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FUNGICIDAL AND INDUCING PROTECTION FOR CUCUMBER POWDERY MILDEW IN EGYPT

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ABSTRACT : Values of powdery mildew severity during Spring season of 2003 were generally higher than those recorded during Summer and / or Autumn seasons of 2002. The highest value of mean disease severity in Spring season of 2003 was recorded at Sakha, Kafr El-Sheikh (43.96%) followed by 42.7% Gamasa (Damitta) and 41.9% at Nubaria (Behira):

The lowest values of mean disease severity during all planting period were recorded during Summer of 2002 at Oseim, Giza (10.8%) followed by 15.4 and 16.2% at Qaha, Qalubiya and Shibin El-Kom Minufia, respectively.

All tested fungicides decreased the diseased severity but the systemic funicides (Topas followed by Sumi-8 and Pancho) were most effective (5.96-9.60%), than the contact ones (Karathane 48%, Soril 81 and Sulphonil which exhibited 11.36-16.03% disease severity):

The disease severity on the cucumber susceptible cultivars treated with phosphate salts decreased by increasing of the salt concentrations from 250 ppm to 750 ppm. Potassium phosphates were more effective in controlling cucumber powdery mildew than sodium ones. Evidently, tow foliar applications of phosphates, particularly of K_2HPO_4 were active in powdery mildew controlling, the first application was at 4th true leaf stage while the second was at the beginning of flowering stage.

Average of the disease severity on cucumber plants treated with each of NaH_2PO_4, Na_2HOP_4, KH_2PO_4 or K_2HPO_4 (at con. 750 ppm) were 8.14, 12.33, 7.20 and 6.62%, respectively compared with 41.30% for the inoculated and untreated plants. Generally, disease severity reduction by phosphate salt treatment was less efficiency than fungicidal treatment.

INTRODUCTION

Cucumber is considered one of the major vegetable crops in Egypt. It can be grown in different seasons throughout the year in open field or in

protected cultivations. Cucumber powdery mildew (*Sphaerotheca fuliginea*) is economically very important and responsible for severe losses in fruit yield in Egypt.

Many researchers indicated that systemic fungicides such as Benlate, Afugna, and Topas were more effective in controlling powdery mildew disease than contrast ones such as Karathane (Ahmed, 1995 and Sedlakova and Lebeda, 2004):

On the other hand, one of the potential methods for inducing local or systemic protection toward plant diseases is the use of inorganic phosphorus salts. As early as 1930, a study was carried out to determine the efficiency of various phosphorus (P) containing compounds as fertilizers. It concluded that phosphate which deriving from Phosphorous acid (H_3PO_3) was a poor source of nutritional phosphorus, since plants treated by phosphite grew weakly. Forty years later, phosphite returned to the market when it was found that were very efficient against Oomycota specially *Phytophthora* and *Pythium* (Guest and Grant, 1991):

Today, it is well documented that phosphate which deriving from phosphoric acid (H_3PO_4) has also a fungicidal effect. The toxic effect of phosphate salts against pathogenic fungi may be comes from their activation on defense mechanisms of plant.

Now, foliar spray with inorganic phosphate salts either as a protective treatment or as a curative treatment is one potential methods used for controlling plant diseases. It has low cost, low animal toxicity, environmental safety and nutrient value which make them ideal foliar fertilizer and can be practically used in the field (Reuveni *et al.*, 1995a):

Reuveni *et al.* (1995b) reported that phosphatic plant protection was remained efficient up to 25 days after inoculation.

Many researchers recorded that phosphate salts could induce local or systemic plant resistance to various fungal diseases such as maize rust (Reuveni *et al.*, 1994), grapevine downy mildew (Reuveni, 1997), tomato early blight (El-Desouky *et al.*, 2003), rice blast (Du *et al.*, 2000), pearl millet downy mildew (Chaluvaraju *et al.*, 2004) and fig die-back (Morsy, 2007):

In respect of powdery mildew diseases (Descalzo *et al*, 1990) indicated the dibasic and tribasic phosphate were effective against cucumber powdery mildew under greenhouse conditions. Reuveni *et al.*

(1993) reported that a single spray of 100 mM solutions of K_2HPO_4, KH_2PO_4, NaH_2PO_4, or Na_2HPO_4 on the first true leaf of cucumber plants, 2 hrs. before inoculation with conidial suspension of *Sphaerotheca fuliginea* induced the systemic protection to powdery mildew on the second and third leaves.

Mosa (1997) noticed that cucumber infection with powdery mildew pathogen was reduced by 92% when the plants were treated with 50 mM K_2HOP_4, three days after inoculation.

Napier and Oosthuyse (2000) found that monopotassium phosphate (KH_2PO_4) sprayed in alternation with fungicides has been successful in the control of powdery mildew diseases.

El-Desouky *et al.* (2003) concluded that potassium phosphate salts (KH2PO4 or K2HPO4) were more effective in controlling tomato early blight (Alternaria solani) than sodium phosphate ones (NaH_2PO_4 or Na_2HPO_4) . They also added that disease severity decreased by increasing of phosphate salt concentration.

In this investigation, survey of powdery mildew in seven Egyptian governorates was studied and the effect of some contact and systemic fungicides at the recommended doses and four phosphate salts at different concentrations against the pathogen were also studied.

MATERIALS AND METHODS

a. Diseases survey:

Powdery mildew disease of cucumber was surveyed in Egypt through the two successive seasons of summer and autumn 2002 and spring 2003 in seven governorates, i.e. Behira, Damitta, Giza, Ismaillia, Kafr El-Sheikh, Minufia and Qalubia.

Different locations in these governorate, i.e. Nubaria (Behira), Gamasa (Damitta), Oseim (Giza), kasassin (Ismailia), Sakha (Kafr El-Sheikh), Shibin El-Kom (Minufia), Qaha (Qalubia) cultivated with cucumber under greenhouse conditions were selected in this study.

Two sites in each location were chosen and 5 to 7 greenhouse were examined in each site. The disease severity was monitored weekly starting from the appearance of first symptoms using 0-9 rating scale based on the percentage of leaf area affected (Warkentin *et al.*, 1996): Where 0 = No infection, 1 = < 1%, 2 = 1-5% , 3 = 5-10%, 4=10-20%, 5 =

20-40% , 6 = 40-60% , 7 = 60-80%, 8 = 80-90% , 9 = > 90% of leaf area affected.

b. Fungicidal treatment:

Ten fungicides listed in (Table 1) include three contact fungicides, i.e. Karathane 48%, Sori 81% and Sulphonil as well as seven systemic ones, i.e. Afugan, bayfidan, Bellkute 40%, Pancho 5%, Sumi-8, Topas 10% and Trifimine 15% were tested to study their efficiency in controlling powdery mildew disease on Beit-Alpha F1 cucumber plants under field conditions.

Table (1): Trade name, Common name, Chemical name, rates of application and manufactures of the test fungicides.

Trade name	Common name	Chemical name	Rate/1001 water	Manufacture
Contact fungicides				
Karathane 48%	Dinocap	2(1-methylhyptyl)4,6dinitrophynlcrotonate	50 ml	Rohom&Soda
Soril 81	Sulphur	Micronized sulphur	250 g	Rohom&Hass
sulphonil	Sulphur	Micronized sulphur	200 g	Wadi El-Nile
Systemic fungicides				
Afugan	Pyrazophos	Ethy-1-2diethoxythiophos-phoryloxy-5-mthylprothozol (1.507) pyrimicine-6-carboxylate	100 ml	Hoechst
Bayfidan	Triadimenol	1-(4-chorophenoxy)-3.3dimethyl-l-(1H-1,2,4-triazole l-yl) butane-2-ol N-(2,3-dichloro-4-hydro	20 ml	Eayer
Bellkute 40%	Iminoctadin	N-(2,3-dicholor-4-hydoryx-phenyl)-l-methyl-cyclohexane carboxamide	50 g	Nippon Soda
Pancho 5%	Cyflufenamid	(z)-N-[α-(cyclopropylmethoxyimino)-2,3-difluoro-6-(trifuloromethyl) benzyl]-2-phenylacetamide	20 ml 35 ml	Nippon Soda
Sumi-8	Diniconazole			
Topas 10%	Penconazole	(E)-1-(2,4-ichlorophhenyl)-4,4-dimethyl-2-(1,2,4-trizole-l-yl)1-pemten-3-1	25 ml	Syngenta
Trifimine 15%	Triflumizole	4-cholor-α,α,α-tifloro[1-(1H-imidazol-l-yl)-2- propxyethlidene]-o-toludien	20 ml	Sumitomo

Tow fungicidal experiments were carried out during Autumn season of 2005 and 2006 in a randomized complete block design at Nubaria, (Behera): Disease severity were assessed weekly starting with the first symptom appearance till the end of the growing period.

c. Inducing protection:

Three different concentrations, i.e. 25 mM, 50 mM and 75 mM of potassium and sodium phosphate salts (K_2HPO_4, KH_2PO_4, NaH_2PO_4 or

Na2HOP4) obtained from Merck Company, Darmstadt, Germany were prepared. They were sprayed on three susceptible cucumber cultivars, i.e. Afdal, Beit-Alpha and Betostar groun under greenhouse conditions.

Three seeds of each cucumber cultivar were planted in each 25 cm in diameter pot filled with sandy clay soil (1:1 w/w): Artificial inoculation was done at 3rd true leaf stage (Shata, 2007): The plants were treated with phosphate salt solution twice, the first was at 4th true leaf stage and the second one was at the beginning of flowering stage. Four replicates were used for each salt treatment. Also, four another replicates sprayed with water only were served as control treatment.

RESULTS AND DISCUSSION

a. Disease survey:

Survey of this disease was carried out in greenhouses located in seven governorates in Egypt. Results obtained indicated that powdery mildew infection was found in all surveyed governorates.

Data presented in Table (2) show that values of powdery mildew severity during Spring season of 2003 were generally higher than those recorded during Autumn and / or Summer seasons of 2002. This result is generally in agreement with those reported by Abd El-Sayed (2000) and El-Desouky and El-Deweny (2001): The highest values of mean disease severity in Spring season of 2003 were recorded at Sakha, Kafr El-Sheikh (43.9%) followed by 42.7% at Gamasa. (Damitta) and 41.9% at Nubaria (Behira):

On the other hand, the highest value of mean disease severity during Summer season 2002 were recorded at Sakha, Kafr El-Sheikh (32.12%) followed by Gamasa, Damitta (30.58%), while the highest value of mean diseased severity during Autumn season of 2002 were recorded at Sakha, Kafr El-Sheikh (34.36%) followed by Gamasa, Damitta (33.04%):

The lowest values of mean disease severity during all planting period were recorded during Summer of 2002 at Oseima, Giza (10.8%) followed by 15.4 and 16.16 at Qaha, Qalubiya and Shibin El-Kom, Minufiya, respectively. This increment may be due to the favorable factors related to the disease development. Many reports on some factors including the temperature, relative humidity, genotypes and plant density are the limiting factors of powdery mildew incidence and development (Hill, 1995 and Daayf *et al.*, 1997):

Table(2): Disease severity (D.S.) of powdery mildew disease on cucumber in commercial fields at seven Egyptian governorates during different growing seasons of 2002 and 2003.

Governorate / Location	Season / Disease severity					
	Field No.	Summer 2002		Autumn 2002		Spring 2003	
		D.S.	Mean	D.S.	Mean	D.S.	Mean
Behira (Nubaria)	1	16.0	20.18	36.8	32.68	43.9	41.88
	2	19.8		33.0		41.0	
	3	17.2		28.4		49.5	
	4	22.9		38.5		39.0	
	5	25.0		26.7		36.0	
Damitta (Gamasa)	1	25.0	30.58	36.0	33.04	44.0	42.72
	2	28.4		33.5		42.0	
	3	30.5		30.0		49.9	
	4	35.0		38.0		39.0	
	5	34.0		27.7		38.7	
Giza (Oseim)	1	10.0	10.80	17.5	20.64	20.0	22.86
	2	12.3		19.2		22.5	
	3	8.0		21.0		19.8	
	4	12.3		21.0		25.0	
	5	11.0		24.5		27.0	
Ismailia (Kasassin)	1	17.0	19.20	22.8	24.16	36.0	33.94
	2	14.5		29.0		30.2	
	3	20.5		24.6		33.5	
	4	18.0		25.5		35.0	
	5	26.0		18.9		35.0	
Kafr El-Sheikh (Sakha)	1	28.0	32.12	37.5	34.36	40.0	43.96
	2	29.9		35.0		46.5	
	3	29.2		29.4		48.0	
	4	36.5		40.0		43.5	
	5	37.0		29.9		41.8	
Minufia (Shibin El-Kom)	1	13.0	16.16	25.0	23.48	35.0	33.40
	2	15.0		19.5		33.0	
	3	17.5		23.6		28.2	
	4	15.3		27.0		37.5	
	5	20.0		22.3		33.3	
Qalubia (Qaha)	1	12.6	15.40	23.0	22.20	33.3	31.64
	2	14.2		21.1		30.5	
	3	16.7		24.6		29.8	
	4	14.5		22.0		34.6	
	5	19.0		20.3		30.0	

b. Fungicidal treatment:

All testes fungicides decreased the diseased severity. There were significant differences between these fungicides and the untreated control. Data obtained in Table (3) show that the systemic and contact fungicides were effective in reducing the incidence of the disease at all dates of application but they were more effective when applied in the second season than in the first season. The same trend of effect was found clearly

with the systemic fungicides than those of the contact ones. At the first spray which applied two days after the disease appearance the values of disease severities were lower in the systemic treatments that were reduced in response to the fungicidal application.

Generally, results obtained show that the systemic fungicides were most effective (5.96-9.60%), than the contact ones (11.36-16.03%):

Topas followed by Sumi-8 and Pancho take the first rank while Afugan, Bayfidan, Bellkute and Trifimine take the second rank in this respect. They can be used as a protectant and eradicant fungicides against cucumber powdery mildew.

On the other hand, the contact fungicides may applied only before disease incidence as protectant fungicides. These results are generally in agreement with those reported by (Ahmed, 1995 and Sedlakova and Lebeda, 2004): The presented results are disagree with these obtained with El-Shami *et al.*, (1995) who reported that Karathane was the most effective fungicide, while Sumi-8 was the least effective one for controlling cucumber powdery mildew. It showed the rapidity of the parasites to cause infection and making therapy by using protective fungicides effective . This fact emphasized the necessity of sprays with protectant fungicides before the establishment of powdery mildew in cucumber or when the pathogen resists any systemic fungicides.

Table (3): Effect of different fungicides on the severity of powdery mildew infection on cucumber cultivar Beit-Alpha F1 during two successive Autumn seasons of 2005 and 2006 at Nubariya (Beheira):

Fungicide	Autumn 2005				Autumn 2006			
	1st spray	2nd spray	3rd spray	Mean	1st spray	2nd spray	3rd spray	Mean
Contact fungicides								
Karathane 48%	11.6	13.5	14.7	13.26	15.0	11.1	8.0	11.36
Soril 81	14.9	16.2	16.8	15.96	13.2	15.4	13.0	13.86
sulphonil	17.3	18.6	18.6	18.16	17.0	17.6	13.5	16.03
Systemic fungicides								
Afugan	14.6	11.1	6.5	10.73	10.1	8.3	4.0	7.50
Bayfidan	16.8	12.0	5.0	11.26	11.9	9.1	3.0	8.00
Bellkute 40%	16.0	14.2	6.6	12.26	13.0	10.2	4.5	9.23
Pancho 5%	16.0	13.0	9.0	12.66	9.9	7.2	3.0	6.70
Sumi-8	12.5	10.3	4.5	9.10	12.2	10.6	6.0	9.60
Topas 10%	11.9	10.0	4.5	8.80	8.2	6.9	2.8	5.96
Trifimine 15%	15.0	14.1	7.2	12.10	11.8	10.9	3.7	8.80
Check	38.0	50.5	67.6	52.06	33.5	44.6	56.7	44.93
L.S.D at 5 %	3.1	3.8	4.7	-	2.6	3.3	4.0	-

c. Inducing protection:

In respect of cucumber protective spray with phosphate salts solutions, i.e. NaH_2PO4, Na_2HPO_4, KH_2PO_4 or K_2HPO_4, symptoms of powdery mildew were initially observed only on untreated plants (control treatment) one week after the second application.

Analysis of variance revealed that interaction between cucumber cultivars and different phosphate salts were significantly different. Data in Table (4) generally indicated that the disease severity on the cucumber susceptible cultivars treated with phosphate salts was significantly reduced compared with the control treatments (31.00 to 49.90% disease severity with average 41.30% among the inoculated and untreated plants and 4.6 to 19.5% disease severity with average 9.83% among the uninoculated and untreated ones):

Table (4): The effect of four phosphate salts with three concentrations and four cucumber cultivars inoculated with S. *fuliginea* on the severity of powdery mildew under greenhouse conditions.

Phosphate salt cons. (ppm)	Cultivars / Disease severity			
	Afdal	Beit-Alpha	Betostar	Mean
$Na\ H_2PO_4$				
250	28.89	27.46	33.45	29.93
500	13.50	16.00	15.00	14.83
750	07.30	09.10	08.30	08.14
$Na_2\ HPO_4$				
250	16.00	7.86	18.20	14.02
500	14.63	8.52	15.03	12.72
750	8.00	7.00	14.00	9.67
KH_2PO_4				
250	14.52	18.83	17.61	16.98
500	08.50	08.22	06.74	08.15
750	06.60	07.20	07.80	07.20
K_2HPO_4				
250	10.00	14.00	25.40	16.47
500	11.31	09.54	14.03	11.63
750	07.04	06.8	06.03	06.62
Inoculated & untreated	49.90	43.00	31.00	41.30
Uninoculated & untreated	19.50	04.60	05.40	09.83
Mean	15.39	13.44	15.57	-
LSD at 50%	for Phosphate salt cons = 2.31 Cucumber hybrids = 2.65 Phosphate salt X hybrids = 3.18			

The disease severity was greater on plants treated with low doses of any used phosphate salts, where average of the disease severity on plants treated with NaH_2PO_4, Na_2HOP_4, KH_3PO_4 and K_2HPO_4 were 29.93,

14.02, 16.98 and 16.47%, respectively at con. 250 ppm, and were 14.83, 12.72, 8.15 and 11.63%, respectively at con. 500 ppm, while average of the disease severity were 8.14, 9.67, 7.20 and 6.62%, respectively at con. 750 ppm. This result was confirmed by Mosa (1997) and El-Desouky *et al.* (2003) who found that disease severity decreased by increasing of the salt concentrations.

It could be concluded that potassium phosphates were more effective in controlling powdery mildew on cucumber (with average 6.62 to 16.98% disease severity) than sodium phosphates (with average 8.14 to 29.93% disease severity): Similar conclusion was reported on tomato early blight by El-Desouky *et al.* (2003) .

Evidently, two foliar applications of phosphates, particularly of K_2HPO_4 were active in controlling the pathogen of cucumber powdery mildew.

Phosphate salt reaction may be ascribed to the role of phosphorus in the physiological procedures of plant cell, including plant cell respiration. This conclusion was reported by Reuveni and Reuveni (1995) and Mosa (1997) who indicated that K_2HOP_4 treatment caused a remarkable increase of peroxides activity in both infected and non-infected plants. They added also that phosphatic treatment inhibited conidial spores production of powdery mildew pathogen.

The action of phosphate salts can to be synergistic with that of fungicides for improving disease control. where Napier and Oosthuyse (2000) reported that incorporating phosphate salts into any integrated pest management program to control plant pathogens reduce fungicide application and fungicide residue on food crops by up to 50% and gave a good disease control.

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الملخص العربى

المقاومة الكيميائية والمستحثة للبياض الدقيقى على الخيار فى مصر

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تم إجراء حصر لمرض البياض الدقيقى للخيار فى سبع محافظات مصرية خلال عامى ٢٠٠٢ و ٢٠٠٣م ، كانت شدة الإصابة على الخيار فى مصر فى ربيع ٢٠٠٣م أعلى منها فى خريف أو صيف ٢٠٠٢م .

تم تسجيل أعلى متوسط لشدة الإصابة بالمرض فى سخا ، محافظة كفر الشيخ ، حيث وصلت ٤٣,٩٦% ، يليها جمصة ، محافظة دمياط حيث سجلت ٤٢,٧% ثم النوبارية ، محافظة البحيرة التى سجلت ٤١,٩% .

من ناحية أخرى ، كانت أقل شدة للمرض على الخيار فى مصر خلال فترة الدراسة هى فى صيف ٢٠٠٢م ومقدارها ١٠,٨% فى أوسيم بمحافظة الجيزة تليها ١٥,٤% فى قها بمحافظة القليوبية ثم ١٦,٢% فى شبين الكوم بمحافظة المنوفية .

أظهرت جميع المبيدات الفطرية المستخدمة تأثيراً واضحاً فى تقليل شدة الإصابة بالمرض خاصة المبيدات الجهازية مثل التوباس وسومى ٨ التى تفوقت على المبيدات التلامسية مثل الكارثين والسوريل التى يتم رشها وقائياً فى العادة .

تم رش المجموع الخضرى للخيار بأملاح الفوسفات مرتين تحت ظروف الصوبة خلال فترة نمو المحصول ، الأولى عند ظهور الورقة الحقيقة الرابعة والثانية فى بداية مرحلة التزهير وذلك للحث على المقاومة . كان محلول فوسفات البوتاسيوم أفضل من محلول فوسفات الصوديوم ، وكان التركيز الأعلى (٧٥٠ جزء فى المليون) أفضل من التركيز الأقل (٢٥٠ أو ٥٠٠ جزء فى المليون) ، وقد وصل متوسط شدة الإصابة عند الرش بمحلول فوسفات البوتاسيوم تركيز ٧٥٠ جزء فى المليون إلى ٦,٦% فى مقابل ٤١,٣% بالنسبة لمعاملة المقارنة المعداة وغير المعاملة بالمحلول الملحى.