

Efficacy of Some Essential Oils on Controlling Powdery Mildew on *Zinnia* (*Zinnia Elegans*, L.)

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Abstract

Some essential oils were evaluated as biocontrol agents against powdery mildew on *Zinnia elegans*, L. A field experiment was carried out during the two successive seasons of 2006 and 2007 using marjoram, clove, cinnamon, garlic, ginger and fennel oils, added as foliar spray at 2 levels of 0.05 and 0.1 ppm besides Kema zein 75% and distilled water as a control. Disease incidence and severity as well as other vegetative parameters such as plant height, number of branches per plant, leaf area, fresh and dry weights of shoots, root length and fresh and dry weights of roots were determined in the two seasons. Also, peroxidase and polyphenol oxidase activities were determined after 24 hour from the last spray in leaves samples.

The highest significant decrease in disease incidence and severity and the best results for most studied growth and flowering parameters and total green colour were recorded with ginger, cinnamon and clove oils, respectively each at 0.1 ppm compared to the other treatments in both seasons. In addition, the activities of peroxidase (POX) and polyphenol oxidase (PPO) enzymes were increased as a result of oils sprayed on plants.

These findings provide for a rational basis of a possible utilization of these essential oils as a safe and alternative method to fungicides for controlling powdery mildew of *Zinnia* plants.

Keywords: *Zinnia elegans*, Essential oils, Powdery mildew, Biocontrol agents

1. Introduction

Zinnias are one of the easy to grow herbaceous summer annual flower, blooming from mid-summer all the way until frost. About 10 species of *Zinnia* are garden flowers but only the *Zinnia elegans* is the most popular. *Zinnia elegans* belongs to family Asteraceae and native to the Southwest United States, Mexico and Central America and therefore, likes an arm-hot climate. *Zinnia* plant's leaves are lance-shaped, sandpaper like in texture, stalkless, and have erect stems that bear opposite leaves and terminal flower heads. Zinnias come in an array of colors, multi-colors and hues. Zinnias come as yellow, orange, white, red, rose, pink, purple, lilac and multi-colored blooms. *Zinnia* varieties include both miniatures and giants that range from about a foot to over three feet tall. However, zinnia plants are challenged by many pathogens, of which *Erysiphe cichoracearum* is one of the important pathogens since it causes the most serious, powdery mildew disease in *Zinnia*. This pathogen attacks all plant parts causing damage to leaves and flowers, and flowers thus making them unmarketable.

The present work aimed to study the efficacy of certain essential oils in controlling powdery mildew on *Zinnia* caused by *Erysiphe cichoracearum*.

2. Material and Methods

A field experiment was carried out during the two successive seasons of 2007 and 2008 at the Experimental Farm of the Faculty of Agriculture, Kafr El- Sheikh University to evaluate some essential oils as biocontrol agents for powdery mildew on *Zinnia ellegans*, L.

Seeds were sown in nursery beds on March 15th in both seasons and seedlings were transplanted in May 1st to a clay soil in plots 1x 1.5m² at 50 cm apart as a twins in the hill, and each bed was divided into two parts (1x0.75 m²), so each part contained 12 plants (6 hills) and considered a replicate. Therefore, every treatment consisted of

36 plants (18 hills) in the three replicates. The experiment was arranged in a completely randomized block design.

The plants including control were fertilized with the recommended dose of N, P and K (100, 200 and 100 kg/ fed., respectively), beginning from May 15th and repeated three times with two weeks interval. The used fertilizers were ammonium sulphate "20% N", calcium super phosphate "15.5% P₂ O₅" and potassium sulphate "48% K₂ O". The common agricultural practices i.e. watering, weeding control, etc. were done whenever plants needed.

The used oils were marjoram, clove, cinnamon, garlic, ginger and fennel added as a foliar spray at 2 levels of 0.05 and 0.1 ppm. Tween-20 was used as a surfactant at the rate of 0.1% "v/v". Kemah zein 75% was used at the recommended dose (2 g/l). The plants were sprayed four times beginning from June 15th with one week interval by a hand atomizer as soon as the first signs of the symptoms were observed. For control treatments, plants were sprayed with distilled water only. Percentage of disease incidence and severity were determined after 7 days from the last spray according to the scale reported by Horsfall and Barrett (1945) and Biswas *et al.*, (1992).

2.1 Enzyme extraction and assay

Leaf samples of each treatment, healthy and infected were collected after 24h of the treatment for peroxidase and polyphenol oxidase enzymes activity assay. Also, untreated healthy and infected leaves were used as control. Enzyme extract was obtained by grinding leaf tissue in 0.1 M sodium phosphate buffer at pH 7.1 (2m/g leaf tissues) in a porcelain mortar. The extracted tissues were strained through four layers of cheesecloth. Filtrates were centrifuged at 3000 rpm for 20 min. at 6°C. The clear supernatants were collected and considered as crude enzyme extract. Peroxidase (POX) activity was determined according to the method of Allam and Hollis (1972) by measuring the oxidation of pyrogallol to pyrogalline in the presence of hydrogen peroxide. Peroxidase activity was measured following the changes in absorbance at 425 nm every 1 min. up to 4 minutes. Polyphenol oxidase (PPO) was determined according to Maxwell and Batman (1976). The changes in absorbance following spectrophotometrically were measured at 495 nm, and recorded every 1 min. up to 4 min. All measurements were assayed using Beckman Spectrophotometer Du®7400.

The treatments were conducted as follows:

- | | |
|-------------------------------|-----------------------------|
| 1- Distilled water (control). | 2- Kemah zein 75%. |
| 3- Marjoram oil at 0.05 ppm. | 4- Marjoram oil at 0.1 ppm. |
| 5- Clove oil at 0.05 ppm. | 6- Clove oil at 0.1 ppm. |
| 7- Cinnamon oil at 0.05 ppm. | 8- Cinnamon oil at 0.1 ppm. |
| 9- Garlic oil at 0.05 ppm. | 10- Garlic oil at 0.1 ppm. |
| 11- Ginger oil at 0.05 ppm. | 12- Ginger oil at 0.1 ppm. |
| 13- Fennel oil 0.05 ppm. | 14- Fennel oil at 0.1 ppm. |

At the end of the experiment, the following data were recorded:

- 1- Plant height (cm),
- 2- Branch number/ plant.
- 3- Leaf area (cm²).
- 4- Shoots fresh and dry weights /plant (g).
- 5- Root length (cm).
- 6- Roots fresh and dry weights /plant (g).
- 7- Flower number /plant.
- 8- Flower diameter (cm).
- 9- Flower fresh and dry weights (g).
- 10- Total green colour (SAPD).

Means between treatments were compared with Duncan's Multiple Range Test according to Snedecor and Cochran (1982).

3. Results

3.1 Effect on disease incidence and severity

In this investigation, the essential oils of marjoram, clove, cinnamon, garlic, ginger and fennel plants were evaluated to control powdery mildew disease of Zinnia plants under field conditions. Data presented in Table (1) and illustrated in fig (1) showed that all essential oils and Kemah zein 75% treatments significantly decreased disease incidence in terms of average number of powdery mildew spots/leaf and disease severity (percent of surface infected area) on Zinnia plants more than control (distilled water treatment) in both seasons. Results indicated that, the best treatment condition was obtained at 0.1 ppm compared to 0.05 ppm in most cases, to control the disease. The oil of ginger at 0.1 ppm was the most efficient treatment than others on disease incidence and severity in both seasons. It significantly decreased disease incidence and severity from 30.78-1.2 %, 87.2-6.0%, respectively in the first season and from 35.69-1.6%, 91.5-6.5%, respectively in the second one. This was followed by cinnamon oil treatment, since it decreased disease incidence and severity from 30.78-1.4%, 87.2-6.7%, respectively in the first season and from 35.69-1.7%, 91.5-6.8%, respectively in the second season. Treatment with clove oil decreased both disease incidence and severity from 30.78-1.6%, 87.2-7.0%, respectively in the first season and from 35.69-1.8%, 91.5-7.5%, respectively in the second one. The treatment of oil of Marjoram was the least effective treatment used at either 25 or 50% in both seasons. In general, all used treatments gave best or similar results with those obtained when the fungicide Kemazein 75% was used.

3.2 Effect on peroxidase and polyphenol oxidase activity

Data presented in Table (2) show that peroxidase and polyphenol oxidase activities were significantly increased as a results of spraying plants with these treatments. The higher activity of peroxidase was observed when Ginger oil at 0.1 ppm used as recorded 2.115, 2.146, 2.149 and 2.155, respectively. This followed by the treatment of Fennel oil at 0.1 ppm as recorded 1.961, 1.980, 1.981 and 1.988, respectively against 0.403, 0.405, 0.409 and 0.413, respectively for control.

As for polyphenol oxidase activity, data presented in Table (3) revealed that, all oils tested and Kemah 75% zein increased polyphenol oxidase activity over control. It was clear from data that, the higher concentration of all the essential oils caused higher activity of peroxidase and poly phenol oxidase than the lower concentrations in both seasons. The highest values for polyphenol oxidase activity were recorded when the treatment of cinnamon oil at 0.1 ppm was used as gave 0.115, 0.145, 0.154 and 0.157, respectively in both seasons. This was followed by the treatment of 0.1 ppm ginger oil at which gave 0.114, 0.143, 0.152 and 0.155, respectively. The lowest enzyme activities in both seasons resulted from the treatment of marjoram oil at both concentrations.

3.3 Effect on some growth characters

3.3.1 Plant height

Data presented in Table (4) revealed that all oils and Kemah zein 75% treatments significantly increased plant height over control in both seasons. The tallest plants in both seasons resulted from the treatment of ginger oil (0.1 ppm), Kemah zein 75% as gave 196.00, 177.58, and 194.50, and 177.51 cm followed by clove oil (0.1 ppm) than cinnamon oil (0.1 ppm) as gave 190 and 176.98 cm, respectively in the first season.

In the second rank lies oil of clove (0.05 ppm) and (0.1 ppm) in the second season as gave 188.00 and 175.36 cm, respectively. The shortest plants were obtained from the treatment of oil of marjoram (0.05 ppm) and (0.1 ppm) as gave 160.33 and 158.44 cm, respectively against 116.00 and 125.71 cm for control in both seasons.

3.3.2 Branch number

As shown in Table (4) the data revealed that all essential oils and Kemah zein75% treatments significantly increased number of branches over control in the two seasons. Both cinnamon oil concentrations (0.05 and 0.1 ppm) and Kemah zein75% gave the highest number of branches as recorded 10.67, 10.33 and 10.30, respectively in the first season while in the second one, were the treatments of cinnamon oil at 0.1 ppm and Kemah zein75% as gave 8.55 and 8.49, respectively.

In the second rank were the oils of cinnamon (0.05 ppm) and clove (0.1 ppm) in the first and second seasons as gave 10.33 and 8.12, respectively. The lowest branch number resulted from the treatments of marjoram oil (0.05 and 0.1 ppm) and fennel oil (0.05 ppm) in the first season and marjoram oil (0.05 ppm) in the second one as recorded 6.00, 6.33 and 6.00 and 5.85, respectively.

3.3.3 Leaf area

It was obvious from data in Table (5) that all used oils at both concentrations and Kemah zein75% gave the wide leaves than control in both seasons. The widest leaves resulted from plants sprayed with oil of cinnamon at 0.1 ppm in both seasons and Kemah zein75% in the second one as recorded 52.20 and 48.66 and 48.55 cm², respectively. This followed by the treatment of ginger oil at 0.1 ppm and Kemah zein75% in the first season as gave 49.57 and 48.95 cm² and ginger oil at 0.05 ppm and Kemah zein75% in the second one as recorded 48.50 and 48.55 cm², respectively.

In the second rank lies the treatment of cinnamon oil at 0.05 ppm in the first season as gave 44.23 cm² whereas in the second one were the treatments of cinnamon oil at 0.05 and ginger oil at 0.1 ppm as gave 47.84 and 47.88 cm², respectively. The smallest leaves resulted from the treatments of garlic oil 0.05 ppm in the first season and marjoram oil at 0.05 ppm in the second one as gave 29.33 and 31.79 cm², respectively against 21.58 and 27.25 cm² for control in both seasons.

3.3.4 Shoot's fresh and dry weights

It is clear from data in Tables (5 and 6) that all oils and Kemah zein75% treated plants gave significantly high values for both fresh and dry weights of shoots than control in both seasons. The heaviest fresh and dry shoots /plant in the first season resulted from the treatments of Ginger oil at 0.1 ppm and Kemah zein 75% as recorded 336.08 326.09 g fresh weight and 42.23, and 40.12 g dry weight. Whereas in the second one were the treatments of clove oil at 0.1 ppm as recorded 286.08 and 41.17 g, respectively. This was followed by the treatments of cinnamon oil at 0.1 ppm for fresh weight and ginger oil at 0.05 ppm for dry weight in the first season, as gave 315.62 and 38.27g, respectively. However, in the second one were the treatments of ginger oil at 0.1 ppm and Kemah zein75% for fresh weight and clove oil at 0.05 ppm and Kemah zein75% for dry weight as gave 283.78 and 280.55 g fresh weight and 36.92 and 36.88 g dry weight, respectively.

The lightest fresh and dry shoots /plant in both seasons were obtained from the treatment of marjoram oil at 0.05 ppm as recorded 178.04, 244.48, 20.27 and 25.15 g, respectively against 99.25, 112.52, 9.04 and 11.42 g, respectively for control.

3.3.5 Root length

Data in Table (6) reveal that all used treatments gave significantly taller roots than control in both seasons. The tallest roots in the first season resulted from the treatments of clove oil at 0.1 ppm, ginger oil at 0.1 ppm and cinnamon oil at 0.1 ppm as recorded 17.67, 17.62 and 17.00 cm, respectively against 11.67 cm for control without significant differences among themselves in most cases. Whereas in the second season was the treatment of clove oil at 0.1 ppm as gave 13.15 cm against 7.52 cm for control, with significant differences among themselves in all cases.

3.3.6 Root's fresh and dry weights

Data presented in Table (7) show that essential oils and Kemah zein75% treatments significantly increased both roots fresh and dry weights over control in both seasons. The heaviest fresh roots resulted from Ginger oil at 0.1 ppm and Kemah zein75% in the first season and clove oil at 0.1 ppm in the second one as gave 16.24 and 16.20; and 11.13 g/ plant. The lightest fresh roots resulted from the treatment of cinnamon oil at 0.05 ppm in the first season and fennel oil at 0.05 ppm in the second one as gave 15.16 and 9.10 g, respectively against 11.40 and 8.58 g for control in both seasons. As for roots dry weight, data show that the heaviest roots resulted from the treatments of clove oil at 0.05 ppm, clove oil at 0.1 ppm and ginger oil at 0.1 ppm in the first season with significant differences among themselves in all cases as gave 2.30, 2.31 and 2.30 g, respectively. In contrast to this, there were no significant differences among most treatments in the second season. The heaviest roots resulted from the treatments of clove oil at 0.1 ppm, cinnamon oil at 0.1 ppm, Kemah zein 75%, clove oil at 0.05 ppm and cinnamon oil at 0.05 ppm as gave 1.53, 1.51, 1.50, 1.48 and 1.48 g, respectively. The lightest dry roots in both seasons resulted from the treatment fennel oil at 0.05 ppm as gave 2.10 and 1.27 g against 1.55 and 1.18 g for control in the two seasons, respectively.

3.4 Effect on flowering characters

3.4.1 Flower number

Data in Table (8) indicated that all used treatments significantly increased the flower number over control in both seasons. In the first season, there were non-significant differences among most treatments. The highest flower number resulted from the treatments of clove oil at 0.1 ppm, Kemah zein75%, cinnamon oil at 0.1 ppm, ginger

oil at 0.1 ppm, cinnamon oil at 0.05 ppm, ginger oil at 0.05 ppm and clove oil at 0.05 ppm as gave 27.00, 27.00, 26.95, 26.67, 26.33, 26.00 and 25.67, respectively against 10.01 for control.

In contrast to this, the significantly highest flower number in the second season resulted from the treatment of ginger oil at 0.1 ppm as gave 18.11. The lowest flower number resulted from the treatments of marjoram oil at 0.05 ppm and fennel oil at 0.05 ppm in the first season as gave 18.00 and 17.00, and marjoram oil at 0.05 ppm in the second one as gave 15.19 against 11.21 for control.

3.4.2 Flower diameter

Data of the effect of the used treatments on flower diameter presented in Table (8) showed that all used treatments increased flower diameter over control in both seasons. The biggest flower in the first season resulted from plants treated with ginger oil at 0.05 ppm, ginger oil at 0.1 ppm, fennel oil at 0.1 ppm and cinnamon oil at 0.1 ppm without significant differences among themselves in most cases, as recorded 7.17, 6.97, 6.83 and 6.73 cm, respectively against 4.00 cm for control. Whereas in the second one this resulted from the plants treated with ginger oil at 0.05 ppm, followed by cinnamon oil at 0.05 ppm as recorded 6.97 and 5.87 cm, respectively against 3.21 cm for control.

3.4.3 Flower fresh and dry weights

From Table (9) it may be observed that all used essential oils at both concentrations and Kemah zein75% gave the heavier fresh and dry weights of flower than control in both seasons. The heaviest fresh and dry weights in the first season resulted from the plants treated with oil of ginger at 0.1 ppm as gave 3.03 and 0.71 g, respectively. Whereas in the second one were the plants treated with both cinnamon oil at 0.05 ppm and ginger oil at 0.05 ppm for fresh weight and ginger oil at 0.05 ppm for dry weight as gave 5.13, 5.18 and 1.03g, respectively. The lightest fresh and dry weights in the first season resulted from plants treated with garlic oil at 0.05 ppm as gave 2.50 and 0.54 g against 1.95 and 0.32 g for control. However, in the second one this resulted from the plants treated with fennel oil at 0.1 ppm as gave 4.28 and 0.64 g against 2.52 and 0.51 g for control.

3.5 Effect on total green colour

Data in Table (10) revealed that all treated plants were greener than untreated ones in both seasons. The greenest plants were those treated with ginger oil at 0.1 ppm and Kemah zein75% in the first season as gave 33.85 and 3380 SAPD, and cinnamon oil at 0.1 ppm in the second one as gave 38.72 SAPD, respectively. The palest plants were those treated with marjoram oil at 0.05 ppm in the first season and marjoram oil at 0.1 ppm in the second one as gave 25.44 and 33.65 SAPD, respectively against 23.85 and 28.84 SAPD for control in the two seasons, respectively.

4. Discussion

In this study, results indicated that disease incidence and severity of powdery mildew on *Zinnia elegans*, L was significantly decreased by spraying some essential oils: ginger, cinnamon and clove each at 0.1 ppm, four times beginning from June 15th with 7 days interval. The results showed that these three treatments significantly surpassed others in most cases and the essential oils treatments gave best or similar results with those obtained when the fungicide Kemazein 75% was used.

These findings could be explained according to previous authors who stated that essential oils have important ecological functions. One of these functions is to protect the plant against infection by pathogens (Taiz and Zeiger, 1991 and El-Kazzaz *et al.*, 2003). The mycelia growth of *Aspergillus flavus* Link was completely inhibited and the hyphal diameter decreased and hyphal wall appeared as precipitates and disappeared in some regions when oil of *Cymbopogon citratus* L. was used. In addition, they found that oil treatment caused plasma membrane disruption and mitochondrial structure disorganization (Helal *et al.*, 2007)). Scarito *et al.* (2007) studied the effect of essential oils of oregano and clove at 0.125 and 0.5 ml/L concentrations on roses. They found that, an inhibitory activity of both essential oils at higher concentration without toxicity phenomena were found at either concentration of the essential oils treatments. Other investigators reported that the essential oils contained specific components, antifungal compounds and fungitoxic agents that can inhibit the growth of certain microorganisms (Farang *et al.*, 1989; Zambonelli, 1996; El-Shoraky, 1998; Chao *et al.*, 2000; El-Shazly, 2000; Abd El-Kader *et al.*, 2003; Voda *et al.*, 2003; Moleyar and Narasimham, 2004; Sheng *et al.*, 2005 and Krishna Kishore and Pande, 2007).

Results also showed that spraying zinnia plants with these essential oils caused higher activity of peroxidase and polyphenol oxidase enzymes than control. The highest activity of enzymes was correlated with decreases of infection with pathogen of powdery mildew disease. This means that spraying plants with essential oils gave a defense to plants from invasion with pathogen. Many investigators explained these results since they reported

that peroxidase is known to be involved in the oxidation of polymerization of hydroxycinnamyl alcohols to yield lignin and cross-linking isodityrosine bridges in cell wall, peroxidase also produces free radicals and hydrogen peroxide which are toxic to many microorganisms (Vance et al., 1980; Fry, 1982 and Pena and Kuc, 1992). Also, Ride, 1983 and Tarrad, 1983 stated that the increase in peroxidase activity enhances lignifications in response to infection with pathogens which may restrict fungal penetration.

These findings provide for a rational basis of a possible utilization of these essential oils as a safe and alternative method to fungicides for controlling powdery mildew of Zinnia plants.

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Table 1. Effect of some essential oils and Kemah zein 75% treatments on incidence and severity of powdery mildew disease of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatment	Conc.	Average no. of spots/leaf (Disease incidence)		Percent of surface infected area (Disease severity)	
		2006	2007	2006	2007
Distilled water (control)	-	30.78a	35.69a	87.2a	91.5a
Kemah zein 75%	2 g/l	2.7e	2.3g	8.9e	10.2f
Marjoram oil	0.05 ppm	9.6c	11.9b	23.5b	24.5b
	0.1 ppm	9.7b	10.8c	19.2c	20.4c
Clove oil	0.05 ppm	1.9j	2.1h	7.4i	7.8k
	0.1 ppm	1.6l	1.8j	7.0l	7.5n
Cinnamon oil	0.05 ppm	1.8k	1.9i	7.3j	7.6m
	0.1 ppm	1.4m	1.7k	6.7m	6.8o
Garlic oil	0.05 ppm	2.3h	2.4f	8.5f	10.4e
	0.1 ppm	2.6f	2.5e	8.2g	8.7j
Ginger oil	0.05 ppm	2.0i	1.9i	7.2k	7.7l
	0.1 ppm	1.2n	1.6l	6.0n	6.5p
Fennel oil	0.05 ppm	3.2de	3.4d	9.1d	11.5d
	0.1 ppm	2.4g	2.1h	7.5h	9.5i

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test.

Table 2. Activity of peroxidase in leaves of *Zinnia elegans*, L. after 24 hours from the last treatment with essential oils 75%

Treatments	Conc.	Peroxidase activity/minute after 24 h			
		1	2	3	4
Distilled water (control)	-	0.403g	0.405m	0.409k	0.413e
Kemah zein 75%	2gm/L	1.112cde	1.115j	1.121h	1.125cd
Marjoram oil	0.05 ppm	0.677fg	0.701l	0.713j	0.723e
	0.1 ppm	0.723efg	0.748k	0.759i	0.766de
Clove oil	0.05 ppm	1.461bcd	1.575f	1.606e	1.629bc
	0.1 ppm	1.556def	1.672e	1.687d	1.692cd
Cinnamon oil	0.05 ppm	1.411bcd	1.506h	1.533f	1.572bc
	0.1 ppm	1.767ab	1.892d	1.907c	1.914ab
Garlic oil	0.05 ppm	1.235cd	1.250i	1.357g	1.369c
	0.1 ppm	1.464bcd	1.561f	1.600e	1.626bc
Ginger oil	0.05 ppm	1.531bc	1.544g	1.549f	1.555bc
	0.1 ppm	2.115a	2.146a	2.149a	2.155a
Fennel oil	0.05 ppm	1.771ab	1.943c	1.981b	1.991ab
	0.1 ppm	1.961a	1.980b	1.981b	1.988ab

Means within a column having the same letters are not significantly different according to Duncan,s Multiple Range Test.

Table 3. Activity of polyphenol oxidase (PPO) in leaves of *Zinnia elegans*, L. after 24 hours from the last treatment with essential oils 75%

Treatments	Conc.	polyphenol oxidase activity/minute			
		1	2	3	4
Distilled water (control)	-	0.043d	0.071h	0.073f	0.077h
Kemah zein 75%	2g/l	0.113a	0.117b	0.119b	0.082gh
Marjoram oil	0.05 ppm	0.072bc	0.073gh	0.076ef	0.078h
	0.1 ppm	0.050d	0.097cde	0.100bc	0.102cdef
Clove oil	0.05 ppm	0.058cd	0.090efg	0.092cde	0.095efgh
	0.1 ppm	0.087b	0.102bcde	0.104bc	0.105bcde
Cinnamon oil	0.05 ppm	0.111a	0.112bcd	0.114b	0.116bc
	0.1 ppm	0.115a	0.145a	0.154a	0.157a
Garlic oil	0.05 ppm	0.074bc	0.111bcd	0.114b	0.115bcd
	0.1 ppm	0.088b	0.115bc	0.119b	0.123b
Ginger oil	0.05 ppm	0.082b	0.094def	0.095cd	0.097defg
	0.1 ppm	0.114a	0.143a	0.152a	0.155a
Fennel oil	0.05 ppm	0.050d	0.077fgh	0.081def	0.085fgh
	0.1 ppm	0.111a	0.112bcd	0.114b	0.115bcd

Means within a column having the same letters are not significantly different according to Duncan,s Multiple Range Test.

Table 4. Effect of some essential oils and Kemah zein 75% on plant height (cm) and branches number of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatments	Conc.	Plant height (cm)		Branch No./ plant	
		2006	2007	2006	2007
Distilled water	-	116.00j	125.71l	3.67f	4.05l
Kemah zein 75%	2g/l	194.50a	177.51a	10.30ab	8.49a
Marjoram oil	0.05 ppm	160.33i	164.31i	6.00e	5.85k
	0.1 ppm	164.00h	158.44k	6.33e	6.10i
Clove oil	0.05 ppm	188.00c	171.48e	7.33d	7.54e
	0.1 ppm	190.00b	175.36c	8.00c	8.12b
Cinnamon oil	0.05 ppm	165.00gh	170.64g	10.33ab	7.90c
	0.1 ppm	175.00e	176.98b	10.67a	8.55a
Garlic oil	0.05 ppm	165.30g	165.48h	7.00d	6.56g
	0.1 ppm	170.00f	170.71f	8.00c	7.13f
Ginger oil	0.05 ppm	183.00d	175.23d	8.00c	7.66d
	0.1 ppm	196.00a	177.58a	10.00b	8.17b
Fennel oil	0.05 ppm	166.00g	162.70j	6.00e	5.94j
	0.1 ppm	170.00f	164.31i	7.00d	6.27h

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test

Table 5. Effect of some essential oils and Kemah zein 75% on leaf area (cm²) and shoots fresh weight (g) /plant of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatments	Conc.	Leaf area (cm ²)		Shoots F.W. / plant (g)	
		2006	2007	2006	2007
Distilled water	-	21.58m	27.25l	99.25m	112.52l
Kemah zein 75%	2g/l	48.95b	48.55ab	326.09a	280.55b
Marjoram oil	0.05 ppm	30.60j	31.79k	178.04l	244.48k
	0.1 ppm	31.80i	34.27i	187.63j	259.80h
Clove oil	0.05 ppm	35.50f	37.22g	289.05f	277.62c
	0.1 ppm	37.63e	46.55d	305.77d	286.08a
Cinnamon oil	0.05 ppm	44.23c	47.84c	295.64e	268.53g
	0.1 ppm	52.20a	48.66a	315.62b	277.32d
Garlic oil	0.05 ppm	29.33l	39.12f	242.51h	245.83j
	0.1 ppm	34.67g	41.59e	268.06g	268.97f
Ginger oil	0.05 ppm	42.37d	48.50b	312.78c	275.24e
	0.1 ppm	49.57b	47.88c	336.08a	283.78b
Fennel oil	0.05 ppm	30.23k	32.45j	182.06k	258.81i
	0.1 ppm	33.52h	35.20h	188.45i	269.13f

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test.

Table 6. Effect of some essential oils and Kemah zein 75% on shoots dry weight (g) /plant and root length (cm) of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatments	Conc.	Shoots D.W./ plant (g)		Root length (cm)	
		2006	2007	2006	2007
Distilled water	-	9.04m	11.42l	11.67d	7.52m
Kemah zein 75%	2g/l	40.12a	36.88b	16.58b	12.95bc
Marjoram oil	0.05 ppm	20.27l	25.15k	16.00c	10.45k
	0.1 ppm	21.50k	30.28f	16.33bc	11.60f
Clove oil	0.05 ppm	30.77h	36.92b	16.60bc	12.88c
	0.1 ppm	33.74e	41.17a	17.67a	13.15a
Cinnamon oil	0.05 ppm	32.75f	26.85i	16.33bc	12.47e
	0.1 ppm	37.22c	35.49c	17.00ab	13.02b
Garlic oil	0.05 ppm	31.53g	28.61g	16.03c	11.26h
	0.1 ppm	34.33d	26.52j	16.08c	10.67j
Ginger oil	0.05 ppm	38.27b	32.62e	16.67bc	11.45g
	0.1 ppm	42.23a	35.22d	17.62a	12.74d
Fennel oil	0.05 ppm	22.63i	26.83i	16.00c	10.26l
	0.1 ppm	21.77j	27.75h	16.01c	11.08i

Means within a column having the same letters are not significantly different according to Duncan,s Multiple Range Test.

Table 7. Effect of some essential oils and Kemah zein 75% on roots fresh and dry weights (g)/ plant of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatments	Conc.	Roots F.W./ plant (g)		Roots D.W./ plant (g)	
		2006	2007	2006	2007
Distilled water	-	11.40i	8.58l	1.55g	1.18f
Kemah zein 75%	2g/l	16.20a	10.88b	2.26b	1.50a
Marjoram oil	0.05 ppm	15.38g	9.66j	2.27b	1.35cd
	0.1 ppm	15.46f	10.24f	2.20d	1.45b
Clove oil	0.05 ppm	15.83d	10.83c	2.30a	1.48ab
	0.1 ppm	16.01b	11.13a	2.31a	1.53a
Cinnamon oil	0.05 ppm	15.16h	10.34e	2.10f	1.48ab
	0.1 ppm	15.58e	10.91b	2.24c	1.51a
Garlic oil	0.05 ppm	15.38g	9.75i	2.17e	1.32d
	0.1 ppm	15.46f	10.14g	2.10f	1.38c
Ginger oil	0.05 ppm	15.90c	10.00h	2.20d	1.36cd
	0.1 ppm	16.24a	10.55d	2.30a	1.45b
Fennel oil	0.05 ppm	15.33g	9.10k	2.10f	1.27e
	0.1 ppm	15.35g	9.77i	2.20d	1.34cd

Means within a column having the same letters are not significantly different according to Duncan,s Multiple Range Test.

Table 8. Effect of some essential oils and Kemah zein 75% on flower number and flower diameter (cm) of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatments	Conc.	Flower No./ plant		Flower diameter (cm)	
		2006	2007	2006	2007
Distilled water	-	10.01f	11.21k	4.00e	3.21l
Kemah zein 75%	2g/l	26.95a	17.85b	6.62b	4.85c
Marjoram oil	0.05 ppm	18.00de	15.19j	5.50d	4.66f
	0.1 ppm	19.00cd	15.61i	6.40b	4.82cd
Clove oil	0.05 ppm	25.67ab	16.21h	5.67d	4.31h
	0.1 ppm	27.00a	17.81b	5.83cd	4.08i
Cinnamon oil	0.05 ppm	26.33a	16.81g	6.33bc	5.87b
	0.1 ppm	27.00a	17.75c	6.73ab	4.50g
Garlic oil	0.05 ppm	20.67c	16.88f	5.50d	4.01j
	0.1 ppm	24.33b	17.20e	6.33bc	4.87c
Ginger oil	0.05 ppm	26.00ab	17.52d	7.17a	6.01a
	0.1 ppm	26.67a	18.11a	6.97a	4.81d
Fennel oil	0.05 ppm	17.00e	15.58i	6.33bc	4.72e
	0.1 ppm	17.37de	16.92f	6.83ab	3.95k

Means within a column having the same letters are not significantly different according to Duncan,s Multiple Range Test.

Table 9. Effect of some essential oils and Kemah zein 75% on flower fresh and dry weights (g) of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatments	Conc.	Flower F.W. (g)		Flower D.W. (g)	
		2006	2007	2006	2007
Distilled water	-	1.95j	2.52i	0.32i	0.51h
Kemah zein 75%	2g/l	2.90b	4.86bc	0.65b	0.83c
Marjoram oil	0.05 ppm	2.65h	4.71de	0.55gh	0.80c
	0.1 ppm	2.71ef	4.80c	0.57e	0.78cd
Clove oil	0.05 ppm	2.65h	4.68e	0.55fgh	0.71ef
	0.1 ppm	2.70g	4.37g	0.56efg	0.68ef
Cinnamon oil	0.05 ppm	2.89c	5.13a	0.63c	0.96b
	0.1 ppm	2.93b	4.80c	0.65b	0.73de
Garlic oil	0.05 ppm	2.50i	4.40g	0.54h	0.66fg
	0.1 ppm	2.74e	4.75cd	0.57ef	0.83c
Ginger oil	0.05 ppm	2.77d	5.18a	0.66b	1.03a
	0.1 ppm	3.03a	4.92b	0.71a	0.81c
Fennel oil	0.05 ppm	2.72f	4.52f	0.59d	0.51h
	0.1 ppm	2.76d	4.28h	0.61c	0.83c

Means within a column having the same letters are not significantly different according to Duncan,s Multiple Range Test.

Table 10. Effect of some essential oils and Kemah zein 75% on total green colour (SAPD) of *Zinnia elegans*, L. during 2006 and 2007 seasons

Treatments	Conc.	Total green colour (SAPD)	
		2006	2007
Distilled water	-	23.85k	28.84m
Kemah zein 75%	2g/l	33.80a	37.49b
Marjoram oil	0.05 ppm	25.44j	34.71j
	0.1 ppm	25.94i	33.65l
Clove oil	0.05 ppm	28.98g	35.88g
	0.1 ppm	31.61c	37.55b
Cinnamon oil	0.05 ppm	30.46e	36.81d
	0.1 ppm	31.45d	38.72a
Garlic oil	0.05 ppm	30.06f	35.34i
	0.1 ppm	31.69c	37.21c
Ginger oil	0.05 ppm	33.39b	35.44h
	0.1 ppm	33.85a	36.75e
Fennel oil	0.05 ppm	25.95i	34.66k
	0.1 ppm	26.48h	36.40f

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range

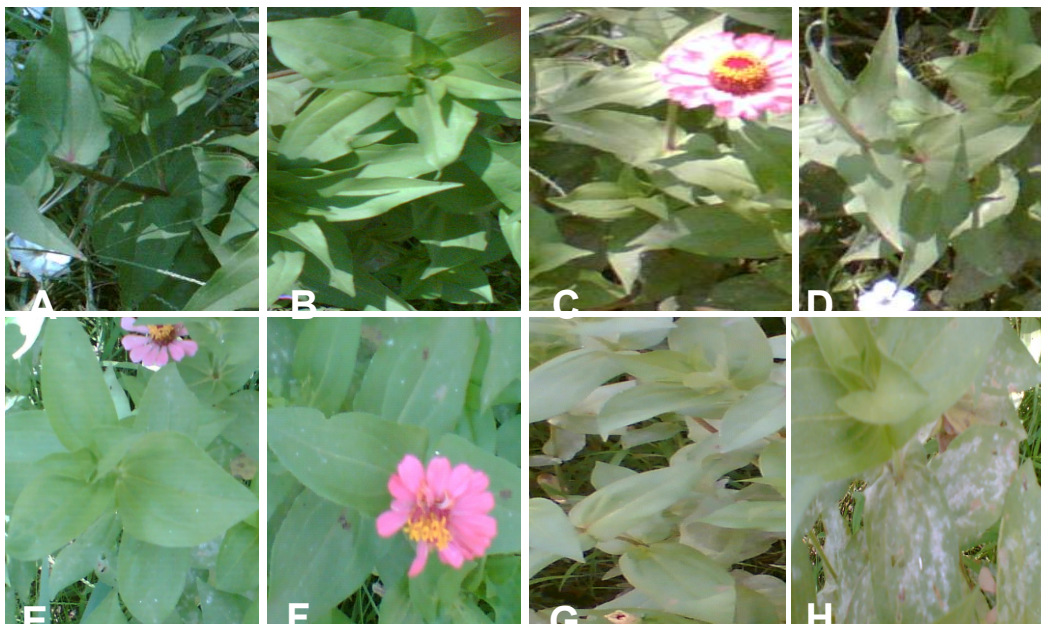


Figure 1. Effect of ginger oil (A), cinnamon oil (B), garlic oil (C), fennel oil (D), clove oil (E), Kimazien 75% (F), marjoram oil (G) on powdery mildew incidence of *Zinnia* compared with control (H).