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Safe Method to Control Powdery Mildew Disease of Pepper and Cucumber

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ABSTRACT

Two experiments were conducted in 2013 and 2014 at El-Bostan Farm at the north coast of Egypt. Powdery mildew is one of the most serious foliar diseases effecting several crops. The main objective of this study was to evaluate the effect of compost solution on disease severity of powdery mildew infected pepper and cucumber plants. The treatments iculude injection of compost solution into drip irrigation system and three foliar sprays of organic solution treatments (control, once per week and once per two weeks). Data indicated that organic solution improved plant growth and yield during the two successive seasons. Combination between injection and foliar treatments using compost solution greatly decreased the severity of infection by *Leveillula taurica,*on pepper *Sphaerotheca fuliginea* on cucumber and significantly increased plant yields, compared with the single treatment. Combination treatments were the most effective, when compost was applied for twice / week. Economic analysis suggested injection of compost solution twice a week in addition to foliar application once a week can save 40% of the mineral fertilizer beside saving 61.7% of fungicide, compared to a system with mineral fertilizer application only.
Keywords: Powdery mildew, Pepper, Cucumber, *Leveillula taurica*, *Sphaerotheca fuliginea*, Compost.

INTRODUCTION

Powdery mildew of pepper caused by *Leveillula taurica* and cucumber caused by *Sphaerotheca fuliginea* are the most serious foliar diseases, attacking pepper and cucumber plants, in Egypt (Mosa 1997) and other countries. Fungicides and resistance or tolerant cultivars are used to control this disease; however, each of these control methods has limitations. The use of alternative control methods of diseases can effectively replace chemical fungicides. The effects of compost extracts against pathogens have effects on into several pathogen,: inhibition of spore germination, antagonism and competition with pathogens and induced resistance against pathogens (Budde and Weltzien, 1990). The application of safety chemicals to activate acquired resistance provides novel alternative for disease control in agronomic systems (Ward *et al*., 1991). Application of organic waste increased the fresh and dry weight of cucumber shoots significantly through the autumn and spring seasons at the early and final growth stages. The highest values obtained at early stage were associated with the addition of compost in autumn and spring seasons and with addition of chicken manure at the final stage of autumn and spring seasons (El-Sheikh and Hegazy, 1998). Combining extracts of manure with inorganic fertilizer increased early yield of cucumber compared to mineral fertilizer only. On the other hand, the highest early yield was obtained by using 100% compost manure. Using 75% pigeon manure and 25% inorganic fertilizer gave the lowest early yield . Organic manure application as a nutrient solution affected total yield of cantaloupe significantly. The highest total yield was recorded with inorganic solution. On the contrary, the lowest total yield resulted from plants that received the organic manure solution alone while those plants that received the inorganic plus organic manure solution gave higher total yield (Abou-El-Hassan, 2003). Hence, this investigation aimed to study safe method to control powdery mildew disease of pepper and cucumber, under natural infection conditions.

MATERIALS AND METHODS

Compost soluation preparation.

The compost was made from a mixture of green manure of pepper and cucumber plants and farmyard manure, at the ratio 10:1 (w/w). The chemical analysis of compost is recorded in (Table 1). The mixture was incubated for four months with regular wetness. Compost solution was prepared by soaking the previous mixture incubation period with tap water, at the ratio 1: 4 (v: v) for 24-28 hr. Compost was extracted to take out the soulation then being filtered through three layers of cheesecloth (Mikail, *et al*., 2005).

Greenhouse experiment.

Two experiments were carried out in two successive wenter seasons from October 2013 to December 2014,under greenhouse condtions at El-Bostan farm, El-Behira Governorate, Egypt. Each experiment included three compost solution soil injection times (no injection, once injection and twice injection per week) applied by fertigation system, which combination with three sprayings of organic solution treatments (no spray, once per week and once per two weeks). Seeds of cucumber (*Cucumis sativus* L.) cv. 'Brenjee 82' and pepper (*Capsicum annuum* L.) cv. 'Reda F1'. This solution was applied at the ratio 1L / 100 L water in case of injection treatment and the ratio 1.2 L / l00L water in case of foliar spray treatment. These treatments started after 60 and 30 days from planting in the greenhouse for pepper and cucumber, respectively. All other agriculture practices of cultivation were performed as recommended by the Egyptian Ministry of Agriculture.

Statistical analysis data of was done, using ANOVA method. The differences among means for all traits were tested for significance at 5 % level according to Waller and Duncan (1969).

Disease and yield assessment.

Disease severity was calculated as percentage of infection according to number of leaves per plant X 100 and as percentage of disease index (DI)according to scale rating from 0 to 4 for powdery mildew disease of pepper or cucumber, where 0= no powdery mildew

lesions, 1=25 or less, 2= 26-50, 3= 51-75 and 4= 76-100% infected leaf area **(Reuveni, *et al.*, 1996).** Disease index (DI) was calculated as follows:

$$DI = \frac{\sum R.T}{4XN} \times 100$$

Where, T= number of plants with each category (R) disease severity scale (R =0, 1, 2, 3 and 4).

N= Total number of tested plants

Percentage of disease control (PDC) was calculated as follows:

$$PDC = \frac{DIcr - DItr}{DIcr} X\ 100$$

Where DIcr = disease index in control treatment

DItr = Disease index in measure treatment

Harvest yield was started after 60 dayes after transplanting.

The yield was recorded as average kg/ plant after 60 days from planting in greenhouse as the following.

Data were statistically analyzed using the "F" test and the value of LSD ($P \leq 0.05$) was calculated according to Snedecor and Cochran (1981).

Table 1. Chemical properties of the compost used in the experiment.

EC	pH	Cations Meq/L				Anions Meq/L				N%	C%	C/N %	O.M. %
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO^{--}	$HCO3^{-}$	Cl^{-}	$SO4^{--}$				
7.95	5.39	19.0	51	48	1.05	0.0	3.1	34	38.15	0.32	4.94	15.41	9.88

Economic analysis:

For economical analysis, after considering the cost of organic materials application, the incomes from cucumber and pepper yield were used (CIMMYT, 1988) according to the formula: Net Income = value of obtained yield, cost of mineral/organic / biological nutrient sources; Value cost ratio (VC) = value of yield obtained / cost of mineral / organic/biological nutrient sources. Relative increase in income (RII) = (net income /income of control) x 100.

RESULTS

Application of compost solution led to reduction in the severity of powdery mildew disease of pepper or cucumber and to an increase in their yield compared with the control (Table 2 and 3). Application of compost solution in foliar spray treatment was more effective than injection in irrigation water against the disease and the yield, where the percentage of disease control was 15.0-23.7 or 22.3-34.6% as foliar treatment and 3.3-15.2 or 10.4-19.9 % in injection treatment and the yield was 5.5-5.6 or 3.8-4.4 kg $plant^{-1}$ and 4.9-5.2 or 3.4-3.7 kg $plant^{-1}$, respectively. Disease severity was significantly reduced and yield was increased when compost solution was applied for twice per week, where percentage of disease control was 13.0-23.7 and 17.7-34.6% and the yield was 5.0-5.6 and 3.6-4.4. Meanwhile , disease severity and yield were moderately improved, when compost solution was applied once per week, where percentage of disease effecting control was 6.3-17.6 and 10.4-23.9% and the yield was 4.9-5.5 and 3.4-4.0, respectively. Application of compost solution for twice per week was the most effective against severity of powdery mildew disease of pepper or cucumber and increasing their yield, where percentage of control effecting was 5.0-5.6 or 3.6-4.4, respectively. Application of compost solution was more visible against powdery mildew disease of cucumber than powdery mildew disease of pepper, where the percentage of disease control was 10.4-34.6 and 6.3-23.7%, respectively. Application of compost solution has a substantial effect on disease and the yield through growing season 2014 more than in the growing season 2013, where percentage of control was 6.3-32.5 and 9.1-34.6%. The yield was 4.9-5.5 or 3.4-4.1 kg /cucumber plant and 5.0-5.6 kg / pepper plant or 3.5-4.4 kg / cucumber plant, respectively.

However, combination between injection and foliar spray of compost sulation led to a reduction in severity of powdery mildow disease of pepper or cucumber and to an increase in their yield compared with the control (Tables 2 and 3). Combination between application of compost solution once/ turce as injection treatment and application of compost solution as foliar spray treatment was more effective than combination between application of compost solution for once as injection treatment and application of compost solution as foliar treatment to decrease disease severity and to increase the yield, where percentage of disease control efficiency was 52.5-46.6 and 15.5-34. and the yield was 5.8-6.3 plant or 4.3-4 plant and 5.4-5.8 plant or 3.9-4.3 plant, respectively. Application of compost solution for turce as combined injection and foliar treatments was the most effective on disease severity and increasing the yield, where percentage of disease control was effecting 34.1-46% and the yield was 6.0-6.3 kg/ plant or 4.6-4.8 kg/ plant, respectively. Combination treatments were more effective against powdery mildew disease of cucumber than powdery mildew disease of pepper, where percentage of disease control efficiency was 23.0-46.7% and 15.5-38.6 %, respectively. Combination treatments were more effective during in season 2008 than growing 2009, where, percentage of disease control was 18.6-46.7% and 15.5-42 % and the yield was 5.6-6.3 kg / pepper plant or 4.1-4.8 kg / cucumber plant and 5.4-6.0 kg / pepper plant or 3.9-4.6 kg / cucumber plant, respectively.

Economic analysis.

Data in Tables (4 and 5) clearly indicated that addition of organic solution increased the net income. Addition of organic solution for cucumber and pepper plants increased net income, value cost ratio and relative increase in income (RII) during the two seasons.

Table 2. Effect of compost solution used as combination between injection and spray treatments on the severity of powdery mildew disease and yield of cucumber during, 2013 and 2014 seasons.

Soil injection	Foliar spray	Disease severity (%)		Efficiency (%)		Average yield Kg / plant	
		2013	2014	2013	2014	2013	2014
Once	1	34.9	22.8	23.0	25.5	3.9	4.1
	2	31.0	20.2	31.6	34.0	4.1	4.3
	None	40.6	26.3	10.4	14.1	3.4	3.5
Twice	1	29.8	19.6	34.2	35.9	4.3	4.5
	2	26.1	16.3	42.4	46.7	4.6	4.8
	None	37.3	24.5	17.7	19.9	3.6	3.7
Non	1	35.2	23.3	22.3	23.9	3.8	4
	2	30.6	20.0	32.5	34.6	4.1	4.4
	None	45.3	30.6	0.0	0.0	3.1	3.3
LSD at 5%:		**2013**				**2014**	
Soil injection:		**2.0**				**1.1**	
Foliar:		**1.6**				**0.6**	
Season:		**1.0**				**0.3**	
Interaction:		**2.6**				**1.2**	

The net income of injecting and spraying organic solution treatments was higher than the net income of using chemicals only (fungicides and mineral fertilizers) during the two seasons. The highest yields, net incomes and (RII) in injecting organic solution twice a week combined with spraying once a week followed by injecting twice a week combined with spraying once every two weeks for cucumber and pepper plants during the two tested seasons. The net income of using organic solution increased in the second season due to chemical costs increase during the 2013 and 2014 seasons while the organic solution didn't increase by the same ratio. After considering the cost of organic solution used in different organic solution treatments, it is estimated that almost 40 % of mineral fertilizer and 61.7 % of fungicide were saved (low disease severity) by the integrated use of organic solution by injecting the organic solution twice a week. In addition to economic and monetary benefits, the reduction of chemical used would have a positive significant effect on the environment and human health, energy conservation, soil quality and health. These results in agreement with findings of Yaduvanshi (2003) and Scheuerel (2003).

Table 3. Effect of compost solution as soil injection and foliar spray treatments on the powdery mildew disease and yield of pepper during, 2013 and 2014 seasons.

Soil injection	Foliar spray	Disease severity (%)		Efficiency (%)		Average yield Kg / plant	
		2013	2014	2013	2014	2013	2014
Once	1	46.8	49.4	15.5	18.6	5.4	5.6
	2	44.2	46.1	20.2	24.1	5.5	5.8
	None	51.9	55.2	6.3	9.1	4.9	5.0
Twice	1	41.3	42.7	25.5	29.7	5.8	6.0
	2	36.5	37.3	34.1	38.6	6.0	6.3
	None	48.2	52.5	13.0	13.5	5.0	5.2
Non	1	47.1	50	15.0	17.6	5.3	5.5
	2	40.6	46.3	26.7	23.7	5.5	5.6
	None	55.4	60.7	0.0	0.0	4.8	4.7
LSD at 5%:		**Diesese severity**				**yield**	
Treatment:		**2.2**				**0.5**	
Number:		**1.2**				**0.2**	
Year:		**0.7**				**0.1**	
Interaction:		**2.6**				**0.8**	

Table 4. Comparative analysis of various treatments (per RII) for their potential to give an optimum economic yield of cucumber plant during the 2013and 2014 seasons.

Treatments		Yield	Gross Incoming L.E.	Mineral Cost L.E.	Fungicide Cost L.E.	Organic Cost L.E.	Total Cost L.E.	Net Income L.E.	Value cost ratio L.E.	RII %
					2013 seasons					
No inject soil	no foliar spray	3720	3407	780	248.0	0	1028.0	2379.1	3.3	0.0
	spray at 7 day	4440	4067	780	176.0	48	1004.0	3062.6	4.1	28.7
	spray at 15 day	4200	3847	780	192.0	96	1068.0	2778.7	3.6	16.8
Once (injection /week)	no spray	4080	3737	624	210.0	54	888.0	2848.8	4.2	19.7
	spray at 7 day	4920	4506	624	162.0	104	890.0	3616.2	5.1	52.0
	spray at 15 day	4440	4067	624	173.0	74	871.0	3195.6	4.7	34.3
Twice (injection /week)	no spray	4564	4180	468	187.0	108	763.0	3416.8	5.5	43.6
	spray at 7 day	5400	4946	468	95.0	148	711.0	4234.8	7.0	78.0
	spray at 15 day	4920	4506	468	112.0	128	708.0	3798.2	6.4	59.6
Treatments					2014 seasons					
No inject	no spray	3480	3865	936	297.6	0	1233.6	2631.3	3.1	0.0
	spray at 7 day	3840	4265	936	211.2	50.4	1197.6	3067.1	3.6	16.6
	spray at 15 day	4200	4665	936	230.4	100.8	1267.2	3397.4	3.7	29.1
Once (injectio	no spray	4080	4531	748.8	252.0	56.7	1057.5	3473.8	4.3	32.0
/week)	spray at 7 day	4560	5064	748.8	194.4	109.2	1052.4	4012.0	4.8	52.5
	spray at 15 day	5040	5597	748.8	207.6	77.7	1034.1	4563.4	5.4	73.4
Twice (injectio	no spray	4440	4931	561.6	224.4	113.4	899.4	4031.7	5.5	53.2
/week)	spray at 7 day	5280	5864	561.6	114.0	155.4	831.0	5033.0	7.1	91.3
	spray at 15 day	4800	5331	561.6	134.4	134.4	830.4	4500.5	6.4	71.0

Table 5. Comparative analysis of various treatments (per RII) for their potential to give an optimum economic yield of pepper plant during the 2013 and 2014 seasons.

Treatments		Yield	Gross Incoming L.E.	Mineral Cost L.E.	Fungicide Cost L.E.	Organic Cost L.E.	Total Cost L.E.	Net Income L.E.	Value cost ratio L.E.	RII %
2012/2013 seasons										
No soil inject	no foliar spray	4032	6518	1361	521.4	0	1882.4	4635.9	3.5	0.0
	spray at 7 day	4116	6654	1361	370.0	92	1823.0	4831.0	3.6	4.2
	spray at 15 day	4224	6829	1361	403.7	46	1810.7	5018.0	3.8	8.2
Once (injection /week)	no spray	4284	6926	1089	441.5	113	1643.5	5282.1	4.2	13.9
	spray at 7 day	4536	7333	1089	340.6	163	1592.6	5740.4	4.6	23.8
	spray at 15 day	4872	7876	1089	363.7	159	1611.7	6264.5	4.9	35.1
Twice (injection /week)	no spray	4452	7197	817	393.2	226	1436.2	5761.1	5.0	24.3
	spray at 7 day	4872	7876	817	199.7	318	1334.7	6541.5	5.9	41.1
	spray at 15 day	5208	8419	817	235.5	272	1324.5	7094.9	6.4	53.0
Treatments					2013/2014 seasons					
No inject	no spray	3528	5881	1633.2	657.8	0	2291.0	3590.0	2.6	0.0
	spray at 7 day	3780	6301	1633.2	466.8	96.6	2196.6	4104.5	2.9	14.3
	spray at 15 day	4032	6721	1633.2	509.3	48.3	2190.8	4530.4	3.1	26.2
Once (injection /week)	no spray	3948	6581	1306.8	557.0	118.65	1982.5	4598.7	3.3	28.1
	spray at 7 day	4200	7001	1306.8	429.7	171.15	1907.7	5093.6	3.7	41.9
	spray at 15 day	4452	7421	1306.8	458.9	166.95	1932.6	5488.7	3.8	52.9
Twice (injection /week)	no spray	4032	6721	980.4	496.0	237.3	1713.7	5007.5	3.9	39.5
	spray at 7 day	4452	7421	980.4	252.0	333.9	1566.3	5855.0	4.7	63.1
	spray at 15 day	4872	8121	980.4	297.1	285.6	1563.1	6558.4	5.2	82.7

RII: Relative increase in income

Stated that considerable economic losses would be suffered without pesticide use and quantified the significant increases in yield and economic margin that result from pesticide use and economic threshold is defined as the disease density at which action must be taken to prevent the disease severity from increasing and causing economic damage.

DISCUSSION.

Application of compost solution alone as soil injection ito irrigation sulution /or combined with the foliar spray has reduced severity of powdery mildew diseases of pepper and cucumber and increased their yields compared with the control. Combination between injection and foliar treatments using compost solution were the most effective against two disease and yield. The superiority of using organic compost mixed with inorganic nutrient solution treatments may result from balance between macro and micro elements availability (Abou El-Hassan, 2003). Yousry and Yasser (2006) reported that organic solution contains considerable amounts of macro and micro nutrients, amino acids, vitamins and hormones which would possibly increase plant growth and yield. On the other hand, amino acids and hormones might induce resistance of cucumber and pepper plants to powdery mildew and reduce the spores germination and inhibit fungus growth on leaves by using organic solution as foliar spraying (York and Brinton, 1996. In addition, microorganisms in the organic solution are believed to fight aganist disease by competing with pathogens for colonization sites and nutrient supplies, secreting antibiotic or anti-fungal substances, or directly parasitizing pathogens, while soluble nutrients improve plant health and bolster natural defense mechanisms. As fungal diseases have proven to be among the most difficult pest problems to control with nonchemical methods and are among the most damaging crop problems yet, control through the use of compost tea has the potential to allow major advances in biological agricultural systems(Weltzien 1989).

Using extracted manure solution can prevent the infection of the host. Organic soil amendment led to physical effects on soil properties including; (a) reducing the bulk density of the soil (b) increasing water holding capacity, (c) increasing water infiltration and drainage in fine- textures and (d) improved soil aggregation (Recheigl, 1995). Sandy soils amended with unsterilized and chicken manure compost markedly inhibited the infection of tomato plants, relatively to the control, by the phytopathogen *Fusarium oxypsorum*, suggesting that biotic substrate microflora and / or abiotic ones i.e. substrate physicochemical properties may play a role in reducing the severity of attack by *Fusarium oxypsorum* (Youssef, 2007). The mechanisms by which biotic and abiotic factors make soil suppressive can be divided into several categories. Nutrient competition, microbial antagonism, parasitism and systemic induced resistance (Garbeve *et al*., 2004).

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المكافحه الآمنة لأمراض البياض الدقيقي فى الفلفل والخيار

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المعمل المركزي للمناخ الزراعي، مركز البحوث الزراعية، الدقي، ١٢٤١١، جيزة – مصر.

تسبب أمراض البياض الدقيقي أضرار لعديد من المحاصيل وينتج عن ذلك خسائر فادحة لتلك المحاصيل. أجريت هذه الدراسة بغرض تقييم فعالية محلول كمبوست (مخلوط يتكون من مخلفات نباتات الطماطم والفلفل والخيار + السماد البلدي القديم) ضد مرضي البياض الدقيقي فى الفلفل والخيار ومحصولهما تحت ظروف الإصابة الطبيعية واستخدم هذا المحلول اما حقناً فى ماء الري او رشاً على المجموع الخضري كمعاملات منفرده او متداخلة ، حيث اجريت تلك المعاملة مرة او مرتين أسبوعياً وتم تقيم كفاءة هذه العملية إقتصادياً. وأظهرت النتائج ان استخدام محلول الكمبوست (المخلوط) ادي الى خفض شدة المرض وزيادة المحصول بالمقارنة مع معاملة المقارنة. مع ان استخدام هذا المحلول كمعاملة رشاً على المجموع الخضري مرتين أسبوعياً ضد مرض البياض الدقيقي فى الخيار كان أكثر فعالية من معاملة الحقن فى ماء الري أو مرة واحدة أسبوعياً ضد مرضي البياض الدقيقي فى الفلفل والخيار. التداخل بين معاملتى الحقن فى ماء الري والرش على المجموع الخضري خفضت شدة المرض بدرجة كبيرة وزاد المحصول بدرجة ملحوظة فى حين ان التداخل مع المعاملة مرتين أسبوعياً كانت الأكثر كفاءة فى خفض المرض وزيادة المحصول لكلا المحصولين. كما أشارت نتائج التحليل الاقتصادي للمعاملات المختلفة إلى أن معاملة حقن المحلول المغذى العضوي مرتين أسبوعيا مع الرش بالمحلول العضوي مرة أسبوعيا أدت إلى توفير ٤٠ % من السماد المعدني الكلى المضاف للنباتات الفلفل والخيار خلال موسمي الزراعة وكذا ٦١.٧% من المبيدات المضافة.