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ANTIFUNGAL EFFECT OF POWDERED SPICES AND THEIR EXTRACTS ON GROWTH AND ACTIVITY OF SOME FUNGI IN RELATION TO DAMPING-OFF DISEASE CONTROL

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Abstract: The antifungal effect of twenty powdered spice plants and their extracts at concentrations of 2, 4, 8 and 1, 3, 6%, respectively was evaluated in relation to the radial mycelial growth of various soilborne fungi causing damping-off disease. The spice powder or extract were added to the culture medium PDA to obtain the proposed concentrations. Concentration of 8% of powdered spices and 6% of their extracts were able to cause complete growth inhibition of major tested fungi. High significant inhibitory effect on radial fungal growth was observed for different concentrations of carnation (*Dianthus caryophyllus*), cinnamon (*Cinnamomum burmannil*), garlic (*Allium sativum*) and thyme (*Thymus vulgaris*). Meanwhile, fennel (*Foeniculum vulgare*), marjoram (*Origanum majorana*) and chamomile (*Matricaria hamomilla*) showed a low inhibitory effect on tested fungi. Moderate inhibitory effect was observed with the other tested spices. In the greenhouse, efficacy of spice plants as powder or their extracts in addition to the fungicide Rizolex-T used as seed dressings against faba bean damping-off incidence was evaluated in pot experiment using soil artificially infested with the disease agents (*Fusarium solani* and *Rhizoctonia solani*). Spice extracts showed superior reducing effect on damping-off disease incidence at pre-emergence growth stage to that of powder treatments and Rizolex-T as well, while an opposite effect was observed at post-emergence growth stage. Carnation and cinnamon spices showed the highest protecting effect against disease incidence when applied as powder or extracts. It is interesting to note that spice plants as powder or extracts gave a similar effect to the fungicide Rhizolex-T in reducing damping-off incidence either at pre- or post-emergence stages of faba bean growth. Promising applicable technique could be suggested in the light of the results obtained. The use of spice plants as powder or extract for seed dressing might be considered as safe, cheep and easily applied method for controlling soilborne plant pathogens considering the avoidance of environmental pollution and the side effect of pesticide application.

Key words: spice plants, plant extracts, fungi, control, disease

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INTRODUCTION

Spice plants made into powder were widely used by ancient civilizations to improve the palatability of foods and beverages as well as for their preserving characteristics. Many plants are used as insecticides, molluscicides and rodenticides (Daoud *et al.* 1990; Evan 1992; Anwar *et al.* 1992 and Poswal *et al.* 1993).The use of plants or plant products as fungicides is of a great importance and needs more attention (Bodde 1982). Various plant products like gum, oil, resins etc. are used as fungicidal agents (Dwivedi *et al.* 1990; Daoud *et al.* 1990). The biological control of plant diseases may have minimum adverse effect on physiological processes of plant and less environmental hazards (Isman 1989). Biological fungicides, being plant products are easily convertible into a common organic material and may create fewer health problems compared synthetic alternatives. The garlic extract, oil (Singh *et al*. 1984) and juice (Harun and Labosky 1985) showed fungicidal properties against *Fusarium* of watermelon. Bio-control of fungal diseases is not common and investigations are required to find out suitable plants that can be used to control pathogenic fungi.

Spices are recognized to prevent the microbial deterioration of food. Antimicrobial activity of spices depends on several factors, *i.e.* kind of spice, composition and concentration of spice and its occurrence level, substrate composition and processing conditions and storage (Shelef 1983; Farag *et al*. 1989). Several scientific reports describe the inhibitory effect of spices on a variety of microorganisms, although considerable variation of resistance of different microorganisms to a given spice and of the same microorganisms to different spices has been observed (Akgul and Kivanç 1988). Gould (1995) emphasized a possible use of spices and their derivatives like alternatives for inclusion in a new perspective of food conservation called "natural antimicrobial system", which could use the synergistic effect of antimicrobial compounds from animal, plant and/or of microbial origin, in order to create an inhospitable environment for microbial survival in foods.

The objective of the research work performed was to study the antifungal activity of powdered spices or their ethanol-water extracts (20/80, v/v) in culture media on the mycelial growth of some soilborne pathogenic fungi. The most promising spices were evaluated as seed dressings or soaking treatments against damping-off disease of faba bean in the greenhouse.

MATERIALS AND METHODS

The present work was developed at the laboratory and greenhouse of Plant Pathology of National Research Centre (NRC), Egypt. Tests were performed with the plant pathogenic fungi *Fusarium solani, Rhizoctonia solani, Alternaria solani* and *Macrophomina phaseolina* which are kept at the fungus collection of the same laboratory.

Laboratory tests

Plant material of twenty spices and their extracts (Table 1) were evaluated for their inhibitory effect on fungal radial growth using *in vitro* test. The spice plant materials kindly obtained from Medicinal and Aromatic Plants Research Department, NRC, Egypt, were washed with distilled water and dried in shade. The dried plant materials were then finely grinded to powder.

Table 1. Spice plants classification and main active principles of the spices

Common name	Scientific name	Family	Major active component	Extracted plant part
Anis	*Pimpinella anisum*	*Umbelliferae*	anetol	seeds
Ammi	*Ammi visnaga*	*Umbelliferae*	visnagin	florescence
Basil	*Ocimum basilicum*	*Lauraceae*	linallol	leaves
Caraway	*Carum carvi*	*Umbelliferae*	carvone	seeds
Garlic	*Allium sativum*	*Liliaceae*	allicin	cloves
Carnation	*Dianthus caryophyllus*	*Umbelliferae*	eugenol	flowers
Chamomile	*Matricaria chamomilla*	*Compositae*	isobutyle	flowers
Cinnamon	*Cinnamomum burmannil*	*Lauraceae*	cinnamic aldehyde	cortical tissues
Coriander	*Coriandrum sativum*	*Umbelliferae*	linallol	seeds
Cumin	*Cuminum cyminum*	*Umbelliferae*	phellandrene	seeds
Fennel	*Foeniculum vulgare*	*Umbelliferae*	anethol	seeds
Fenugreek	*Trigonella foenum*	*Fabaceae*	trigonelline	seeds
Halfa-Gar	*Cymbopogom proximus*	*Geraminae*	saponin	leaves
Henna	*Lawsonia inermis*	*Lythraceae*	ionone	leaves
Marjoram	*Origanum majorana*	*Labiatae*	carvacrol	leaves
Mint	*Mentha piperita*	*Labiatae*	carvone	leaves
Rosemary	*Rosmarinus officinalis*	*Labiatae*	borneol	leaves
Salvia	*Salvia officinalis*	*Labiatae*	saliva	leaves
Thyme	*Thymus vulgaris*	*Labiatae*	thymol	seeds
Wormwood	*Artemisia absinthium*	*Compositae*	thujone	leaves

Fifty grams of each plant material in powder form was homogenized by laboratory blender in 200 ml of ethanol (96%) and distilled water (20:80, v:v) for 10 min, then left in dark glass bottles for 72 h for tissue maceration. The extracts were filtered through thin cheesecloth sheets.

The final extracts were collected separately in other dark glass bottles and exposed to 60°C in water bath for 30 min for ethanol evaporation. The collected extracts were then stored in a refrigerator at 5°C until needed.

The powdered spices were added to sterilized PDA flasks before solidifying to obtain the proposed concentrations of 2, 4 and 8% (v/v), while the spices extracts were added to other PDA flasks to obtain concentrations of 1, 3 and 6% (v:v). A bactericide (chloramphenicol, 0.10 mg/l) was added to the media to avoid bacterial contamination. Amended media were poured into 9 cm diameter Petri dishes, and another set of untreated PDA medium was used as control. All plates were inoculated individually with 0.5 cm diameter discs of the tested fungal cultures. After seven days of incubation, at 25±2°C, orthogonal measurements of colonies were taken using the control plates as a reference. The reduction in fungal growth was calculated in relation to control treatment.

Greenhouse tests

The most promising effective spices on the basis of *in vitro* radial fungal growth were used in the greenhouse experiment. The effect of carnation, cinnamon, garlic and thyme as powder materials or their extracts on damping-off disease incidence of faba bean was studied in a pot experiment. The root pathogens *F. solani* and *R. solani* were used in the experiment as models of soilborne plant pathogens. Loamy soil was individually artificially infested (at the rate of 5% w:w) with the inoculum of each tested fungus previously grown for two weeks on sand barley medium (1:1, w:w and 40% water) at 25±2°C.

Faba bean seeds (cv. Giza 3) were surface disinfected by immersing in sodium hypochlorite (2%) for 2 min, and washed several times with sterilized water, then dried between two sterilized layers of filter paper, and divided to two groups.

The first group of disinfected faba bean seeds were coated individually with different powdered spices at the rate of 5g/kg seeds. Seed dressing was carried out by applying the tested powdered spices to the gum moistened seeds in polyethylene bags and shaken well to ensure even distribution of added materials, then left onto plastic tray to dry. The second group of disinfested faba bean seeds were soaked individually in previously prepared extracted spices (5%, v:v, extract: distilled water) for 12 h, then picked up and left to dry onto plastic tray. The fungicide Rizolex-T at the recommended dose (3 g/kg) was applied as seed dressing. Disinfected and untreated faba bean seeds sown for comparative purposes.

Plastic pots (30 cm in diameter) were filled with the infested soils. Five treated faba bean seeds were sown in each of five replicated pots for a particular treatment. Percentage of disease incidence was calculated as pre- and post-emergence damping-off after 15 and 40 days, respectively.

Statistical analysis

One way analysis of variance (ANOVA) was used to analyze differences in fungal radial growth on PDA plates amended with spice powders or extracts, as well as to analyze differences between the incidence of damping-off in the greenhouse pot experiment where infested with pathogens soil was used to test the efficacy of applied seed dressings. General Linear Model option of the Analysis System SAS (SAS 1988) was used to perform the analysis of variance. Duncan's Multiple Range Test was used for separation of means (Winer 1971).

RESULTS

Laboratory tests

Results presented in Table 2 show the response of soilborne fungi to the inhibitory effect of tested powdered spices. Radial growth of tested fungi decreased significantly with increasing concentrations of added spices.

Table 2. Fungal growth reduction[A] in response to different amounts of powdered spices *in vitro*

Family	Spices	Conc.[B] (w/v)	Reduction in fungal growth %[C]			
			Fusarium solani	*Rhizoctonia solani*	*Alternaria solani*	*Macrophomina phaseolina*
Umbelliferae	anis	2 8	66.6 d 100 a	55.5 f 100 a	66.6 d 100 a	44.4 g 66.6 d
	ammi	2 8	38.8 g 83.3 a	55.5 f 100 a	61.1 de 83.3 a	0 h 83.3 a
	caraway	2 8	60.0 de 73.3 b	63.3 de 100 a	72.2 bc 100 a	38.8 g 52.2 f
	carnation	2 8	92.2 a 100 a	91.1 a 100 a	93.3 a 100 a	93.3 a 100 a
	coriander	2 8	48.8 fg 83.3 a	0 h 83.3 a	52.2 f 83.3 a	0 h 83.3 a
	cumin	2 8	63.3 de 100 a	0 h 100 a	72.2 bc 100 a	50.0 f 100 a
	fennel	2 8	0 h 42.2 g	0 h 0 h	7.7 h 83.3 a	0 h 0 h
Liliaceae	marjoram	2 8	38.8 g 53.3 f	0 h 62.2 de	27.7 I 72.2 bc	25.5 I 51.1 f
	mint	2 8	48.8 fg 86.6 a	0 h 35.5 g	48.8 fg 83.3 a	0 h 85.5 a
	rosemary	2 8	38.8 g 52.2 f	0 h 97.3 a	50.0 f 66.6 d	0 h 100 a
	salvia	2 8	28.8 I 95.4 a	0 h 86.6 a	28.8 I 72.2 bc	0 h 71.1 bc
	thyme	2 8	75.5 b 100 a	100 a 100 a	100 a 100 a	43.3 fg 97.5 a
Compositae	chamomile	2 8	38.8 g 72.2 bc	0 h 0 h	33.3 g 83.3 a	0 h 57.7 f
	wormwood	2 8	28.8 i 83.3 a	35.5 g 100 a	30.0 g 100 a	0 h 0 a
Lauraceae	basil	2 8	61.1 de 75.5 bc	71.1 bc 100 a	65.5 d 85.5 a	51.1 f 83.3 a
	cinnamon	2 8	65.5 de 100 a	88.8 a 100 a	99.0 a 100 a	91.1 a 100 a
Fabaceae	fenugreek	2 8	28.8 i 100 a	0 h 100 a	61.1 de 100 a	0 h 100 a
Geraminae	halfa-Gar	2 8	70.0 bc 100 a	72.2 bc 100 a	48.8 fg 100 a	51.1 f 72.2 bc
Liliaceae	garlic	2 8	0 h 100 a	0 h 100 a	50.0 f 100 a	0 h 100 a
Lythraceae	henna	2 8	27.7 i 83.3 a	50.0 f 100 a	13.3 i 85.5 a	0 h 83.3 h

[A] reduction in fungal growth at different treatment, calculated relatively to ist growth in untreated control
[B] concentrations of powered spices were added as (w/v) to growth medium
[C] mean values within columns followed by the same letter are not significantly different ($p = 0.05$)

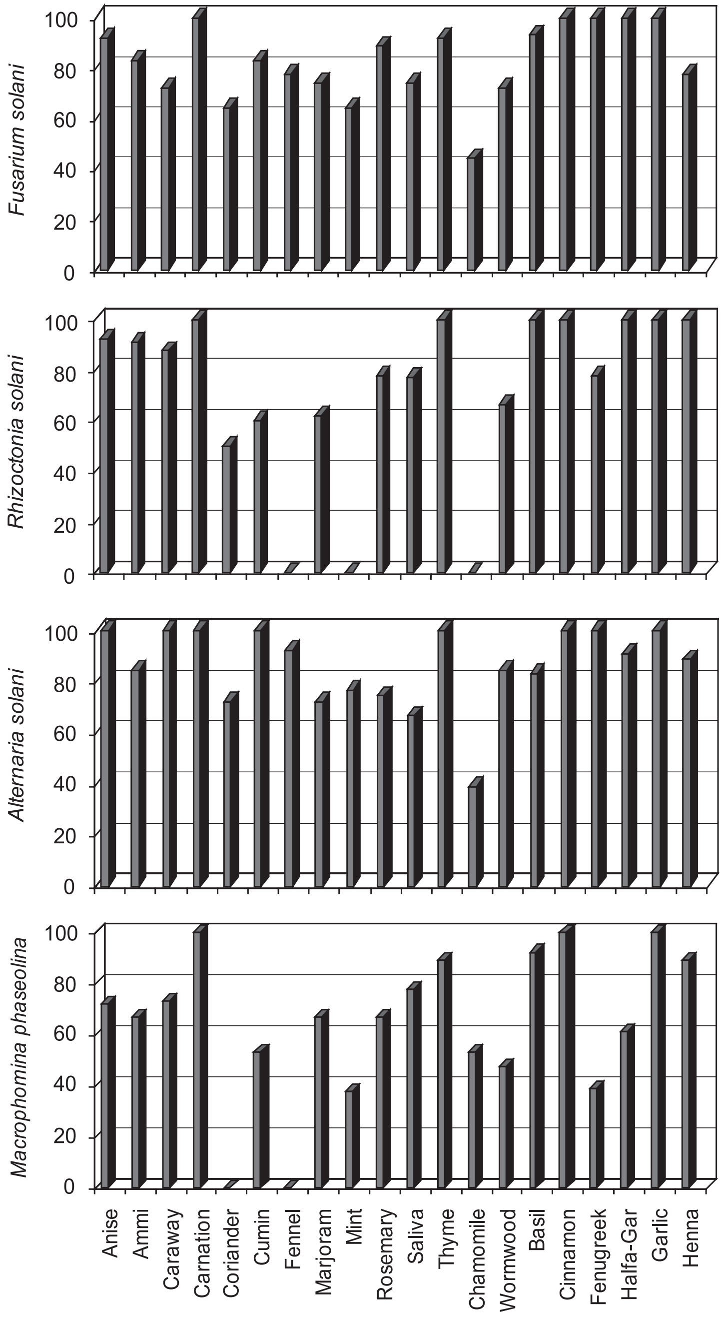

Fig. 1. Reduction (%) in fungal growth in response to 3% concentration of various spices plant extracts

High significant inhibitory effect on radial fungal growth was observed at different concentrations of carnation, cinnamon and thyme powder. Meanwhile, fennel, marjoram and chamomile powder showed a low inhibitory effect on tested fungi. A moderate inhibitory effect was observed in case of other tested powdered spices. Concentration of 8% of powdered spices was able to cause complete growth inhibition of major of tested fungi. *R. solani* showed tolerance to fennel, mint and chamomile powder used even at high concentration of 8%, while *F. solani* was more sensitive to that concentration. Presented data also show that fennel and wormwood at all tested concentrations had no inhibitory effect on the radial growth of *M. phaseolina*, this was also observed when fennel powder was tested against *R. solani.*

On the other hand, a similar pattern of reduction in radial fungal growth at increasing concentrations of spice extracts was observed for extracts of spice plants at concentrations of 1, 3 and 6% which indicated a superior inhibitory effect on radial fungal growth when compared with powdered spices. Concentration of 6% of spice extracts caused a complete growth inhibition of the tested fungi. Concentration of 3% was chosen to show the differences between the activity of tested spice extracts against various pathogenic fungi, as illustrated in Figure 1. It is also observed that extracted fennel, mint and chamomile have a weak effect on the radial growth *R. solani*.

Greenhouse tests

The efficacy of *in vitro* highly effective spice plants and Rizolex-T as seed dressing on faba bean damping-off incidence was evaluated in greenhouse pot experiment. Data in Table 3 reveal that all tested products significantly reduced the percentage

Table 3. Incidence of faba bean damping-off caused by *F. solani* and *R. solani* in response to seed dressing with powder or extract of spice plants[A] under greenhouse conditions

Treatment		*Fusarium solani*		*Rhizoctonia solani*	
		damping-off incidence % [B]			
		pre-emergence	post-emergence	pre-emergence	post-emergence
Spice powder (5 g/kg)	carnation	8.0 c	10.7 d	8.0 c	12.0 cd
	cinnamon	8.0 c	10.7 d	8.0 c	10.7 d
	garlic	12.0 b	13.3 c	12.0 b	11.6 cd
	thyme	12.0 b	13.3 c	12.0 b	13.3 c
Spice extract (5%)	carnation	4.0 d	17.0 b	4.0 d	18.0 b
	cinnamon	4.0 d	17.0 b	4.0 d	18.0 b
	garlic	4.0 d	18.0 b	4.0 d	17.3 b
	thyme	4.0 d	18.0 b	4.0 d	17.3 b
Fungicide 3 g/kg	Rhizolex-T	8.0 c	18.7 b	8.0 c	18.7 b
Control		20.0 a	22.3 a	20.0 a	26.3 a

[A] spice plant powder were used at the rate of 5g/kg seeds, while extracts of 5% concentration were used for bean seeds soaking

[B] mean values within columns followed by the same letter are not significantly different (p = 0.05) of both pre- and post-emergence damping-off of faba bean compared with the check treatment. Spice extracts showed superior reducing effect on pre-emergence damping-off incidence compared to powder treatments and Rizolex-T. The corresponding disease percentages ranged between 4%, 8–12% and 8%, respectively. This observation relates to seeds sown in soil infested either with *F. solani* or *R. solani.* Meanwhile, obtained data revealed a different relation in case of post-emergence damping-off. Spice plant powders occupied the first place in reducing faba bean post-emergence damping-off, this being followed by spice extracts and the fungicide. Spice plant powders showed a protecting effect against introduced pathogenic fungi reflecting in a significant disease reduction of 10.7–13.3% comparing with 17.0–18.7% in case of seeds treated with spice extracts or Rhizolex-T. Carnation and cinnamon spices showed the highest protecting effect against disease incidence when applied as powder or extracted material. It is interesting to note that spice plants as powder or extracts gave a similar effect to the fungicide Rhizolex-T in reducing either pre- or post-emergence damping-off of faba bean.

DISCUSSION

There has been constant increasing of alternative search on efficient compounds for plant disease control, aiming at partial or total replacement of antimicrobial chemicals. Systematic investigation of biological interactions between microorganisms and plant products has been a valuable source of new and effective antimicrobial substances, which could have act differently on/in the microbial cell compared to other conventional antimicrobials. Plants synthesize secondary metabolites and some of them as well as their derivatives have antimicrobial. Among these secondary metabolites are found alkaloids, flavonoids, isoflavonoids, tanins, cumarins, glycosides, terpens and phenolic compounds (Simões *et al*. 1999). In agricultural studies, these compounds have broad-spectrum activities against fungi, nematodes, and insects (Lee *et al.* 1997; Wilson *et al.* 1997 and Calvet 2001). Spices offer a promising alternative for food safety and plant protection. Inhibitory activity of spices and their derivatives on the growth of bacteria, yeasts, fungi and microbial toxin synthesis has been reported (Notermans and Hoogenboon-Verdegaal 1992; Sagdiç *et al*. 2003). In the present study twenty different spice plants as powders and extracts showed inhibitory effect against tested soilborne fungi. High inhibitory effect on the radial fungal growth increasing with their concentration was observed to reach complete inhibition at 6 and 8% for extracts and powder spices, respectively. Extracts of spice plants showed superior inhibitory effect against fungal growth to the powder form, this could be attributed to the accumulation of active components in mycelium. Carnation, cinnamon and thyme showed a high significant inhibitory effect on fungal growth compared to fennel, marjoram and chamomile powder. A moderate inhibitory effect was observed in case of the other tested powder spices. Regarding inhibitory effect of spice plants, there were many investigators conducted. It was reported that various powder concentrations of mint, sage, bay, anise and red pepper significantly inhibited the growth of *Aspergillus parasiticus* (Karapinar 1985). Chilli, coriander, pepper, cumin and asafoetida were found to inhibit food spoilage moulds (Thyagaraja and Hosono 1996). Several scientific reports describe the inhibitory effect of spices on a variety of microorganisms, although a considerable variation in resistance of different microorganisms to different spices has been observed (Akgul and Kivanç 1988).

Similar results were also obtained in the present study. *R. solani* showed a tolerate response to fennel, mint and chamomile powder even at high concentration, while *F. solani* was more sensitive. Obtained data also show that fennel and wormwood at all used concentrations had no inhibitory effect on the radial growth of *M. phaseolina*, this was also observed for fennel powder tested against the growth of *R. solani.*

Greenhouse experiments revealed that carnation, cinnamon, garlic and thyme used for seed dressing had significant efficacy against damping-off caused by *R. solani* and *F. solani*. These spices contain antifungal compounds of eugenol, cinnamic aldehyde, allicin and thymol as major components. They could protect faba bean against both pre- and post-emergence damping-off up to 40 days when applied as powder better than extracts. This might be attributed to a slow release of active components of spice powder when introduced into the soil as seed dressing. There are a number of plant-based antimicrobial constituents, including many essential oils, tannins, glycosides, and resins, that can be found in certain spices. Specific examples include eugenol in cloves, allicin in garlic, cinnamic aldehyde and eugenol in cinnamon, allyl isothiocyanate in mustard, eugenol and thymol in sage, and carvacrol (isothymol) and thymol in oregano (Jay 2000). Krishna Kishore and Pande (2007) reported that peanut seed treatment with the test compounds (citral, eugenol, geraniol, limonene, and linalool) had no effect on the incidence of crown rot in peanut in *Aspergillus niger* –infested soil. However, soil amendment with 0.25% (v/w) clove oil and cinnamon oil reduced pre-emergence rotting by 71 and 67% and post-emergence wilting by 58 and 55%, respectively. It has been demonstrated that some compounds derived from plants, such as thymol and palmarosa oil, provide disease control potential. Thymol and palmarosa oil are antibacterial agents produced by thyme and palmarosa and had significant efficacy against *Ralstonia solanacearum* as a result of efficient reduction of this pathogen population in soils to an undetectable level (Momol *et al.* 2000). Furthermore, tomato plants grown in soils treated with thymol or palmarosa oil did not develop wilt symptoms under greenhouse experimental (Pradhanang *et al.* 2003). Antifungal activity of spices and their derivatives were studied by viable cells count, mycelial growth and mycotoxin synthesis. There is little information on spices and their derivativesàction on/in a fungal cell. In general, inhibitory action of natural products on moulds involves cytoplasm granulation, cytoplasmic membrane rupture and inactivation and/or inhibition of interacellular and extracellular enzymes. These biological events could take place separately or concomitantly culminating with mycelial growth inhibition (Cowan 1999). Also, it was reported that plant lytic enzymes act in the fungal cell wall causing breakage of b-1,3 glycan, b-1,6 glycan and chitin polymers (Brull and Coote 1999). Moreover, the mode by which microorganisms are inhibited by spices and their chemical compounds seems to involve different mechanisms. It has been hypothesized that the inhibition involves phenolic compounds, because these compounds sensitize the phospholipid bilayer of the microbial cytoplasmic membrane causing increased permeability and unavailability of vital intracellular constituents (Juven *et al*. 1994). Reports have indicated that spices containing carvacrol, eugenol and thymol (phenolic compounds) had highest antibacterial performances (Kim *et al*. 1995). Many authors emphasized that the antimicrobial effect of essential oil constituents are dependent on their hydrophobicity and partition in the microbial plasmatic membrane. The effect of specific ions due to their addition in/on plasmatic membrane had a great effect on the proton motive force, intracellular

ATP content and overall activity of microbial cells, including turgor pressure control, solutes transport and metabolism regulation (Lanciotti *et al*. 2004).

Hence, the objective of this study was to determine if spice plants could provide effective control of some soilborne plant pathogens. Considering their attribute and broad-spectrum activities, successful development of such compounds as antifungal would not only provide a potent tool for control of faba bean damping-off, but also could promise success in multipurpose biorational alternatives to conventional fungicides for the management of other plant diseases.

Promising applicable technique could be suggested in the light of the results obtained in the present study. The usage of spice plants as powder or extract for seed dressing might be considered as safe, cheep and easily applied method for controlling soilborne plant pathogens taking in consideration the avoidance of environmental pollution and side effects of pesticide application.

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POLISH SUMMARY

PRZECIWGRZYBOWE DZIAŁANIE PROSZKÓW I WYCIĄGÓW Z PRZYPRAW ROŚLINNYCH NA WZROST I AKTYWNOŚĆ NIEKTÓRYCH GRZYBÓW WYWOŁUJĄCYCH ZGORZEL SIEWEK

W artykule przedstawiono wyniki badań nad przeciwgrzybowymi właściwościami proszków lub wyciągów z 20 przypraw roślinnych. Proszki i wyciągi dodawano do płytek z pożywką PDA odpowiednio w stężeniach 2,4 i 8% oraz 1,3 i 6%, a następnie pożywkę szczepiono grzybami patogenicznymi *Fusarium solani* i *Rhizoctonia solani* wywołującymi zgorzel siewek, po czym wykonywano pomiary wzrostu kultur w celu określenia właściwości inhibicyjnych użytych preparatów. Wysoce istotny

efekt inhibicyjny obserwowano przy użyciu różnych stężeń preparatów z goździka (*Dianthus caryophyllus*), cynamonu (*Cinnamonum burmannil*), czosnku (*Allium sativum*) i macierzanki (*Thymus vulgaris*). Koper (*Foericulum vulgare*), majeran (*Origanum majorana*) i rumianek (*Matricaria chamomilla*) wykazały niską aktywność przeciwgrzybową wobec testowanych patogenów. Pozostałe przyprawy wykazywały umiarkowany efekt inhibicyjny. W wazonowym doświadczeniu szklarnianym ziemię zakażano poszczególnymi patogenami, a proszki i wyciągi z przypraw oraz fungicyd Rizolex-T użyto do zaprawiania nasion bobu. Następnie obserwowano występowanie zgorzeli przedwschodowej i powschodowej bobu.

Stwierdzono, że ekstrakty działały lepiej niż proszki i Rizolex-T w zwalczaniu zgorzeli przedschodowej. Natomiast odwrotną zależność zaobserwowano w przypadku zgorzeli powschodowej. Wyciągi i proszki z goździka i cynamonu wykazały najwyższą aktywność, zarówno w ograniczaniu zgorzeli przedwschodowej jak i powschodowej. Wykorzystanie przypraw roślinnych w zwalczaniu tych chorób jest bezpieczne, tanie i łatwe, nie powoduje zanieczyszczenia środowiska i efektów ubocznych obserwowanych przy stosowaniu pestycydów.