2. Efficacy of different fungicides on powdery mildew disease caused by *Oidium mangiferae* on different mango varieties.

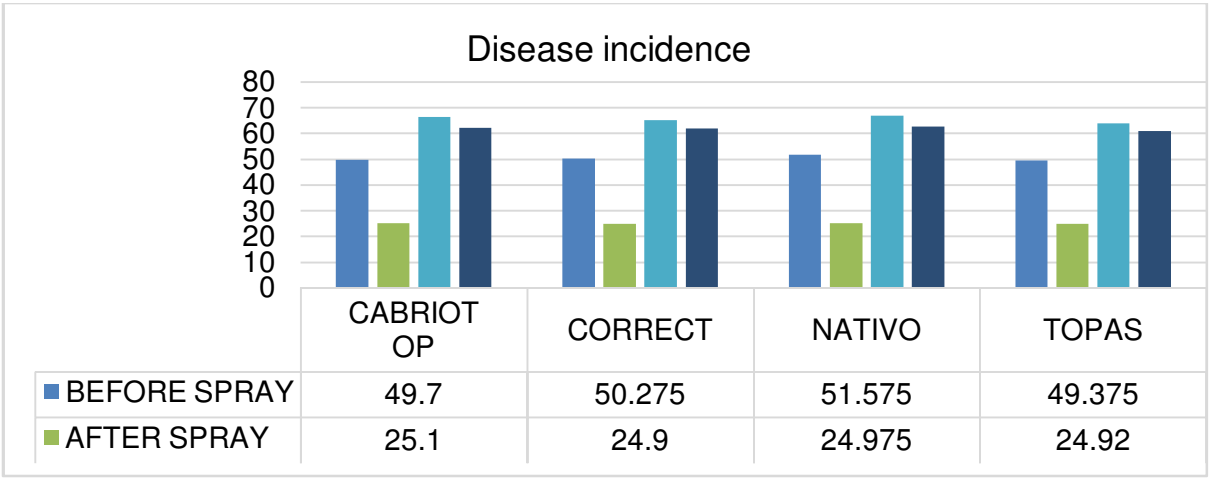

Fig. 3. Overall performance of different fungicides and reduction percentage of powdery mildew over control.

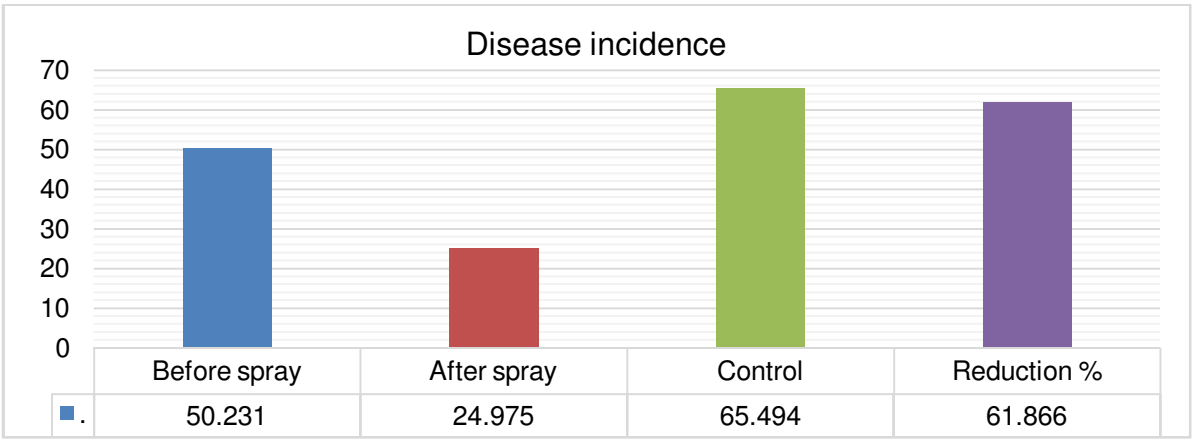

Fig. 4. Overall disease incidence % of powdery mildew on four different mango varieties and reduction percentage over control.

IV. DISCUSSION

The powdery mildew disease symptoms were observed on the leaves, flowers, and fruits in leading mango varieties *viz*; Anwar Ratol, Beganpali, Chunsa, Dasehri, Desi, Fajri, Lal Badshah, Langro, Sindhri, Siroli, Sonaro, Sufaida, and Totapari. Characteristic symptoms, the apparent growth of white powdery pathogens was found present with diseased main inflorescence branches. These were also arisen on fresh tissues of near about

whole floral divisions. The small-sized young fruits were also covered partially or completely by the mildew, and some of the infected fruits showed cracks and corky tissues. These similar symptoms are reported on different mango varieties [1, 17, 22, 27].

The performance of different mango varieties with an orientation to Mango powdery mildew disease represents the highest disease incidence percent of Mango powdery mildew was recorded in Beganpali, Langro, Sindhri, Siroli and Sonaro variety (98.33%), followed by Chunsa and Desi variety (89.00%), Totapari (69.00%) and Sufaida variety (59.00%), while the lowest (DI %) was recorded in Fajri, Dasehri and Anwar ratol variety (9.00%) followed by Lalbadshah (39.00%) Mango variety. About 14 to 94% disease incidence on Zafaran, Yakta, Tota Pari, Swarnarika, Sindhri, Shan e Mustafa, Shan e Ali, Sensation, Saroli, Samar Bahisht, Ratole No. 12, Raspuri, Neelam, Manila (Carabao), Malda, Malda Late, Mahmood Khan, Langra, KishanBhog, Ghulab e Khas, Fajri, Fajri, Early Gold, Dusehri, Desi, Dasheri, Chaunsa, Chaunsa white, Chaunsa Black, Armughan, Anwar ratol, Anmol, Alphonso, and Almas varieties reported [17, 25, 26, 28, 29, 30-34]. Similar to the (DI %), the (DSI) of Mango powdery mildew showed that the highest disease severity percent of *O. mangiferae* was noticed in Sufaida Variety (57.00%) followed by Chunsa variety (55.70%), Fajri variety (53.00%), Dasehri variety (49.00%), Desi variety (48.00%), Siroli variety (35.50%), Sindhri and Anwar ratol variety (34.00%). The lowest (DI %) was observed in Lalbadshah variety (4.00%) followed by Sonaro variety (8.00%), Beganpali variety (19.00%), Totapari, and Langro variety (20.00%), respectively. Also between 20 to 44.3% severity reported [25, 27, 32, 34].

The studies concerning the efficacy of four different fungicides at four different farms on four different varieties reveals that Initially powdery mildew disease incidence percentwere ranged from (61 to 64.6%) on Siroli mango variety at all four observed farms; however, it was highest at Farm 3 comparative to other farms. The range of (DI %) for Dasehri (51.4 to 55.6), Chunsa (40.7 to 43.0%), and Sindhri (42.1 to 44.6%) was comparatively lower than Siroli variety (Fig. 2). Whereas, the minimum (DI %) was ranged from (40.7 to 43.0%) on Chunsa variety was comparatively lower than Sindhri variety (42.1 to 44.6%) before spray in selected trees in the experimental area. The data was again recorded 15 days after spraying fungicides. The minimum (DI %) was ranged on Chunsa variety (14.5 to 17.4%) was comparatively lower than Sindhri variety (20.7 to 24.8%), while the maximum (DI %) was ranged from on Siroli variety (30.7 to 32.5%) was comparatively lower than Dasehri variety (28.7 to 31.2%) in case of using fungicides. The response of Correct, Nativo and Topas fungicides to the treatment was approximately the same when they were applied to Farms 2, 3 and 4, while the incidence was ranged between 24.9, 24.925 and 24.975%, with 61.765, 60.986 and 62.57 reduction percent over control respectively followed by Cabriotop (25.1%) with 62.113 reduction percent over control when applied at Farm 1. All the fungicides gave a good response as compared to control, in which the disease incidence remains between 51.7 to 84.6%. The observations were also recorded before spray and after spray as control. The minimum (DI %) was recorded after all fungicide sprays in four common varieties and farms (24.9%) and the maximum (DI %) was observed in control (65.49%), whereas 61.866% reduction over control was recorded after spray in four common varieties and farms of all four fungicides. The results also represent that only one spray is not enough, as mango growers commonly practice, therefore further analysis should be carried out. Whereas 61.866% reduction over control was recorded after spray in four common varieties and all farms four fungicides. While Jiskani *et al.,* [33] evaluated four foliar fungicides *viz*. Baytan Foliar, Calixin, Topas, and Bayleton to their efficacy, along with assuring of Mango powdery mildew. Two sprayings at 15 days intervals were done on Sindhri, Siroli and Summer Behisht, Chaunsa varieties and revealed that Bayleton 25 WP at the rate of 35g per 100 liters of water was found to be the most effective for control of disease followed by Calixin, Baytan Foliar and Topas as compared to control (no fungicide). However, Sharma *et al.,* [35] mentioned that Trifloxystrobin is a new strobilurin fungicide against fungal plant pathogens active a wide range. Their research showed that highly effective in controlling powdery mildew on mango disease by Trifloxystrobin. Whereas, Reuveni *et al.,* [27] reported that earlier applications did not improve disease control; later applications, beginning at the first-open-flower stage, were less effective. Whereas, Ravikumar *et al.,* [36] reported that the incidence rate of powdery mildew on leaves, inflorescence and fruits was 18%, 16.60% and 17.08% respectively after treatment with Fluxapyroxad 250g/l + Pyraclostrobin 250g/l 500 SC @ 2 ml/L of water, and significantly lower than that of control (leaves, inflorescence and fruits incidence rate was 54.73%, 52.80% and 53.33%). However, [34] conducted two experiments on a 10-year-old mango tree. In the control of powdery mildew in 2012 and 2013, compared with the control, spraying any treatment on mango trees significantly reduced the severity of powdery mildew and significantly increased fruit yield. In addition, the results of the two seasons test showed that alternate spraying of Cultar (Paclobutrazol), basic potassium phosphate, and punch fungicide had the best effect on reducing the disease severity and increasing fruit yield, followed by spraying Punch fungicide, and spraying single basic potassium phosphate. At the same time, in this regard, the treatment efficiency of Brelex was the lowest, followed by spraying Agrotone. The intermediate number of other treatments recorded. The disease severity rate of the control treatment was 44.3%, and the fruit yield was low. Whereas, Goiania [37] suggested that chemical control is a suitable way to control the attacks of mildew.

V. CONCLUSION

Powdery mildew (DI %) was observed on the Siroli mango variety in all four farms, but it was the highest in Farm 3 compared with other farms. The range of Dasehri, Chunsa, and Sindhri (DI %) is relatively lower than that of Siroli (Fig. 2). The minimum (DI %) of Chunsa was lower than that of Sindhri before spraying. After 15 days of spraying the fungicide, the minimum (DI %) of Chunsa was relatively lower than that of Sindhri, and the maximum (DI %) of Siroli was relatively lower than that of Dasehri. All fungicides applied in Farm 2, 3,

and 4 showed the same reaction, followed by fungicide applied in Farm 1. Compared with the control, all fungicides showed a good effect. After spraying fungicides in 4 common varieties and farms gave the minimum (DI %), while the maximum value (DI %) was recorded in the control, the decrease was more than that in the control group. The results also show that only one spray is not enough, as Mango growers commonly practice, therefore further analysis should be carried out.

FUTURE SCOPE

The research is very useful for the Mango growers to control powdery mildew of Mango caused by *Odium mangiferae*. Very little work has been conducted on powdery mildew of Mango. More research is needed to introduce biological control and integrated disease management.

ACKNOWLEDGEMENTS

Authors would like to appreciate all the efforts provided by the respected editor and admirable referee(s) for their valued suggestions and comments to improvise this manuscript.

CONFLICT OF INTEREST

The authors of this manuscript confirm that there is no any conflicts of interest associated with the research article.

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How to cite this article: Abdul Qayoom Majeedano, Absar Mithal Jiskani, Muhammad Ibrahim Khaskheli, Muhammad Mithal Jiskani, Tariq Majidano and Sayed Sajjad Ali Shah (2021). Fungicide efficacy for control of Mango Powdery Mildew caused by *Oidium mangiferae*. *International Journal of Emerging Technologies*, **12**(1): 80–86.