Scientific J. of Horticultural Research
https://sjhr.journals.ekb.eg
ISSN (print): 2974-4563
ISSN (online): 2974-4571
doi: 10.21608/sjhr.2025.393859.1007

INFLUENCE OF GARLIC AND CINNAMON EXTRACTS ON WILT DISEASE AND PRODUCTIVITY OF BLACK CUMIN (*NIGELLA SATIVA* L.) PLANTS

F.E.M. Saleh*, H.A. Gouda** and A.F. Ahmed*
* Medicinal and Aromatic Plants Res. Dept., Hort. Res. Inst., Agric. Res. Cent., Giza, Egypt
** Plant Pathology Research Institute, Agric. Res. Cent., Giza, Egypt

Scientific J. of Horticultural Research, 3(1):11-28 (2025).

Received:
10/1/2025
Accepted:
29/1/2025

Corresponding author:
F.E.M. Saleh
fullsaleh@yahoo.co.uk

ABSTRACT: In this study, the effect of extracts from garlic (*Allium sativum*) and cinnamon (*Cinnamomum zeylanicum*) plants at concentrations of 2, 4 and 6% was evaluated compared to the chemical fungicide (Rizolex) as an antifungal against wilt disease as well as on growth and yield of *Nigella sativa* plants. The experiments were carried out in both the laboratory and the field over the 2021/2022 and 2022/2023 seasons, at the Experimental Farm of the Agricultural Research Station in Arab-El-Awamer, Assiut Governorate. According to the laboratory investigation, the most effective treatment was 6% aqueous cinnamon extract, followed by 6% garlic extract, which reduced fungal growth by 77% and 75%, respectively. Applying extracts of garlic or cinnamon as *N. sativa* seed treatment under greenhouse conditions prevented the fungal infection at all concentrations applied. The maximum yield and the least disease severity were achieved with the highest concentration of 6% garlic extract, compared to the control and other treatments. A 6% concentration of extracts from cinnamon and garlic found to be the most effective treatment in the field testing, which markedly improved all of the features that were being examined. Meanwhile, the highest percentage of fixed oil and antioxidants (24.95 and 76.94%, respectively) of *N. sativa* was obtained from plants treated with 6% garlic extract as a natural remedy. The results revealed that linoleic and oleic were the main fatty acids, with no significant differences between treatments. Additionally, it was shown that applying garlic extract to *N. sativa* seeds significantly raised the content of linolenic and palmitoleic acids compared to the other treatments. The findings confirmed the use of garlic and cinnamon extracts as a chemical substitute for total protection, demonstrating their essential growth enhancers and strong antioxidant qualities.

Keywords: *Nigella sativa, Fusarium*, extracts, antioxidant, fixed oil

INTRODUCTION

Nowadays, medicinal plants are employed for a diverse array of ailments due to their effectiveness and diminished side effects in comparison to synthetic pharmaceuticals. Black cumin (*Nigella sativa* L.) is the most important medicinal plants, which is an annual herb that belongs to the Ranunculaceae family (Al-Gaby, 1998). Despite its Mediterranean origins, this significant plant is extensively cultivated in various regions (Gad *et al*., 1963). The black cumin seeds, along with their principal bioactive constituents, have been recognized for their remarkable efficacy in the treatment of numerous diseases, encompassing infectious maladies and acute non-infectious disorders (Yimer *et al*., 2019). Furthermore, black cumin seeds serve as a rich source of minerals while also providing substantial quantities of carbohydrates, fats, and proteins (Cheikh-Rouhou *et al*., 2007). Fixed oil is the essential product derived from *N. sativa* seeds (Khan *et al.*, 2022). Among its fatty constituents, the principal unsaturated fatty acids were linoleic acid (50%–60%), oleic acid (20%), and dihomolinoleic acid (10%), while the main saturated fatty acids were palmitic and stearic acids (Karna, 2013).

Nigella sativa has been demonstrated to be an auspicious herb for fostering both agricultural and industrial economic advancement. The productivity of black cumin is profoundly compromised by a myriad of diseases, notably *Fusarium* wilt and root rot, which are particularly devastating afflictions in the principal black cumin cultivation regions worldwide. Species belonging to the *Fusarium* genus are recognized as significantly pathogenic fungi affecting various agricultural crops, leading to substantial losses and the production of mycotoxins that ultimately reach consumers via the food chain. In Egypt, many previous reports revealed that *F. oxysporum* exhibited the highest virulence against *Nigella sativa* L. (Mohamed *et al*., 2017, and Al-Sman *et al*., 2020). Infected plants exhibit symptoms such as light green foliage, leaf abscission, leaves shedding, and plants drying up and dying, causing yield loss of approximately 90% (Deacon, 2004).

The excessive and inappropriate application of chemical fungicides is often undesirable, posing significant threats to human, animal, and environmental health and is expensive, and there is a growing concern that pathogens may develop resistance to an array of fungicides (Shabana *et al*., 2004 and Deising *et al*., 2008).

Therefore, an alternative approach involves the utilization of plant metabolites. Plant extracts, endowed with anti-inflammatory, antioxidant, and antimicrobial properties, represent a crucial component as a biological factor employed in the control of plant diseases. Plant extracts are effective in dealing with the eradication of soil-borne diseases (Javaid and Rauf, 2015).

One species of such plant is garlic (*Allium sativum* L.), an annual herbaceous plant belonging to the genus *Allium* within the family Alliaceae. Garlic is replete with enzymes and sulfur-containing compounds, such as allicin, allyl sulfide, diallyl disulfide, and methanethiosulfonic acid (Bajac *et al*., 2018). Allicin, or diallylthiosulfinate, is renowned for its antimicrobial and antioxidant properties. Diallyl disulfide, on the other hand, exhibits anti-inflammatory, antioxidant, metabolic regulation, and detoxifying capabilities, as well as antimicrobial, antifungal, and antiviral activities (Bazaraliyeva *et al*., 2022). Aqueous extracts of *A. sativum* have demonstrated efficacy in inhibiting *F. solani* in both peanuts (Ahmed *et al*., 2012).

Another plant species of note is *Cinnamomum zeylanicum* Blume (family Lauraceae). The aqueous extract of cinnamon, characterized by cinnamaldehydes and polyphenols as its principal bioactive constituents, has been identified as cytotoxic (Khedkar and Khan, 2023). The *C. zeylanicum* species is recognized for possessing varying concentrations of phytochemicals; the total polyphenol content was found to be the highest in the extract, followed by saponins, tannins, coumarins, and flavonoids, cinnamon contains a number of specific bioactive compounds that greatly increase its antioxidant capacity (Sivapriya and John, 2020). According to Isaac-Renton *et al*. (2015), cinnamaldehyde, the predominant active component of cinnamon, is instrumental in conferring resistance to oxidative stress and microbial infections.

The purpose of this investigation was to assess the effectiveness of garlic clove and cinnamon bark aqueous extracts in the management of wilt disease affecting *Nigella sativa* plants, as well as their impact on the productivity and quality of *N. sativa* plant.

MATERIALS AND METHODS

The experiments were carried out in both the laboratory and the field over the 2021/2022 and 2022/2023 seasons, at the Experimental Farm of the Agricultural Research Station in Arab-El-Awamer, Assiut Governorate, Egypt, to assess the efficacy of garlic and cinnamon extracts at concentrations of 2, 4 and 6%, for their antifungal activity against wilt disease affecting black cumin plants and their effectiveness on the growth as well as productivity of *N. sativa* plants. Garlic bulbs and cinnamon bark materials were obtained from Medicinal and Aromatic Research Department, Horticulture Research Institute, A.R.C., Egypt. The experiment soil sample's physical and chemical characteristics analysis (Table, 1) was carried out according to Jackson (1973).

1. Isolation and identification of the causative fungi:

Nigella sativa L. plants exhibiting symptoms of wilt disease were procured from the cultivation fields of the Arab El Awamer Research Station, Agriculture Research Center, Assiut Governorate, Egypt, and subsequently transported to the laboratory. The pathogenic organisms were isolated from the infected roots of *N. sativa* plants and incubated at 25 °C for a duration of 7 days, as delineated by Gamliel *et al.* (1996). The isolates were purified and identified by their microscopic and morphological features as well as their cultural traits. Then preserved on Potato Dextrose Agar (PDA) medium in the refrigerator for subsequent utilization.

2. Pathogenicity test:

The pathogenicity of previously isolated *Fusarium oxysporum* (three isolates) and *F. solani* (two isolates), to black cumin plants was assessed in a controlled greenhouse setting. Sterilized clay soil was amalgamated with the inoculum at a concentration of 3% within 40 cm diameter pots, then five surface-sterilized seeds of *N. sativa* were sown in each pot. Inoculum-free pots made up the control treatments. There were five pots used for each treatment. The severity of the disease was ascertained utilizing the formula established by Wongpia and Lomthaisong, (2010) after three months had passed from planting.

Disease severity =

$$\sum \frac{(n\times1)+(n\times2)+(n\times3)+\dots}{t_n}\times100$$

n = the number of samples in each treatment, and t_n = the overall sum of samples.

Wilt severity was assessed for each specimen as follows: 0= healthy plant; 1= lower symptoms on a few leaves; 2= symptoms on the major part of leaves, minor dwarfing; 3= significant dwarfing, yellowing, wilt, and defoliation; 4= some plant shoots with severe symptoms and some plant shoots dead; and 5= completely death for plant

All isolates were effectively re-isolated from plants demonstrating signs of disease, thus satisfying Koch's postulates (Koch, 1876).

Table 1. Physico-chemical properties of the soil at the experimental site.

Properties	Value	Chemical properties	Value
Texture	Sandy calcareous	**pH**	8.42
Sand	89.7%	**Ca^{++}**	1.66 mmol/kg
Silt + clay	10.3%	**Mg^{++}**	0.68 mmol/kg
Water holding capacity	23.7%	**Na^{+}**	0.83 mmol/kg
Available water (%)	6.4%	**K^{+}**	0.26 mmol/kg
Organic Matter	0.75%	**HCO_3**	0.40 mmol/kg
Total $CaCO_3$ (%)	28.9%	**Cl^{-}**	1.50 mmol/kg
$EC_{1:5}$ (dS m^{-1})	0.57	**SO_4^{--}**	1.42 mmol/kg

3. Efficacy of plant extracts as antifungal:

a. Treatments:

1. Untreated plants (control).
2. Fungicide (Rizolex, 3 g/kg seeds).
3. Garlic extract at 2, 4 and 6% concentrations.
4. Cinnamon extract at 2, 4 and 6% concentrations.

b. Preparation of aqueous extracts:

1. Garlic extract:

Ten grams of fresh cloves of *Allium sativum* bulbs were carefully peeled, weighed, cleaned, and washed with distilled water; then they were crushed in 100 milliliters of distilled water and mixed using an electric grinder. To eliminate plant debris, the aqueous extracts were filtered through cheesecloth. The clear supernatant was collected after the filtered extract was centrifuged for ten minutes at 3000 rpm (Cherkupally *et al.*, 2017). Finally, required concentrations (2, 4 and 6%) were prepared by diluting with sterile distilled water.

2. Cinnamon extract:

Cinnamon bark (*Cinnamomum zeylanicum*) was obtained from finely ground by using a mixer and subsequently dissolved in water at 70 °C for 1 hour. To eliminate plant debris, the extracts were filtered using a 0.22 mm filter and then centrifuged at 13,000 rpm for 10 minutes to remove insoluble constituents (Lu *et al.*, 2010), and then required concentrations (2, 4 and 6%) were prepared by diluting with sterile distilled water.

The active constituents from the studied plants were listed in Table (2).

c. *In vitro*:

The effects of garlic and cinnamon extracts at 2, 4 and 6% concentrations were assessed against *F. oxysporum* on potato dextrose agar medium (PDA) using the agar diffusion method (Sahin *et al.,* 2004). Each treatment was repeated three times. The activity of the studied treatments (inhibition percentage of mycelial growth compared to untreated control) was computed (Dennis and Webster, 1971b, and Shivapratap *et al*., 1996) as follows:

Inhibition (%) = (D1 – D2)/D1 × 100, where D1 and D2 refer to the diameter of the pathogen colony in control and treatment, respectively.

d. *In vivo*:

1. Under greenhouse conditions:

Earthen pots filled with sterilized clay soil were amalgamated with the inoculum at a concentration of 3% within 40 cm diameter pots; five replicates were used for each treatment. The seeds of *N. sativa* were immersed for 1 hour in the extracts from garlic *(Allium sativum)* and cinnamon (*Cinnamomum zeylanicum*) plants at concentrations of 2, 4 and 6% that were previously emulsified with 0.05% Tween 20 (Reuveni *et al.*,1996) were evaluated compared to the chemical fungicide (Rizolex). For the control group, the seeds were immersed in hypochloric acid and then sterile distilled water (Land *et al*., 2001). On 1st November, five seeds of *N. sativa* were sown for each pot and irrigated with the same

Table 2. Medicinal plants used in the present study and their bioactive compounds.

Scientific name	Family	Used part	Bioactive compounds	References
Allium sativum	Alliaceae	Bulbs	Alliin, allicin, diallyl sulfide, diallyl disulfide, diallyl trisulfide, ajoene, and *S*-allylcysteine.	Yun *et al. (*2014)
Cinnamomum zeylanicum	Lauraceae	Bark	Cinnamaldehyde, cinnamic acid, eugenol and polyphenols	Khedkar and Khan (2023)

quantity of water as required. After 120 days from the planting, when the initial wilt symptoms appeared, the percentage of disease severity was meticulously recorded. Additionally, the growth and yield parameters were documented at the time of plant harvest.

2. Field experiment:

The objective of this study was to assess the effectiveness of garlic (*Allium sativum*) cloves and cinnamon (*Cinnamomum zeylanicum*) bark extracts on the productivity and quality of *N. sativa* plants in two consecutive seasons, 2021/2022 and 2022/2023, in the experimental farm (naturally infested with wilt pathogens) of Agricultural Research Station in Arab El Awamer, Assiut Governorate. The seeds were immersed for 1 hour in the tested treatments individually. The chemical fungicide (Rizolex, 3 g/kg seeds) was used individually as a comparison with garlic or cinnamon aqueous extracts (2, 4 and 6% concentrations) as natural treatments. Sterile distilled water was used as a control treatment. Using a randomized complete block design (RCBD) and three repetitions, three blocks, each representing a replicate, were created from the experimental design. Each block contained eight uniform plots (one for treatment) with a 1.0 m and 0.5 m space between blocks and plots, respectively. Each plot had an area of 5 m² (2 × 2.5 m), with four rows spaced 60 cm apart and 25 cm between hills (32 plants per plot). The sowing was performed on 1st November and thinned to one plant per hill after three weeks of sowing. During the vegetation period, all other agricultural practices continued as normal.

4. Recorded data:

After the harvesting time (at the first of May in both cultivated seasons), the growth and yield parameters, plant height (cm), number of branches/plant, fresh and dry weight (g)/plant, number of capsules/plant, weight of seeds(g)/plant, and weight of seeds(kg)/feddan were recorded for each treatment, then fixed oil in the seeds was extracted. Additionally, fixed oil percentage as well as fatty acids and antioxidants for black cumin seeds were assessed.

a. Fixed oil extraction:

The seeds (50 g) of black cumin were powdered mechanically and extracted by using hexane (BP 60-80 °C) as a solvent for 6 h in a Soxhlet apparatus. The fixed oils were obtained by removing the solvent under reduced pressure (Horwitz *et al*., 1970).

b. Methylation of fatty acids:

Methyl esters of fatty acids were produced from total lipids utilizing a quick technique in accordance with ISO (2017). Whereas, trans-esterification using methanolic potassium hydroxide was used to create fatty acid methyl esters as a step before saponification. A 5 ml screw-top test tube was filled with around 0.1 g of fixed oil, and 2 ml of iso-octane was added, and the tube was shaken. The tube was allowed to stratify for 30 seconds till the upper solution became clear, then the top layer (ethyl layer) was removed. The cap with a PTFE joint was filled with a methanolic potassium hydroxide solution (0.1 ml, 2N), tightened, and shaken vigorously. The iso-octane solution will be injected into the gas chromatograph.

c. Gas-liquid chromatography (GLC):

The HP6890 series GC apparatus, which was accompanied by a DB-23 column (60 m x 0.32 mm x 0.25 m), was used to inject fatty acid methyl esters. Nitrogen was the carrier gas had a splitting ratio of one to fifty and a flow rate of 1.5 ml/min. The temperature of flame ionization detector's (FID) was 280 °C, whereas the temperature of the injector's was 250 °C. At a rate of five degrees Celsius per minute, the temperature was increased from 150 to 210 degrees Celsius and then held there for twenty-five minutes. The HP6890 series GC apparatus, which was coupled with a DB-23 column (60 m × 0.32 mm × 0.25 m), was used to inject fatty acid methyl esters. Using standard methyl esters, retention times were compared in order to identify peaks.

d. Determination of antioxidant capacity of black cumin:

Antioxidant activity of *N. sativa* fixed oil was determined using the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals. At the first, 0.2 ml of a 0.001 M methanolic solution of DPPH was combined with 2 ml volumes of different fixed oil dilutions in ethyl acetate. The solutions' absorbance was measured at 517 nm in relation to a solvent blank. Then the capacity to scavenge free radicals was determined (Burits and Bucar, 2000).

5. Analytical statistics:

The collected data were statistically analyzed using ANOVA (analysis of variances as a split-plot design (under greenhouse conditions data), *Fusarium* strains as the mean plot and treatments as subplots, as well as a randomized complete block design for field data, and the differences between the treatments were evaluated using the LSD test ($p \leq 0.05$) in the statistical program, Statistics 8.1 (Analytical Software, 2005).

RESULTS AND DISCUSSION

1. Isolation and identification of the causative fungi:

The isolated fungi collected from various areas of the Assiut governorate, which were associated with black cumin plants exhibiting wilt symptoms, were purified and identified based on their cultural and morphological characteristics as *Fusarium oxysporum* and *F.* solani. *Fusarium oxysporum* is the main *Fusarium* species responsible for wilting black cumin plants. Similar findings were found in Iran (Khaledi and Hassani, 2021), Egypt (Mohamed *et al*., 2017 and Hanan *et al*., 2020).

2. Pathogenicity test:

The results indicated that the virulence of all tested isolates of *Fusarium oxysporum* and *Fusarium solani* to infect black cumin seeds was varied, as shown in Table (3). Comparing the tested isolates to the control, *F. oxysporum* 1 was the most aggressive (53.3% severity), followed by *F. oxysporum* 3 (47%). Other isolates were moderately or weakly pathogenic. These results are in line with other results; in Egypt (Mohamed *et al*., 2017 and Hanan *et al*., 2020) and in Iran (Khaledi and Hassani, 2021), which found that the majority of the isolates of *F. oxysporum* were found in the black cumin seed coat, with a small number found in embryos. Numerous processes, including the synthesis of extracellular enzymes and/or mycotoxins, are thought to be responsible for these fungi's pathogenicity and aggression (Ortega *et al*., 2013).

3. Efficacy of plant extracts as antifungal:

a. *In vitro*:

The two investigated plant extracts exhibited significant antifungal efficacy against the most aggressive *Fusarium oxysporum* 1 at all tested concentrations, according to data in Table (4). With increasing concentration, the extract's severe inhibitory effect on fungal growth reaches its maximum at 6%. Under the same conditions, garlic extract (6%) produced a 75% inhibition

Table 3. Percentages of disease severity of *Nigella sativa* L. plants infected with isolates of *Fusarium* spp.

Isolated fungi	Disease severity (%)
Control	0.0
***Fusarium oxysporum* 1**	53.3
***Fusarium oxysporum* 2**	40.0
***Fusarium oxysporum* 3**	47.0
***Fusarium solani* 1**	15.5
***Fusarium solani* 2**	28.8
LSD at 0.05	2.72

Table 4. ***In vitro*, the effect of garlic and cinnamon extracts on the growth rate of pathogenic *Fusarium oxysporum.***

Treatments	Concentrations %	Inhabitation %
Control	-	0.0
Allium sativum	2	56.1
	4	62.5
	6	75.0
Cinnamomum zeylanicum	2	56.0
	4	68.7
	6	77.5

Control: water (distilled and sterilized)

of growth, while cinnamon extract (6% concentration) had the strongest inhibitory effect of *in vitro* test (Table, 4 and Fig., 1), with 77.5% inhibition, followed by garlic extract (6%) with 75% inhibition compared to the control (0% growth inhibition). Our findings align with Ùesan *et al*. (2015), who found that *Allium sativum* extract, at a 10% concentration, effectively inhibited *Botrytis cinerea in vitro*. Cinnamon and garlic extracts inhibited the growth of soilborne fungi (Nehal and Abdel-Kader, 2007). The growth and development of *F. sporotrichioides* and *F. oxysporum* hyphae are affected fungistatically by the aqueous extract of cinnamon bark at 3 and 5% concentrations (Martinko and Mioč, 2024 and Carmello *et al*., 2022). According to some researchers, plant extracts' hydrophobicity causes their inhibitory action, through partition of mitochondria and fungal cell wall, membrane lipids, increasing permeability and allowing ions and cell contents to leakage (Burt, 2004). The antimicrobial components of plant extracts interact with membrane proteins and enzymes, altering metabolic pathways and cell death (Omidbeygi *et al*., 2007).

b. *In vivo*:

1. Under greenhouse conditions:

Under greenhouse conditions, the study assessed the efficacy of treating black cumin seeds with 2, 4 and 6% concentrations of garlic and cinnamon extracts in addition to a chemical fungicide against *Fusarium* isolates (Table, 5). The results confirmed that all treatments significantly lowered the severity of wilt disease in *N. sativa* plants. Extracts of garlic and cinnamon at 6% concentration were superior in reducing the severity of the disease compared to other treatments. At the maximum dose (6%) of garlic extract, seedling wilt dropped to 4.4% in the virulent *F. oxysporum* 1 and *F. oxysporum* 3, while cinnamon extract (6) also lowered disease severity but did not achieve the same effects.

Our findings align with prior research managed by Sealy *et al.* (2007), which indicated that garlic extract possesses the capacity to influence a spectrum of soil borne fungal infections. Ùesan *et al*. (2015) revealed that garlic extract at a concentration of 10% significantly mitigated the severity of gray mold disease in blackcurrant under field conditions when compared to the control group. Fawzi *et al*. (2009) discovered that both boiled and cold water extracts from cinnamon plants exhibited markedly potent antifungal activity, effectively inhibiting the growth and hydrolytic enzymes of *F. oxysporum*. Meanwhile, Monteiro *et al*. (2013) showed that cinnamon extracts significantly reduced *F. oxysporum* f.sp. *cubense* mycelial growth and inhibited the progress of the disease in banana seedling.

In addition to examining the extract's effectiveness for treating wilt disease, we also examined the effects on the growth and yield of *N. sativa* plants. The results showed that *Fusarium oxysporum* infected *Nigella* seedlings and reduced plant growth and seed production, as shown in Tables (6) and (7).

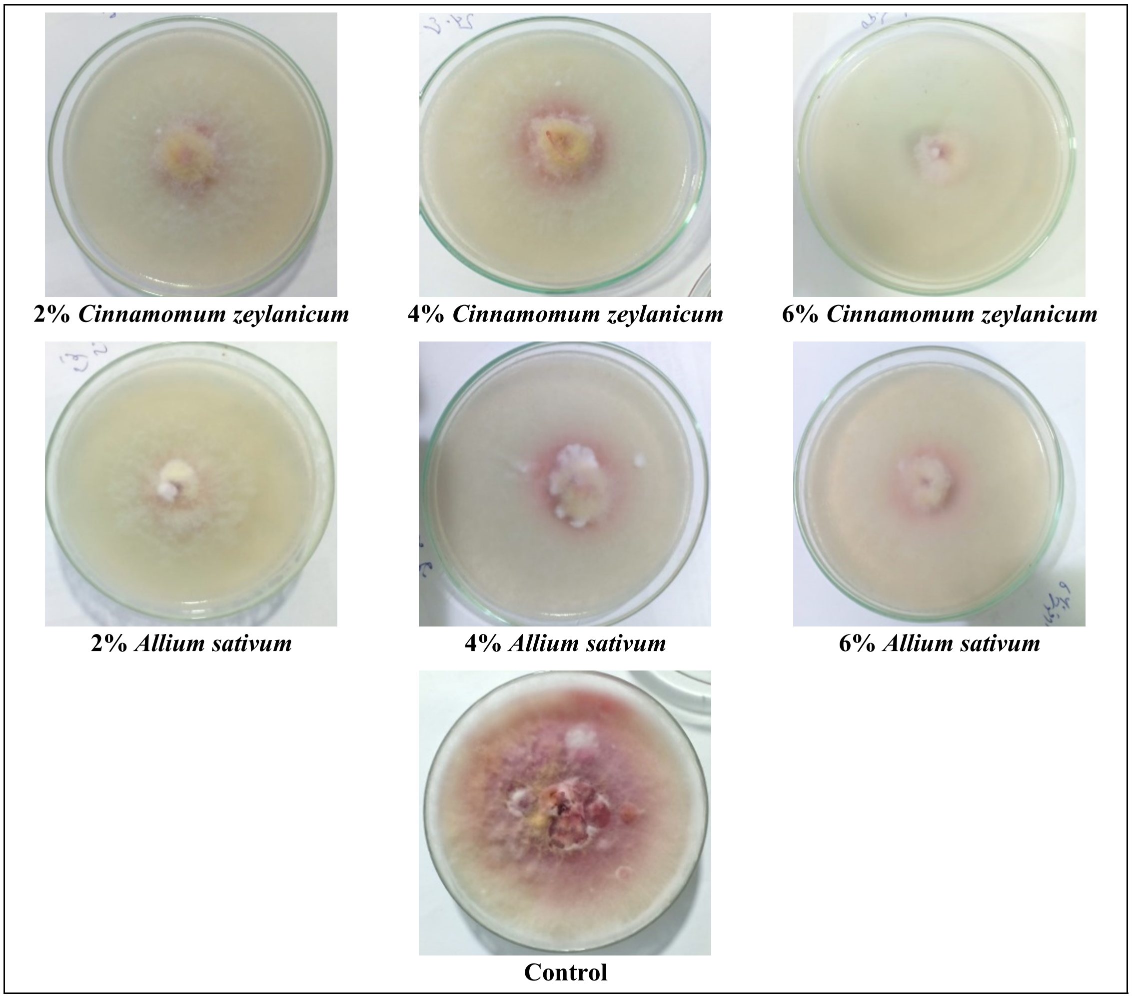

Fig. 1. ***In vitro*, the efficacy of garlic and cinnamon extracts at 2, 4 and 6% concentrations for controlling *Fusarium oxysporum* growth.**

Table 5. Activity of garlic and cinnamon extracts against selected *Fusarium* spp. expressed as disease severity (%) on *Nigella sativa* plants under greenhouse conditions during the 2022/2023 season.

Treatments (A)	Isolated fungi (B)					
	Fusarium oxysporum 1	*Fusarium oxysporum* 2	*Fusarium oxysporum* 3	*Fusarium solani* 1	*Fusarium solani* 2	Mean (B)
Control (uninfested)	0.0	0.0	0.0	0.0	0.0	0.0
Control (infested and untreated)	53.3	40.0	47.0	15.5	28.8	36.9
Fungicide	0.0	15.5	22.2	11.1	0.0	9.8
Garlic 2%	8.8	15.5	4.4	13.3	22.2	12.8
Garlic 4%	8.8	13.3	11.1	11.1	20.0	12.9
Garlic 6%	4.4	8.8	0.0	11.1	4.4	5.7
Cinnamon 2%	23.3	22.2	22.2	22.2	13.3	20.6
Cinnamon 4%	22.2	15.5	15.5	0.0	4.4	11.5
Cinnamon 6%	20.0	4.4	2.2	0.0	0.0	5.3
Mean (A)	15.64	15.02	13.84	10.34	9.37	
LSD at 0.05		A= 0.154	B = 0.238	A×B = 0.524		

Table 6. Under greenhouse conditions, the effect of garlic and cinnamon extracts as seed treatments on disease severity, plant height (cm) and branches number/plant of *Nigella sativa* plants infected with pathogenic *Fusarium oxysporum* 1 during the 2021/2022 and 2022/2023 seasons.

Treatments	Disease severity		Plant height		Number of branches/plant	
	First season	Second season	First season	Second season	First season	Second season
Control (uninfested)	0.00	0.00	50.43	50.83	5.30	5.10
Control (infested and untreated)	54.23	53.30	42.43	43.50	3.63	3.83
Fungicide	0.00	0.00	55.97	55.27	6.50	6.47
Garlic 2%	9.37	8.80	54.53	54.33	5.72	5.30
Garlic 4%	8.40	8.80	54.63	55.53	6.17	6.30
Garlic 6%	4.73	4.40	61.40	62.73	6.63	7.20
Cinnamon 2%	23.83	23.30	52.53	51.87	6.23	5.43
Cinnamon 4%	24.20	22.20	54.33	53.67	6.47	6.30
Cinnamon 6%	21.00	20.00	55.80	56.40	7.60	7.10
Mean	16.20	15.64	53.56	53.79	6.03	5.89
LSD at 0.05	0.916	0.519	1.74	1.87	0.445	0.348

Table 7. Under greenhouse conditions, the effect of garlic and cinnamon extracts as seed treatments on number of capsules/plant and seed weight (g)/plant of *Nigella sativa* plants infected with *Fusarium oxysporum* 1 during the 2021/2022 and 2022/2023 seasons.

Treatments	Number of capsules/plant		Seed weight (g)/plant	
	First season	Second season	First season	Second season
Control (uninfested)	20.67	21.83	6.93	7.27
Control (infested and untreated)	10.00	10.83	3.13	3.23
Fungicide	32.53	33.72	10.30	10.30
Garlic 2%	36.32	37.32	9.20	9.51
Garlic 4%	37.60	38.27	9.57	10.97
Garlic 6%	43.40	43.73	11.90	12.70
Cinnamon 2%	29.00	30.00	8.70	9.80
Cinnamon 4%	34.83	35.17	9.43	9.67
Cinnamon 6%	40.00	40.67	10.10	11.89
Mean	31.59	32.39	8.81	9.48
LSD at 0.05	1.03	0.94	0.447	0.635

On the other hand, all of the study's parameters; plant height, branches number/plant, number of capsules/plant, and seed weight (g)/plant), were increased significantly in all treated plants in comparison to the controls. The seed treatment with garlic extract and cinnamon extract at 6% concentration produced the highest number of branches after fungicide treatment, whereas control (with fungus and with no treatments) produced the fewest branches. However, the application of garlic extract at a concentration of 6%, followed by cinnamon extract at a concentration of 6%, produced the largest increase in the number of capsules/plant and also seed weight (g)/plant. Similar findings were obtained by Fatima and Khot (2015); they found the fungi that were associated with black cumin seeds passively affect germination and seedling growth.

This study showed the effectiveness of garlic and cinnamon extracts against wilt disease (*Fusarium oxysporum*) and also their impact on *Nigella sativa* plants. It is widely recognized that plants synthesize a group of bioactive compounds within their tissues as secondary metabolites, which demonstrate antifungal properties. Each of these groups demonstrates a distinct mode of action; Rivlin (2001) suggested that the antifungal and antibacterial activity of garlic plants related to allicin and other phenolic compounds, which are organosulfur compounds. In agreement with these results, Iciek *et al*. (2016) reported that garlic extracts contain a mixture of diallylpolysulfides molecules, which reduces the risk of pathogen resistance by interacting with thiols and protein thiols (low molecular weight substances), disrupting cellular redox balance and enzyme function. Diallylpolysulfides' (DAPS) thiophilic nature also disrupts metal ion homeostasis of those that are free in solution and those that are bound to enzymes, and due to their lipophilic nature, they produce changes in membrane structures of the pathogen (Münchberg *et al*., 2007, and Busch *et al*., 2010). Moreover, phenolic acids, flavonoids, and phenolic diterpenes, which are related to phenolic compounds, are responsible for imparting antioxidant properties that absorb or neutralize the effects of free radicals (Decker *et al*., 2000).

Many studies concluded that the efficiency of cinnamon aqueous extract in the inhibition of *Fusarium* sp. was related to the synergy of many phytochemical compounds, such as cinnamaldehyde, eugenol, cinnamic acid, and others (Ramaiah *et al*., 2015 and Carmello *et al*., 2022). Additionally, cinnamon bark aqueous filtrates have effectively managed *Botrytis cinerea;* moreover, they have promoted the growth of plants treated with cinnamon compared to the untreated group (Kowalska *et al*., 2020).

Whatever Castillo *et al*. (2012) reported, plant extracts contain natural mixtures of numerous constituents with different concentrations; consequently, it is challenging to attribute antifungal activity to a specific constituent of these mixtures. In agreement with this report, Bagamboula *et al*. (2004) suggested that the inhibitory effects of plant extracts may arise from synergistic interactions among the diverse compounds.

2. Field conditions:

a. Growth and productivity:

The effects of chemical fungicides (Rizolex T, 3 g/kg seeds) and extracts of garlic and cinnamon at 2, 4 and 6% concentrations on various growth and production characteristics of *Nigella sativa* plants were examined, as shown in Tables (8) and (9). Cinnamon extract (6%) increased plant height and recorded the highest mean values (72.50 and 77.00 cm in both seasons). Garlic extract (6%) came in second (72.57 and 75.50 cm). The highest mean values of the number of branches per plant were obtained when garlic extract was used as a seed treatment at concentrations of 6% and 4%, respectively.

Different treatments resulted in varying seed yields per plant and per feddan (Table, 9). The greatest concentration of garlic extract produced the largest and most notable rise in seed weight per plant and per feddan (27.27 g and 698.03 kg, respectively), closely followed by cinnamon bark extract 6%, which reached up to 26.2 g/plant and 670.72 kg/feddan in the second season. The obtained results concluded that the application of garlic clove extract or cinnamon bark extract as seed treatment not only significantly enhanced wilt disease resistance in *N. sativa* plants but also markedly increased growth and yield of the plant.

The present findings are in concordance with several prior studies; plant-derived organic compounds, whether endogenous or exogenous application, affect physiological processes that control cell division and growth differentiation, which includes cell elongation (Elakbawy *et al*., 2022). According to Jambhulkar *et al*. (2018), they reported that treating seeds with an aqueous extract of garlic decreased the early leaf spot

Table 8. Effect of seed treatment by garlic and cinnamon extracts at 2, 4 and 6% concentrations on vegetative growth of *Nigella sativa* plants under field conditions during 2021/2022 and 2022/2023 seasons.

Treatments	Plant height (cm) /plant		No. of branches /plant		Herb Fresh weight (g) /plant		Herb Dry weight (g) /plant	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control	67.73	67.63	14.73	14.43	84.43	81.67	17.97	18.00
Fungicide	70.40	72.50	15.90	15.47	88.67	94.33	24.20	25.27
Garlic 2 %	71.55	73.73	14.83	16.10	89.27	92.63	22.07	23.93
Garlic 4 %	72.00	74.55	15.73	16.17	90.07	96.53	22.70	26.17
Garlic 6 %	72.57	75.50	17.23	17.03	93.67	99.57	27.93	28.87
Cinnamon 2%	66.60	68.30	14.80	14.60	83.27	83.00	18.53	19.47
Cinnamon 4%	69.03	68.90	15.67	14.53	86.67	88.80	23.53	23.80
Cinnamon 6%	72.50	77.00	15.27	15.60	88.43	93.57	25.40	27.10
Mean	70.298	72.265	15.52	15.49	88.058	91.263	22.792	24.075
LSD at 0.05	3.301	4.593	0.637	0.533	4.925	5.852	1.541	3.433

Table 9. Effect of seed treatment by garlic and cinnamon extracts at 2, 4 and 6% concentrations on the yield of *Nigella sativa* plants under field conditions during 2021/2022 and 2022/2023 seasons.

Treatments	No. of capsules/plant		Seed yield (g)/plant		Seed yield (kg)/fed	
	First season	Second	First season	Second	First season	Second
Control	49.20	50.00	16.41	17.27	420.01	442.03
Fungicide	56.43	56.37	23.63	23.17	605.01	593.07
Garlic 2 %	58.63	55.20	25.03	24.70	640.85	632.32
Garlic 4 %	59.40	61.30	25.03	25.30	640.85	647.68
Garlic 6 %	61.27	63.73	26.33	27.27	674.13	698.03
Cinnamon 2%	51.27	51.60	22.97	23.47	587.95	600.75
Cinnamon 4%	55.77	53.47	23.97	24.50	613.55	627.20
Cinnamon 6%	58.23	57.23	26.07	26.20	667.31	670.72
Mean	56.28	56.11	23.68	23.98	606.21	613.97
LSD at 0.05	2.256	2.305	1.179	0.968	30.20	24.79

disease and increased the yield in groundnut plants. Kowalska *et al.* (2020) and Darmadi *et al.* (2016) confirmed the positive effects of cinnamon bark extract on tomato plant growth and quality in both greenhouse and field environments, as well as its ability to inhibit *Botrytis cinerea* and mitigate the severity of wilt disease. The biostimulant properties of natural extracts are explained by many investigators. Posmyk and Szafranska, (2016) said that because plant extracts have distinct molecular groups, they stimulate plant metabolic processes through different pathways that differ from those correlated with fertilizers or phytohormones. The fact that garlic extracts contain a range of growth-promoting ingredients, such as proteins, starch, vitamins, and organosulfur compounds, including diallyl disulfide and allicin, explains the improvement in plant growth (Hayat *et al*., 2018; and Mohamed *et al*., 2020). Similarly, cinnamon extract contains numerous vital constituents, including proteins, carbohydrates, vitamins, and minerals; consequently, it is regarded as a potent stimulant for plant growth and development (Elkady *et al*., 2022).

b. Fixed oil content and antioxidant activity:

The results in Table (10) show the effect of *N. sativa* seeds treated with garlic and cinnamon extracts (each administered separately prior to planting) on the fixed oil content, as well as their antioxidant activity which was assessed through the scavenging

Table 10. Effect of seed treatment by garlic and cinnamon extract at 2, 4 and 6% concentrations on fixed oil content and antioxidant activity of *Nigella sativa* seeds in the 2023 growing season.

Treatments	Fixed oil %	Antioxidant activity
Control	21.35	61.32
Rizolex (fungicide)	27.25	71.49
Garlic 2%	24.00	63.94
Garlic 4%	24.95	73.38
Garlic 6%	24.95	76.94
Cinnamon 2%	21.95	66.35
Cinnamon 4%	23.30	72.33
Cinnamon 6%	23.50	76.31
Mean	23.91	70.258
LSD at 0.05	0.206	0.048

activity of free radical DPPH in *Nigella sativa* seeds. The findings of our investigation into black cumin revealed that the yield of fixed oil in seeds ranged from 21.35% in the control group to 27.25% subsequent to treatment with a chemical fungicide. Concerning the extract treatments, the data revealed that the application of garlic clove extract at elevated concentrations significantly augmented the fixed oil yield, reaching 24.95%. Our findings are similar to findings by Can *et al.* (2021). Additionally, Mondal *et al.* (2022) reported that sulfur, as a macronutrient, is an essential element at the time of seed germination, and a crucial factor for improving seed yield and oil content in oil seeds.

Moreover, the findings elucidated that across all treatments, the fixed oil of *N. sativa* demonstrated an extraordinary radical scavenging activity, attaining an impressive 76.31%. Furthermore, the elevation of garlic and cinnamon extracts from 2 to 6% concentrations correlated with a significant enhancement in the antioxidant percentage of seeds. The pinnacle of antioxidant activity was realized when the seeds were treated by garlic extract at a 6% concentration (76.94%), closely followed by cinnamon extract at the same concentration (76.31%). These results mentioned that garlic and cinnamon extracts can enhance the plant's inherent antioxidant system of *Nigella sativa*, which help plants combat oxidative stress and neutralize deleterious reactive oxygen species produced during various metabolic processes and improve its overall health, pointing to a considerable potential for their increased utilization in agricultural practices. It has been demonstrated that aqueous extract of *Allium sativum* bulbs enhances the antioxidative response of eggplant and cucumber plants; this effect seems to be influenced by concentration (Hayat *et al.*, 2016 and Ali *et al.*, 2019). It has been demonstrated that certain plant biostimulants increase antioxidant activity in various of crop plants (Ma *et al*., 2022).

c. Fixed oil constituents (fatty acids):

Data illustrated in Table (11) revealed that the content of fatty acids in the *N. sativa* seeds under control as well as the most effective treatments, which were garlic clove and cinnamon bark extracts at 6% concentration, compared to a chemical fungicide. Through gas-liquid chromatography (GLC) analysis, 14 distinct compounds were identified in the fixed oil of *N. sativa* seeds across all treatments, primarily consisting of unsaturated fats. Seven unsaturated fatty acids accounted for approximately 84.48% to 84.87% of the total composition. It was observed that approximately 78.7% to 81.1% of the oil was unsaturated fatty acids that composed of oleic acid and linoleic acid. The fixed oil of *N. sativa* seeds contains saturated fatty acids, which make up approximately 15% of the total composition. Among these, palmitic acid

Table 11. Effect of garlic and cinnamon extract on fatty acids contents of *Nigella sativa* fixed oil affected by fungicide, garlic and cinnamon extracts at 6% concentration during the 2023 cultivated season.

Fatty acids	Control	Fungicide	Garlic 6%	Cinnamon 6%
cis-11-Eicosenoic acid	0.41	0.43	0.38	0.39
Eicosadienoic acid	2.69	3.03	2.93	2.98
Linoleic acid	58.53	58.34	57.45	58.24
Linolenic	0.36	0.29	2.19	0.26
Margaroleic acid	0.03	0.03	0.04	0.04
Oleic acid	22.38	22.18	21.28	22.28
Palmitoleic acid	0.21	0.27	0.60	0.26
Arachidic acid	0.18	0.20	0.18	0.18
Behenic acid	0.03	0.08	0.04	0.05
Lignoceric acid	0.27	0.31	0.31	0.29
Margaric acid	0.06	0.06	0.05	0.06
Myristic acid	0.18	0.24	0.22	0.24
Palmitic acid	11.71	11.86	11.79	12.04
Stearic acid	2.67	2.66	2.53	2.67
Total saturated (%)	15.10	15.41	15.12	15.52
Total unsaturated (%)	84.61	84.57	84.87	84.48
Total	99.71	99.98	99.99	100

constitutes about 77% of the total saturated fatty acids, showing no significant variation among the treatments studied. The highest concentration of linolenic acid (2.19%) was recorded in plants treated with garlic, in contrast to the 0.26% to 0.36% found in other treatments and the control group. Amin *et al.* (2010) confirmed that linoleic acid and oleic acid were the predominant fatty acids in the *N. sativa* plants.

CONCLUSION

The results of this study demonstrated that aqueous extracts of garlic cloves and cinnamon bark have strong antifungal properties against seed-borne fungi. In addition, they have antioxidant qualities as well as a potential biostimulant influence on *Nigella sativa* growth and production, supporting the potential application of these natural compounds for integrated crop protection. Study summary, plant extracts can be used as environmentally friendly alternatives and essential elements of sustainable plant disease management.

REFERENCES

Ahmed, S.; Zaman, N. and Khan, S.N. (2012). Management of root rot disease of groundnut (*Arachis hypogeae* L.) by plant extracts. Afr. J. Microbiol. Res., 6(21):4489-4494.

Al-Gaby, A. M. A. (1998). Amino acid composition and biological effects of supplementing broad bean and corn proteins with *Nigella sativa* (black cumin) cake protein. Nahrung, 42:290- 294.

Ali, M.; Cheng, Z.H.; Hayat, S.; Ahmad, H.; Ghani, M.I. and Liu, T. (2019). Foliar spraying of aqueous garlic bulb extract stimulates growth and antioxidant enzyme activity in eggplant (S*olanumme longena* L.). J. Integr. Agric., 18(5):1001-1013.

Al-Sman, M.K.; Abo-Elyousr, K.A.M.; Eraky, A. and El-Zawahry, A. (2020). Efficiency of *Pseudomonas spp*. based formulation for controlling root rot disease of black cumin under greenhouse and field conditions. Archives of

Phytopathology and Plant Protection, 52(19/20):1313-1325.

Amin, S.; Mir, S.R.; Kohli, K.; Ali, B. and Ali, M.A. (2010). Study of the chemical composition of black cumin oil and its effect on penetration enhancement from transdermal formulations. Nat. Prod. Res., 24(12):1151–1157.

Analytical software (2005). Statistis 8.1 for Windows analytical software. Tallahassee, Florida, USA.

Bagamboula, C.F.; Uyttendaele, M. and Debevere, J. (2004). Inhibitory effect of thyme and basil essential oils, carvacrol, thymol, estragol, linalool, and p-cymene towards *Shigella sonnei* and *S. flexneri*. Food Microbiol, 21(1):33-42.

Bajac, J.; Nikolovski, B.; Kocić-Tanackov, S.; Tomšik, A.; Mandić, A.; Gvozdanović-Varga, J.; Vlajić, S.; Vujanović, M. and Radojković, M. (2018). Extraction of different garlic varieties (*A. sativum* L.), determination of organosulfur compounds and microbiological activity. Proc. the IV International Congress Food Technology, Quality and Safety, Novi Sad, Serbia, 23-25 October 2018, pp. 82.

Bazaraliyeva, A.; Moldashov, D.; Turgumbayeva, A.; Kartbayeva, E.; Kalykova, A.; Sarsenova, L. and Issayeva, R. (2022). Chemical and biological properties of bioactive compounds from garlic (*Allium sativum*). Pharmacia 69(4):955-964.

Buriro, M.; Sanjrani, A.S.; Chachar, Q.I.; Chachar, S.D.; Chachar, B.; Buriro, A.W.G.; and Mangan, T. (2015). Effect of water stress on growth and yield of sunflower. Journal of Agricultural Technology, 11(7):1547-1563

Burits, M. and Bucar, F. (2000). Antioxidant activity of *Nigella sativa* essential oil. Phytother. Res., 14(5):323-328.

Burt, S. (2004). Essential oils: their antimicrobial properties and potential applications in foods. Int. J. Food Microbiol., 94(3):223-253.

Busch, C.; Jacob, C.; Anwar, A.; Burkholz, T.; Ba, L.A.; Cerella, C.; Diederich, M.; Brandt, W.; Wessjohann, L. and Montenarh, M. (2010). Diallylpoly-sulfides induce growth arrest and apoptosis. Int. J. Oncol., 36(3):743-749.

Can, M.; Katar, D.; Katar, N.; Bagci, M. and Subasi, I. (2021). Yield and fatty acid composition of black cumin (N*igella sativa* L.) populations collected from regions under different ecological conditions. Applied Ecology and Environmental Research, 19(2):1325-1336.

Carmello, C.R.; Magri, M. and Cardoso, J. (2022). Cinnamon extract and sodium hypochlorite in the *in vitro* control of *Fusarium oxysporum* f. sp. *lycopersici* and *Alternaria alternata* from tomato. J. Phytopathol., 170(11/12):802-810.

Castillo, F.; Hernández, D.; Gallegos, G.; Rodríguez, R. and Aguilar, C.N. (2012). Antifungal properties of bioactive compounds from plants. In: Dhanasekaran, D.; Thajuddin, N. and Panneerselvam, A. (eds.), Fungicides for Plant and Animal Diseases, InTech Publishing Janeza Trdine, Rijeka, Croatia, pp. 81-106.

Cheikh-Rouhou, S.; Besbes, S.; Hentati, B.; Blecker, C.; Deroanne, C. and Attia, H. (2007). Chemical composition and physicochemical characteristics of lipid fraction of *Nigella sativa* L. Food Chem., 101:673-681.

Cherkupally, A.; Kota, S.R.; Amballa, H. and Reddy, B.N. (2017). *In vitro* Antifungal potential of plant extracts against *Fusarium oxysporum*, *Rhizoctonia solani,* and *Macrophomina phaseolina.* Ann. Plant Sci., 6(9):1676-1680.

Darmadi, A.A.K.; Suprapta, D.N. and Ginantra, K. (2016). Effect of cinnamon leaf extract formula (C*innamomum burmanni* Blume) on *Fusarium* wilt that attacks tomato plants in Bali. Int. J. Pure App. Biosci., 4(4):33-38.

Deacon, J. (2004). Fungal Biology. Blackwell Publishing Ltd., Oxford, UK, 384 p.

Decker, E.A.; Warner, K.; Richards, M.P. and Shahidi, F. (2000). Measuring antioxidant effectiveness in food. J. Agric. Food Chem., 53(10):4303-4310.

Deising, H.B.; Reimann, S. and Pascholati S.F. (2008). Mechanisms and significance of fungicide resistance. Brazilian Journal of Microbiology, 39(2):286-295

Dennis, C. and Webster, J. (1971). Antagonistic properties of species-groups of *Trichoderma*: II. Production of volatile antibiotics. Transactions of the British Mycological Society, 57(1):41-48.

Elakbawy, W.M.; Shanab, S.M.M. and Shalaby, E., (2022). Enhancement of plant growth regulator production from micro algae cultivated in treated sewage wastewater (TSW). BMC Plant Biology, 22(1):1-14. http://dx.doi.org/10.1186/s12870-022-03764-w

Elkady, E.M.A.A.; El-Mahdy, M.T.; Elakad, M.M. and Mostafa, R.A.A. (2022). Effect of Spraying with Amino Acids, Yeast, and Some Plant Extracts on Fruiting of Sewi Date Palm. Assiut Journal of Agriculture Science, 53(4):79-91.

Fatima, S., and Khot, Y.C. (2015). Studies on fungal population of black cumin (*Nigella sativa* L.) from different parts of Marathwada. An International Peer-Reviewed Journal of Multidisciplinary Research, 2(2): 24-31.

Fawzi, E.M.; Khalil, A.A. and Afifi, A.F. (2009). Antifungal effect of some plant extracts on *Alternaria alternata* and *Fusarium oxysporum*. African Journal of Biotechnology, 8(11):2590-2597.

Gad, A.M.; El-Dakhakhny, M. and Hassan, M. (1963). Studies on the chemical composition of Egyptian *Nigella sativa* L. oil. Planta Medica, 11(2):134-138.

Gamliel, A.; Katan, T.; Yunis, H. and Katan, J. (1996). *Fusarium* wilt and crown rot of sweet basil: Involvement of soil-borne and airborne inoculum. Phytopathology, 86:56–62.

Hanan, M.H.; Sozan, E.A. and Shimaa A.S. (2020). Effect of some organic acids on growth, yield, oil production, and enhancing anatomical changes to reduce *Fusarium* wilt of *Nigella sativa* L. Plant Archives, 20(2):9231-9243.

Hayat, S.; Ahmad, H.; Ali, M.; Hayat, K.; Khan, M.A. and Cheng, Z. (2018). Aqueous garlic extract as a plant biostimulant enhances physiology, improves crop quality and metabolite abundance, and primes the defense responses of the receiver plants. Appl. Sci., 8(9):1-25. https://doi.org/10.3390/app8091505

Hayat, S.; Cheng, Z.; Ahmad, H.; Ali, M.; Chen, X., and Wang, M. (2016). Garlic, from remedy to stimulant: Evaluation of antifungal potential reveals diversity in phytoalexin allicin content among garlic cultivars; allicin-containing aqueous garlic extracts trigger antioxidants in *Cucumber.* Front. Plant Sci., 7:1-15. https://doi.org/10.3389/fpls.2016.01235

Horwitz, W.; Chichilo, P.; and Reynolds, H. (1970). Official Methods of Analysis of the Association of Official Analytical Chemists, 11th edition. The Association of Official Analytical Chemists, Washington DC, USA, 1015 p.

Iciek, M.; Kowalczyk-Pachel, D.; Bilska-Wilkosz, A.; Kwiecien, I.; Gorny, M., and Wlodek, L. (2016). S-sulfhydration as a cellular redox regulation. Biosci. Rep., 36(2):1-16. https://doi.org/10.1042/BSR20150147

Isaac-Renton, M.; Li, M.K. and Parsons, L.M. (2015). Cinnamon spice and everything not nice: many features of intraoral allergy to cinnamic aldehyde. Dermatitis, 26(3):116–121.

ISO (2017). Animal and Vegetable Fats and Oils-Gas Chromatography of Fatty Acid Methyl Esters, Part 2: Preparation of Methyl Esters of Fatty Acids. International Organization for Standardization Publisher, Genève, Switzerland, 15 p.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall, Inc. Englewood Cliffs, N.J. New Delhi, India, 498 p.

Jambhulkar, P.P.; Meghwal, M.; Sharma, S.K.; Yusuf, M.D. and Rokadia, P. (2018). Aqueous plant extracts for organic management of early and late leaf spots in groundnut (*Arachis hypogaea* L.). Int. J. Curr. Microbiol. App. Sci., 6: 2538-2545.

Javaid, A. and Rauf, S. (2015). Management of basal rot disease of onion with dry leaf biomass of *Chenopodium album* as soil amendment. Int. J. Agric. Biol., 17(1):142-148.

Karna, S.K.L. (2013). Phytochemical screening and gas chromatography-mass spectrometry and analysis of seed extract of *Nigella sativa*. Int. J. Chem., 1(4):183-188.

Khaledi, N. and Hassani, F. (2021). Effect of seed-borne *Fusarium* species on constituents of essential oils from seeds of black cumin populations. Journal of Plant Protection Research, 61(3): 229-242

Khan S.; Ali, M.; Albratty, M.M.A.; Najmi, A.Y.; Azeem, U.; Khan, S.A. and Rather, M.A. (2022). *Nigella sativa*: From chemistry to medicine. In: Khan, A. and Rehman, M.U. (eds.), Black Seeds (*Nigella sativa*): Pharmacological and Therapeutic Applications. Elsevier: Amsterdam, The Netherlands, pp. 29-62. https://doi.org/10.1016/C2020-0-01733-0

Khedkar, S. and Khan, M.A. (2023). Aqueous extract of cinnamon (*Cinnamomum spp.*): Role in cancer and inflammation. Evidence-based Complementary and Alternative Medicine, 2:1-20. https://doi.org/10.1155/2023/5467342

Koch, L. (1876). Die Arachniden Australiens. Nürnberg, Bauer and Raspe, 1: 741–888

Kowalska, J.; Tyburski, J.; Krzymi´nska, J. and Jakubowska, M. (2020). Cinnamon powder: An in vitro and in vivo evaluation of antifungal and plant growth promoting activity. Eur. J. Plant Pathol., 156(1):237-243.

Land, B.B.; Navas-Corles, J.A.; Hervas, A. and Jimenez-Diaz, R.M. (2001). Influence of temperature and inoculum density of *Fusarium oxysporum* f. spp. *ciceris* on suppression of *Fusarium* wilt of chickpea by rhizosphere bacteria. Phytopathology, 91(8): 807-816

Lu, J.; Zhang, K.; Nam, S.; Anderson, R.A.; Jove, R. and Wen, W. (2010). Novel angiogenesis inhibitory activity in cinnamon extract blocks kinase and downstream signaling. Carcinogenesis, 31(3):481–488.

Ma, Y.; Freitas, H. and Dias, M.C. (2022). Strategies and prospects for biostimulants to alleviate abiotic stress in plants. Front. Plant Sci., 13(102):1-15. https://doi.org/10.3389/fpls.2022.1024243

Martinko, K. and Mioč, E. (2024). Antifungal Effect of cinnamon bark extract on the phytopathogenic fungus *Fusarium sporotrichioides.* Food Technol. and Biotechnol., 62(4):457-464.

Mohamed, A.S.K.; Abo-El-Yousr, A.M.; Amal, E. and Aida, E.Z. (2017). Isolation, identification, and biomanagement of root rot of black cumin (*Nigella sativa L.*) using selected bacterial antagonists. International Journal of Phytopathology, 6(3):47-56.

Mohamed, M.H.; Badr, E.A.; Sadak, M.S.H. and Khedr, H.H. (2020). Effect of garlic extract, ascorbic acid, and nicotinamide on growth, some biochemical aspects, yield, and its components of three faba bean (*Vicia faba* L.) cultivars under sandy soil conditions. Bull. Nat. Res. Cent., 44:1-8. https://doi.org/10.1186/s42269-020-00359-z

Mondal, S.; Pramanik, K.; Panda, D.; Dutta, D.; Karmakar, S. and Bose, B. (2022). Sulfur in Seeds: An Overview. Plants, 11(3):1-14. https://doi.org/10.3390/plants11030450

Monteiro, F.P.; Ferreira, L.C.; Silva, J.L.; Pacheco, L.P. and Souza, P.E. (2013). Influence of plant extracts and essential oils against panama disease (*Fusarium oxysporum* f. sp. *cubense*) in banana seedlings. Journal of Agricultural Science, 5(4):63-63.

Münchberg, U.; Anwar, A.; Mecklenburg, S. and Jacob, C. (2007). Polysulfides as biologically active ingredients of garlic. Org. Biomol. Chem., 5(10):1505-1518.

Nehal, S.E. and Abdel-Kader, M.M. (2007). Antifungal effect of powdered spices and their extracts on growth and activity of some fungi in relation to damping-off disease control. Journal of Plant Protection Research, 47 (3):268-278.

Omidbeygi, M.; Barzegar, M.; Hamidi, Z. and Naghdibadi, H. (2007). Antifungal activity of thyme, summer savory, and clove essential oils against *Aspergillus flavus* in liquid medium and tomato paste. Food Control, 18(12):1518-1523

Ortega, L.M.; Kikot, G.E.; Astoreca, A.L. and Alconada, T.M. (2013). Screening of *Fusarium graminearum* isolates for enzymes extracellular and deoxynivalenol production. Journal of Mycology, 23:1-7. https://doi.org/10.1155/2013/358140

Posmyk, M.M. and Szafranska, K. (2016). Biostimulators: A new trend towards solving an old problem. Front. Plant Sci., 7:1-6. https://doi.org/10.3389/fpls.2016.00748

Ramaiah, A.K.; Kumar R. and Garampalli, H. (2015). In vitro antifungal activity of some plant extracts against *Fusarium oxysporum* f. sp. *lycopersici*. Asian J. Plant Sci. Res., 5(1):22-27.

Reuveni, M.; Agapov, V. and Reuveni, R. (1996). Controlling powdery mildew caused by *Sphaerotheca fuliginea* in cucumber by foliar sprays of phosphate and potassium salts. Crop Protection, 15(1):49-53.

Rivlin, R.S. (2001). Historical perspective on the use of garlic. J. Nutr., 131(l3):951-954.

Sahin, F.M.G.; Daferera, D.; Sokmen, A.; Sokmen, M.; Polissiou, M.; Agar, G. and Ozer, H. (2004). Biological activities of the essential oils and methanol extract of *Origanum vulgare* spp. *vulgare* in the Eastern Anatolia region of Turkey. Food Contr., 15(7):549–557.

Sealy, R.; Evans, M.R. and Rothrock, C. (2007). The effect of a garlic extract and root substrate on soilborne fungal pathogens. HortTechnology, 17(2):169-173.

Shabana, Y.M.; Abdel Fattah, G.M.; Ismail, A.E. and Rashad, Y.M. (2004). Control of the brown spot pathogen of rice (*Bipolaris oryzae*) using some phenolic compound antioxidants. Brazilian Journal of Microbiology, 39(3):438-444.

Shivapratap, H.R.; Philip, T. and Sharma, D.D. (1996). In vitro antagonism of *Trichoderma* species against mulberry leaf spot pathogen, *Cercospora moricola*. Indian Journal of Sericulture, 35(2):107-110.

Sivapriya, T. and John, S. (2020). Qualitative, quantitative, and antioxidant analysis of phytochemicals present in *Cinnamomum zeylanicum* species. Indian Journal of Health Sciences and Biomedical Research, 13(2):105-111.

Ùesan, T.E.; Enache, E.; Iacomi, B.; Oprea, M.; Oancea, M.F. and Iacomimi, C. (2015). Antifungal activity of some plant extracts against *Botrytis Cinerea* Pers. in the blackcurrant crop (*Ribes Nigrum* L.). Acta Sci. Pol., Hortorum Cultus, 14(1): 29-43.

Wongpia, A. and Lomthaisong, K. (2010). Changes in the 2DE protein profiles of chilli pepper (*Capsicum annuum)* leaves in response to *Fusarium oxysporum* infection. Science Asia, 36(4):259-270.

Yimer, E. M.; Tuem, K. B.; Karim, A.; Ur-Rehman, N. and Anwar, F. (2019). *Nigella sativa* L. (black cumin): A promising natural remedy for a wide range of illnesses. Evidence-Based Complementary and Alternative Medicine, 6:1-16. https://doi.org/10.1155/2019/1528635

Yun, H.M.; Ban, J.O.; Park, K.R.; Lee, C.K.; Jeong, H.S.; Han, S.B. and Hong, J.T. (2014). Potential therapeutic effects of functionally active compounds isolated from garlic. Pharmacol. Ther., 142(2):183–195.

تأثير مستخلصات الثوم والقرفة على مرض الذبول وانتاجية نباتات حبة البركة

فل الندى محمد صالح* ، حسن عبد المتجلى عبد الموجود جودة** ، عادل فهمى أحمد*
* قسم بحوث النباتات الطبيه والعطرية، معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر
** معهد بحوث امراض النبات، مركز البحوث الزراعية، الجيزة، مصر

أُجريت هذه الدراسة خلال الموسيمين الزراعيين ٢٠٢٢/٢٠٢١ و٢٠٢٣/٢٠٢٢ فى مزرعة التجارب بمحطة بحوث عرب العوامر التابعة لمركز البحوث الزراعية محافظة اسيوط ، مصر. في هذه الدراسة تم تقييم تأثير المستخلصات من نباتات الثوم والقرفة بتركيزات ٢، ٤ و٦٪ مقارنة بالمبيد الفطرى ريزولكس بتركيز ٣ جم/كجم بذور كمضادات للفطريات المسببة لذبول النبات في المعمل والصوبة الزراعية وتم دراسة تاثير ذات المعاملات على نمو وجودة نبات حبة البركة في الحقل. أظهرت الدراسة المعملية أن استخدام المستخلص المائي لنبات القرفة بتركيز ٦٪ هو الاكثر فاعلية حيث أدى الى تثبيط نمو الفطر بنسبة ٧٧٪ مقارنة بالكنترول. أدت معاملة بذور حبة البركة بمستخلصات الثوم أوالقرفة بالتركيزات المستخدمة الى تثبيط العدوى الفطرية وسجلت أدنى شدة للمرض وأعلى إنتاج وذلك تحت ظروف الصوبة الزاعية عند استخدام أعلى تركيز (٦٪) من مستخلص الثوم يليه مستخلص القرفة مقارنة بمعاملة المقارنة والمعاملات الاخرى. في تجربة الزراعة في الحقل أدت معاملة بذور حبة البركة بمستخلصات الثوم والقرفة قبل الزراعة الى زيادة النمو والإنتاج وكان تركيز ٦٪ هو الأكثر فاعلية حيث أدى الى زيادة معنوية في كل الصفات المدروسة. في حين تم الحصول على أعلى نسبة زيت ثابت و مضادات أكسدة (٢٤,٩٥ و٧٦,٩٤٪على التوالي) من النباتات المعالجة بمستخلص الثوم كعلاج طبيعي عند تركيز ٦٪. أظهر تحليل الأحماض الدهنية في الزيت الثابت أن الأحماض الدهنية غير المشبعة: الأوليك و اللينوليك هما المكونان الرئيسيان مع وجود إختلافات غير معنوية بين المعاملات. كما وُجد أن معاملة البذور بمستخلص الثوم أدى الى زيادة نسبة حمضي اللينولينيك والبالميتوليك زيادة معنوية مقارنة بالمعاملات الأخرى.أظهرت النتائج أن مستخلصي الثوم والقرفة لهما خصائص جيدة مضادة للأكسدة ومنشطات نمو حيوية مما يؤدى الى تأكيد إستخدامها في الحماية الشاملة كبديل للمواد الكيماوية.