

INTEGRATED METHODS FOR CONTROLLING POTATO FOLIAGE DISEASES UNDER ORGANIC AGRICULTURE SYSTEM

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Abstract

Late blight caused by *Phytophthora infestans* (Mont.) de Bary and early blight caused by *Alternaria solani* (Ell. and Mart.) as well as gray mould incited by *Botrytis cinerea* Person are considered the most destructive potato foliage diseases. Plant extracts, organic acids and fungicide were tested against the three pathogens under field conditions. This study showed that, organic acids followed by plant extracts were the most effect on potato Valor variety in different seasons when compared with fungicide and increased yield. Salicylic acid was the most effective organic acids increased in percentage reduction of disease incidence in plants either cultivated in organic or mineral fertilization fields in season 2004 and 2005. The percentage reduction of disease incidence and disease severity was higher in organic fertilization than in mineral one. Camphor and garlic extracts were the most effective while, the least zanzalkht.

INTRODUCTION

Potato represents one of the most important vegetable crops in family Solanaceae. Several fungal diseases attack the foliage system of potato plants during all growth stages. Late blight caused by *P. infestans*, early blight caused by *A. solani* and gray mould caused by *B. cinerea* are the most potato foliage diseases. Disease severity against different pathogens was determined under on Valor variety. Plant extracts, organic acids and fungicide were tested against three pathogens under field conditions. The efficacy of plant extracts (*Allium sativum*) garlic bulb extracts, neem leaf extract (*Melia azedarach*) and *Ocimum* leaf extracts) were used to control the early blight disease caused by *A. solani* (Prasad and Naik 2003) . *Allium sativum* screened for activity against *A. solani*. It exhibited good fungi toxicity and completely inhibited mycelial growth at a concentration 5000 ppm. They suggested that all the tested materials were significantly affected under greenhouse conditions but their effect were differed from each to other (Hilderbrandt *et al.*, 2006).

Salicylic acid as systemic induced resistance (SIR) to late blight in different potato cultivars caused by *Phytophthora infestans* in field trials in Sweden and in growth chamber experiments. The non pathogen *P. cryptogea* and salicylic acid were

used as inducer agents. In the field, plants were naturally infected by *P. infestans* while the indoor plants were inoculated. The degree of SIR obtained varied with the cultivar used and also with the type of inducer (Quintanilla and Brishammar 2006). Salicylic acid a signal substance produced upon eliciting potato leaves with arachidonic acid. Systemic acquired resistance (SAR) against *Phytophthora infestans* in potato was obtained after injection in the intercellular space. Good protection occurred in the upper leaf when low concentration. was applied (10 ppm). Salicylic acid (SA) its putative role as a signaling molecule. However, its role as a signaling molecule for SAR in potato seems questionable (Coquoz *et al.*, 2007). Fifteen fungicidal treatments were evaluated during 2006 for their efficacy in controlling late blight of potato caused by *P. infestans* in Prince Edward Island, Canada. They detected that, Mancozeb as Dithane and Fluazinan gave good disease control and the other treatments gave partial disease control (Platt *et al.*, 2007).

MATERIALS AND METHODS

- Field experiments

These experiments were conducted at the conditions of El Knaiat valley, El-Sharkia governorate where Valor potato variety was used in summer season (January) 2004, 2005. Different treatments were distributed in complete randomized plots. Three plots (3 x 3) each contained 4 rows with 48 plants were used for each treatment. The tuber seeds of potato were planted in the deep 15 cm and length 30 cm in light clay soil. All field experiments were divided into two groups. First group was fertilized with (chicken manure) as organic fertilization produced by All Qaullila company in El-Sharkia governorate. Seven kilograms/m² dry matter of organic compost was added before planting 1 kg/10 liter diluted water was sprayed after 45, 65 days from planting. Second group was fertilized with mineral fertilization as super calcium phosphate at 20 kg/300 m² and super nitrate was added after 40, 60 days as 50 kg/300 m². In all field experiments, percentage of disease plants, disease severity and yield were determined two weeks after treatment.

- Potato pathogens

Alternaria solani and *B. cinerea* were grown on Czapek Dox agar medium (Salam *et al.*, 2006) while, *P. infestans* was grown on corn meal agar medium for 14 days at 18 ± 2 °C in the dark (Abd-El-Moity, 1985). The isolated fungi were purified using the hyphal tip and/or single spore techniques according to Brown (1924) and Hawker (1960). The fungal suspension was prepared by adding de-ionized distilled water to the culture and incubated at 5 - 8°C in refrigerator for 2 - 3 hrs to stimulate releasing

of zoospores. The zoospore suspension was adjusted to be 8×10^4 zoospore/ml. Fungal suspension of each tested fungus separately was collected and adjusted using sterilized water to be 8×10^4 (*A. solani*) and 13×10^4 (*B. cinerea*) cfu/ml. using haemocytometer technique (Brame and Flood, 1983). Inoculating by these fungi was carried out under greenhouse conditions using fungal suspensions.

- Preparation of all treatments

Plant extracts obtained from (*Allium sativum*) garlic bulbs, (*Melia azedarach*) neem leaves, (*Eucalyptus* sp.) camphor leaves and (*Azadirachta indica*) zanzalkht leaves were used. Extracts were prepared by mixing 10 g of frozen plant materials with 100 ml of water using electric blender for 5 minutes. The plant extracts were obtained by filtrating the previously mentioned mixture blended plant and water through double layers of cheese clothes. The filtrated plant extracts were centrifuged at 3000 rpm for 10 minutes just to get rid of any solid particles. Prepared plant extracts were sterilized using sterilizer membrane 0.2 μ m Millipore. Different concentrations (2.5, 5, and 10 %) of plant extracts (garlic, camphor, neem and zanzalkht) were prepared as mentioned before and formulated as 1: 1 (v/v). Organic acids as (ascorbic and citric acids) were used at 500 ppm. while, salicylic acid at 200 ppm. was formulated as 1: 1 (v/v). Chemical fungicide dithane M₄₅ was used as 2.5 g/liter distilled water. Potato plants were examined periodically. Three replicates were used for each treatment. Control was conducted in this study, treated with pathogenic fungi.

- Statistical analysis

The results of the previous experiments were statistically analyzed according to the procedures reported by Snedecor and Cochran (1980). The means of all treatments were compared by the least significant difference value "L.S.D." at 5% level of probability.

RESULTS AND DISCUSSION

- Efficiency of different plant extracts for controlling potato foliage diseases

Using different concentrations of plant extracts on potato Valor variety at two success seasons (2004 and 2005) in organic and mineral fertilizations under field conditions were led to significant control of three potato pathogens. Data in Table (1) clear that, the percentage reduction of disease incidence and disease severity was higher in organic fertilization than in mineral one. The highest concentrations of plant extracts 10% were more effective for controlling pathogens. Generally percentage

reduction of diseased plants and severity was higher in 2005 than 2004 season in all investigated diseases and plant extracts.

Neem and zanzalkht at 10% recorded the same percentage (55.56%) when used against early blight disease caused by *A. solani* on plants cultivated in organic fertilization in season 2004 while, garlic extract 10% was the most effective on plants cultivated in mineral fertilization (49.99%). When percentage of gray mould disease was determined data indicated that, garlic extract was the most effective in controlling the disease in organic fertilization at conc. 10% (83.3% reduction) while, in mineral fertilization neem extract at conc. 10% recorded 75.03% reduction of diseased plants and severity was higher in 2005 than 2004 season in all investigated diseases and plant extracts.

Data also showed that, camphor and neem extracts at 10% was the most effective against late blight caused by *P. infestans* which recorded 55.56%, while, camphor and zanzalkht extract at 10% recorded (40.65 and 49.99%, respectively) on plants cultivated in mineral fertilization. When the percentage of disease was determined in season 2005 in organic and mineral fertilization data revealed that, the percentage reduction of disease incidence was increased in organic fertilization than mineral fertilization. The percentage reduction of early blight caused by *A. solani* was increased by using neem and garlic extracts at 10% (72.21% and 55.65%) respectively in mineral fertilization. Garlic extract at three concentrations were the most effective against gray mould disease caused by *B. cinerea* in organic and mineral fertilization which recorded (93.33% and 85.03%, respectively) at conc. 10%. Neem extract at the highest conc. 10% increased the reduction of percentage of late blight disease in organic fertilization and garlic extract at conc. 10% in mineral fertilization recorded the same data 60.01%.

Table 1. Efficiency of different plant extracts concentrations for controlling potato foliage diseases.

Plant extracts		Fertilization	Reduction %of diseases plant						Reduction% of disease severity						Yield (kg/plot)	
			<i>Alternaria solani</i>		<i>Botrytis cinerea</i>		<i>Phytophthora infestans</i>		<i>Alternaria solani</i>		<i>Botrytis cinerea</i>		<i>Phytophthora infestans</i>			
			2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Garlic	2.5 %	Organic	35.08	50	28.05	73.26	21.97	33.36	8.33	30.21	7.53	57.36	33.56	29.03	39.31	39.2
		Mineral	40.65	43.32	44.46	63.33	21.97	40.01	16.12	14.5	19.23	43.15	16.33	30.16	33.43	39.2
	5 %	Organic	35.08	61.03	83.3	80.03	36.86	53.36	27.8	33.26	15.35	63.91	45.23	36.91	43.81	39.8
		Mineral	40.65	49.99	55.51	78.33	21.97	60	22.14	21.62	27.67	59.36	30.63	34.03	39.84	39.36
	10%	Organic	44.42	61.03	83.3	93.33	40.65	53.36	27.5	39.17	17.77	68.52	51.63	48.79	40.4	42.08
		Mineral	49.99	55.56	55.51	85.03	40.65	60.01	25.46	33.72	36.2	74.94	33.56	43.27	40.54	39.52
Camphor	2.5 %	Organic	25.74	33.36	35.08	46.63	31.31	40.02	11.83	26.46	11.04	32.12	36.51	36.16	51.8	48.15
		Mineral	21.97	36.63	33.28	40.62	21.97	40.02	24.43	22.56	23.54	21.52	24.06	28.86	43.8	43.2
	5 %	Organic	25.74	44.43	55.56	46.63	40.65	40.02	18.73	36.4	15.46	42.32	38.21	47.36	51.24	51.25
		Mineral	31.31	43.32	33.28	64.92	40.65	46.63	31.13	40.93	33.43	32.21	31.63	39.66	44.18	41.84
	10%	Organic	35.08	50	72.26	59.95	55.56	53.36	17.06	56.2	17.79	50.46	48.46	61.63	53.54	53.62
		Mineral	31.31	49.99	47.16	71.68	40.65	60	37.24	53.53	35.29	41.85	34.52	52.41	49.21	44.5
Neem	2.5 %	Organic	35.08	55.46	35.08	59.95	21.97	53.36	31.23	28.16	31.57	24.23	31.76	23.97	42.9	44.99
		Mineral	21.27	36.63	47.16	47.35	21.97	26.71	23.14	15.42	28.81	29.52	18.58	21.41	30.33	41.46
	5 %	Organic	55.56	61.03	44.46	66.63	21.97	53.36	47.9	34.76	43.63	30.71	48.5	38.46	52.4	45.23
		Mineral	31.31	49.99	61.11	47.35	21.97	26.71	30.59	30.88	37.43	38.66	26.03	31.93	37.13	43.24
	10%	Organic	55.56	72.21	80.53	80.06	55.56	60.01	58.33	46.31	51.02	47.52	62.86	43.53	52.34	52.81
		Mineral	31.31	62.2	75.03	78.33	31.31	60	39.73	43.12	46.33	41.46	33.23	47.86	34.85	38.85
Zanzalakt	2.5 %	Organic	25.74	16.64	25.74	40.01	21.97	26.71	11.86	27.04	17.49	22.61	30.13	34.19	37.4	39.76
		Mineral	21.97	30.4	33.28	20.66	21.97	20.06	14.53	24.16	23.13	19.51	15.46	16.86	31.16	41.2
	5 %	Organic	25.74	16.64	25.74	60.01	21.97	46.63	28.36	28.63	36.12	32.63	37.22	36.86	43.86	46.96
		Mineral	21.97	30.4	33.28	20.66	31.31	26.7	20.67	25.69	30.63	31.32	23.81	26.6	31.26	43.3
	10%	Organic	55.56	38.96	44.42	73.36	40.65	53.36	29.63	33.62	46.2	40.49	49.01	39.2	44.34	47.64
		Mineral	31.31	49.99	44.46	53.93	49.99	40.01	27.54	35.61	37.64	44.83	31.93	38.4	34.52	50.33
Dithane M ₄₅	Organic	25.74	22.21	49.99	33.54	40.65	47.65	28.81	26.62	54.77	59.31	38.72	47.91	60.83	41.8	
	Mineral	21.97	49.99	33.28	63.33	35.08	53.36	30.56	42.13	17.09	38.03	24.86	45.96	61.15	41.18	
Contro	Organic	0	0	0	0	0	0	0	0	0	0	0	0	33.2	39.4	
	Mineral	0	0	0	0	0	0	0	0	0	0	0	0	31.59	37.1	
L.S.D. 0.05	Organic	7.95	7.62	11.51	10.12	7.66	8.76	7.3	5.01	5.6	5.06	4.6	6.96	8.76	7.66	
	Mineral	10	8.79	13.01	11	41.18	10.44	6.3	5.38	4.49	6.27	3.79	4.77	2.57	2.74	

All plant extracts at three different concentrations increased the reduction of disease severity in organic and mineral fertilization compared with control. The reduction of disease severity was increased in season 2004 in mineral fertilization than in organic fertilization when plant extract was used against three pathogens. Neem extract at 10 % was the most effective when used against *A. solani* in organic fertilization (58.33%) and in mineral fertilization (39.73%). Neem was the most extracts recorded the highest effect when used against *B. cinerea* at all tested concs. (2.5, 5, 10%) in organic and mineral fertilization (31.57, 43.63, 51.02%) and (28.81, 37.43, 46.33%) when the reduction of disease severity was determined data showed that, neem extract at 10% conc. recorded 62.86% when used against late blight caused by *P. infestans* in organic fertilization whereas, camphor extract was the most effect at 2.5, 5, 10% conc. while in mineral fertilization were (24.06, 31.63, 34.52%).

In season 2005 camphor extract was the most effect at the concentration 10% when used against *A. solani* in organic and mineral fertilization (56.2%, 53.53%). Garlic was the most effective investigated extracts which increased the reduction of severity of *B. cinerea* in organic and mineral fertilizations which recorded (68.52% and 74.94 % respectively). Camphor extract at conc. 10% increased the reduction of *P. infestans* severity in organic and mineral fertilization 61.63% and 52.41%, respectively. The yield was determined when plant extracts used against three pathogens. Data recorded that, the yield increased in organic fertilization than mineral fertilization in two investigated seasons (2004, 2005). Camphor extract was the most effective which increased yield in organic and mineral fertilization in season 2004 by 53.54, 49.21 Kg / pot. In season 2005 camphor extract at 10% recorded 53.62 Kg / pot in organic fertilization while, zanzalkht extract recorded (50.33 Kg / pot) in mineral fertilization. This might due to garlic extract contains special materials which inhibited the activity of hydrolytic enzymes produced by pathogens due to inhibition of this group of enzyme, the pathogen can not digested the complex materials in medium to convert them to the food state necessary for its metabolism as the result the pathogen can not progress (Abd-El- Moity, 1981). The obtained data were accordance with Mc.Calla and Maspins (1964) whom reported that, some plant organs contain relatively high amount of certain chemical compounds showed inhibitory effects to different fungi. No doubt those antimicrobial agents involve numerous heterogeneous groups of biologically active ingredients. These compounds were included alkaloids, essential oils, phenol compounds, etc. as well as from reviews by using plant extracts at three concentrations on potato plants led to reduce early and late blights as well as gray mould diseases was discussed. The effect of neem extract on the pathogens might due to its antifungal effect or increase the

phenylalanine ammonialyase activity in the leaves. Garlic is act on disease through certain volatile thieols compounds (Coley Smith, 1976 and Abd-El-Moity, 1981).

- Efficiency of organic acids for controlling potato foliage diseases

Data in Table (2) show that, all tested organic acids caused significant reduction of disease incidence in both tested seasons compared with control treatment. On Valor variety salicylic acid was the most organic acids increased the percentage of reduction of *A. solani* disease incidence in plants cultivated in organic fertilization fields at season 2004 (83.33%) and (72.21%) at season 2005. Ascorbic and salicylic acids were recorded the same percentage in mineral fertilization fields at season2004 (40.65%) while, salicylic and citric acids recorded 49.99% in mineral fertilization fields in season2005. Salicylic acid was the most organic acids increased the percentage reduction of *B. cinerea* disease incidence in plants cultivated in organic fertilization at seasons 2004 and 2005 (83.33and 100%, respectively), whereas, salicylic acid was the most effective in mineral fertilization at season 2004 (66.72%) and citric acid at season 2005 (80.03%).

Salicylic acid was the most organic acids increased the percentage reduction of *P. infestans* disease incidence in organic and mineral fertilizations fields during season 2004 (75.03%) and season 2005 (73.36%). The reduction of *A. solani* and *B. cinerea* disease severity was increased by using salicylic acid in organic and mineral fertilizations at season 2004 (71.13, 59.04%) and (54.95, 66.32%). Salicylic acid was the most effective on the reduction of *A. solani* disease severity in organic fertilization (63.16%) and in mineral fertilization (58.46%) at season 2005. Ascorbic acid increased reduction of *B. cinerea* disease severity in organic fertilization (66.63%) whereas, salicylic acid was the most effective in mineral fertilization (65.61%).

The reduction of *P. infestans* disease was increased by using ascorbic in organic fertilization (47.13%) while salicylic acid the most effective in mineral fertilization (51.33%) at season 2004. Salicylic acid was the most effective in organic and mineral fertilizations(61.64 and 45.96%) at season 2005. The yield increased by using ascorbic acid in organic fertilization at seasons 2004and 2005 (60.6, 52.6 kg / plot) and in mineral fertilization season 2004 (55.35 kg / plot) while, salicylic acid was the most effective in mineral fertilization at season 2005 (64.23 kg / plot). The effect of these chemicals might be due to their direct effect or the role of these chemicals in inducing disease resistance (Coquoz *et al.*, 2007) suggested that, SA-binding by protein SA-binding protein (SA-BP) caused inhibition of its catalase activity and induction of defense response. SA essential for the development of SAR could possibly play a role in local resistance. Data also indicated that, using tested fungicide (dithane M₄₅) differed in their reaction. This might be due to selective relationship between fungicide and fungi (Mayton *et al.*, 2001).

Table 2. Efficiency of organic acids for controlling potato foliage diseases on Valor variety.

Organic acids	Fertilization	Reduction% of diseases plants						Reduction% of disease severity						Yield (kg/plot)	
		<i>Alternaria solani</i>		<i>Botrytis cinerea</i>		<i>Phytophthora infestans</i>		<i>Alternaria solani</i>		<i>Botrytis cinerea</i>		<i>Phytophthora infestans</i>			
		2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Ascorbic acid 500 ppm	Organic	58.36	38.96	75.06	73.38	66.63	40.02	45.13	51.59	43.98	66.63	17.13	35.27	60.6	52.6
	Mineral	40.65	18.92	44.46	56.62	49.99	20.06	44.83	52.43	26.39	42.51	35.56	38.44	55.35	43.8
Citric acid 500 ppm	Organic	75.3	66.67	75.03	86.76	31.33	40.02	58.58	62.61	35.86	61.93	34.52	38.16	52.9	49.8
	Mineral	31.31	49.99	33.28	80.03	40.65	33.36	36.68	35.43	50.46	32.31	37.09	35.83	51.26	44.33
Salicylic acid 200ppm	Organic	83.33	72.21	83.33	100	75.03	73.36	71.13	71.16	54.95	64.31	35.12	61.64	54.55	48.38
	Mineral	40.65	49.99	66.72	71.68	75.03	73.36	59.04	58.46	66.32	65.61	51.33	43.96	53.53	64.23
Dithane M ₄₅	Organic	25.74	22.21	49.99	33.54	40.65	47.65	28.81	26.62	54.77	59.31	38.72	47.91	60.83	41.8
	Mineral	21.97	49.99	33.28	63.33	35.08	53.36	30.56	42.13	17.09	38.03	24.86	45.96	61.15	41.18
Control	Organic	0	0	0	0	0	0	0	0	0	0	0	0	33.2	39.2
	Mineral	0	0	0	0	0	0	0	0	0	0	0	0	31.59	37.1
L.S.D. 0.05	Organic	19.07	17.34	21.62	12.89	21.66	10.04	20.1	13.57	11.1	13.62	12.8	13	3.38	4.94
	Mineral	18.06	14.18	16.7	19.74	13.99	11.55	21.12	14.15	10.94	11.63	13.68	13.16	6.69	4.82

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طرق متكاملة لمكافحة أمراض المجموع الخضري في البطاطس تحت نظام الزراعة العضوية

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١. قسم النبات الزراعى - كلية الزراعة - جامعة الزقازيق

٢. المعمل المركزى للزراعة العضوية - مركز البحوث الزراعية - الجيزة - مصر

يصاب المجموع الخضري للبطاطس بالعديد من مسببات المرضية خلال مراحل نموه المختلفة والتي تؤدي لخسارة كبيرة فى المحصول ، ومن أهم تلك الأمراض مرض الندوة المتأخرة التى يسببها الفطر فيتوفترا إنفستانس ، والندوة المبكرة التى يسببها الفطر ألترناريا سولانى ، والعفن الرمادى الذى يسببه الفطر بوترايتس سينريا. لذا قامت هذه الدراسة باختبار تأثير المستخلصات النباتية والاحماض العضوية وكذلك المبيد الكيماوي واختبارها ضد مسببات المرضية الثلاثة علي الصنف فالور تحت ظروف الحقل. وجد ان الاحماض العضوية كانت اكثر تأثيرا يليهم المستخلصات النباتية عند مقارنتها بالمبيد الكيماوي علي الصنف فالور كما ادوا لزيادة المحصول. وجد ان حامض السيلسلك كان اكثر الاحماض العضوية تأثيرا في خفض نسبة المرض في الحقول العضوية والمعدنية في كلا الموسمين كما ان خفض نسبة وشدة المرض كانت اعلي في الحقول المسمدة عضويا عن المعدنية. كان مستخلصي الكافور والثوم اكثر تأثيرا بينما كان الزنلخت أقل تأثيراً.