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Integrated Control Program of Powdery Mildew on Mango Trees in Egypt by Foliar Sprays of Fungicides Combined with Fertilizers

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ABSTRACT

The powdery mildew of mango caused by Oidium mangiferae has become a serious and widespread problem in many parts of Egypt. A field experiment was conducted for four seasons 2019-2022 to investigate the efficacy of four fungicides, COBOX 50% WP (Copper Oxchloride), TOPAS 10% EC (Penconazole), PUNCH 40%EC (flusilazole and Carbendazim) and KEMAZED 50%WP (Carbendazim) along with control (water spray) against mango powdery mildew on the most popular cv. Taimour. Each fungicide was sprayed in 15-d-intervals with di-potassium phosphate, mono-potassium phosphate, and calcium phosphate alone in one season in 2019 at two governorates (Aldaqahlia and Domietta). Under ALmansoura condition, the best treatment was TOPAS, which recorded 15.75 and 26.25% disease severity compared with control which recorded 67.5 and 74.25% disease severity on the leaves and blooms, respectively. The integrated control program combined the fertilizers with fungicides in three successive seasons 2020,2021 and 2022. This program was decreasing the disease and also was decreasing the number of sprays fungicides so this study gained eco-friendly methods to control a serious disease and cost saving and the most important is decreeing the residual effect of pesticides in fruits.

INTRODUCTION

Mango (*Mangifera indica* L.) is considered the queen of the fruits of the tropics and sub-state, the mango fruit has a high nutritional value, as it is rich in nutrients and contains vitamins A, C, proteins, malic and citric acids and carotene. The cultivated area in Egypt until it reached 300,000 acres in 2022, with an average production of 10 tons / acre. Egypt stands as the tenth biggest mango exporter in the world, exporting around 30,000 tones to markets in Europe including France, Germany, the Netherlands, the UK and Russia, and Gulf countries such as the UAE, Oman, Kuwait, Saudi Arabia and Lebanon (Joyce T., 2022). Powdery mildew (*Oidium mangifera*) this disease particularly affects flowering saplings, but it is also found on young leaves, young fruits, and juicy vegetative branches. Symptoms of powdery mildew begin to appear in mangoes in early spring, just before the flower racemes emerge. It appears in the form of small white, minute spots on the flower covers before they open. Then the infection intensifies quickly, spreading to all parts of the inflorescence or the flower raceme and the secondary flower branches. The surfaces of these infected parts take on a distinctive powdery appearance and persist. Infection often until the end of May or mid-June (Nelson, 2008) and McRae (1924) reported that the *Oidium mangiferae* is responsible for the dropping off young mango fruits. Fungus attack flowers and drops off the plant. Fruits may carry infection in their early stage of development and drop off prematurely to produce huge yield losses (Wagle, 1928). Pathogen was observed serious on the leaves of grown up trees, particularly during spring which cause premature falling of leaves (Bose, 1953).Powdery mildew of mango is a curable disease. It could be controlled effectively with the proper use of effective fungicides for high production. The current recommendation for the first fungicide application is before or at 20-30 percent flowering. In preliminary studies Akhtar *et al.* (1999) efficiently control the disease with spray of proper fungicides at 30-40 percent blooming or when first conidia trapped followed by two further sprays with 15 days interval of the first spray depending on the weather and disease conditions. The disease could be reduced by the use of proper (Curative) fungicides when it occurs in high infestation form, but is too late and cause more than 50 percent reduction in yield. Chemical control is not always effective because the fungus can develop resistance against certain chemicals. So, alternative sprays are necessary for the efficient control of

disease. Number of fungicides is present in the market against the disease. One of the potential methods of reducing the severity of powdery mildew in an environmentally safe manner is the use of natural compounds. Natural compounds are those products which are not produced by synthesis but which occur in nature in mineral salts, plants and biological agents (Casulli*et al*., 2000). A successful disease-control program could involve just a single practice, but the long-term reduction of disease losses generally requires the application of several control measures. The best way to ensure success of a disease-management program is to use integrated disease-control measures (Verma and Deepraj, 1998b; Dik*et al*., 2002). Generally, IPM is regarded as the use of environmentally safe practices to reduce the disease incidence and development or use of multiple control tactics integrated into a single pest control strategy. The aim of this study is a wide range of fungicide has been registered for the control of this malady but serious losses still occurs. These fungicides are not applied properly which ultimately increase economic losses.

MATERIALS AND METHODS

This study was carried out on adult trees of mango cultivars 'Taimour cv. in four seasons 2019-2022 in two locations (Almansoura) at Aldaqahlia Governorate, and Raas Albar at Domietta Governorate, Egypt, the trees planted at 4 x 5 m. in sandy soil, age 7 years old were selected for this study. It were received the same cultural practices that are recommended. The experiment had eight treatments as in Table (1) each treatment applied on four replicates trees, in the first season the tree was sprayed with treatments of fertilizers (calcium phosphate, di-potassium phosphate and mono potassium phosphate) and fungicides (COBOX, TOPAS, PUNCH and KEMAZED) individual after 15 days these treatments were beginning in February 2019. In the second season 2020 we choose the best treatment from first season and we made an integrated program for controlling powdery mildew by using fertilizers combined with fungicides. The first and second spray was di-potassium phosphate 1st February the third and fourth spray with COBOX fungicide in half February. on 1st march we sprayed the fifth and sixth spray with mono potassium phosphate fertilizer after one week we sprayed the seventh and eighth spray with TOPAS fungicide after two weeks we sprayed the ninth and tenth spray with calcium phosphate fertilizer and then the eleventh and twelfth spray were after one week with PUNCH fungicide finally the last two sprays with KEMAZED fungicide after two weeks. In the third season 2021 we applied the integrated program at Almansoura location in two seasons 2021-2022 hence, RaasAlbar's soil had high salinity so we applied the program in Aldaqahlia Governorate. Disease severity (DS %) percentage were calculated.

Assessment of Powdery Mildew Severity

Naturally infected inflorescences by mango powdery mildew were examined to estimate disease severity at the end of the bloom season. Ten inflorescences were randomly selected from each tree, examined to assess the severity of the disease depending on the devised scale 0-4 by Reuveni and Reuveni (1995) where:

0 = No powdery mildew colonies observed,
1 = 1–10% of the inflorescence infected,
2 = More than 10–25% of the inflorescence infected,
3 = More than 25–50% of the inflorescence infected,
4 = More than 50% of the inflorescence infected.

The severity of the disease was calculated using the following formula:

Disease severity % 100
$\Sigma = '(nxv)/ 4Nx100$

Where:

n = Number of the infected inflorescence in each category.
v = Numerical values of each category.
N = Total number of the examined inflorescence.

The efficiency of the treatments were calculated

Statistical analysis

%Disease severity on leaves and bloom were statistically analyzed as a complete randomized block design and least significant differences (L.S.D 0.5) was calculated according to Fisher (1948) and Snedecor and Cochran (1967) using Web Agri. Stat Package Computer Program (WASP).

Table 1: Compounds and chemicals used as applications in the current study

Treatments	Active ingredient	Dose/100L water
Calcium Phosphate	$Ca_3(Po_4)_2$	1.5kg
Di-Potassium Phosphate(DKP)	di-Potassium hydrogen orthophosphate (K_2HPO4)	544gm
mono-Potassium Phosphate(MKP)	monoPotassiumhydrogen orthophosphate (KH_2PO4)	200 gm
COBOX 50% WP	Copper oxchloride	250-300 gm
TOPAS 10%EC	Penconazole	25ml
PUNCH 40%EC	Flusilazole and Carbendazim	6 ml
KEMAZED 50%WP	Carbendazim	50 gm

RESULTS

Data in table 2 showed that all the tested fungicides significantly (l.s.d.0.05) reduced powdery mildew disease of mango plants as compared to non-sprayed control plant. The data revealed that TOPAS (penconazole) and Copper Oxcholride were the most and statistically effective fungicides in %disease severity by 15.25% and 26% respectively, in leaves at Almansoura. Fungicides PUNCH (flusilazole and carbendazim**)** and KEMAZED (carbendazime) were closed to each other in reducing disease severity percent. On the other hand, using fertilizers reducing the disease in compare with control, the best one was potassium phosphate it gave 34.75% disease severity. At Raas Albar in Domietta governorate we found that disease severity percent was higher than Almansoura, this because the salinity of the soil but in general the treatments play the same role in controlling the disease hence fungicides were the best treatments hence TOPAS, Punch and Kemazed were the most effective and the calcium phosphate fertilizer was close to Copper Oxchloride fungicide. Meanwhile, DKP was the best one, under Aldaqahlia Governorate in Almansoura condition it gave 34.75%, While, Calcium phosphate was more significant reducing disease severity under RassAlber, Domietta governorate, condition which recoded (36%) disease severity. but in general all fertilizers treatments play the same role in controlling the disease hence.

On the other side, All fungicides treatment were reduced the powdery mildew disease severity compared with control treatment.

Under ALmansoura condition, the best treatment was TOPAS, which recorded 15.75 and 26.25% disease severity compared with control which recorded 67.5 and 74.25% disease severity on the leaves and blooms, respectively. However, under Rass Albar location, data in table (2) cleared that, KEMAZED followed by PUNCH chemical fungicides treatments were recoded the lowest disease severity % either on leaves or blooms compared with control treatment that were recorded (53.75% and 56.25%, on leaves) and 56.25 % and 54.755% on blooms), compared with control treatment which recorded (100% disease severity on the leaves and also on blooms), respectively. while, no significant effect between all fertilizers treatment compared with control treatment.

Data in table (3) obtained that the second investigated season recorded the lowest %disease severity at AL-Mansoura than RaasAlbar. In general, the data of the examined chemical fungicides *i.e.* KEMAZED and PUNCH were the most effective in reducing the disease severity% which were 23.25% and 36.25% respectively in leaves at AL-Mansoura location, followed by TOPAS and Copper Oxchloride fungicides which recoded (41.25% on leaves and 38.75% on blooms) diseases severity % compared with control treatment which recoded (91.25 on leaves and 92.5% on blooms) and (45% and 46.25%) diseases severity % compared with control treatment which recoded (67.5% and 76.25%) disease severity%, respectively

On the other hand, data of the same table indicated that all treatments reduced the disease severity of mango powdery mildew under field conditions as a result of spraying mango plants with solutions of either calcium phosphate or di-potassium phosphate, both salts display similar disease severity (43.75% and 41.25% on leaves and 35 and 55% on blooms) respectively, compared with control treatment which recorded (100% and 67.5 ,on leaves) and (100 and 57.5% on blooms) respectively, under Al Mansoura location.

Table 2: Effect of fertilizers and fungicides on disease severity of Mango powdery mildew disease at two governorates ((ALdaqahlia and Domietta) through season (2019).

% Disease severity (DS)of powdery mildew and percentage of reduction(R)								
Treatments	**AL-Mansoura**				**RaasAlbar**			
	leaves		**bloom**		**leaves**		**bloom**	
	%DS	**%R**	**%DS**	**%R**	**%DS**	**R**	**%DS**	**%R**
Zero Time	38	43.7	55	25.9	44	56	50	50
Calcium Phosphate	36	46.6	37.25	50	62.5	37.5	76.25	23.75
DKP	34.75	48.5	37.5	49.5	70.25	29.75	75	25
MKP	46.5	31	31.25	58	73.75	26.25	70	30
COBOX	26	61	26	65	62.5	37.5	60	40
TOPAS	15.75	76.6	26.25	65	51.25	48.75	66.25	33.75
PUNCH	31.25	54	31	59	56.25	43.75	54.75	45.25
KEMAZED	32.5	52	40	46	53.75	46.25	46.25	53.75
Control	67.5	////	74.25	///	100	///	100	///
L.S.D 5%	6.861	////	8.363	///	6.672	///	5.841	///

Table 3: Effect of the first integrated control program in two Governorates applications on disease severity% on leaves and blooms under Al-Mansoura and RaasAlbar conditions., through season (2020)

% Disease severity of powdery mildew and percentage of reduction										
treatments	**sprays**	**time**	**Almansoura**				**RaasAlbar**			
			leaves		**bloom**		**leaves**		**bloom**	
			%DS	**%R**	**%DS**	**%R**	**%DS**	**%R**	**%DS**	**%R**
ZERO TIME	0		43.75	////	42.5	/////	37.5	////	41.25	////
	1	15FEB.								
DKP	2	21 FEB.	41.25	39	55	4.3	40	43	56.25	30
CONTROL	/////////		67.5	/////	57.5	/////	70	////	80	////
	3	1ST MARCH								
COBOX	4	15 MARCH	45	33.33	46.25	40	58.75	26.6	53.75	36.8
CONTROL	/////////		67.5	/////	76.25	//////	80	/////	85	////
	5	1 ST APRIL								
MKP	6	7 APRIL	49	37	45	45.45	56.25	43.75	52.5	47.5
CONTROL	/////////		77.5	/////	82.5	/////	100	/////	100	/////
	7	15 April								
TOPAS	8	30 April	41.25	55	38.75	58	40	60	42.5	57.5
CONTROL	/////////		91.25	/////	92.5	//////	100	/////	100	/////
CalciumPhosphate	9	15 MAY								
	10	21 May	43.75	56.25	35	65	43.75	56.25	41.25	58.75
CONTROL	/////////		100	//////	100	/////	100	/////	100	/////
	11	7MAY								
PUNCH	12	21 May	36.25	63.75	33.75	66.25	37.5	62.5	37.5	62.5
CONTROL	/////////		100	/////	100	/////	100	/////	100	/////
	13	6 JUNE								
KEMAZED	14	21 June	23.75	76.25	23.75	76.25	32.5	67.5	36.25	63.75
CONTROL	///////		100	/////	100	/////	100	/////	100	/////
L.S.D 5%	////		6.002	/////	6.160	/////	3.968	/////	4.076	/////

On the opposite side data showed under Rass Albar location condition,KEMAZED followed by PUNCH chemical fungicides treatment were the most reduction of disease severity % either on leaves or on blooms compared with control treatment which recoded (32. 5 and 37.5 disease severity % on leaves) and (36.25 and 37.5 disease severity % on blooms) compared with control treatments that recorded (100 %) either on leaves or blooms for both of KEMZED and PUNCH control treatments.

While, calcium phosphate fertilizer treatment gave the most disease severity% reduction (43.25% and 35% compared with control treatment which recoded (100% disease severity % either on leaves or on blooms), respectively.

Generally, data in table (4) showed that, applying the program of controlling powdery mildew disease in mango trees at Almansoura in two seasons was been done At the frist of February, and also, which was been started with fungicide followed by fertilizer treatment were more reduced disease severity% than the previous integrated program which was started with fertilizer treatment followed by chemical fungicide treatment, and also after the disease symptoms were been cleared.

Data in table (4) indicated that, the best treatment was fungicide kemazedrecorded 18.75%, 17.5%, 15.75% and 13.75 % disease severity in two seasons on leaves and bloom respectively, compared with (100% disease severity either on leaves or on blooms), followed by the fungicide punch which were recoded 22.5% disease severity, on leaves And 17.5% disease severity on bloom at the first second season) , respectively.

However, calcium phosphate fertilizer treatment, at the second season, showed the most reducing in the % disease severity (20.25% and 16.75% disease severity%) on the leaves and blooms, respectively compared with control treatment which recorded (100%) disease severity either on leaves or on blooms.

DISCUSION

Mangoes are considered one of the best and most popular fruits for Egyptians, hence they are cultivated in large areas and many are exported, but this type is the most dangerous disease that kills a large part of the production and leads to heavy losses, which is powdery mildew caused by a fungus *Oidium mangiferae* El-Meslamany *et.al.*2020

Table 4: Effect of the second integrated control program on disease severity of powdery mildew in mango trees in two seasons, (2021 and 2022) under location Al-Mansoura conditions

% Disease severity of powdery mildew and percentage of reduction									
treatments	**sprays**	**time**	**season 2021**				**season 2022**			
			leaves		**bloom**		**leaves**		**Bloom**	
			%DS	**%R**	**%DS**	**%R**	**%DS**	**%R**	**%DS**	**%R**
ZERO TIME	0	0	27	/////////	31.25	/////////	33.75	/////////	38.75	/////////
COBOX	1 2	1 FEB 15 FEB	30	48	31.25	50	30	49	31.25	56
CONTROL	/////////		57.5	/////////	62.5	/////////	58.75	/////////	71.25	/////////
DKP	3 4	1 MARCH	37.5	46.5	32.5	51	30	53	28.75	62.3
CONTROL	/////////		70	/////////	66.25	/////////	63.75	/////////	76.25	/////////
TOPAS	5 6	15 MARCH 30 MARCH	33.75	60	25	73.3	26.25	66	22.5	73
CONTROL	/////////		83.75	/////////	93.75	/////////	77.5	/////////	83.75	/////////
MKP	7 8	15 APRIL	27.5	72.5	28.75	71.25	23.75	66.25	22.5	75.5
CONTROL	/////////		100	/////////	100	/////////	90	/////////	98	/////////
PUNCH	9 10	21 April 6 may	22.5	77.5	25	75	18.75	81.25	17.5	82.75
CONTROL	/////////		100	/////////	100	/////////	100	/////////	100	/////////
Calcium Phosphate	11 12	21 may	25	75	26.25	73.75	20.25	79.75	16.75	83.25
CONTROL	/////////		100	/////////	100	/////////	100	/////////	100	/////////
KEMAZED	13 14	30 may 15June 30 June	18.75	81.75	17.5	82.5	15.75	84.25	13.75	86.25
CONTROL	///////		100	/////////	100	/////////	100	/////////	100	/////////
L.S.D 5%	////		3.483	/////////	4.563	/////////	5.332	/////////	4.526	/////////

Mangoes are the only hosts for this obligate parasitic fungus. As a result of the wide climatic range of the mango plant, the disease appears on leaves, flowers and fruits. (Reuveni *et al*., 2018)

In this study, it has been found that salts of K2HPO4, KH2PO4, $Ca_3(Po_4)_2$,combined with fungicides KEMAZED ,PUNCH,TOPAS and COBOX in integrated control program were evaluated for their efficiency on management of mango powdery mildew under field conditions during one growing season at ALdaqahlia governorate in location Almansoura and Domietta Governorate in location Raas Albar followed that two seasons at ALdaqahlia governorate in location Almansoura for avoiding the salinity of soil in Domietta governorate .The obtained data showed that spraying of mango trees (Taimour cv.) in all seasons with any of the tested treatments significantly reduced the severity of powdery mildew compared with control treatment. In addition, results of both seasons at Aldaqahlia governorate in Almansoura revealed that alternation spray among the KEMAZED (Carbendazim), MKP, DKP and calcium phosphate was the most superior treatment in reducing severity of the disease and the fungicide PUNCH was the next one of fungicide in reducing the disease. The obtained results showed that the di- potassium phosphate (K2HPO4) was high efficacy and most effective salt. This results are confirmed with those obtained by several investigators (Abada*et al*., 2009 and Abdel-Kader *et.al.*, 2012).

This study demonstrated that a fertilizer compound such as MKP, DKP and Calcium phosphate are an eco-friendly potential means for controlling powdery mildew on leaves and bloom clusters of mango trees, these results are matching with (Reuveni, M.andReuveni, R., 1995a) in grapevines, roses (Reuveni, R. *et al*.,1994), apple and nectarine (Reuveni M. and Reuveni,R., 1995b). Although systemic fungicides, applied as foliar sprays, were more effective than salt solutions in controlling powdery mildew on mango, the sprays number of fungicide applications was reduced when they were combined with phosphate sprays ,and therefore it offers environmentally friendly possibilities for disease control, with reduction of fungicides, These data clearly indicate that

phosphates have a role in this inhibition (Tables2 ,3 and4).Reuveni M. *et.al*1998 they observed by microscopic examination that foliar sprays of MKP and DKP on mildewed tissue bearing sporulating colonies of *O.mangiferae*on mango bloom clusters suppressed the fungus as evidenced by hyphal deformation and shrinkage of conidia and conidiophores,. No visible damage was observed on the host organs as result of phosphate application, and it is more likely that a direct effect on the fungus, may play an important role in the protection mechanism. The mode of action of MKP is different from that of sterol inhibitor fungicides (Koller and Scheinpflug, 1987) or the strobilurin BAS 490F (Ammerman*et al*., 1992; Gold and Leinhos, 1995).Spraying phosphate salts in combined with fungicides may reduce the development of fungicide-resistant populations of *O.mangiferae*, or to exploit synergistic interaction between the compounds ,by which the overall activity can be increased or the amounts used can be reduced without loss of activity and to delay or reduce the process of selection of resistant strains (Gissi, 1996).Synergy. The increased protection provided by MKP when used in mixtures with reduced rates of fungicides or with their recommended rates, but with reduced number of applications, compared with the recommended rates for standard fungicides. In case of this study we found that the integrated control program was more successive in Almansoura than RaasAlbar because of the salinity of soil in RaasAlbar so we applied the program in two seasons at Almansoura as table 4 showed. So extensive Extension studies are required to educate peoples for the proper use of fungicides (i.e. use of proper fungicides at proper time with proper equipment) to obtain maximum disease control.

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الملخص العربي

برنامج المكافحة المتكامل للبياض الدقيقي على أشجار المانجو بواسطة الرش الورقي لمبيدات الفطريات مع الأسمدة

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أصبح البياض الدقيقي للمانجو الناجم عن *Oidium mangifera*e مشكلة خطيرة وواسعة الانتشار في أجزاء كثيرة من مصر. أجريت تجربة ميدانية لمدة أربعة مواسم 2019–2022 للتحقق من فعالية أربعة مبيدات فطريه، COBOX 50٪ WP (النحاس أوكس كلوريد)، TOPAS 10٪ EC (Penconazole)، PUNCH 40٪ EC (فلوسيلازول وكاربيندازيم) و KEMAZED 50٪ WP (كاربيندازيم) جنبا إلى جنب في مكافحة البياض الدقيقي للمانجو صنف. تيمور. تم رش كل مبيد فطري كل 15 يوم مع ثنائي فوسفات البوتاسيوم وأحادي فوسفات البوتاسيوم وفوسفات الكالسيوم بمفرده في موسم واحد في محافظتين (الدقهلية ودمياط). في المنصورة كانت أفضل معامله هي توباس حيث سجلت شدة مرض 15.75 و26.25٪ مقارنة بالكنترول حيث سجلت 67.5 و74.25٪ شدة مرض على الأوراق والزهور على التوالي.

جميع مبيدات الفطريات وأملاح الفوسفات كانت فعالة جدا في الحد من المرض مقارنة بالكنترول. تم دمج برنامج المكافحة المتكاملة بين الأسمدة ومبيدات الفطريات في ثلاثة مواسم ناجحة 2022،2021،2020. كان هذا البرنامج يقلل من المرض ويقلل أيضًا من عدد رشات المبيدات الفطريه، لذا اكتسبت هذه الدراسة اهميه حيث انها صديقة للبيئة والتحكم على مرض خطير وتوفير التكاليف والاهم من ذلك تقليل متبقيات المبيدات في الثمار.