INTERACTION OF *CUCUMBER MOSAIC VIRUS* WITH THE ROOT-KNOT NEMATODE, *MELOIDOGYNE INCOGNITA*, AND EFFECTS OF CERTAIN MEDICINAL AND AROMATIC PLANTS ON INFECTED CUCUMBERS

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Summary. Three experiments were conducted in a greenhouse to investigate the interaction of *Cucumber mosaic virus* (CMV) with the root-knot nematode, *Meloidogyne incognita*, in cucumber. In the first experiment, the effects of different inoculum levels of *M. incognita* (0, 100 and 1000 second stage juveniles per pot containing 2 kg soil), alone or in combination with CMV, were investigated on cucumber cv. Alpha Beta. Numbers of galls and egg masses of the nematode were greater on the roots of cucumber infected with the nematode alone than on those of plants inoculated with both the nematode and the virus. In the second experiment, the intercropping of cucumber with some medicinal plants was tested by planting them beside cucumbers. The numbers of juveniles of *M. incognita* in the soil were reduced ($P \leq 0.05$) and there were no significant differences among the tested plant species, one medicinal (*Ambrosia maritima*) and three aromatic (*Dianthus caryophyllus*, *Ocimum basilicum* and *Zinnia elegans*). In the third experiment, amendment of the soil with leaf powders of the same plants reduced the numbers of galls and egg masses of the nematode in the roots of cucumbers. In all cases, the treatments reduced the concentration and number of local lesions of the virus and enhanced plant growth and yield.

Keywords: Control, medicinal and aromatic plants, virus-nematode interaction.

Cucumber mosaic virus (CMV) has a host range of over 700 species of plants. It is transmitted by aphids, which can acquire this virus within 5 to 10 seconds. CMV is then spread from plant to plant within a few hours. The virus is also spread mechanically in the plant sap when cuttings are taken from infected stock plants and may be transmitted by both seed and pollen, with symptoms developing in very young plants (Ozaslan *et al*., 2006). It is well known that *Meloidogyne* spp. are not vectors of plant viruses but, under field conditions, it is observed that *Meloidogyne* spp. occur concomitantly with viruses in the same plant, as is the case with cucumber. Often, a plant stressed by a pathogen is less susceptible to attack by another parasite. However, whether this would occur with CMV and *M. incognita*, both common in Egypt, was not known. Varshney *et al.* (2005) and Ahmed *et al*. (2007) observed that more root-knot nematodes were recorded in plants inoculated only with the nematode than in those inoculated with both nematode and virus.

In Egypt, farmers tend to use intercropping to increase the production per area unit and to save on irrigation water. Some plant species are known to inhibit infection of CMV (Abo-Elghar, 1976; Taniguchi, 1980). Jayashree and Sabitha (1999) and Sabitha and Jayashree (1999) found that leaf extract of common basil affected the development of lesions of *Okra yellow vein mosaic virus* and *Pumpkin yellow vein mosaic virus*. Also, some medicinal plants when intercropped with certain plants reduced infection by root-knot nematodes (El-Hamawi *et al*., 2004; El-Nagdi, 2006). As flowers of carnation and zinnia contain substances toxic to nematodes and these substances may be found in the roots, stems and other plant parts, we also used these plants as intercropping and organic amendments. Hence the purpose of this study was to investigate *i*) the reciprocal effects of the root-knot nematode *M. incognita* (Kofoid *et* White) Chitw., at different inoculum levels, and CMV infecting cucumber (*Cucumis sativus* L.), alone or in combination, and *ii*) the effect of intercropping and dry matter of certain medicinal and aromatic plants on yield and growth of cucumber and on the severity of infestation by the root-knot nematode and the virus.

MATERIAL AND METHODS

First experiment

Seeds of cucumber cv. Alpha Beta were sown into 20-cm-diam. clay pots filled with steam sterilized clay loam soil (2 kg). After germination, plants were thinned to one per pot. A pure culture of the nematode was reared on tomato plants and juveniles were extracted using the sieving and decanting method. Two weeks after cucumber seeding, plants were inoculated with second-stage juveniles (J_2) of the nematode at inoculum levels of 0, 100 (N1) or 1000 (N2) J_2/pot. The nematode suspension was poured into four holes made around the plant stem in each pot. Also, *Cucumber mosaic virus* (V) was added to cucumber plants, either alone or in combination with each level of the nematode. Plants not in-

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oculated with either pathogen were used as controls.

CMV mechanical inoculation. Young leaves from the original infected source plant, *Cucumis sativus*, tested by ELISA test using CMV-specific antibody, were used as inoculum source. Leaves were ground in a cooled porcelain mortar in four parts of cold phosphate extraction buffer, pH 8. The extract was inoculated onto young, tender leaves of the test plants with an absorbent cotton swab on carborundum-dusted leaves (Gera *et al*., 1978). There were five replicates per treatment and the pots were arranged according to a completely randomized design in a greenhouse maintained at 30 ± 5 °C. Plants were managed as recommended (Anonymous, 2006) with reference to irrigation, fertilization, etc.

Nematode and plant growth assessment. Two months after nematode inoculation, cucumber plants were uprooted and galls and egg masses of the nematode on the roots were counted. The percentage reduction of the nematode variables as compared to the control was calculated. Also, shoot and root lengths and weights were recorded. Yield was recorded as number of fruits per plant. Weights of fruits were not recorded as they were too small to be recorded.

Second experiment

Cucumber seeds were sown as described previously. Two weeks after germination, plants were thinned to one per pot. Seeds of the medicinal/aromatic plants, damsisa (*Ambrosia maritima* L.), carnation (*Dianthus caryophyllus* L.), common basil (*Ocimum basilicum* L.) and zinnia (*Zinnia elegans* Jacq.) were sown at the same time of cucumbers (one plant/plant species/pot), as intercropped plants with cucumbers inoculated with 1000 J_2 of *M. incognita*. Therefore, each of these plants was intercropped with cucumber inoculated with nematode only (N), CMV only (V) and with the nematode and the virus (N+V). Non-intercropped cucumbers, inoculated with N, V, or N+V, served as controls. Inoculations of the nematode and the virus were made as in the first experiment. Each treatment was replicated five-fold and all pots were arranged in the greenhouse according to a completely randomized design. Two months later, plants were uprooted and nematode, virus and plant growth variables were recorded.

Serology tests (ELISA). Three leaves from each treated or control plant were tested. The double antibody form of ELISA was the assay method used in this study, both to detect the virus and its concentration (Clarck and Adams, 1977). Commercial DAS-ELISA kits specific for CMV (SANOFI, Sante Animal, Paris, France) were used according to manufacturer's instructions for optical density (O.D.) and measured at λ = 405 nm in an ELISA micro-well reader (Dynatech Immunoassay MR 7000). Samples of leaf extracts were tested at a dilution of 1:5 (w/v). Uninoculated plant samples were included as negative controls and lyophilized samples obtained from SANOFI were used as positive and negative controls in each ELISA plate. Positive threshold values were set at twice the average value for the negative controls and the colour intensity indicated the virus concentration. Negative values indicated that no virus was found in the samples and ELISA reader was capable of reading values less than twice the average value for the negative controls.

Assessment of local lesion of CMV. CMV infectivity was determined by counting the average number of local lesions (12 leaves were used in each trial) subsequently formed 7 days after back inoculation on *Chenopodium amaranticolor* Coste *et* Reyn and then converted to percentage inhibition of virus infection. In other words, the local lesion assay of the virus was performed on three plants of *C. amaranticolor* for each treatment in a greenhouse at 25 ± 2 °C. The third to sixth leaves from the top of the plant were used. Carborundum (0.037 µm) was sprinkled onto the *Chenopodium* leaves and CMV inoculum was rubbed on the leaf surface with a small cotton ball. Local lesions on the surface were counted seven to ten days after inoculation (numbers of local lesions per leaf and then averages of four leaves were calculated) according to the inoculation scheme of Noordam (1973).

The inhibition percentage of virus infectivity was calculated using the formula:

$$\text{Inhibition percentage} = (C\text{-}T)/C \times 100$$

where C = average number of local lesions on control leaves of *C. amaranticolor* and T = average number of lesions on the leaves inoculated with the virus and treated with inhibitors (Baranwal and Verma, 1992, 1997).

Third experiment

Leaf powders of the previously mentioned plants were mixed with the soil (2 kg) in each pot at the rate of 5 g per pot 15 days before planting cucumber and watered to favour decomposition. Then, cucumber seeds were sown in each pot as described before. After germination, one group of cucumber plants was inoculated with 1000 second-stage juveniles of *M. incognita* (N), another with CMV (V), and a third group simultaneously with both nematodes and virus (N+V). Untreated cucumber plants served as controls. There were five replicates per treatment and pots were arranged according to a completely randomized design in the greenhouse. Two months later, plants were uprooted and the severity of nematode and virus infections and plant growth variables were assessed. As the nematicidal activity of the soil amendments is more when the C/N ratio is less than 20:1 (Stirling, 1992), C/N ratios of the leaf powders were determined according to Yeomans and Bremmer (1988).

The mechanical inoculation of the virus was made as

in the first experiment and serology (ELISA test) and local lesion assays were made as described in the second experiment.

Statistical analysis

All data were subjected to analysis of variance and means were compared according to Duncan's Multiple Range Test at $P \leq 0.05$ (Duncan, 1955).

RESULTS

First experiment

Generally, the numbers of galls and egg masses of the root-knot nematode were greater on the roots of cucumber inoculated with the nematode alone (N) than on those inoculated simultaneously with the nematode and the virus (N+V) (Table I).

Inoculation of the two pathogens significantly reduced shoot growth and the number of fruits per plant, while root length and weight appeared less affected. The negative effects on plant growth and yield of cucumber increased with the increase of the inoculum level of the nematode and, in general, were more severe in simultaneous inoculation than in single inoculation of the two pathogens

Typical severe symptoms of virus infection 15-21 days after inoculation were yellow-green mosaic and leaf deformation.

Second experiment

In the controls, the numbers of galls and egg masses of the nematode on the roots and optical density (OD) and number of leaf lesions (LL) of the virus in cucumbers were greater in plants inoculated singly with the two pathogens than in those inoculated simultaneously with both. The same trend was observed with the nematode when cucumbers were intercropped with the medicinal and aromatic plants, but not with the virus, except when cucumbers were intercropped with *Z. elegans*. Intercropping of the medicinal and aromatic plants significantly reduced the number of galls and egg masses of *M. incognita* on the roots of cucumber compared to the untreated check (Table II).

Intercropping cucumbers infected with the virus only (V) with *D. caryophyllus* reduced the concentration (OD) of the virus compared to non-intercropped cucumbers inoculated with the virus only, followed by intercropping with *Z. elegans*, *A. maritima* and *O. basilicum* in an ascending order (Table II). When cucumbers were inoculated with both the nematode and the virus (N+V) the greatest reduction in virus concentration was achieved by intercropping with *D. caryophyllus*, followed by intercropping with *Z. elegans*, *A. maritima* and *O. basilicum*. Complete inhibition of the virus, both in terms of optical density (OD) and leaf lesions (LL), was observed in cucumbers inoculated with the virus only and intercropped with *Z. elegans* and in those inoculated with the virus (V) or virus and nematode (N+V) and intercropped with *D. caryophyllus* (Table II).

There were no significant differences in the number of galls on the roots when cucumbers were infected with either N or N+V and intercropped with *D. caryophyllus*, *O. basilicum* or *Z. elegans*. Also, these three aromatic plants reduced the numbers of galls on the roots of cucumber more than the medicinal plant *A. maritima*. The same trend was observed with the effect on numbers of egg masses, but with the tested plants ranked differently.

Table I. Effect of single and combined infection of *Meloidogyne incognita* and *Cucumber mosaic virus* (CMV) on numbers of root galls and egg masses of the nematode and plant growth of cucumber cv. Alpha Beta in 20-cm-diam. pots.

Treatment	Galls per plant	Egg masses per plant	Shoot length (cm)	Shoot weight (g)	Root Length (cm)	Root Weight (g)	Fruits per plant
Healthy (C)	00 e	00 e	145.6 a	88.2 a	40.6 a	14.2 a	32 a
N1	46 c	10 d	138.2 b	65.0 c	35.0 cd	14.3 a	26 b
V	00 e	00 e	112.0 d	54.5 e	28.4 d	9.2 c	12 e
N1+V	32 d	21 c	127.7 c	75.7 b	37.0 bc	13.4 a	23 c
N2	110 a	74 a	101.6 f	60.9 d	34.3 c	11.4 b	20 d
N2+V	68 b	35 b	105.7 e	71.7 b	39.2 ab	14.1a	24 bc

Data are means of five replicates.

Means followed by the same letter(s) in each column are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

N1 = 100 nematode J_2/pot; N2 = 1000 nematode J_2/pot; V = *Cucumber mosaic virus* (CMV); C = control.

Table II. Effect of infection severity of *M. incognita* and *Cucumber mosaic virus*, inoculated singly or simultaneously, on cucumber cv. Alpha Beta intercropped with four medicinal or aromatic plants.

Treatment		Galls per plant	Egg masses per plant	ELISA test (O.D.)	Back assay No. of LL
Intercropped plant	Pathogen inoculated				
Ambrosia maritima	N	26 c	16 b	-	-
	N + V	20 d	14 cb	0.185 (+)	12 b
	V	0 h	0 f	0.198 (+)	12 b
Dianthus caryphyllus	N	15 ef	8 de	-	-
	N + V	12 fg	7 e	0.078 (-)	0 d
	V	0 h	0 f	0.066 (-)	0 d
Ocimum basilicum	N	17 de	12 e	-	-
	N + V	13 fg	7 e	0.212 (+)	8 c
	V	0 h	00 f	0.314 (+)	9 bc
Zinnia elegans	N	16 ef	11 cd	-	-
	N + V	10 g	6 e	0.180 (+)	6 c
	V	0 h	0 f	0.084 (-)	0 d
None	N	99 a	63 a	-	-
	N + V	90 b	60 a	0.826 (+)	15 b
	V	0 h	0 f	1.114 (+)	20 a

Data are means of five replicates.
Means followed by the same letter (s) in each column are not significantly different according to Duncan's multiple range test (P≤0.05).
N = nematode; V = virus; N + V = nematode + virus.
O.D. = Optical density at 405 nm.
Back assay No. of LL = number of local lesions on *Chenopodium amaranticolor*.

Among the non-intercropped cucumber plants, the greatest plant growth and fruit numbers occurred in non-inoculated plants and the least in those inoculated with the virus. All cucumber plants intercropped with medicinal and aromatic plants had significantly (P≤0.05) increased shoot and root lengths and weights and number of fruits compared to the inoculated but non-intercropped control (Table III). Among the plants intercropped with medicinal and aromatic plants, significant differences were observed only between those inoculated with the nematode alone. The greatest increases in shoot length occurred when cucumbers infected with N or N+V were intercropped with *O. basilicum* or *Z. elegans*, respectively. For shoot weight, there was no significant difference between cucumbers infected with N only and intercropped with *A. maritima* and *Z. elegans*, whereas there were significant differences among all treatments when cucumbers were infected with N+V. The largest shoot weights were recorded for cucumbers infected with N+V and intercropped with *O. basilicum* (103.2 g) or *A. maritima* (95 g), significantly larger than those of the controls, including healthy plants. For root length, there were significant differences among all treatments for cucumber infected with N only and no significant difference between *A. maritima* and *O. basilicum* when intercropped with cucumber infected with N+V, and between *A. maritima* and *Z. elegans* when intercropped with cucumber infected with N only. The greatest root lengths were recorded when *O. basilicum* and *A. maritimia* were intercropped with cucumbers infected with N+V, whereas *D. caryophyllus* gave the least root length when cucumbers were infected with N+V. Differences in root weights were not significant when cucumbers were infected with N only and intercropped with *A. maritima* or *O. basilicum*. Also, root weights were not significantly different when cucumbers were inoculated with N+V and intercropped with *Z. elegans* or *O. basilicum*. Cucumbers inoculated with V only had the greatest root weights when intercropped with *D. caryophyllus*.

In the number of fruits, there were significant differences among all cucumbers infected with N only, but not among all intercropping plants, except *D. caryophyllus* when cucumbers were infected with N+V. No significant differences in fruit numbers occurred when cucumbers were inoculated with the virus only and intercropped with *A. maritima*, *D. caryophyllus* or *O. basilicum*.

Third experiment

Leaf powder of carnation had the lowest C/N ratio (13.3:1), followed by powders of common basil, sea am-

Table III. Effect of intercropping cucumbers with four medicinal or aromatic plants on *M. incognita*, *Cucumber mosaic virus* and plant growth of cucumber cv. Alpha Beta.

Treatment		Shoots		Roots		Fruits per plant
Intercropped plant	Pathogen inoculated	Length (cm)	Weight (g)	Length (cm)	Weight (g)	
Ambrosia maritima	N	125.8 c	71.2 d	26.8 f	16.9 bc	26 b
	N + V	114.7 ef	95.6 b	50.4 a	15.8 c	28 b
	V	88.4 j	34.8 g	26.5 f	8.2 fg	10 fg
Dianthus caryphyllus	N	95.2 i	26.7 i	32.3 d	6.1 h	18 d
	N + V	79.8 k	36.0 g	20.2 g	7.4 gh	14 e
	V	110.3 g	74.8 d	29.5 e	12.2 d	12 ef
Ocimum basilicum	N	160.4 a	86.5 c	47.2 bc	15.6 c	33 a
	N + V	116.6 e	103.2 a	48.4 ab	17.7 ab	28 b
	V	102.4 h	62.5 e	22.4 g	10.7 e	10 fg
Zinnia elegans	N	139.8b	71.4 d	31.0 de	8.2 fg	23 c
	N + V	120.8 d	65.9 e	45.4 c	18.8 a	27 b
	V	112.5 fg	64.0 e	25.2 f	9.4 ef	8 gh
None	N	74.8 k	42.1 f	20.8 g	8.5 fg	14 e
	N + V	80.9 k	40.6 f	25.8 f	9.6 ef	18 d
	V	54.0 l	36.4 g	14.2 h	6.5 h	6 h
	None	90.7 i	83.6 c	35.2 d	11.8 d	22 c

Means followed by the same letter (s) in each column are not significantly different according to Duncan's multiple range test (P≤0.05).
N = nematode; V = virus; N + V = nematode + virus; None = healthy plant.

brosia and zinnia in an ascending order (Table IV).

In the pots inoculated with the nematode only (Table V), the greatest gall reduction was achieved by treating the soil with leaf powders of *A. maritima* (68.7%), *O. basilicum* (67.7%) and *D. caryophyllus* (64.4%) and the least with leaf powder of *Z. Elegans* (43.4%). When cucumbers were inoculated with N+V, the greatest gall reduction was obtained with *A. maritima* (76.7%), followed by *D. caryophyllus* (73.3%), *O. basilicum* (68.9%) and *Z. elegans* (55.6%). In soil inoculated with the nematode only, the largest reductions in number of egg masses occurred with *D. caryophyllus* (79.4%), *A. maritima* (77.8%) and *O. basilicum* (76.2%) and it was slightly less with *Z. elegans* (60.3%). In contrast, on plants inoculated with nematode and virus (N+V), leaf powders of all the tested medicinal and aromatic plants reduced the number of egg masses similarly (78.3-81.7%).

Amending the soil with leaf powders of the tested plants reduced concentration (OD) and number of leaf lesions (LL) of the virus compared to plants with virus infection only, with the best result given by leaf powder of *Z. elegans*, followed by leaf powders of *D. caryophyllus*, *A. maritima* and *O. basilicum*. Complete inhibition of the

Table IV. C/N ratio of leaf powders of the tested plants used as amendments.

Plant species	Organic carbon %	Nitrogen %	C/N
Sea ambrosia (*Ambrosia maritima* L.)	26.9	1.4	19.2:1
Common basil (*Ocimum basilicum* L.)	24.5	1.6	15.3:1
Zinnia (*Zinnia elegans* Jacq.)	29.4	1.4	21.0:1
Carnation (*Dianthus caryophyllus* L.)	19.6	1.5	13.1:1

Table V. Effect of leaf powder of four medicinal or aromatic plants on *M. incognita* and *Cucumber mosaic virus* on cucumber cv. Alpha Beta.

Treatment		Galls per plant	Egg masses per plant	ELISA test (O.D.)	Back assay No. of LL
Plant leaf powder	Pathogen inoculated				
Ambrosia maritima	N	31 ef	14 cd	-	-
	N+V	21 f	13 cd	0.645 (+)	9 bc
	V	0 h	0 e	0.218 (+)	5 c
Dianthus caryophyllus	N	35 e	13 cd	-	-
	N+V	33 e	11 d	0.188 (+)	8 c
	V	0 h	0 e	0.210 (+)	11 b
Ocimum basilicum	N	32 ef	15 c	-	-
	N+V	28 f	11 d	0.621 (+)	12 b
	V	0 h	0 e	0.826 (+)	15 b
Zinnia elegans	N	56 c	25 b	-	-
	N+V	40 d	11 d	0.112 (-)	0 d
	V	0 h	0 e	0.096 (-)	0 d
None	N	99 a	63 a	-	-
	N + V	90 b	60 a	0.826 (+)	15 b
	V	0 h	0 e	1.114 (+)	20 a
	None	-	-	-	-

Means followed by the same letter (s) in each column are not significantly different according to Duncan's multiple range test (P≤0.05).
N = nematode; V = virus; N + V = nematode + virus; None = healthy plant.

virus was observed in cucumbers inoculated with the virus (V) or both nematode and virus and grown in soil amended with leaf powder of *Z. elegans* (Table V).

All treatments significantly (P≤0.05) increased shoot and root lengths and weights and number of fruits of cucumbers compared to the untreated check (Table VI). The tallest plants were recorded when the soil was amended with leaf powder of *O. basilicum* and cucumbers were inoculated with N+V, followed by those inoculated with N only and the soil amended with leaf powder of *O. basilicum*. Among the cucumbers inoculated only with the virus, the tallest plants were those in soil amended with *O. basilicum*, followed by those in soil amended with *Z. elegans* and *D. caryophyllus*. The largest shoot weight was recorded when cucumbers were inoculated with N+V and treated with leaf powder of *A. maritima*, followed by those inoculated with N only or V only and treated with leaf powder of *D. caryophyllus*. The longest roots were those of cucumbers inoculated with N only and treated with leaf powder of *A. maritima*, followed by those inoculated with N+V, V only and treated with leaf powder of *D. caryophyllus*. However, root weights were greater when cucumbers were inoculated with N+V and the soil amended with leaf powder of *D. caryophyllus*, followed by those inoculated with N+V and treated with leaf powder of *A. maritima* or *Z. elegans*. Finally, the greatest number of fruits was recorded for cucumbers inoculated with N+V in soil amended with leaf powder of *A. maritima* or *D. caryophyllus*.

DISCUSSION

The numbers of galls and egg masses of *M. incognita* on the roots of cucumber were greater in plants infected with the nematode only (N) than in those infected with N+V. This might be due to reduced supply of nutrients to the roots caused by the virus and the nematode infections as suggested by Varshney *et al.* (2005). McLaughlin *et al.* (1993) also observed that, in *Trifolium repens* L., combined infection of N+V significantly reduced the numbers of nematode galls and egg masses, which indicates that the virus probably induced changes in the plant physiology that suppressed nematode development (Goswami and Chenulu, 1974). The inhibitory effect of CMV on the nematode in cucumbers has also been demonstrated in other crops (Iheukwumere *et al.*, 2007, 2008).

The decrease in number of galls and egg masses of *M. incognita* on the roots of cucumber plants either inoculated alone or in combination with *Cucumber mosaic virus*, when intercropped with certain plants, may be due to the toxic nature of the exudates from the tested plants. Similar results were obtained by intercropping *A. maritima* with soybean (El-Hamawi *et al.*, 2004) or

cowpea (El-Nagdi, 2006). The active ingredients, mainly sesquiterpene lactones, were found in plant parts of *A. maritima* and might be responsible for its effect on *M. incognita* (Salem *et al*., 1984). Plants of zinnia also proved to have a nematicidal effect on root-knot and reniform nematodes (Yassin and Ismail, 1994). These plants may contain or secrete certain toxins that inhibit nematode penetration or motility. In a similar work, sesame plants reduced the number of galls and egg masses on the roots of squash (Youssef and El-Nagdi, 2004). Also, henna (*Lawsonia inermis* L.) plants were reported to have a nematicidal effect on *M. incognita* (Korayem and Osman, 1992).

The numbers of local lesions of the virus in simultaneous inoculations (N+V) were less than in single infection by the virus (V). This may be explained by a negative interaction between the virus and the nematode. The nematode may have stressed the cucumbers, thus causing a reduction of the multiplication and infectivity of the virus. Similar results have been reported in other host plants (Goswami *et al*., 1994).

In this study, the greatest nematode reduction occurred in plants grown in soil amended with leaf powder of certain medicinal and aromatic plants and inoculated with the nematode only or both the nematode and the virus. Also, these plant materials greatly improved plant growth components compared to the untreated check. The reduction in nematode infection may be due to secondary products and volatile gases derived from the decomposition of plant components that are toxic to nematodes (Mahmood and Saxena, 1992). Haikal and Omer (1988) found that certain aromatic plants contain tannins and essential oils that are toxic to nematodes. Mian and Rodriguez-Kabana (1982) and Montasser (1991) concluded that tannins may be responsible for the suppressive effect on *M. incognita*. Also, essential oils were reported to reduce certain phytonematodes (Abd-Elgawad and Omer, 1995). Less nematode reduction occurred when leaf powder of zinnia was used, probably due to its slow decomposition, which may be attributed to its high C/N ratio (21:1). It is possible that the nematicidal activity of the soil amendments is more when the C/N ratio is less than 20:1 (Stirling, 1992).

This study has demonstrated that combined infection of CMV and root-knot nematode causes a significant decrease in the growth and yield of cucumber cv. Alpha Beta, with the virus having an inhibitory effect on the development of the nematode and vice versa. This would suggest that assessment of the incidence of either pathogen on the host crop should be done in the absence of the other. Finally, the intercropping of some medicinal plants or amending the soil with their leaf powders may help in reducing the severity of both pathogens and thus increase plant growth and yield.

Table VI. Effect of dry matter of four medicinal or aromatic plants on *M. incognita* and *Cucumber mosaic virus* on growth of cucumber cv. Alpha Beta.

Treatment		Shoot length (cm)	Shoot weight (g)	Root length (cm)	Root weight (g)	Fruits per plant
Plant leaf powder	Pathogen inoculated					
Ambrosia maritima	N	95.5 f	42.3 d	29.8 b	8.1 d	19 b
	N + V	89.0 g	65.6 b	26.8 b	11.3 b	27 a
	V	78.2 h	38.4 de	24.6 c	7.6 e	10 d
Dianthus caryophyllus	N	109.5 d	50.8 c	23.8 c	9.5 c	18 b
	N + V	100.0 e	44.1 d	28.0 b	13.0 a	25 a
	V	96.0 f	40.0 d	21.2 cd	8.2 d	16 bc
Ocimum basilicum	N	129.8 b	37.0 de	24.8 c	8.4 d	19 b
	N + V	133.0 a	40.4 d	21.4 cd	6.8 e	17 bc
	V	112.4 c	33.5 ef	22.2 cd	6.2 e	14 c
Zinnia elegans	N	113.5 c	25.1 g	23.0 c	8.4 d	18 b
	N + V	129.3 b	42.9 d	21.0 cd	10.4 bc	19 b
	V	100.5 d	35.6 e	18.5 d	9.5 c	16 bc
None	N	74.8 h	42.1 d	20.8 d	8.5 d	14 c
	N + V	80.9 h	40.6 d	25.8 bc	9.6 c	18 b
	V	54.0 i	36.4 e	14.2 e	6.5 e	6 e
	None	90.7 g	83.6 a	35.2 a	11.8 b	22 a

Means followed by the same letter (s) in each column are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

N = nematode; V = virus; N + V = nematode + virus; None = healthy plant.

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