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Preventive Control of Powdery Mildew Disease of Mango

K.P. Akhtar[1], I.A. Khan[1&2*], M.R. Kazmi[1], R.I. Hassan[1] and B. Fatima[1]

[1]University of Agriculture/Mango Project, Faisalabad, Pakistan
[2]Department of Agronomy, Horticulture, Entomology and Plant Pathology, College of Agriculture, Sultan Qaboos University, P.O. Box 34, Al-Khod 123, Oman

التحكم الوقائي لمرض البياض الدقيقي في أشجار المانجو

الملخص: يتسبب فطر (أوبديم مانجفري – بيرثت) في إصابة أشجار المانجو بمرض البياض الدقيقي. وتتم الإصابة بالمرض عند تحرر الأبواغ من الأنسجة الحاضنة للخيوط الفطرية، تحت الظروف المناخية المناسبة، وحملها في الهواء. التنبؤ السليم بموعد تحرر الأبواغ المحمولة هوائيا ساعد كثيرا في خفض عدد مرات الرش بالمبيدات الفطرية. تم استخدام مصايد الأبواغ لرصد تركيزها في الهواء خلال شهور فبراير ومارس وأبريل من عامي ١٩٩٦ و١٩٩٧ . كما تم رصد معدلات الرطوبة النسبية ودرجات الحرارة اليومية خلال نفس الفترة وذلك لمعايرتها بتركيز الأبواغ في الهواء. كانت العلاقة إيجابية بين عدد الأبواغ في الهواء من جهة وارتفاع درجات الحرارة وانخفاض الرطوبة النسبية بعد موجة من درجات الحرارة المنخفضة والرطوبة النسبية المرتفعة والأجواء الغائمة من جهة أخرى. ووجد أن أقصى تركيز للأبواغ في الهواء كان عند درجة حرارة قدرها ٢٥° م تقريبا ورطوبة نسبية تراوحت بين ٤٠ – ٦٠%. وظهرت أعراض المرض في الأشجار بعد ٥ – ٨ أيام من ملاحظة أول انتشار للأبواغ في الهواء. تم في هذه الدراسة اختبار مفعول عشر مبيدات فطرية على ثلاثة أنواع من المانجو (لانجرا وأشهاري وأنور ريتول). ولقد كان للرش الوقائي عند أول ظهور للأبواغ أثرا إيجابيا في التحكم بالمرض. وأمكن التحكم الوقائي بالمرض (بنسبة بلغت ٩٩%) عن طريق التوقيت المناسب بالرش مرتين بالمبيدات الفطرية. وتعتمد درجة حساسية الأزهار للمرض على مرحلة تطورها. ساعد التنبؤ السليم على خفض عدد مرات الرش المطلوبة من سبعة إلى مرتين أو ثلاث فقط. ولم تكن هناك فروق تذكر بين مختلف أنواع المانجو في معدلات الإصابة بالمرض أو الاستجابة للمبيدات الفطرية. كما تم التعرف في هذه الدراسة على شجيرات من المانجو أظهرت مقاومة مستمرة لمرض البياض الدقيقي.

ABSTRACT: *Oidium mangiferae* Berthet was found to be associated with the powdery mildew disease of mango. The air-borne conidia are released from the old tissue harboring the dormant fungal hyphae under favorable weather conditions, which produce the disease. Proper forecasting of release of airborne innoculum significantly reduced the required number of sprays needed for chemical control. Spore traps were used to monitor the concentration of airborne conidia during the months of February, March and April 1996 and 1997. Daily temperature and relative humidity were noted and the spore counts from the spore traps were correlated to the meteorological data. There was a positive trend between rising temperature, lowering relative humidity and number of spores in the air after a low temperature, high humidity and cloudy spell of weather. The maximum spore occurrences were noted around 25°C and relative humidity of 40-60%. It took 5-8 days for the emergence of disease symptoms after the first detection of airborne conidia. Ten fungicides were tested on three mango varieties (Langra, Dashehari, and Anwar Retol). The preventive sprays at the stage of first detection of air born conidia were effective in controlling the disease. Optimal timing of two sprays of fungicide were sufficient to provide preventive control (>90%). The susceptibility of inflorescence varied with its developmental stage. Proper forecasting reduced the number of sprays from 7 to 2 or 3. There was no varietal difference in incidence of the disease or response to fungicide applications. During the course of this study, we identified seedling plants which consistently showed resistance to powdery mildew.

Mango production has been declining due to new disease incidences associated with changing weather patterns. Among the diseases of mango, powdery mildew is a weather dependent problem. The relationship of incidence of powdery mildew disease with temperature and humidity has been a subject of epidemiological studies (Palti *et al.*, 1974; Gupta and Deng, 1981; Schoeman *et al.*,1995).

*Corresponding Author.

The crop losses due to powdery mildew are usually very high (100%), especially, if timely preventive control is not practiced. The damage due to infection occurs before the appearance of disease symptoms. The fungus attacks inflorescences, young leaves and fruit at early developmental stages (Lonsdale and Kotze, 1993a,b).

O. mangiferae is an obligate parasite. During conditions unfavorable for infection, or when the susceptible tissues are not available, the fungus survives as dormant mycelium on older leaves and stem tissues. The fungal conidia are released under favorable temperature and humidity conditions. The air-borne conidia land on the susceptible tissues and produce the disease. Velvety and powdery deposits on a dark to smoky gray background are the characteristic symptoms of disease (Kotze, 1985). Detecting the release of airborne conidia is important for proper preventive control.

The fungus causing powdery mildew disease of mango responds well to a range of fungicides. Efficacy and economics of chemical control is dependent on time and frequency of application, doses and spray techniques (Brooks, 1991; Ghaffar *et al.*, 1975; Haq *et al.*, 1994; Rawal and Ullasa, 1989). Generally, the residual effect of fungicide lasts for 7-10 days and the potential for disease spread remains present for nearly two months, necessitating repeat applications of the fungicide. Such multiple applications are not only expensive but also hazardous and inefficient. Proper forecasting of disease spread can significantly reduce the required number of sprays needed to control the disease (Brooks, 1991; Schoeman *et al.*, 1995), while making the control environmental friendly and economical. Epidemiological prediction models should be developed and combined with other IPM strategies like the use of genetically resistant varieties.

We report results of a series of experiments conducted to determine: (1) the role of temperature and relative humidity on the release of conidia; (2) proper chemical control; and (3) the prospects of employing genetic resistance.

Materials and Methods

FORECASTING STUDIES: Volumetric spore samplers were installed in experimental mango orchards at one site in 1996 and two sites located about 200 km apart in 1997. In the first year, samples were taken once daily at sampler height (~1m), and two heights (sampler height and 5m above ground level) and twice daily in 1997. From the second site, samples were taken once daily from two orchard locations separated by a distance of about 15 km (at sampler height). The sampler was rotated constantly by an electric motor between the sampling hours. The samples of air-borne microflora were trapped to one side of the microslide coated with glycerine and placed in the slide chamber in such a way that the coated side faced the orifice. Slides were observed daily under a microscope using mounting medium (lactophenol and Hoeyer's mounting medium) under cover slip. The number of spores were counted daily and correlated with climatic factors.

Efforts were made to study the taxonomic characters of the sexual form of the pathogen. No ascospores were recorded in any sample. The characters of the asexual form of the pathogen (e.g. mycelial characters), the shape and size of conidiophore and conidia, and colours of the pathogen at its various stages were examined and compared to data of Boeswinkel (1980) and Pathak (1987) for identification purposes.

From the 1st of February to the end of May during both years, observations were recorded on the first appearance of powdery mildew on the inflorescence and its subsequent development and spread in the orchard. Disease incidence was recorded from 20 randomly selected inflorescences from five plants of each of three varieties (Langra, Dashehari, and Anwar Retol). The data were compiled as percent of inflorescence area covered by mildew symptoms.

PREVENTIVE CONTROL: During 1997, *in vitro* germination of conidia was tested with or without fungicide in the germination medium (a humid surface site on cover slip). Fungicide solutions of seven chemicals named Nordox, Anvil, Thiovit, Topas, Darosal, Topsin-M and Rubigan were prepared. One drop from each of the concentrations was placed on cover slips and allowed to dry. Fresh spores (conidia) were dusted from diseased panicles with the help of a camel hairbrush on to cover slips. Van Tieghem cells were prepared by fixing a glass ring in the centre of a Petri dish. The ring was half filled with distilled water and cover slips inverted over the ring. A high humidity chamber was created by this arrangement. The plates were incubated at 25°C. The experiment was replicated three times. Data on germination of conidia were recorded after 24 and 48 hours of incubation. The total germination values (after 48h) were averaged as percent of control. The percentage data was analysed on a general linear model (GLM), using Statistical Analysis System (SAS, 1993). Means were separated by Tukey's test.

Ten fungicides (only 3 in 1996 and all 10 in 1997) were applied to three mango varieties, Langra, Dashehari and Anwar Retol, at two frequencies, i.e. 2 and 3 sprays along with an unsprayed control. Treatments were replicated 5 times. The first spray was performed when the first spore was trapped by the

spore sampler, followed by the 2nd and 3rd sprays at 15 day intervals. The concentrations of fungicides were adjusted according to the active ingredients provided in the commercial formulations. The field sprays were applied with a wheel barrow spray machine, until complete wetting of tree canopies seen as dropping from the drip line.

Twenty inflorescences were tagged in each plant and data were collected on the percent-infected inflorescence twenty days after the last spray. Data on fruit set were also noted from tagged inflorescence. Disease severity was recorded by following the scale of Dator (1984). The data on disease incidence and varietal response were arranged in a randomized complete block design and subjected to analysis of variance. The means with significant variances were separated by LSD (Steel and Torrie, 1980).

VARIETAL RESISTANCE: Twenty-three established mango orchards from different locations of Punjab were inspected to assess the incidence of powdery mildew infection on various mango cultivars during 1996 and 1997. Six mango varieties namely, Langra, Chausa, Anwar Retol, Dashehari, Fajri and Sindri were selected for intensive observations during the flowering and fruit setting period. In many orchards, seedlings mangoes (without grafted scion) were also available which were included in this survey study. Data were collected from 100 randomly selected inflorescences of five plants of each variety/seedling tree. Varietal response was recorded following the scale of Kumar and Beniwal (1987) and rated as resistant, moderately resistant, tolerant, moderately tolerant and susceptible.

Results and Discussion

FORECASTING STUDIES: The spore trapping and weather data are presented in Figure 1, 2 and 3. There was a positive trend between rising temperature, lowering relative humidity and number of spores in the air after a low temperature, high humidity and cloudy spell of weather. The maximum spore occurrences were noted around the temperature of 25°C and relative humidity of 40-60%. It took 5-8 days for the emergence of disease symptoms after the first detection of airborne conidia.

Correlation coefficients were calculated between the spore counts and two weather factors, i.e. temperature and relative humidity (Table 1). A positive correlation between release of conidia and rise in temperature was seen in three of seven counts. Only two of seven counts showed significant correlation with the minimum or lowering temperature. A negative correlation between spore counts and relative humidity was consistent and is supported by earlier reports of

TABLE 1

Correlation between air born conidia of Oidium mangiferae and weather factors[#]

Spore/Conidia Trapped	Min. Temp.	Max. Temp.	% Relative Humidity
1996			
Site - 1, Spore Trap at 1m, 24 hrs. counts	0.161*	NS	NS
1997			
Site-1, Spore Trap at 1m, 8:00 am-5:00pm	NS	NS	NS
Site-1, Spore Trap at 1m, 6:00pm - 7:00 am	NS	NS	-0.583**
Site-1, Spore Trap at 5 m, 8:00am - 5:00 pm	NS	0.610**	-0.845**
Site-1, Spore Trap at 5m, 6:00pm - 7:00am	NS	0.207*	-0.700**
Site-2A, Spore Trap at 1m, 24 hrs. counts	0.200*	0.840**	-0.295**
Site-2B, Spore Trap at 1m, 24 hrs. counts	NS	NS	-0.342**

[#]NS, $P>0.05$; * $P<0.05$; ** $P<0.01$.

TABLE 2

Effect of different concentrations of fungicides on in vitro conidial germination of Oidium mangiferae (1997)

Fungicides	Conc./liter	Germination after 24h	Germination after 48h	% Decrease over control*
Nordox	1g	3	8	63.7
	2g	0	3	86.4
	4g	0	0	100.0
	8g	0	0	100.0
Anvil	0.15ml	4	6	72.7
	0.30ml	2	4	81.8
	0.60ml	1	3	86.4
	1.20ml	0	0	100.0
Thiovit	0.63g	0	3	86.4
	1.25g	0	0	100.0
	2.50g	0	0	100.0
	5.00g	0	0	100.0
Topas	0.12ml	1	3	86.4
	0.25ml	1	2	90.9
	0.50ml	0	0	100.0
	1.00ml	0	0	100.0
Darosal	0.15ml	4	6	72.7
	0.30ml	2	3	86.4
	0.60ml	0	0	100.0
	1.20ml	0	0	100.0
Topsin-M	0.25g	0	2	90.9
	0.50g	0	0	100.0
	1.00g	0	0	100.0
	2.00g	0	0	100.0
Rubigan	0.07ml	3	8	63.7
	0.15ml	2	6	72.7
	0.30ml	0	0	100.0
	0.60ml	0	0	100.0
Control	Distilled Water	16	22	------

*The Tukey's test for comparison of mean values showed no differences ($P<0.05$).

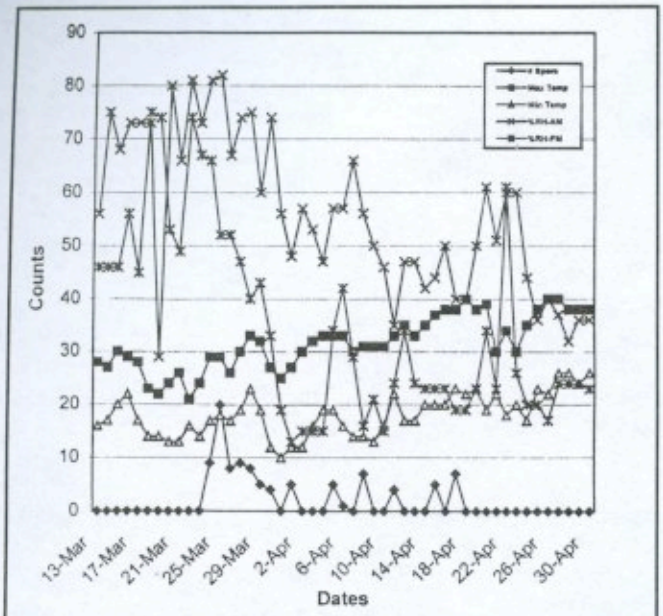

Figure 1. Spore trap and epidemiological data collected at ground level (1m) during 1996 flowering season from site-1

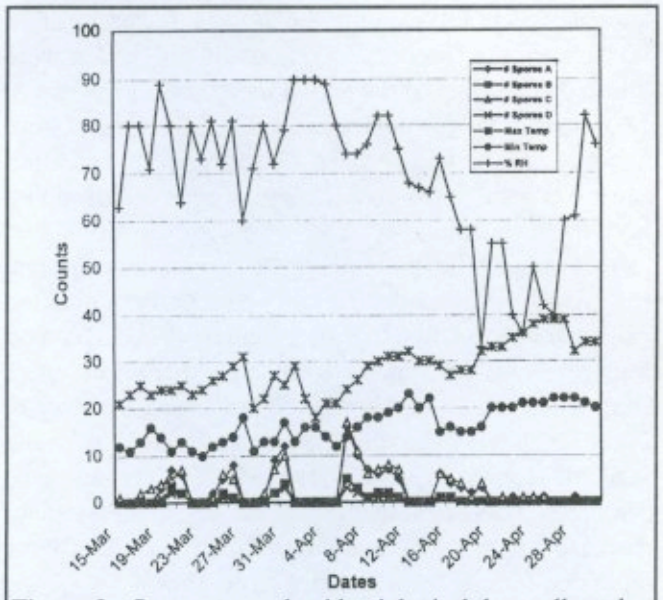

Figure 2. Spore trap and epidemiological data collected at two levels in the air during 1997 flowering season from site-1

Schoeman *et al.* (1995). Their report also indicated a diurnal behavior of spore release process, which was not exactly duplicated in our experiments. However, there were clear differences between years, locations and height at which the spore traps were placed. Our data are in close agreement with the findings of Gupta (1989) who reported 26°C as the threshold temperature for spread of powdery mildew disease in mango. Simultaneously, our results are in sharp contrast to the data reported by the same author showing positive correlation between 100% relative humidity and spread of powdery mildew disease. The differences could be explained by the nature of data collected i.e. the release of spores in our case and probably the actual development of disease symptoms reported by Gupta (1989). The differences reported in the relationship of environmental factors with the disease symptoms and the spore release process lend support to the need for proper forecasting, which was the basis of the present study.

PREVENTIVE CONTROL: Conidia germination and release of spores were effectively controlled by several commercial chemical fungicides. All seven fungicides at four concentrations of each, prevented the germination of conidia (Table 2). The statistical analysis showed non significant differences among the fungicides in their efficacy to prevent germination of fungal conidia.

Fungicide treatments applied at the first detection of air born conidia proved effective over the control (Table 3). Three fungicides (Topsin-M, Dithane M-45, Antracol) were tested during the 1996 season on three mango varieties (Anwar Retol, Desherari, Langra). Two sprays of either Topsin-M or Dithane M-45 gave effective control of powdery mildew. The control efficiency of Topsin-M and Dithane M-45 was significantly better than Antracol. In the second year (1997), seven more chemicals were tested and found to be equally effective or better than Topsin-M, Dithane M-45 and Antracol. The reduction of disease incidence had a corresponding effect on the increase in fruit set. There was no varietal difference seen for incidence of disease or response to fungicide applications. Apart from temperature and relative humidity, wind speed could play a significant role in the spread of disease.

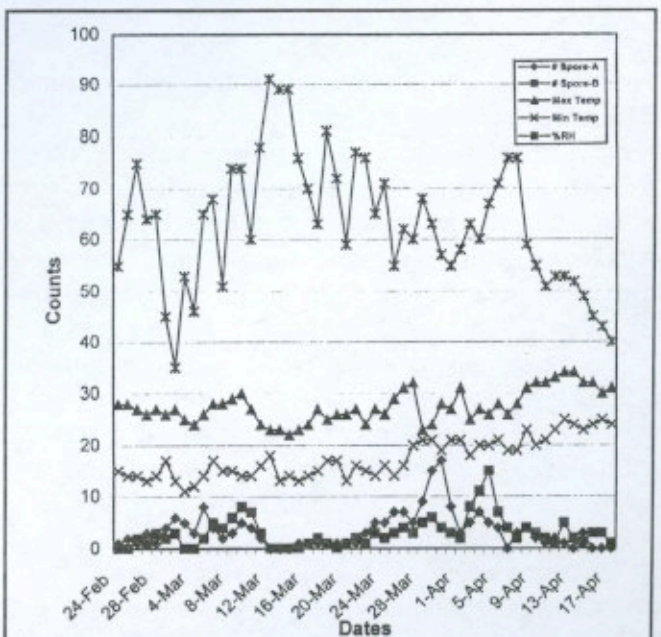

Figure 3. Spore trap and epidemiological data collected at ground level during 1997 flowering season from two points (A&B) of site-2

TABLE 3

Effect of field application of fungicides on the incidence of powdery mildew disease and fruit set in mango varieties.

Treatment	1996			1997		
	Mean Disease Incidence*	% Decrease over Control	% Fruit Set on 20 Panicles	Mean Disease Incidence*	% Decrease over Control	% Fruit Set on 20 Panicles
Topsin-M	2.8[b]	97.0	71.7	2.8[d]	97.1	77.3
Dithane M-45	33.3[a]	63.7	70.0	41.7[b]	57.1	50.0
Antracol	3.9[a]	56.6	61.7	41.7[b]	57.1	45.0
Thiovit	-	-	-	2.8[d]	97.1	78.7
Rubigan	-	-	-	6.3[d]	93.6	64.3
Darosal	-	-	-	16.7[c]	82.9	52.0
Nordox	-	-	-	25.0[c]	74.3	34.7
Anvil	-	-	-	25.0[c]	74.3	41.0
Aliette	-	-	-	47.2[b]	51.4	18.7
Topas	-	-	-	6.3[d]	93.6	71.0
Control	91.7	-	26.3	97.2[a]	-	17.0

*The differences between means sharing the same letter are not significant at 1% level.

The susceptibility of inflorescences varied with its developmental stage. Proper forecasting has the advantage of reducing the number of sprays from the usual 7-8 to 2 or 3 for obtaining an effective control. The combined data of two years were analysed for statistical significance using RCBD. F-values were highly significant for chemical control and interaction of varieties, chemicals and number and time of sprays. The variances for varietal effect were non significant. The presentation of data in this paper showed an improvement over an earlier report (Akhtar *et al.*, 1998). Our findings are similar to the results reported by Rawal and Ullasa (1989), Haq *et al.* (1994) and Ghaffar *et al.* (1975).

VARIETAL RESISTANCE: Detailed varietal responses to powdery mildew were prepared according to the methods of Kumar and Beniwal (1987). No significant differences were found among the commercial mango varieties in susceptibility to this disease. The incidence of disease during the 1996 and 1997 years was equally serious and broadly distributed in all selected orchards and on all six varieties under investigation. During the course of this study, we identified trees in the seedling germplasm (land races) showing resistance to powdery mildew. None of the cultivars under investigation were found to be resistant. Singh (1984) reported the existence of a large genetic diversity in the genus *Mangifera*. Our observations of resistant land races support his findings. Sharma and Majumdar (1989) presented evidence of inheritance of disease resistance in mango which could be conveniently selected and propagated by vegetative methods. As such, there is a strong potential for breeding programs to develop powdery mildew resistant varieties of mango.

Conclusions

The release of air born innoculum of powdery mildew is influenced by weather factors i.e. temperature and relative humidity. This study and reports of many other workers have shown the possibility of developing a safe chemical control through reduced number of sprays by proper forecasting of the release of air born conidia. Commercial varieties of mango are generally susceptible to the disease. Genetic resistance does exist in the land races and undescribed germplasm of mango which could be used in selection and breeding programs for developing resistant varieties.

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