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Fungicidal Activity of 46 Plant Extracts against Rice Leaf Blast, Rice Sheath Blight, Tomato Late Blight, Cucumber Gray Mold, Barley Powdery Mildew and Wheat Leaf Rust

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Abstract : Ethanol extracts from 46 plants were tested for their fungicidal activity against six plant diseases consisting of *Maynaporthe grisea, Rhizoctonia solani, Botrytis cinerea, Phytophthora infestans, Puccinia recondita,* and *Erysiphe graminis* in the greenhouse studies. Strong activity at 5 and 10 mg/pot was produced from the extracts of *Helianthus annuus* flowers and *Zea mays* leaves against *P. grisea.* In a test with *B. cinerea,* extracts of *H. annuus* leaves, *H. annuus* flowers, *Chrysanthemum coronarium* var. *spatiosum, Cucurbita moschata* seeds, *Lycopersicon esculentum, Z. mays,* and *Z. mays* leaves had strong activities at 5 mg/pot. In a test with *P. recondita,* strong activity was obtained from the extracts of *Capsicum frutescens, C. moschata* seeds, *H. annuus* seeds, *L. esculentum,* and *Malva verticillata* at 5 mg/pot. Against *E. graminis,* extracts of *Cucumis sativus, H. annuus* seeds, *Salanum tuberosum, Z. mays,* and *Z. mays* leaves produced strong activities at 10 mg/pot. All the extracts were ineffective against *P. infestans* and *R. solani.* Among seven extracts tested, the extracts of *H. annuus* leaves and flowers were highly effective against all the strains of *B. cinerea* resistant to carbendazim, procymidone, and diethofencarb. Furthermore, potent fungicidal activity was produced from the extracts of *C. coronarium* var. *spatiosum* and *C. moschata* seeds against the SSR, SRR, and RSR strains of *B. cinerea,* and *Z. mays* and *Z. mays* leaves against SSR and RSR. Extract of *L. esculentum* showed very strong activity only against RRS of *B. cinerea.*(Received June 2, 2001; accepted September 19, 2001)

Key words : fungicidal activity, vegetable extracts, alternative fungicide.

Introduction

One of the most important and challenging aspects of pesticide research is the urgent need to develop new and effective methods of controlling various insect pests and fungi; these methods should cause no harm to human health and the environment, and they must be accepted as safe by the general public (Brown, 1978; Hayes and Laws, 1991). Natural products, with their tremendous structure diversity, are an important source of new alternatives. Many natural products showing pesticidal activities are isolated every year (Swain, 1977; Wink, 1993). If their properties allow and if sufficient quantities can be obtained from natural sources such as plants, these compounds may be used as agricultural chemicals.

Plant extracts may provide an alternative to the insecticides currently used against insect pests, because they are virtually constituted with various bioactive chemicals (Swain, 1977; Wink, 1993). Since these are often active against plant diseases, biodegradable to nontoxic products, and suitable for use in integrated management programs, they could lead to the development of new and possibly safer disease control agents. Therefore, much efforts have been focused on vegetable materials for potentially useful products as commercial insecticides or as lead compounds (Balandrin *et al.*, 1985; Benner, 1993; Isman, 1995; Hedin *et al.*, 1997). However, little work has been done on the fungicidal activities of vegetable extracts in spite of their excellent nutritional, pharmacological and industrial significance (Olabanji *et al.*, 1997; Gibson et al., 1998; Billson *et al.*, 1999). In this study,

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we have examined fungicidal activities of 46 plant extracts against six plant diseases.

Materials and Methods

Plant materials and sample preparation

The plants were purchased from Boeun shop, Kyungdong Market, Seoul (Table 1). They were dried in an oven at 60℃ for 3 days and finely powdered using a blender (Model: RM 100, F. Kurt Retsch GmbH & Co. KG, Germany). Each sample was extracted twice with 500 ml of 70% ethanol at room temperature and filtered through Toyo filter paper No. 2 (Toyo Roshi, Japan). The combined filtrate was concentrated *in vacuo* at 35℃ using a rotary vacuum evaporator (Model: N-3NW, EYELA, Japan). The 46 plants and their yield of the extracts are listed (Table 1).

***In vivo* fungicidal activity test**

Six phytopathogenic fungi were *M. grisea*, *R. solani*, *B. cinerea*, *P. infestans*, *P. recondita*, and *E. graminis*. Except for *P. recondita* and *E. graminis* unable to grow in artificial media, the others were routinely maintained on potato dextrose agar (PDA) slants and V-8 agar slants, and kept for stock at 4℃.

The fungicidal activity of the extracts against pathogens used were determined by the whole plant spray method. The extracts were tested at 5 and 10 mg/pot, respectively. Test samples suspended in distilled water with Tween-20 added at the rate of 250 mg/liter were used. Each test sample solution was sprayed with 50 ml onto two pots on the turntable at the same time. After evaporation in a greenhouse for 1 day, each pathogen was inoculated into the treated test plants. Untreated controls received Tween-20 solution only. All treatments were replicated three times.

In tests with rice blast (RCB) caused by *M. grisea*, rice plants at the 2nd leaf stage in three plants/pot were sprayed with each test solution. Treated plants were inoculated with suspension of conidia in distilled water (1×10^6 spores/ml) and kept in a chamber at 25 ℃ for 24 hr under 100% relative humidity (RH). Treated and control plants were then held in a lighted chamber at 26±2℃ and 85% RH for 5 days, and rated for the disease severity. For rice sheath blight (RSB) caused by *R. solani*, each test solution was sprayed onto rice plants at 3rd leaf stage in three plants/pot. The plants were inoculated by injecting the inoculum at the base of the rice plants. The inoculum was made by culturing mycelial plugs in wheat bran medium grown at 25℃ for 7 days, and macerated in a mixer. Treated and control plants were held in a lighted chamber at 28℃ for 5 days. With cucumber gray mold (CGM) caused by *B. cinerea*, cucumber plants at the 1st leaf stage in one plant/pot were sprayed with each test solution. The cucumber was inoculated with conidia at 1×10^6 spores/ml of *B. cinerea* incubated on PDA medium at 20℃ for 15 days by leaf spray and then placed in a chamber at 20℃ for 4-5 days. For tomato late blight (TLB) caused by *P. infestans*, each test solution was sprayed onto tomato plants at the 2nd leaf stage in two plants/pot. The plants were inoculated with a suspension of 1×10^5 zoosporangia/ml made from 14 days-old culture of V-8 juice agar grown at 20℃. They were kept in a chamber at 18℃ for 4 days and then disease ratings were made. For wheat leaf rust (WLR) caused by *P. recondita*, wheat plants at the 1st leaf stage in four plants/pot were sprayed with each test solution. The plants were sprayed with suspension (60 mg/100 ml of 250 ppm Tween 20) of uredospores collected from the 2nd leaf of wheat, and then placed in a moist chamber. One day after inoculation, plants were held in a growth chamber under 20℃ and 70% RH. The fungicidal activities of the test samples were made 10 days after inoculation (DAI). For barley powdery mildew (BPM) caused by *E. graminis*, barley plants with fully expended first leaf in four plants/pot were sprayed with a suspension of a test material. Treated plants were dusted with conidia of *E. graminis* collected from the primary leaf of barley and held in a chamber at 20℃. The disease severity was rated on 10 DAI.

The control effect of plant extracts on each plant disease was evaluated with control value (CV) calculated by the formula CV (%) = $[(A-B)/A]\times100$, where A and B represent the diseased area on the untreated and treated plants, respectively. The responses were classified as previously described (Lee et al., 1998): the very strong activity ++++, CV >90%; strong +++, CV 81-90%; moderate ++, CV 61-80%; weak +, CV 40-60%; little or no activity -, CV <40%. Four strains of *B. cinerea* resistant to carbendazim, procymidone, and diethofencarb were used as previously described (Lee et al., 1998): SSR, susceptible to both carbendazim and procymidone but highly resistant to diethofencarb; SRR, susceptible to carbendazim but highly resistant to both procymidone and diethofencarb; RRS, highly resistant to carbendazim and procymidone but susceptible to diethofencarb; and RSR, highly resistant to both carbendazim and diethofencarb but susceptible to

Table 1. List of 46 plants and their yield extracted with 70% ethanol

Scientific Name	Family Name	Fresh Weight(g)	Dried Weight(g)	Yield[a] (%)
Actinidia arguta	Actinidiaceae	500	60.4	4.8
Allium cepa	Liliaceae	500	46.6	5.5
Allium fistulosum	Liliaceae	500	17.2	4.9
Allium monanthum	Liliaceae	500	92.6	1.9
Allium sativum	Liliaceae	500	23.4	1.4
Allium tuberosum	Liliaceae	500	31.8	2.0
Amaranthus mangostanus	Amaranthaceae	500	32.2	2.5
Aster glehni	Compositae	389	59.0	14.2
Brassica campestris subsp. napus var. *pekinensis*	Brassicaceae	500	108.3	4.3
Brassica campestris var. *chinensis*	Cruciferae	500	23.8	1.3
Capsella bursapastoris	Brassicaceae	500	111.1	1.8
Capsicum annuum	Solanaceae	500	17.9	3.8
Capsicum frutescens	Solanaceae	500	50.0	4.1
Chrysanthemum coronarium var. *spatiosum*	Compositae	500	35.7	1.6
Cichorium intybus	Compositae	500	20.0	1.2
Citrullus vulgaris	Cucurbitaceae	500	21.3	2.3
Citrullus vulgaris (Seed)	Cucurbitaceae	267	35.8	8.2
Colocasia antiquorum var. *esculenta*	Araceae	500	150.0	1.6
Cucurbita moschata	Cucurbitaceae	500	29.4	3.4
Cucurbita moschata (Seed)	Cucurbitaceae	500	18.7	1.9
Cucumis sativus	Cucurbitaceae	500	51.3	2.6
Daucus carota	Umbelliferaeceae	500	90.4	6.5
Helianthus annuus (Seed)	Compositae	500	35.9	5.2
Helianthus annuus (Leaf)	Compositae	500	25.6	4.7
Helianthus annuus (Flower)	Compositae	347	28.8	3.3
Ipomoea batatas	Convolvulaceae	500	206.0	6.7
Lactuca sativa	Compositae	500	25.0	2.0
Lactuca sativa var. *capitata*	Compositae	500	85.1	4.7
Lycopersicon esculentum	Solanaceae	500	16.9	5.5
Lycopersicon esculentum var. *cerasiforme*	Solanaceae	500	38.9	6.4
Malva verticillata	Malvaceae	500	43.2	3.7
Nelumbo nucifera	Nymphaeaceae	500	157.9	2.1
Oenanthe javanica	Umbelliferaeceae	500	26.9	2.0
Perilla frutescens	Labiatae	500	66.7	1.9
Petroselinum crispum	Umbelliferaeceae	500	50.0	8.7
Pimpinella brachycarpa	Umbelliferaeceae	500	132.1	3.8
Raphanus sativus	Brassicaceae	500	68.8	5.0
Rubus coreanus	Rosaceae	268	94.3	5.0
Salanum tuberosum	Solanaceae	500	195.3	6.1
Sedum sarmentosum	Crassulaceae	500	12.5	1.9
Solanum melongena	Solanaceae	500	94.6	1.9
Spinacia oleracea	Chenopodiaceae	500	26.3	2.4
Ulva lactuca	Ulvaceae	500	29.4	3.2
Zea mays	Graminales	500	51.4	6.7
Zea mays (Leaf)	Graminales	500	43.2	4.6
Zingiber officinale	Zingiberaceae	500	27.5	1.2

[a](Dried weight of ethanol extract/dried weight of the vegetable)×100.

Table 2. Controlling value of plant extracts to six plant diseases on various host plants when applied at 10 mg/pot

Sample Name	Plant Diseases[a]					
	RCB	RSB	CGM	TLB	WLR	BPM
A. arguta	-[b]	+	+++	++	++	-
A. cepa	-	+	++	-	-	++
A. fistulosum	-	+	+	-	+	+
A. monanthum	-	+	++	-	-	-
A. sativum	-	+	-	-	-	-
A. tuberosum	-	+	-	-	-	++
A. mangostanus	-	-	-	-	-	-
A. glehni	-	-	-	-	-	-
B. campestris subsp. napus var. *pekinensis*	-	-	-	-	-	-
B. campestris var. *chinensis*	-	-	-	-	-	++
C. bursapastoris	-	-	-	-	-	-
C. annuum	-	++	-	-	++	+
C. frutescens	-	-	+	-	++++	-
C. coronarium var. *spatiosum*	-	-	++++	-	++	++
C. intybus	-	-	-	-	-	-
C. vulgaris	-	-	-	-	-	-
C. vulgaris (Seed)	-	-	++	-	-	-
C. antiquorum var. *esculenta*	-	-	-	-	-	-
C. moschata	-	-	++	-	-	-
C. moschata (Seed)	-	++	++++	-	++++	++
C. sativus	-	-	+	-	-	+++
D. carota	-	-	+++	-	-	++
H. annuus (Seed)	-	-	++	-	++++	+++
H. annuus (Leaf)	-	-	++++	++	-	-
H. annuus (Flower)	++++	-	++++	++	-	++
I. batatas	-	++	++	-	-	-
L. sativa	-	-	+	-	-	-
L. sativa var. *capitata*	-	-	-	-	-	-
L. esculentum	-	++	++++	-	++++	-
L. esculentum var. *cerasiforme*	-	-	+	-	-	-
M. verticillata	-	-	+++	-	++++	-
N. nucifera	-	-	-	-	-	+
O. javanica	-	-	-	-	-	-
P. frutescens	-	-	+++	-	++	-
P. crispum	-	-	-	-	-	-
P. brachycarpa	-	-	-	-	-	-
R. sativus	-	-	+	-	-	-
R. coreanus	-	-	-	-	-	-
S. tuberosum	-	-	+++	-	-	+++
S. sarmentosum	-	-	-	-	-	-
S. melongena	-	-	-	-	-	-
S. oleracea	-	-	-	-	-	-
U. lactuca	-	-	++	-	-	-
Z. mays	-	-	++++	-	-	+++
Z. mays (Leaf)	++++	-	++++	-	-	+++
Z. officinale	-	-	+	-	-	-

[a]RLB, Maynaporthe grisea on rice; RSB, Rhizoctonia solani on rice; CGM, Botrytis cinerea on cucumber; WLR, Puccinia recondita on wheat; BPM, Erysiphe graminis on barley; and TLB, Phytophthora infestans on tomato.
[b]Control value: ++++, >90%; +++, 81-90%; ++, 61-80%; +, 40-60%; and -, <40%.

procymidone.

Results

In this study, fungicidal activities of extracts from 46 plants in Actinidiaceae (1), Amaranthaceae (1), Araceae (1), Brassicaceae (3), Chenopodiaceae (1), Compositae (6), Convolvulaceae (1), Crassulaceae (1), Cruciferae (1), Cucurbitaceae (3), Graminales (1), Labiatae (1), Liliaceae (5), Malvaceae (1), Nymphaeaceae (1), Rosaceae (1), Solanaceae (6), Ulvaceae (1), Umbelliferaeceae (4), and Zingiberaceae (1) were tested against six phytopathogenic fungi on various host plants.

Fungicidal activity of the plant extracts against the six plant diseases varied with plant species and pathogens used (Table 2, 3). Ethanol extracts of *H. annuus* flower and *Z. mays* leaf gave over 90% control value (CV) against RLB at 10 mg/pot. At 5 mg/pot, strong activities given over CV 80% were obtained for these plants. However, the other extracts from 44 plants had no activity against RLB when treated at 5 and 10 mg/pot. In the tests with RSB, moderate fungicidal activities were produced from the extracts of *Capsicum annuum, Cucurbita moschata* seed, *Ipomoea batatas,* and *Lycopersicon esculentum* at 10 mg/pot, and the extracts exhibited little and moderate activities at 5 mg/pot. However, other extracts had little or no activity against RSB when treated at 5 and 10 mg/pot.

In the tests with CGM, strong activities with over 80% at 10 mg/pot were produced from extracts of *Actinidia arguta, Chrysanthemum coronarium* var. *spatiosum, Cucurbita moschata* seed, *Daucus carota, H. annuus* leaf, *H. annuus* flower, *L. esculentum, Malva verticillata, Perilla frutescens, Salanum tuberosum, Z. mays,* and *Z. mays* leaf, and the moderate activities were observed in the extracts of *Allium cepa, Allium monanthum, Citrullus vulgaris* seed, *C. moschata, H. annuus* seed, and *I. batatas.* When treated at 5 mg/pot, the extracts of *H. annuus* leaf and *H. annuus* flower produced the very strong activities with over 90%, and the extracts of *C. coronarium* var. *spatiosum, C. moschata* seed, *L. esculentum, Z. mays,* and *Z. mays* leaf had strong activities with over 80%. However, the moderate activity was produced in the extracts of *A. arguta, D. carota, M. verticillata, P. frutescens,* and *S. tuberosum,* whereas little or no fungicidal activities were observed in the other plants. Against TLB, the extracts of *A. arguta, H. annuus* leaf and *H. annuus* flower showed the moderate fungicidal activities at 10 mg/pot. At 5 mg/pot, little or no fungicidal activities

Table 3. Controlling value of plant extracts to six plant diseases on various host plants when applied at 5 mg/pot

Sample Name	Plant Diseases[a]					
	RCB	RSB	CGM	TLB	WLR	BPM
A. arguta	-[b]	-	++	+	+	-
C. frutescens	-	-	+	-	+++	-
C. coronarium var. *spatiosum*	-	-	+++	-	++	+
C. moschata (Seed)	-	+	+++	-	+++	+
C. sativus	-	-	+	-	-	++
D. carota	-	-	++	-	-	+
H. annuus (Seed)	-	-	+	-	+++	++
H. annuus (Leaf)	-	-	++++	+	-	-
H. annuus (Flower)	+++	-	++++	+	-	+
I. batatas	-	++	+	-	-	-
L. esculentum	-	+	+++	-	++++	-
M. verticillata	-	-	++	-	+++	-
P. frutescens	-	-	++	-	+	-
S. tuberosum	-	-	++	-	-	++
Z. mays	-	-	+++	-	-	++
Z. mays (Leaf)	+++	-	+++	-	-	+++

[a]RLB, Maynaporthe grisea on rice; RSB, Rhizoctonia solani on rice; CGM, Botrytis cinerea on cucumber; WLR, Puccinia recondita on wheat; BPM, Erysiphe graminis on barley; and TLB, Phytophthora infestans on tomato.
[b]Control value: ++++, >90%; +++, 81-90%; ++, 61-80%; +, 41-60%; and -, <40%.

Table 4. Control value of plant extracts against four *Botrytis cinerea* strains with different resistant reaction to three fungicides in a greenhouse test

Sample Name	Strains[a]			
	SSR[b]	SRR	RRS	RSR
C. coronarium var. *spatiosum*	++++	++++	-	++++
C. moschata (Seed)	++++	++++	-	++++
H. annuus (Leaf)	++++	++++	++++	++++
H. annuus (Flower)	++++	++++	++++	++++
L. esculentum	-	-	++++	-
Z. mays	++++	-	-	++++
Z. mays (Leaf)	++++	-	-	++++

[a]Exposed at 10 mg/pot.

[b]SSR, susceptible to both carbendazim and procymidone but highly resistant to diethofencarb; SRR, susceptible to carbendazim but highly resistant to both procymidone and diethofencarb; RRS, highly resistant to carbendazim and procymidone but susceptible to diethofencarb; and RSR, highly resistant to both carbendazim and diethofencarb but susceptible to procymidone.

were observed in all plants.

Of the 46 plant extracts at 10 mg/pot, the extracts of *Capsicum frutescens*, *C. moschata* seed, *H. annuus* seed, *L. esculentum*, and *M. verticillata* revealed the very strong activities against WLR, and the moderate activities were observed in *A. arguta*, *C. annuum*, *C. coronarium* var. *spatiosum*, and *P. frutescens*. At 5 mg/pot, the strong activities with over 80% were obtained from the extracts of *C. frutescens*, *C. moschata* seed, *H. annuus* seed, *L. esculentum*, and *M. verticillata*, whereas little or no fungicidal activities were exhibited from the extracts of the other samples. In tests with BPM, when treated with 10 mg/pot, strong activities with over 80% were produced with the extracts of *Cucumis sativus*, *H. annuus* seed, *S. tuberosum*, *Z. mays*, and *Z. mays* leaf (Table 2). However, these plant extracts except for the extract of *Z. mays* leaf producing a strong activity exhibited the moderate activities (Table 3).

Because of their excellent fungicidal activity, the control effect of the seven test extracts against three strains of *B. cinerea* resistant to carbendazim, procymidone, and/or diethofencarb were determined at 10 mg/pot (Table 4). Extracts of *H. annuus* leaf and flower were highly effective against all the strains of *B. cinerea*. Strong activity was produced from the extracts of *C. coronarium* var. *spatiosum* and *C. moschata* seed against the SSR, SRR, and RSR, and *Z. mays* and *Z. mays* leaf against the SSR and RSR strains. However, extract of *L. esculentum* containing strong activity against RRS had no activity against SSR, SRR, and RSR.

Discussion

In the greenhouse studies with 46 plants belonging to the family Actinidiaceae, Amaranthaceae, Araceae, Brassicaceae, Chenopodiaceae, Compositae, Convolvulaceae, Crassulaceae, Cruciferae, Cucurbitaceae, Graminales, Labiatae, Liliaceae, Malvaceae, Nymphaeaceae, Rosaceae, Solanaceae, Ulvaceae, Umbelliferaeceae, Zingiberaceae, and many ethanol extracts showed very strong fungicidal activity against the economically important plant diseases. Fungicidal activity varied with the plant species and pathogens tested. In the tests with phytopathogenic fungi, *B. cinerea*, *P. recondita*, and *E. graminis* were inhibited more effectively by application of the extracts of various plants than *P. grisea*, *R. solani*, and *P. infestans*. Jacobson (1989) pointed out that the most promising botanicals as sources of novel plant-based pesticides at present and in the future are species of the families Meliaceae, Rutaceae, Asteraceae, Annonaceae, Labiatae, and Canellaceae. It has been also reported that Annonaceous plant species can be employed as safe, effective, economical, and environmentally friendly pesticides on the home garden, ornamental, and greenhouse (Hostettman and Potterat, 1997). Secondary plant metabolites jointly or independently contribute to generation of biological activities. Since these plant-derived extracts and phytochemicals act in many ways on various types of disease complexes, and may be applied to the plant in the same method as other agricultural chemicals, they have been considered as potential alternatives for synthetic fungicides (Hedin, 1982; Hostettman and Potterat, 1997), or lead compounds for

synthetic fungicides such as podoblastin produced from *Podophyllum peltatum* (Miyakado, 1986; Hostettman and Potterat, 1997). However, little information is available for fungicidal activity of vegetable plants.

In our *in vivo* studies, 15 plant extracts showed strong fungicidal activity with over 80% against *M. grisea*, *B. cinerea*, *P. recondita*, and *E. graminis*, although nearly most of all the test samples were ineffective to *R. solani* and *P. infestans*. Especially, the very strong activities of extracts from *C. frutescens*, *C. coronarium* var. *spatiosum*, *C. moschata* seed, *H. annuus* seed, *H. annuus* leaf, *H. annuus* flower, *L. esculentum*, *M. verticillata*, *Z. mays*, and *Z. mays* leaf against fungi confirmed their superiority and usefulness as potent fungicides. These plants might give a new clue for managing these plant diseases in field ecosystem, although their effects on non-target organisms or environment remain unknown. It has been reported that 16 leguminous seed extracts used were very effective against *P. recondita* and *E. graminis* but exhibited no activity against *B. cinerea*, *R. solani* and *P. infestans* (Lee *et al.*, 1998).

Currently, control of plant diseases is primarily based on repeated or continued applications of synthetic fungicides. However, their extensive use for the decades has led to widespread development of resistance (Georghiou and Saito, 1983; Georgopoulos, 1987). Therefore, more emphasis has to be given to the need for selective plant disease control agents for use in integrated management. Certain plant-derived materials are found to be highly effective against fungicide-resistant pathogens. For example, natural compounds such as cinnamaldehyde and salicylaldehyde were effective against four strains of *Fusarium sambucinum* resistant to thiabendazole (Vaughn and Spencer, 1994). Based on our results, the extracts of *H. annuus*, *C. coronarium* var. *spatiosum*, *C. moschata* seed, and *Z. mays* were highly effective against the four strains of *B. cinerea* resistant to carbendazim, procymidone or diethofencarb, indicating that they could be useful to reduce field populations of *B. cinerea* resistant to the fungicides.

This study implies that the plant-derived materials might be useful for developing new types of fungicides, or as biorational management agents for controlling plant pathogens on crops.

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Literature cited

Balandrin, M., J. Klocke, E. S. Wurtele and W. H. Bollinger (1985) Natural plant chemicals: sources of industrial and medicinal materials. Science 228: 1154~1160.

Benner, J. P. (1993) Pesticidal compounds from higher plants. Pestic. Sci. 39:95~102.

Billson, H., J. A. Pryer and R. Nichols (1999) Variation in fruit and vegetable consumption among adults in Britain. An analysis from the dietary and nutritional survey of British adults. Eur. J. Clin. Nutri. 53:946~952.

Brown, A. W. A. (1978) Ecology of Pesticides, John Wiley & Sons, New York.

Georghiou, G. P. and T. Saito (1983) Pest Resistance to Pesticides, Plenum Pub., New York.

Georgopoulos, S. G. (1987) The development of fungicide resistance, pp.239~251. In Populations of Plant Pathogens-Their Dynamics and Genetics (eds. M. S. Wolfe and C. E. Caten), Blackwell Scientific Pub.

Gibson, E. L., J. Wardle and C. J. Watts (1998) Fruit and vegetable consumption nutritional knowledge and beliefs in mothers and children. Appetite 31:205~228.

Hayes, W. J., Jr. and E. R. Laws, Jr. (1991) Handbook of Pesticide Toxicology, Vol. 1, Academic Press.

Hedin, P. A. (1982) New concepts and trends in pesticide chemistry. J. Agric. Food Chem. 30:201~215.

Hedin, P. A., R. M. Hollingworth, E. P. Masler, J. Miyamoto and D. G. Thompson (1997) Phytochemicals for Pest Control, ACS Symp. Ser. No. 387, Am. Chem. Soc., Washington, D.C.

Hostettman, K. and O. Potterat (1997) Strategy for the isolation and analysis of antifungal, molluscicidal, and larvicidal agents from tropical plants, pp.14~26. In Phytochemicals for Pest Control (eds. P. A. Hedin, R. M. Hollingworth, E. P. Masler, J. Miyamoto and D. G. Thompson), ACS Symp. Ser. No. 387, Am. Chem. Soc., Washington, D.C.

Isman, M. B. (1995) Leads and prospects for the development of new botanical insecticides. Rev. Pestic. Toxicol. 3:1~20.

Jacobson, M. (1989) Botanical pesticides: past, present, and future, pp.1~10. Insecticides of Plant Origin (eds. J. T. Arnason, B. J. R. Philogene and P. Morand), ACS Symp. Ser. No. 387, Am. Chem. Soc., Washington, D.C.

Lee, H. S., B. S. Kim, H. T. Kim, K. Y. Cho and Y. J. Ahn (1998) Fungicidal activities of leguminous seed

2(3):21~27.
Miyakado, M. (1986) The search for new insecticidal and fungicidal compounds from plants. J. Pesticide Sci. 11:483~492.
Olabanji, S. O., O. V. Makanju, D. Ceccato, M. C. Buoso, A. M. I. Haque, R. Cherubini and G. Moschini (1997) PIGE-PIXE analysis of medicinal plants and vegetables of pharmacological importance. Biol. Trace Element Res. 58:223~236.
Swain, T. (1977) Secondary compounds as protective agents. Ann. Rev. Plant Physiol. 28:479~501.
Vaughn, S. F. and G. F. Spencer (1994) Antifungal activity of natural compounds against thiabendazole-resistant *Fusarium sambucinum* strains. J. Agric. Food Chem. 42:200~203.
Wink, M. (1993) Production and application of phytochemicals from an agricultural perspective, pp.171~213. In Phytochemistry and Agriculture (eds. T. A. van Beek and H. Breteler), Vol. 34, Proc. Phytochem. Soc. Europe, Clarendon Press, Oxford.

46종 식물추출물의 식물병 방제효과

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요약 : 46종 식물의 에탄올 추출물을 대상으로 기주식물상의 주요 식물병 6종에 대하여 방제효과를 온실실험으로 조사하였다. 46종의 시험식물 추출물을 pot당 5, 10 mg씩 처리하였을 때 해바라기꽃과 옥수수잎 추출물이 벼도열병에 80% 이상의 방제효과를 나타내었다. 5 mg의 농도에서 해바라기 잎과 꽃, 쑥갓, 호박씨, 토마토, 옥수수와 옥수수잎의 추출물이 잿빛곰팡이병에 80% 이상의 방제효과를 나타내었고, 밀녹병에 대해서는 피망, 호박씨, 해바라기씨, 토마토 및 아욱의 추출물이 80% 이상의 방제효과를 나타내었다. 보리흰가루병에 대해서는 오이, 해바라기씨, 감자 및 옥수수와 잎의 추출물이 10 mg의 농도에서 80% 이상의 방제효과를 나타내었다. 그러나 토마토역병과 벼잎집무늬마름병에 대해서는 모든 시료가 활성을 나타내지 않았다. 살균제 carbendazim, diethofencarb, procymidone 저항성 균주에 대해서는 해바라기잎과 꽃의 추출물이 모든 균주에 높은 방제효과를 나타내었고, 쑥갓과 해바라기씨의 추출물은 SSR(carbendazim 감수성, diethofencarb 감수성, procymidone 저항성 균주) 및 RSR(carbendazim 저항성, diethofencarb 감수성, procymidone 저항성 균주)에 90% 이상의 방제효과를, 옥수수와 잎은 SSR (carbendazim 감수성, diethofencarb 감수성, procymidone 저항성 균주)에 강한 방제효과를 보였다. 그러나 RRS (carbendazim 저항성, diethofencarb 저항성, procymidone 감수성 균주)에 대해서는 사용된 시료 중 토마토 추출물만이 방제효과를 보였다.

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