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NEMATICIDAL EFFICACY OF BIOFUMIGATION WITH VARIOUS BRASSICA CROPS AGAINST *Meloidogyne Incognita* (KOFOID ET WHITE) CHITWOOD ON TOMATO CROP IN NORTH SINAI

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ABSTRACT

Biofumigation is the practice of using *Brassica* green manure plants with high content of glucosinolates which enzymatically hydrolyses to nematicidal isothiocynate (ITCs) compounds. *Brassica* species as well as cultivars differ in both type and concentration of glucosinolate (GSLs). Under North Sinai conditions, however, the highly effective amongst *Brassica* species that can be effectively used are not documented for specific target yet. In this study two successive field trials were conducted using tomato (cv. Elisa) aimed to evaluate and determine the efficacy of four *Brassica* species namely (Fodder radish (*Raphanus sativus*) Terranova H-4-169/0300), canola (*Brassica napus*) (cv. Serow 4), mustard (*Brassica alba*) local commercial cultivar and rocket salad (*Eruca sativa*) local commercial cultivar in comparison with Vydate (as positive control) and untreated plots (as a negative control) in suppressing population density of root-knot nematode *Meloidogyne incognita*, reproductive factor and galling index as studied nematode parameters. Two weeks after tomato seedlings transplanting both root-knot nematode population density and reproductive factor were recorded. After termination of the two experiments (12 weeks) nematode parameters and tomato plant growth attributes were recorded. Fodder radish was significantly the most effective brassica green manure in controlling root- knot nematode *M. incognita* compare to other three studied brassicas. All studied parameters of fodder radish green manure were comparable with that of Vydate. The study recommends that biofumigation methods using fodder radish green manure can be used through integrated pest management program (IPM) for both conventional and organic agriculture tomato production systems.

INTRODUCTION

Root-knot nematodes (*Meloidogyne* spp.) are a group of endoparastic nematodes form feeding cells in the roots of host plants which utilize photosynsate for energy needs **(Kochba and Samish, 1971)**. Root-knot nematodes attack a wide range of vegetable crops causing severe damage in both quantity and quality of the yield. In the last few decades, soil chemical fumigant methyl bromide was effectively used as a root-knot nematode control. However, due to increasing environmental concerns, methyl bromide has been phased out in accordance with the requirements of the Montreal Protocol for the preservation of ozone layer. Most countries including Egypt banned methyl bromide. More emphasis is currently put on the development of environment friendly, efficient and sustainable alternative methods. There is growing interest towards using

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Brassicaceae plants via biofumigation method as green manures for control of soil fungi, nematodes and other soil-borne pests under sustainable vegetable production systems **(Lazzeri *et al*., 1993 ; Buskov *et al*., 2002)**. Biofumigation (BF) is a novel pest management technique which represents a potential alternative to traditional chemical fumigation **(Lord *et al.*, 2011)**. It involves growing *Brassica* plants to full blooming stage, followed by macerating and incorporating biomass into soil **(Kirkegaard *et al*., 1993)**. The family Brassicaceae (Brassicass contains more than 350 genera with about 3000 species, of which many are known to contain GSL. The glucosinolate rich green manures GSL concentration in the cells of the various species in this family is substantially different. Over 130 glucothinolates have been identified of which more than 30 are present in *Brassica* species **(Fahey *et al*., 2001; Soerensen, 2001)**. The type and concentration of glucosinolates have been found to vary between *Brassica* species as well as between cultivars of the same species **(Sang *et al*., 1984**). A single Brassica species can contain several types of GSLs **(Sang *et al*., 1984)** and the types and quantities of GSL are highly variable between species and even verities **(Rosa, 1997)**. Glucosinolates (GSL) molecules and myrosinase enzyme from plant cells, which in conjunction with water facilitates a hydrolysis process and produce active biocidial volatiles such as isothiocynates (ITC) gases **(Agerbirk and Olsen, 2013)**. It has been found that the biocidal activity of such plants is due to the presence of glucosinolates which are enzymatically hydro zed by myrosinase enzyme into various compounds e.g. thiocynates, isothiocynates, nitriles and epithionitriles **(Fahey *et al.*, 2001)**. Among of the four produced compounds isothiocynates are high biologically biocidal compound. Several green manure crops have suppressed major nematode pests efficiently **(McSorley and Dickson, 1995)**. Under Egyptian conditions the adoption of biofumigation as an alternative to traditional chemical fumigation lacks of essential knowledge on the efficiency of various previous species and the most proper application method of such technique, target crops and pathogenic organisms. The objective of the current study was to evaluate four brassicas green manures on suppression of root-knot nematodes on tomato crop.

MATERIALS AND METHODS

Identification of *Meloidogyne* Species

Tomato plants infected with root-knot nematode were collected from the experimental site, thoroughly washed under a stream current tap water to remove the adhering soil particles and then cut into small pieces. A single egg-mass from the adult females was isolated and reared separately on tomato seedlings (*Solanum lycopersicum* L. cv. Elisa), which were grown in 10 cm plastic pots filled with steamed sterilized sandy clay soil and kept in a greenhouse at 25±2°C. Sixty days after inoculation, infected tomato plants were taken off and their roots were examined for species identification.

Perineal patterns of the root-knot nematode adult females were prepared for each sample according to **(Netscher and Taylor, 1974)** and identified to species level based on juvenile magerments and perineal patterns examination of adult females **(Eisenback and Hirschmann, 1981; Jepson, 1987)**.

Two field experiments were conducted at the Farm of Faculty of Environmental Agricultural Sciences, Arish University during the two successive seasons of 2016-2017 and 2017-2018 using four *Brassica* species for controlling of root-knot nematodes on tomato crop using cultivar (Elisa) as a sensitive root-knot nematode cultivar. Soil sampling was done prior to *Brassica* species green manures cultivation to determine numbers of second stage juveniles (J_2) in 250 cm³ soil. The experiment comprised of 6 treatments namely:

1- Fodder radish (*Raphanus sativus*) Terranova H-4-169/0300.

2- Canola (*Bressica napus*) cv. Serow 4.

3- Mustard (*Bressica alba*) local commercial cultivar.

4- Rocket Salad (*Eruca sativa*) local commercial cultivar.

5- Vydate (oxamyl positive control).

6- Untreated (negative control).

The treatments were arranged in a randomized complete block design (RCBD) in plots measuring 2.5 × 3.5 m area replicated 4 times repeated for two studied successive seasons (2016-2017 and 2017-2018). All studied *Brassica* green manure crops were cultivated in plots of 2.5 × 3.5 m area in mid-December during the two growing seasons with seeding rate of 6 kg/ha. Plots were provided with 3 drip irrigation lines with 120 cm spaces and having 35 cm distance between drippers. Watering was done three times a week while ammonium sulfate was added at a rate of 30 kg/Fe in the lines as normal fertilization and agronomic processes for such brassica were applied in the farm. At the full blooming stage (2 months after cultivation), four plants from each brassica crops were randomly selected from each replicate while the roots were washed to remove any of soil particles. Plants were separated in to shoots and roots then dried at 70˚C in an oven till a constant weight to determine both roots, shoot and whole plant dry weights (g/plant). The roots/shoots ratio of each plant was calculated. After that the dried plant materials were subjected to the determination of C/N ratio of the whole plant. At (15th of Feb. *i.e* 8 weeks after cultivation), the brassica plants in every plot were chopped and incorporated into the soil and then all plots were covered with plastic sheets for a period of four weeks in order to prevent any evolved gasses from escaping to atmosphere and also to increase temperature to accelerate the decomposition process of brassica green manure. Irrigation continued daily during the decomposition period (four weeks). After that, plastic sheets were removed, and soil samples were taken to estimate the root-knot nematode *M. incognita* population density after the decomposition of the four used brassica green manures. Soil was left for two weeks before transplanting seedling tomato (cv. Elisa) in the same plots with 35 cm between seedlings in the same drip irrigation line. Ammonium sulfate fertilizer was added at a rate of 10 g/plant two days after transplanting while another dose was applied twice at 2 and 6 weeks after transplanting with a rate of 5 g/plant. Tomato crop was grown for a period of 12 weeks.

Assessment of Tomato Crop Reaction to Green Manures

Assessment of root-knot nematode population size (*M. incognita)*, reproductive factor as a studied nematode parameters was done 2 weeks after tomato transplanting while the root galling index (1-10) was recorded 12 weeks after tomato transplanting. Three plants from each plot were randomly selected, roots were water washed from soil particles for galling index recording. At 12 weeks, the experiment was terminated in the two studied seasons and tomato crop was uprooted. The roots were assessed for galling while soil samples were subsequently taken to the laboratory for nematode extraction.

The tomato plant length of shoots and root, fresh and dry weight(g) for both shoots and roots as well as fruit fresh weight were recorded after 12 weeks of tomato transplanting. Plants were dried in an oven to a constant weight. These weights were recorded as g/plant for both shoots and roots.

A composite soil samples which consisted of five cores were collected from each treatment and nematodes were extracted from 250 cm³ soil sample **(Hooper, 1990)**.

Reproductive factor (RF=Pf/Pi) was recorded after Brassica decomposition period, 2 weeks and 12 weeks of experimental period. The root galling index was determined by counting the galls using a scale of (1-10) as described by **Bridge and Page (1980)**.

RF= Reproductive factor.

PF= final population.

Pi= initial population.

The reproductive factor (RF) assessment was made according to the formula RF=PF/Pi

RESULTS

Identification of Root-Knot Nematodes *Meloidogyne* Species

Examination of the Perineal pattern of the isolated root- knot nematode females revealed the presence of one root-knot nematode species identified as *M. incognita*. About hundred valid species have been described in the genus *Meloidogyne* (**Trinth *et al.*, 2019**) and four species are of high economic importance to vegetable production i.e *M. incognita, M. javanica*, *M. arenaria* and *M. hapla*. The most dominant species worldwide was shown to be *M. incognita* in 53% of all field samples followed by *M. Javanica* 30% and *M. arenaria* 8% and *M. hapla* 8% Taylor and Sasser (1978).

The obtained data in Table 1 reveal that during the first growing season the mean value of nematode population under fodder radish decomposition treatment was 63.75 juvenile/250g soil. The J_2 population mean values were 152/250g soil and 193/250g soil during the two studied growing seasons, respectively. The other three studied brassica green manure resulted in mean values of nematode population 73.75, 82.00 and 91.25 juvenile /250g soil for canola, mustard and rocket salad green manure respectively. On the other hand, the mean value of nematode population density in the second growing season recorded 71.50 juvenile /250g soil for fodder radish green manure treatment. The other studied three brassica green manure resulted in nematode population mean values of 97.25, 101.00 and 112.25 for both canola, mustard and rocket salad green manure respectively.

Regarding the studied root-knot nematode (*Meloidogyne incognita*) parameters, data in Tables 2 and 3 demonstrate that nematode population mean value after 2 weeks of tomato crop transplanting under fodder radish green manure treatment recorded 38.25 with percentage reduction of 83% lower than untreated control treatment during the first growing season.

The corresponding values during the second growing season were 48.25 and 80.41%, respectively. The nematode population with other studies three Brassica green manure were 40.75, 48.50 and 51.25 juvenile 250g soil during the first growing season with percentage decreasing of 81.89, 78.44 and 77.22%, respectively. The corresponding values during the second growing season were 51.75, 57.50 and 61.75 juvenile /250g soil respectively with percentage reduction of 79.06, 76.65 and 74.92% lower than untreated control treatment for canola, mustard and salad rocket, respectively. On the other hand, Vydate as chemical nematicide application resulted in the overall reduction of nematode population which reached to mean value of 35.75 juvenile /250g soil with percentage reduction of 84.11% lower than untreated control treatment during growing the first season. The corresponding value during the second growing season was 41.00 juvenile/ 250g soil with percentage reduction of 81.85% lower than untreated control treatment. The highest significantly ($P \leq 0.05$) nematode population mean value was recorded in untreated control treatment (264.25 juvenile /250 g soil).

Table 1. Mean value of (*Meloidogyne incognita*) population (juvenile/250 d soil) after 4 weeks of four studied Brassica decomposition during both studied two growing seasons

Brassica species	First season	Second season
Fodder radish	63.75	71.50
Canola	73.75	97.25
Mustard	82.00	101.00
Rocket salad	91.25	112.25
Vydate	152*	193**
Untreated	**152***	**193****

* Initial mean nematode population during first growing season.
** Initial mean nematode population during second growing season.

Table 2. Effect of *Brassica* species green manuring and synthetic chemical nematicide, Vydate on studies nematode parameters in the tomato crop growing soil after 2 and 12 weeks of tomato planting

Treatment	2017/2018					2018/2019				
	Population density 2 W	Population density 12 W	Galling Index 12 W	Reproductive factor 2 W	Reproductive factor 12 W	Population 2 W	Population 12 W	Galling index 12 W	Reproductive factor 2 W	Reproductive factor 12 W
Fodder radish	38.25[e]	75.75[e]	2.31[c]	0.25[e]	0.50[e]	48.25[e]	74.25[e]	2.43[e]	0.25[e]	0.39[e]
Canola	40.75[d]	91.50[d]	2.91[c]	0.27[d]	0.60[d]	51.75[d]	97.25[d]	2.78[d]	0.27[d]	0.50[d]
Mustard	48.50[c]	101.25[c]	3.10[c]	0.32[c]	0.67[c]	57.50[c]	112.50[c]	3.28[c]	0.30[c]	0.59[c]
Rocket salad	51.25[b]	107.50[b]	5.08[b]	0.34[b]	0.71[b]	61.75[b]	118.25[b]	3.68[b]	0.32[b]	0.62[b]
Vydete	35.75[f]	71.00[f]	2.13[c]	0.24[f]	0.47[f]	41.00[f]	70.75[f]	2.23[f]	0.21[f]	0.37[f]
Untreated	225.00[a]	264.25[a]	9.78[a]	1.48[a]	1.74[a]	246.25 [a]	273.50[a]	9.85[a]	1.28[a]	1.42[a]
L.S.D 0.05	1.56	2.08	1.06	0.01	0.012	2.15	1.59	0.08	0.01	0.008

[A,b,c]; Different letters in the same column mean significant difference between treatments at levels 0.05.

Table 3. Effect of studied *Brassica* species green manuring and Vydate nematicide on percentage reduction of *Meloidogyne incognita* parameters after 2weeks of tomato seedling transplanting.

Treatment	Nematode population density		Reproductive factor	
	First season	Second season	First season	Second season
Fodder radish	83.00	80.41	83.11	81.25
Canola	81.89	79.06	81.75	78.91
Mustard	78.44	76.65	78.38	76.56
Rocket salad	77.22	74.92	77.03	75.00
Vydate	84.11	83.85	84.46	83.59
Untreated control	-------	---------	-----	------

After 12 weeks of tomato crop transplanting, fodder radish green manure application resulted in nematode population density mean value of 75.75 juvenile /250g soil with percentage reduction of 71.33% lower than untreated control treatment during the first growing seasons. The corresponding values in the second growing season were 74.25 and 72.85%, respectively. Application of other three *Brassica* green manures resulted in mean values of nematode population of 91.50, 101.25 and 107.50 juvenile /250g soil with reduction on percentage of 65.37, 61.68 and 59.12% lower than untreated control treatment during the first growing season after 12 weeks of tomato plant transplanting.

Regarding galling index, nematode parameters, obtained data clear that fodder radish green manure application resulted in mean value of 2.31 with percentage reduction of 76.38% lower than untreated control treatment during the first growing seasons. The corresponding value during the second growing season were 2.43 with percentage reduction of 75.33% lower than untreated control treatment. Application of other three *Brassica* green manures resulted in mean values of galling index 2.91, 3.10 and 5.08 during first growing season. The corresponding values under second growing season were 278, 3.28 and 3.68 for canola, mustard and rocket salad, respectively. The overall lower mean value of reproductive factor was recorded under vydate application treatment with 2.13 and 2.23 during two studied growing seasons, respectively. Application of other three *Brassica* green manures resulted in nematode reproduction factors of 0.27, 0.32 and 0.34 for canola, mustard and rocket salad respectively during the first growing season after 2 weeks. The corresponding values during second season were 0.27, 0.30 and 0.32 respectively.

After 12 weeks, nematode reproductive factor recorded under fodder radish green manure treatment recorded 0.50 with percentage reduction of 71.26% lower than untreated control treatment during the first growing season. The corresponding values during the second growing season were 0.39 with percentage reduction of 72.54% lower than untreated control treatment. The application of other three *Brassica* resulted in nematode mean values of 0.60, 0.67 and 0.71 with percentages reduction of 65.51, 61.49 and 59.20 % lower than untreated control treatment.

Under Vydate treatment nematode reproductive factor recorded 0.47 and 0.37 with percentages reduction of 72.99 and 73.94% during both two studied growing seasons, respectively.

Effect of *Brassica* Green Manure Application of Tomato Crop Growth Attributes

Obtained data in Tables 4 and 5 show the effect of studied *Brassica* green manure application of tomato crop growth attributes.

Shoot and root length

Application of fodder radish green manure resulted in significantly increase in both shoots and roots of tomato crop during the two studied growing seasons.

During first growing season shoots and roots lengths recorded 54.15 and 28.50 cm with percentage increases of 95.63 and 62.98% over untreated control treatment, respectively. The corresponding values during second growing season were 63.75 and 31.03 cm, respectively. The other studied *Brassica* green manures resulted in shoots and roots length of 47.80, 43.00 and 38.98 cm with percentages increase of 72.69, 55.35 and 40.82% over untreated control treatment during the first growing season for canola, mustard and rocket salad, respectively. The corresponding values during the second growing season were 57.73, 52.98 and 49.38 cm with percentages

Table 4. Effect of *Brassica* species green manuring and synthetic chemical nematicide, vydate on studies tomato growth parameters 12 weeks after tomato transplanting during the two studied seasons 2017/2018 and 2018/2019

Plant parameters / Treatments	Shoot plant length (cm)	Root plant length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Fresh fruit weight (g)
			Season 2017/2018				
Fodder radish	54.15[a]	28.50[b]	285.40[b]	75.65[b]	95.88[a]	33.44[b]	482.38[b]
Canola	47.80[b]	24.18[c]	277.85[c]	71.78[c]	92.14[b]	27.14[c]	475.83[c]
Mustard	43.00[cd]	23.38[c]	263.43[d]	68.15[d]	81.98[c]	23.51[d]	452.33[d]
Rocket salad	38.98	21.33[d]	252.20[e]	61.35[e]	72.36[d]	22.26[e]	445.50[e]
Vydete	54.53[a]	34.30[a]	299.80[a]	77.38[a]	93.65[b]	35.47[a]	488.80[a]
Untreated	27.43[e]	18.60[e]	191.98[f]	51.45[f]	63.21[e]	21.33[e]	276.00[f]
L.S.D 0.05	**1.52**	**1.17**	**1.85**	**1.12**	**1.51**	**0.99**	**1.38**
			Season 2018/2019				
Fodder radish	63.75[b]	31.03[b]	295.10[b]	79.03[b]	98.63[b]	32.93[b]	495.20[b]
Canola	57.73[c]	27.38[c]	289.88 [c]	74.00[c]	94.17[c]	26.84[c]	488.13[c]
Mustard	52.98[d]	24.33[d]	272.70[d]	69.05[d]	84.74[d]	23.40[d]	477.03[d]
Rocket salad	49.38[de]	23.20[e]	261.15[e]	64.60[e]	78.87[e]	21.64[e]	472.30[e]
Vydete	69.00 [a]	35.58[a]	311.83[a]	82.40[a]	107.17[a]	33.63[a]	502.08[a]
Untreated	46.35[e]	21.05[f]	195.38[f]	63.75[f]	34.95[f]	20.21[f]	286.10[f]
L.S.D 0.05	**3.79**	**0.47**	**1.49**	**0.57**	**0.81**	**0.65**	**1.47**

[A,b,c]; Different letters in the same column mean significant difference between treatments at levels 0.05

Table 5. Effect of soil studied *Brassica* species green manuring and Vydate synthetic chemical nematicide on percentage increases values (%) in tomato crop growth attributes after 12 weeks from tomato seedling transplanting.

Treatment	Plant Length (cm)				Fresh plant weight (g/plant)				Dry weight (g/plant)				Fruit fresh weight	
	Shoots		Roots		Shoots		Roots		Shoots		Roots			
	First season	Second season	First season	Second season	First season	Second season	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Fodder radish	**95.63**	**43.73**	**62.98**	**47.52**	**46.66**	**51.04**	**47.03**	**23.97**	**51.90**	**189.66**	**56.77**	**62.94**	**74.78**	**73.09**
Canola	**72.69**	**30.17**	**33.59**	**33.59**	**44.75**	**48.37**	**39.51**	**16.08**	**45.98**	**176.56**	**27.24**	**31.26**	**72.40**	**70.62**
Mustard	**55.35**	**19.46**	**29.17**	**15.58**	**37.22**	**39.57**	**32.46**	**8.31**	**29.88**	**148.87**	**10.22**	**15.49**	**63.89**	**66.74**
Rocket salad	**40.82**	**11.34**	**17.85**	**10.45**	**31.37**	**33.65**	**19.24**	**1.33**	**14.58**	**131.34**	**4.34**	**7.08**	**65.89**	**65.08**
Vydate	**97.00**	**55.02**	**89.50**	**69.03**	**56.16**	**59.60**	**50.38**	**29.55**	**48.37**	**214.74**	**66.24**	**66.40**	**77.10**	**75.46**
Untreated control	-	-	-	-	-	-	-	-	-	-	-	-	-	-

increasing of 30.17, 19.46 and 11.34% respectively and % over control treatment. The overall increasing values for both shoots and roots lengths were found with vydate treatment which recorded 54.53, 34.30cm during first season and 69.00, 35.58 cm during the second growing season, respectively.

Fresh and Dry Weights of Shoots and Roots

Obtained data in Tables 4 and 5 also show that during first growing season, fodder radish *Brassica* green manure treatment recorded 285.40 and 75.65 g/plant for both shoots and roots with percentage increase of 46.66 and 47.03% over untreated control treatment, respectively. The corresponding values during second growing season were 295.11 and 79.03 g/plant with percentages increase of 51.04 and 23.97% over control treatment, respectively Application of other three *Brassica* green manures resulted in shoots and roots fresh weights of 277.85, 263.43, 252.20 and 71.78, 68.15, 61.35 g/plant during growing season .The corresponding values during second growing season 289.88, 272.70 and 261.15, 74.00, 69.05 and 64.60 g/plant respectively. The overall increasing values recorded for both shoots and roots fresh and dry weights was recorded with Vydate application 299.80 and 77.33 g/plant during first growing season and 311.83 and 82.40 g/plant during the second growing season, respectively.

Fresh fruit weight

Obtained data in Tables 4 and 5 show the effect of *Brassica* green manure applied on fresh fruit weight of tomato crop.

Application of fodder radish green manure resulted in fresh fruit weight of 482.38 and 495.20 g/plant during both two studied growing seasons respectively with percentage increasing of and 74.78 and 73.09% over control treatment. Canola, Mustard and rocket salad *Brassica* green manure application resulted in fresh fruit weights of 475.83, 453.33 and 445.50 g/plant during the fresh growing season. The corresponding values, under second growing season were 488.13, 477.03 and 472.30 g/plant. The percentage increases over control were 72.40, 63.89 and 65.89% during the first season and 70.62, 66.74 and 65.08% during the second season, respectively. The overall increases in fresh fruit weight were found with Vydate application treatment which recorded 488.80 g/plant during first growing season and 502.08 g/plant during the second growing seasons respectively.

DISCUSSION

Four brassicas green manure crops used had a significant effect ($P \leq 0.05$) on both nematode parameters as well as tomato crop growth attributes comparing to untreated treatment with different magnitudes. Such effects were found true during the two studied tomato growing seasons. Among the brassica green manure crops, fodder radish was found the most effective in reducing studied nematode parameters after 4 weeks of decomposition period as well as after 2 and 12 weeks of tomato seedlings transplanting. The effectiveness of *Brassica* green manure used can be arranged as follows, fodder radish, canola, mustard and finally rocket salad. The efficacy of fodder radish in reducing studied nematode parameters and improvement of tomato growth attributes could be partially due to its higher biomass production (g/plant) as well as the higher root/shoot ratio compared to other three studied brassicas. **Zasada and Ferris (2004)** found that under lower biomass additional levels of brassicas, there is difficulty in uniform distribution of the amendment in the soil and high volatility loss of ITCs. **Borek *et al*. (1995)** found that the aromatic GSLs which are often found in *Brassica* roots release ITCs which were found to be highly toxic compare to that found in their shoots. On the other hand, the variation in nematicidal effect could be also due to differential sensitivity of the root-knot nematodes to the ITCs release from any brassica species **(Lazzeri *et al*., 2004; Van Dam *et al*., 2009)**. **Kirkegaard and Sarwar (1998)** cleared that as range of GSL profiles, the differential toxicity of produced ITCs to different pests and the wide range of phonological and morphological diversity in brassicas could provide develop enhanced potential biofumigation for particular target organisms.

Fodder radish organic manure and Vydate were comparable in improvement of tomato growth attributes. This can be attributed to better controlling of root-knot nematodes especially in early stage and therefore allowing the tomato crop to growth with vigor. **Pattison *et al.*, (2006**) found that fodder radish green manure *(Raphanus sativus*) has good biofumigant activity against *Meloidogyne* spp. . Obtained data also reveal that the root-knot suppressive efficacy of all studied treatments was results with elapsing time after 12 weeks compared to 2 weeks of experimental period. The longer the time of experimental period, the lower the efficacy of both brassica organic manures and Vydate treatments. This effect could be due to that nematicidal volatile compounds concentration produced via brassica decomposition decrease with elapsing time **(Borek *et al*., 1996; Brown, 1997; Gimsing and Kirkegaard, 2006; Morra and Kirkegaard, 2002).**

The same previous trend of decreasing root-knot suppressive efficacy with elapsing time was also found true with Vydate treatment. Such effects could be due to that, Vydate as a non-fumigant nematicide has lower efficacy in controlling root-knot nematodes than broader spectrum fumigants **(Netscher and Sikora, 1990)**. As fodder radish green manure is comparable to Vydate in root-knot nematodes management, it can be used as an alternative method under conventional agriculture system in order to reduce the consumption use of synthetic agro-chemical due to their hazard impacts on both human health and environment. The main potential for brassica amendment as part of IPM approach consists firstly on the role of the phytochemicals active compounds **(Kessler and Baldwin, 2002; Salem and Mahdy, 2015)** as direct suppression on nematodes while the secondary effect in the soil condition improvement. The latter effect plays a very important role in promoting microbial and other microorganism diversity in the soil which have a positive impact on stimulation of competition among soil borne pests in the plant rhizosphere.

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الملخص العربي

كفاءه استخدام عملية التدخين الحيوى فى مكافحة نيماتودا تعقد الجذور على الطماطم باستخدام نباتات العائلة الصليبية فى شمال سيناء

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تعتبر نيماتودا تعقد الجذور من أهم الآفات التى تصيب محاصيل الخضر وغيرها من المحاصيل مسببة أضراراً كبيرة فى كل من كمية الإنتاج ونوعيته. استخدم بروميد الميثايل منذ عقود بكفاءة عالية فى مكافحة هذه الآفة. ونظراً لكل من التأثير الضار على البيئية وصحة الانسان بالإضافة إلى تأثير هذا المبيد على تآكل طبقة الأوزون فقد تم منع استخدامه طبقا لبروتوكول مونتريال. اقترحت عدة طرق مكافحة بديلة لهذا المبيد بحيث يمكن استخدامها تحت ظروف كل من نظم الزراعة العادية والعضوية أحد أهم هذه الطرق البديلة وهى باستخدام طريقة التدخين الحيوي حيث يتم زراعة نباتات من العائلة الصليبية وعندما تصل الى مرحلة بداية التزهير يتم تقطيعها وتقليبها فى التربة وتغطى بغطاء بلاستيك وذلك لمنع هروب الغازات المتكونة نتيجة عملية التحلل إلى الجو وكذلك لاسراع عملية تحلل المادة العضوية المضافة ويتم التغطية وبعد 4 أسابيع يزال الغطاء البلاستيكى وتترك التربة لمدة أسبوعين قبل زراعة شتلات المحصول الرئيسي، استخدم في هذه التجربة التى كررت لموسمين زراعيين (2016-2017 و2017-2018) 4 نباتات وهى: Fodder radish (*Raphanus sativus*) Terranova H-4-169/0300) فجل العلف، Canola (*Bressica napus*) c.v Serow الكانولا، (*Bressica alba*) Mustard صنف تجارى محلى الخردل، Rocket Salad (*Eruca sativa*) صنف تجارى محلى الجرجير. واستخدم المبيد الكيماوى Vydate كمعاملة كنترول موجبة، أما المعاملة السالبة فلم يستخدم فيها نباتات صليبية، زرعت شتلات الطماطم صنف Elisa واستمرت التجربة لمدة 12 أسبوع وقد تم تقدير كل من تعداد نيماتودا تعقد الجذور وقياس التعقد ومعامل التكاثر وكذلك تم تقدير كل من طول النبات بجانب الوزن الخضرى والجاف للنبات وكذلك وزن الثمار. ويمكن تلخيص أهم النتائج كما يلي أدت المعاملة باستخدام فجل العلف الى انخفاض معنوى لكل قراءات نيماتودا تعقد الجذور وذلك بعد 2 و12 اسبوع من شتل نبات الطماطم وكذلك أدت هذه المعاملة إلى زيادة معنوية فى كل قراءات نمو نبات الطماطم (طول النبات، الوزن الغض والجاف للنبات، وزن الثمار للنبات) مقارنة بمعاملة الكنترول السالب. ومن هنا فأنه يمكن استخدام فجل العلف من خلال عملية التدخين الحيوى لمكافحة نيماتودا تعقد الجذور فى الطماطم بالتكامل مع غيرها من الطرق الطبيعية المسموح بها تحت ظروف الزراعة العضوية وكذلك مع إضافة أقل الجرعات من المبيدات الكيماوية المسموح بها تحت ظروف الزراعة العادية.

الكلمات الاسترشادية: التدخين الحيوى، التسميد العضوي باستخدام نباتات العائلة الصليبية، نيماتودا تعقد الجذور.

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