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EFFECT OF SALICYLIC AND JASMONIC ACIDS ON THE RESPONSE OF TOMATO PLANTS TO ROOT KNOT NEMATODE *MELOIDOGYNE INCOGNITA*, INFECTION

[72]

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ABSTRACT

In a green-house experiment, 45 day old tomato seedling (*Lycopersicon esculentum* Mill. Cv. Super strain-B) received nematode, *Meloidogyne incognita*, inoculum (500 juveniles/pot) and plant growth regulators (PGR_S); salicylic acid (SA) at 20 & 40 ppm and jasmonic acid (JA) at 5 & 10 ppm. PGR_S were applied as foliar spray and soil drench in separate treatments and in different times; two days before, two days after and two days before + after nematode inoculum. Double applications of SA at 40 ppm as soil drench and JA at 5 ppm as foliar spray as well as JA at 10 ppm (after inoculum soil drench) induced resistance to nematode as indicated by the reduction in the number of females with and without egg masses and number of galls. Most of JA at 10 ppm treatments reduced number of females without egg masses and number of galls. These effects were associated with high production of phenols particularly in roots. Foliar spray applications of SA at 20 ppm after inoculum and SA at 40 ppm before + after inoculum increased females without egg masses and galls number. In the same time, both applications stimulated plant growth as shown by the increase in plant fresh and dry weight, leaves number and soluble proteins concentration which were obtained by SA at20 ppm as well as the increase in shoot fresh & dry weight, fruit weight and chlorophyll concentrations which were obtained by SA at 40 ppm. These treatments were suggested to exhibit tolerant effect in tomato plants.

Key Words: Tomato, *Lycopersicon esculentum* Nematode, *Meloidogyne incognita*, Plant Growth Regulators, Salicylic acid, Jasmonic acid, Plant resistance, Tolerance

INTRODUCTION

The role of salicylic acid (SA) and jasmonic acid (JA) in plant defense against pathogens and pests is well established in the past decade. **Malamy *et al* (1990)** observed that SA increased almost 50 fold in tobacco mosaic virus (TMV)

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inoculated leaves, and at least 10 fold in uninfected leaves of tobacco, TMV-resistant (xnthi-nc) but not susceptible (xanthi) tobacco. An increase, about 400 fold of SA over basal levels was observed in and around hypersensitive lesions (**Enyedi *et al* 1992**). Resistance to pathogens and the production of most if not all, pathogenesis-related (PR) proteins can be induced by SA acetylsalicylic acid (**Raskin, 1995**). SA reduced the root galling, number of females and egg masses in cucumber plants infected with *Meloidogyne javanica* (**Hassan, 1999**). Number of genes or gene products influenced by jasmonic continue to grow. Many of these genes are implicated in plant defense of one sort or another (**Parthier, 1991**). Induction by jusmonate of protease inhibitors, appear to be targeted primarily against certain insects, has been noted in several species. Also, localized jasmonate synthesis in response to wounding is acting as signal stimulate other defense pathways (**Stasiwick, 1995**). In addition to jasmonate putative roles in development and signaling plant defense responses. **Stasiwick (1995)** mentioned that jasmonate may be more directly involved as an antifungal agent. **Thaler (1999)** sprayed JA on agriculturally grown tomato plants to manage pests. Induction with jasmonic was associated with high level of several putative defense proteins and was associated with induced resistance to wide variety of tomato pests. **Zinov *et al* (1998)** mentioned that jasmonate are able to mediate biochemical reactions associated with plant resistance to nematodes. Recently, several evidences demonstrated the effect of SA and/or JA on the expression of defense-related genes and systematic acquired resistance (SAR) response (**Dong-HAnsong *et al* 1999; Wees-SCM-Van *et al* 1999 and Belles *et al* 1999**). The present study was conducted to investigate the role of SA and JA in the management of nematode (*Meloidogyne incognita*) infection in tomato (*Lycopersicon esculentum Mill.*) and the possibility of inducing resistance as indicated by plant growth, developing fruits and some chemical constituents.

MATERIAL and METHODS

Source of Nematode Inoculum and Host Plant

Galled tomato roots infected with root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood, were cut into pieces and placed in mist chamber (**Reddy, 1983**) to extract the 2nd stage juveniles (infective stage). One month old tomato seedlings (*Lycopersicon esculentum Mill.* Cv. Super strain-B) were transplanted singly in 12-cm diameter pots filled with sterilized sandy loam soil, watered daily and fertilized weekly with 20-20-20 NPK, and maintained in the green-house.

Plant Growth Regulators (PGR_S)

Salicylic acid (SA) and Jasmonic acid (JA) were used in two concentrations, each, viz. SA 20 and 40; JA 5 and 10 ppm (20 ml/pot). The PGR_S were applied as foliar spray (Fs) and soil drench (Sd) in separate treatments.

Treatments

Pots were divided into three equal groups receiving nematode inoculum

(500 juveniles / pot), and PGR_S in different timings as follows:

1- PGR_S were applied two days before-nematode inoculum
2- PGR_S were applied two days after-nematode inoculum
3- PGR_S were applied twice, two days before and after-nematode inoculum

Nematode-infected and nematode-free pots, both of which were PGR_S-free, were used as two control treatments.

All treatments were replicated four times. One month after the timing of nematode addition, all plants were uprooted, root systems were severed and rinsed in water to remove soil particles. Plant growth parameters including plant height, fresh weight of roots and shoots and dry weight of shoots, number of leaves, and number and weight of fruits were recorded for each plant.

Samples of roots and leaves were taken for chemical analyses including the determination of total carbohydrates, soluble and reduced sugars, soluble proteins, phenols and chlorophyll.

Staining Roots for Nematode Counting

Roots were stained with acid fuchsin lactophenol and stored in it for more than 24 hr. The stained roots were rinsed with tap water and cut into pieces to facilitate counting of galls and nematode, using dissecting microscope. Soil nematode extraction using modified Baermnn technique revealed no 2^{nd} juveniles.

Chemical Analysis of Roots and Leaves

Determination of Total Carbohydrates

One g sample of leaves was randomly taken and added to 30 ml HCL 2N. The tubes were placed in a boiling water bath for 6 h. After cooling, the sample was transferred into a calibrated flask (100-ml). Total carbohydrates were estimated by the alkaline potassium ferricyanide method (**Shales and Schales, 1945**).

Determination of Total Soluble Sugars

One g. sample of leaves was ground in a mortar with ethanol 80% for 3 times. The extracts were combined and evaporated till dryness. The dried film wa: dissolved in 50 ml of 10 % aqueous isopropanol. Total soluble sugars determination was carried out according to the method of **Shales and Schales (1945).**

Determination of soluble protein

One g.sample was dried and mixed with 5 ml of extraction buffer (0.125 M tris borate, ph 8.9) then shaked for one hour and filtered . The supernatant contained the soluble protein. A colorimetric determination of soluble protein was carried out by using the method of **Bradford (1976).**

Determination of chlorophyll

Fresh weight (0.1 g) of leaves was homogenized with 80% acetone and the extract was obtained by filtration of the solvent in Buchner funnel. Total chlorophylls were determined spectrophotometrically at 663 and 645 nm (Shimadzu UV-160lPC) using the method of **Arnon (1949)** and data were expressed as mg/g fresh weight.

Determination of Phenols

a- Extraction

One g. of fresh weight was taken and extracted with 80% cold methanol (v/v)

for three times at 0 Ċ. The combined extract was filtered (Wt. No. 1) and its volume was made up to 25 ml with cold methanol.

b- Analysis

Phenols determination was carried out according to **Danile and George (1972).** One ml extract was added to 0.5 ml Folin & Ciocalteu's Phenol Reagent, shaken and allowed to stand for 3 min. Then one ml saturated sodium carbonate (25%, w/v) was added to each tube, followed by 10 ml distilled water, shaken and allowed to stand for 60 min. the optical density was determined at 730 nm using spectrophotometer (Shimadzu UV-160A). Amount of total phenolic compound was calculated according to standard curve of pyrogallol (99.5%) and expressed as equivalent microgram of pyrogallol per gram of fresh weight.

Statistical Analysis

The collected data were subjected to the proper statistical analysis of complete randomized design according to procedure outlined by **Snedecor Cochran (1980).** L. S. D. at 5% level of probability was used to compare between means according to **Waller and Duncan (1969).**

RESULTS

Root Growth and Nematode Infection

Data in Table (1) demonstrate the effect of different applications of PGR_S on root growth and nematode infection of tomato plants. Nematode infection reduced root fresh weight. Most PGR_S treatments significantly enhanced root fresh weight. The most effective treatments were before inoculum soil drench with JA at 10 ppm, after inoculum foliar spray with JA at 5 ppm, after inoculum soil drenech with SA at 40 ppm, before + after inoculum soil drench with JA at 5 ppm and after inoculum foliar spry with JA at 10 ppm. Significant increase in females with egg masses number were obtained by SA at 20 ppm as beorfe + after inoculum soil drench and beorfe inoculum foliar spray, JA at 5 ppm as after inoculum foliar spray and before inoculum soil drench as well as before inoculum soil drench and after inoculum foliar spray of SA at 40 ppm. On the other side, reduction in females with egg masses were attained by before + after inoculum foliar spray of JA at 5 ppm, after inoculum soil drench with JA at 10 ppm, beorfe + after inoculum soil drench with SA at 40 ppm and JA at 5 ppm. An increase in females without egg masses were occurred by the following foliar spray treatments; after inoculum with JA at 5 ppm, before + after inoculum with SA at 40 ppm, before inoculum with SA at 20 ppm and after inoculum with SA at 20 ppm. Whereas, a significant reduction were obtained by beorfe + after inoculum soil drench with SA at 40 ppm, and before + after inoculum foliar spray with JA at 5 ppm. Also, reduction in females without egg masses were recorded by different applications of JA at 10 ppm except before inoculum soil drench treatment. A similar trend to females without egg masses were noticed in number of galls. It is worth to mention that, no juveniles were found in the soil or the stained roots.

Table 1. Effect of different applications of SA 20 & 40 ppm and JA 5 & 10 ppm on root fresh weight and the activity of nematode (*M. incognita*) in infecting tomato plants.

Treatments				No. of Females / plant			
PGR	Method	ppm	Timing	Root fresh wt. (g)	W/O egg masses	W/egg masses	No. of galls / plant
SA	Sd	20	B	5.0	43.3	16.0	59.3
			A	4.7	54.7	22.0	76.7
			B + A	5.7	67.3	38.7	106
		40	B	3.7	58.7	26.6	58.3
			A	8.3	68.7	20.0	88.7
			B + A	6.3	26.0	10.7	36.7
	Fs	20	B	5.7	80.7	34.6	115.3
			A	7.0	74.0	23.3	97.3
			B + A	6.7	66.7	26.0	92.7
		40	B	4.7	62.7	20.6	83.3
			A	7.3	59.3	24.7	84.0
			B + A	6.0	85.3	27.3	112.6
JA	Sd	5	B	7.3	74.0	30.7	104.7
			A	7.7	55.3	24.7	80.0
			B + A	8.3	52.0	12.0	64.0
		10	B	12.0	72.7	18.6	91.3
			A	6.7	29.3	10.7	40.0
			B + A	7.3	48.0	27.0	75.0
	Fs	5	B	7.0	51.3	19.3	70.6
			A	9.7	86.7	33.3	120.0
			B + A	7.3	28.0	8.7	36.7
		10	B	7.3	54.0	22.7	76.7
			A	8.0	41.3	14.7	56.0
			B + A	7.3	38.7	14.0	52.7
Control (infected)				4.7	55.3	16.7	72.0
Control (non-infected)				6.3	0	0	0
LSD (0.05)				2.40	18.16	6.82	23.25

SD = Soil drench B = Before B + A = Before + After
Fs = Foliar spray A = After

Vegetative and Reproductive Characters

Data presented in Table (2) revealed that infected control treatments showed the same trend of non- infected control on plant height. Before inoculum foliar spray with JA at 5 ppm significantly increased plant height. Before inoculum and before + after inoculum foliar spray of SA at 20 and 40 ppm respectively enhanced plant height. After inoculum soil drench with SA at 20 ppm & JA at 5 ppm, before inoculum soil drench with SA at 40 ppm and before + after inoculum foliar spray with JA at 10 ppm significantly decreased plant height. It could be noticed (Table 2) that nematode infection markedly reduced shoot fresh and dry weight in infected control. JA treatments positively influenced these characters as shown by before + after inoculum foliar spray and soil drench with JA at 10 ppm as well as beorfe inoculum foliar spray and before + after inoculum soil drench with JA at 5 ppm. Also, some SA treatments showed significant increase in fresh and dry weight such as SA at 20 ppm as after inoculum and before + after inoculum foliar spray. As well as, SA at 40 ppm as after inoculum soil drench, before + after inoculum foliar spray and soil drench. Reduction in leaves number were recorded by infected control. Application of JA at 10 ppm as before inoculum and before + after inoculum soil drench, JA at 5 ppm as before inoculum soil drench and SA at 20 ppm as after inoculum foliar spray increased leaves number. Nematode infection had no effect on fruit numbers. PGR_S slightly affected fruit number. However, some treatments reduced fruit numbers named, before inoculum soil drench with SA at 20 ppm & JA at 10 ppm and beorfe inoculum foliar spray with SA at 40 ppm & JA at 10 ppm, in addition to, after inoculum foliar spray with SA at 20 ppm (Table 2). Nematode infection significantly reduced fruits weight (Table 2). Significant increase in fruits weight were obtained by before + after inoculum treatments; JA at 5 ppm as soil drench and JA at 10 ppm & SA at 40 ppm as foliar spray. Also, by after inoculum soil drench with JA at 5 & 10 ppm and beforc inoculum soil drench with SA at 40 ppm. Decrease in fruits weight were attained by after inoculum foliar spray & soil drench with SA at 20 ppm and after inoculum foliar spray With SAat 40 ppm.

Biochemical Constituents

Data in Table (3) show the effect of nematode infection and applied PGR_S on some chemical constituents such as phenols, soluble proteins and total carbohydrates in both leaves and roots as well as chlorophyll, total soluble sugars and reducing sugars in leaves.

Phenols

Nematode infection (infected-Control) stimulated phenols concentration in leaves and roots. Most of JA treatments with both concentrations gave significant increase in phenols in roots except before inoculum soil drench with JA at 10 ppm, before + after inoculum soil drench with JA at 5 ppm and after inoculum foliar spray with JA at 5 ppm. An increase in phenols in roots were obtained by some SA treatments such as before inoculum foliar spray with SA at 20 ppm and soil drench with SA at 40 ppm as well as after inoculum soil drench with SA at 20 ppm

Table 2. Effect of nematode infection (*M. incognita*) and different applications of SA 20 & 40 ppm and JA 5 & 10 ppm on vegetative and reproductive characters of infected tomato plants.

Treatment				Plant height (cm)	Shoot		Leaves No.	Fruits	
PGR	Method	ppm	Timing		Fresh Wt. (gm)	Dry wt. (gm)		No.	Wt. (gm)
SA	Sd	20	B	23.7	11.3	2.3	4.0	1.0	13.0
			A	21.7	12.3	1.8	4.3	1.3	3.3
			B + A	26.3	10.7	1.8	3.7	2.0	14.7
		40	B	23.0	11.0	1.8	4.7	1.7	10.7
			A	26.0	14.0	2.6	4.3	2	14.3
			B + A	24.7	13.0	2.4	4.0	1.7	12.0
	Fs	20	B	30.0	12.3	2.8	4.3	1.6	14.7
			A	27.3	13.7	2.4	5.3	1.0	7.3
			B + A	25.0	13.7	2.9	4.3	2.0	15.0
		40	B	24.7	12.3	2.0	4.0	1.0	16.0
			A	23.7	10.3	2.0	4.7	2.0	8.7
			B + A	30.7	14.3	3.2	4.0	1.7	15.7
JA	Sd	5	B	29.0	13.7	2.5	5.3	1.7	14.0
			A	20.0	12.7	2.3	4.3	1.3	17.3
			B + A	26.0	15.7	3.1	5.0	1.7	17.3
		10	B	24.3	18.3	3.9	6.0	1.0	13.3
			A	24.0	13.7	3.3	5.0	2.0	16.0
			B + A	27.7	17.0	3.7	6.7	1.3	11.3
	Fs	5	B	31.3	17.0	3.3	5.0	1.3	13.7
			A	26.3	17.3	3.4	5.0	1.3	15.3
			B + A	28.0	14.3	2.6	5.0	2.0	15.0
		10	B	26.7	14.7	2.9	5.0	1.0	15.3
			A	28.3	14.3	4.2	5.0	1.7	10.0
			B + A	22.3	19.0	3.8	5.0	1.3	17.0
Control (infected)				27.7	10.3	2.1	3.7	2.0	12.0
Control (non-infected)				26.3	14.7	2.8	5.3	2.0	14.3
LSD (0.05)				2.60	2.50	0.20	1.44	0.74	2.91

SD = Soil drench B = Before B + A = Before + After
Fs = Foliar spray A = After

and before + after inoculum soil drench with SA at 40 ppm. The highest values of phenols in leaves were recorded by SA treatments as shown by before + after inoculum foliar spray & soil drench with SA at 40 ppm, after inoculum foliar spray with SA at 20 & 40 ppm and before inoculum soil drench with SA at 20 ppm. The lowest values were obtained by before + after inoculum foliar spray and soil drench with JA at 10 ppm.

Soluble Proteins

Nematode infection showed no influence on soluble proteins concentration in roots but reduced them in leaves. No positive effect were obtained by application of PGR_S on soluble proteins in roots. Meanwhile, reduction were obtained in roots by JA at 10 ppm as after inoculum and before + after inoculum foliar spray as well as SA at 40 ppm as after inoculum and before + after inoculum soil drench. An increase in soluble proteins in leaves were recorded mainly by before + after inoculum and after inoculum foliar spray with SA at 20 ppm, after inoculum soil drench with SA at 40 ppm, before inoculum foliar spray and before + after inoculum soil drench with JA at 10 ppm. A decrease in soluble proteins concentration in leaves were obtained after inoculum foliar spray with JA at 5 ppm & SA at 40 ppm and before inoculum soil drench with JA at 5 ppm.

Chlorophyll

Nematode infection significantly reduced chlorophyll concentration in leaves. Application of JA at 5 ppm as before + after inoculum foliar spray markedly increased chlorophyll concentration. Similarly, before + after inoculum foliar spray & soil drench of SA at 40 ppm, after inoculum soil drench of SA at 40 ppm and before inoculum foliar spray of JA at 10 ppm markedly increased chlorophyll concentration. On the contrary, after inoculum foliar spray of JA at 10 ppm decreased chlorophyll concentration.

Total Carbohydrates and Sugars

No significant differences were noticed between infected and non – infected controls in total carbohydrates concentration in roots but reduction were occurred in leaves of infected control. An increase in total carbohydrates in roots were obtained by before inoculum foliar spray with SA at 20 & 40 ppm, before inoculum and before + after inoculum soil drench with SA at 20 ppm. Whereas reduction in total carbohydrates in roots were occurred by before + after inoculum foliar spray with SA at 20 ppm, after inoculum foliar spray with SA at 40 ppm and JA at 10 ppm. In leaves significant increase in total carbohydrates were induced by JA at 10 ppm as before + after inoculum soil drench and foliar spray as well as after inoculum soil drench. Before + after inoculum soil drench with SA at 20 & 40 ppm and before inoculum soil drench with JA at 10 ppm reduced total carbohydrates concentration in leaves.

As shown in Table (3) nematode infection did not influence total soluble sugars concentration but decreased reducing sugars in leaves. Before inoculum foliar spray of SA at 40 ppm, before + after inoculum and after inoculum soil drench of JA at 10 ppm significantly increased total soluble sugars and reducing sugars. Reversed effects were

Table 3. Effect of nematode infection (*M. incognita*) and different applications of SA 20 & 40 ppm and JA 5 & 10 ppm on biochemical constituents in roots and leaves of infected tomato plants.

Treatment				Root			Leaves					
PGR	Method	ppm	Timing	Phenols (ug/g)	Soluble proteins (mg/g)	Total carbohydrates (mg/g)	Phenols (ug/g)	Soluble proteins (mg/g)	Total carbohy-drates (mg/g)	Total soluble sugars	Reduced suagrs (mg/g)	Total chloro-phyll (mg/g)
SA	Sd	20	B	260.5	18.4	26.4	721.9	18.8	27.3	13.3	12.2	3.5
			A	272.7	18.8	23.3	666.9	17.0	21.8	10.8	9.7	2.4
			B + A	251.5	18.1	27.6	542.7	19.3	16.4	8.5	4.1	3.6
		40	B	262.8	17.9	15.6	506.2	17.8	30.8	15.7	12.6	2.4
			A	201.3	17.2	16.7	613.1	23.5	25.2	18.7	10.2	4.3
			B + A	272.5	17.6	25.1	674.6	16.7	19.9	9.2	7.4	4.0
	Fs	20	B	261.7	18.7	27.2	618.3	20.3	26.7	18.3	6.8	2.6
			A	241.3	19.8	16.1	873.2	22.8	31.6	15.8	14.7	2.6
			B + A	190.3	18.9	12.3	662.2	23.7	33.3	17.9	11.7	3.1
		40	B	233.5	17.9	30.1	520.3	16.6	33.9	19.7	11.7	3.1
			A	220.5	19.9	14.9	832.9	16.6	26.3	11.8	10.5	3.2
			B + A	670.6	19.7	23.1	845.3	15.6	32.9	16.6	11.6	4.1
JA	Sd	5	B	373.7	19.6	18.9	387.3	16.5	20.9	11.6	10.8	3.2
			A	314.5	18.3	19.7	533.3	20.7	31.8	18.2	11.2	3.4
			B + A	217.4	18.6	24.6	365.7	16.8	23.7	10.9	9.8	3.8
		10	B	186.9	19.1	16.9	532.1	19.6	16.5	11.1	4.4	2.9
			A	440.3	19.8	23.9	455.4	21.7	39.1	18.4	16.1	2.7
			B + A	281.7	19.8	23.9	334.6	21.7	35.9	18.7	11.7	3.8
	Fs	5	B	278.5	18.4	25.4	462.1	21.5	35.9	10.8	9.4	2.7
			A	191.1	19.9	15.7	571.1	16.4	27.4	15.3	11.8	3.5
			B + A	509.4	18.6	27.5	492.1	17.3	31.9	10.6	9.8	4.4
		10	B	353.3	17.6	19.3	629.7	23.1	33.7	16.1	13.3	4.2
			A	481.1	19.2	13.1	641.9	15.7	20.1	11.2	8.9	1.9
			B + A	324.4	16.7	25.1	313.9	19.4	36.8	18.5	12.6	2.7
Control (infected)				252.5	19.6	21.3	597.7	17.9	23.6	11.2	9.8	2.7
Control (non-infected)				235.1	19.6	21.3	475.1	19.6	25.7	11.3	10.8	3.7
LSD (0.05)				6.55	0.77	0.90	7.40	0.36	1.05	0.33	0.26	0.13

SD = Soil drench Fs = Foliar spray B = Before B + A = Before + After A = After

obtained by before + after inoculum soil drench with SA at 20 & 40 ppm. Also, before + after inoculum foliar spray with JA at 5 ppm reduced total soluble sugars. Before inoculum foliar spray with SA at 20 ppm and soil drench with JA at 10 ppm decreased reducing sugars concentration in leaves.

DISCUSSION

The present study clearly demonstrated that nematode infection negatively influenced tomato plants as evidenced by the reduction in shoot fresh & dry weight, root fresh weight, leaves number and fruits weight. In addition to, reduction in chlorophyll, total carbohydrate, and reducing sugar concentrations in leaves. A good deal of evidence has accumulated demonstrating the role of SA and JA in the plant defense mechanism against pests and pathogens **(Raskin, 1995 and Stasiwick, 1995).** In the present study, the effect of these PGR_S were variable depending on the concentration and method of application. Double application of SA at 40 ppm (before + after inoculum soil drench) and JA at 5 ppm (before + after inoculum foliar spray) as well as the single treatment with JA at 10 ppm (after inoculum soil drench) exhibited a resistance effect to nematode infection, as shown by the reduction of the females with and without egg masses and number of galls. All the aforementioned treatments were characterized by high production of phenols in roots and leaves (SA at 40 ppm). Moreover, reduction in females without egg masses and galls induced by most of JA at 10 ppm treatments. This effect was associated with an increase in phenols concentration in roots. The role of phenols in plant defense has been reported **(Taize and Zieger, 1998).** This role was emphasized by the increase of phenols in infected control. Furthermore, tomato plants were susceptible to nematode with single foliar spray treatments of SA at 20 ppm (before inoculum) and JA at 5 ppm (after inoculum). This effect was accompanied by high levels of phenols in leaves, but slight increase (SA at 20 ppm) or marked reduction (JA at 5 ppm) in roots. This means, that the effect of phenols is localized. It could be concluded that, JA treatments, the higher concentrations of PGRs, the double application and for some extent the soil drench applications were more effective in inducing resistance in tomato plants to nematode infection. An additional clue could be added to the previous conclusion by examining the effect of after inoculum foliar spray with SA at 20 ppm and before + after inoculum foliar spray with SA at 40 ppm. Both applications increased the number of females without egg masses and number of galls, on the other hand, SA at 20 ppm (after inoculum foliar spray) stimulated shoot fresh & dry weight, leaves number and soluble protein concentration. SA at 40 ppm (before + after inoculum foliar spray), stimulated plant height, shoot fresh & dry weight, fruit weight and chlorophyll concentration.

The role of SA in stimulating plant vegetative and reproductive growth in plants free from nematode has been reported by many workers **(Eo & Jo, 1987; Jaiswal & Bhambie, 1989 and Awasthi *et al* 1997).** This positive effects in the presence of positive nematode infection means, that plants became tolerant by these SA applications. Some JA at 10 ppm treatments such as before + after inoculum foliar spray and after inoculum

soil drench stimulated shoot fresh and dry weight, fruits weight and total carbohydrates concentration. This influences were associated by reduction in the nematode infection. Thus, JA treatments developed resistance reaction, whereas the previously mentioned SA treatments developed tolerant reaction against nematode infection.

REFERENCE

Arnon, D.L. (1949). Copper enzymes in isolated chloroplasts. Polyphenoloxidase in *Beta vulgaris*. ***Plant physiology. 24: 1-15.***

Awasthi, C.P.; A.B. Singh; D. Anita and A. Dhiman. (1997). Effect of phenolic compounds on yield and biochemical constituents of broad bean. ***Himachal J. Agric. Research 23: 70–76.***

Belles, J.M.; R. Garro; J. Fayos; P. Navarro; J. Primo and V. Conejero. (1999). Gentisic acid as a pathogen-inducible signal, additional to salicylic acid for activation of plant defense in tomato. ***Molecular Plant Microbe Interactions. 12: 227-235.***

Bradford, M.M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. ***Anal Biochem. 72 : 248 – 254.***

Danial, H. D. and C. M. George. (1972). Peach seed dormancy in relation to indogenous inhibitors and applied growth substances. ***J. Am. Soc. Hort. Sci. 17: 651-654.***

Dong-HAnSong; T.P. Delaney; D.W. Bauer; S.V. Beer and H.S. Dong. (1999). Harpin induces disease resistance in Arabidopsis through the systemic acquired resistance pathway mediated by salicylic acid and the NIMI gene. ***Plant Journal. 20: 207 – 215.***

Enyedi, A.J.; N. Yalpani; P. Silverman and I. Raskin. (1992). Localization, conjugation, and function of salicylic acid in tobacco during hypersensitive reaction to tobacco mosaic virus. ***Proc. Natl. Acad. Sci. USA. 89: 2480 – 2484.***

Eo, K. and G, Jo (1987). The effect of presowing treatment and growth regulators on different growth and yield contributing parameters in soybean (*Glycine masx* (L.) Merril). ***Korean, Journal of Crop Science 32: 392-402.***

Hassan, H. M. (1999). Effect of some antioxidants on the response of cucumber to *Meloidogyne javanica* infection and the activity of the plant peroxidase. ***Egyptian Journal of Agronematology 3: 139-147.***

Jaiswal, P.K. and S. Bhambie (1989). Effect of growth regulating substances on podding and yield of *Vigna radiata* (L.) Wilczek (mungbean). ***Acta. Botanica Indica. 17: 54 – 58.***

Malamy, J.; J.P. Carr; D.F. Klessing and I. Raskin. (1990). Salicylic acid : a likely endogenous signal in the resistance response of tobacco to viral infection. ***Science 250: 1002 – 1004.***

Parthier, B. (1991). Jasmonates, new regulators of plant growth and development: Many facts and few hypothesis on their actions. ***Botanica Acta 104: 405 – 464.***

Raskin, I. (1995). Salicylic acid. , Cited from: Davies, P.J. 1995. ***Plant Hormones; Physiology, Biochemistry and Molecular Biology. pp. 181-181.*** Kluwer Academic Publishers. Boston.

Reddy, P. P. (1983). ***Plant Nematology, pp. 10-29.*** Agricole Publishing Academy (apa), New Delhi.

Shales, O. and S.S. Schales (1945). A simple method for the determination of glucose in blood. ***Arch. Biochem. 8: 285.***

Snedecor, G.W. and W.G. Cochran (1980). ***Statistical Methods. 7th Ed pp: 264-267,*** Iowa State Univ. Press, Ames., Iowa, USA.

Stasiwick, K.P.E. (1995). Jasmonate activity in plants. Cited from : Davies, P. J. 1995. ***Plant Hormones,*** Physiology, Biochemistry and Molecular Biology. ***pp: 194-195.*** Kluwer Academic Publishers. Boston.

Taiz, L. and E. Zeiger. (1998). ***Plant Physiology. P. 574.*** Sinauer Associates, Inc., Publishers. Sunderland, Massachusetts.

Thaler, J.S. (1999). Induced resistance in agricultural crops: effects of jasmonic acid on herbivory and yield in tomato plants. ***Environmental Entomology. 28: 30-37.***

Waller, R.A. and D.B. Duncan (1969). A bay rule for the symmetric multiple comparison problem. ***Amer. State Assoc. J. Dec. : 1485-1503.***

Wees, S.C.M. Van; M. Luijendijk; I. Smoorenburg; L.C. Van-Loon; C.M.J. Pieterse; S.C.M. Van-Wees and L.C. Van-Loon. (1999). Rhizobacteria-mediated induced systemic resistance (ISR) in Arabidopsis is not associated with direct effect on expression of known defense-related genes but stimulates the expression of the jasmonate-inducible gene Atvsp upon challenge. ***Plant Molecular Biology. 41: 534–549.***

Zinov, Eva, S.V.; N.I. Vasyukova; L.I. Il-insakaya; O.L. Ozeretskovskaya and M.D. Sonin (1998). Resistance of tomato plants to roo-knot nematode *Meloidogyne incognita* (Kofold et White) induced by arachidonic acid and methyljasmonate. ***Biological Science 363: 587-5829.***

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تأثير حمض الساليسيليك و حمض الجاسمونيك علىأستجابة نبات الطماطم لنيماتودا تعقد الجذور (*Meloidogyne incognita*)

[٧٢]

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أجريت هذه التجربة فى الصوبة بكلية الزراعة جامعة عين شمس على نباتات الطماطم حيث تم عدوى هذة النباتات عند عمر ٤٥ يوم بنيماتودا تعقد الجذور *Meloidogyne incognita* وذلك بإضافة (٥٠٠ من الطور اليرقى المعدى / نبات) وفى نفس الوقت تم معاملة النباتات بمنظمات النمو التالية: حمض الساليسيليك بتركيز ٢٠، ٤٠ جزء فى المليون و حمض الجاسمونيك بتركيز ٥ ، ١٠ جزء فى المليون وتمت هذه

المعاملات فى صورة رش أو رى بصورة فردية ولكن فى أوقات مختلفة كما يلى:

أ - إضافة منظمات النمو قبل العدوى بيومان.

ب - إضافة منظمات النمو بعد العدوى بيومان.

ج - إضافة منظمات النمو مرتين قبل وبعد العدوى بيومان.

- تم أخذ عينة واحدة بعد شهر واحد من عدوى النباتات وذلك لدراسة تاثير هذة المعاملات على عدد العقد الجذرية الناتجة عن الاصابة وعدد الاناث الواضعة وغير الواضعة للبيض وكذلك لقياس النمو فى النبات وعدد ووزن الثمار وبعض المركبات الكيميائية.

وكانت أهم النتائج المتحصل عليها هى:

- أظهرت الإصابة بالنيماتودا نقص فى نمو النبات ووزن الثمار والكلوروفيل والكربوهيدرات الكلية والسكريات المختزلة فى الأوراق.
- كلا من الرى بحمض الساليسيليك بتركيز ٤٠ جزء فى المليون و الرش بحمض الجاسمونيك بتركيز ٥ جزء فى المليون مرتين(قبل و بعد العدوى) وكذلك المعاملة الفردية بحمض الجاسمونيك كرى بعد العدوى أدى إلى حدوث مقاومة فى نبات الطماطم.
- كذلك معظم معاملات حمض الجاسمونيك بتركيز ١٠ جزء فى المليون أدت إلى حدوث مقاومة للنيماتودا وكانت هذه التأثيرات مصحوبة بزيادة فى تركيز الفينولات فى الجذور بصفة خاصة.
- كذلك حدوث زيادة فى الفينولات فى نباتات الكنترول المصابة وغير المعاملة بمنظمات النمو.
- بعض معاملات الرش أدت إلى زيادة حساسية نباتات الطماطم للإصابة بالنيماتودا مثل الرش بكل من حمض الساليسيليك بتركيز ٢٠ جزء فى المليون وحمض الجاسمونيك بتركيز ٥ جزء فى المليون بعد العدوى وقد اظهرت النباتات المعاملة هنا نقص فى محتوى الفينولات فى الجذر مقارنة بالنباتات التى أظهرت مقاومة.
- معاملة الرش بحمض الساليسيليك بتركيز ٢٠ جزء فى المليون بعد العدوى و ٤٠ جزء فى المليون قبل وبعد العدوى اظهرت زيادة فى مستوى الإصابة بالنيماتودا ولكن هذا التأثير كان مصحوبا بزيادة فى نمو النباتات و الثمار ومحتوى البروتين الذائب (عند تركيز ٢٠ جزء فى المليون) والكلوروفيل (عند تركيز ٤٠ جزء فى المليون). وهذا يدل على أن هذة المعاملات أدت إلى زيادة فى درجة تحمل النبات للإصابة.
- تم مناقشة تأثير منظمات النمو موضع الدراسة على استجابة نبات الطماطم لنيماتودا تعقد الجذور.

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