Induction of systemic acquired resistance in date palm plants against certain plant parasitic nematodes by some chemicals

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Abstract

A field experiment was conducted at Faculty of Agriculture Farm in Giza Governorate, Cairo University, Giza, Egypt on clay loam soil planted to date palm cv. Zaghlool infested with plant parasitic nematodes, *Rotylenchulus reniformis* and *Helicotylenchus* sp. An experiment was carried out to investigate the efficacy of acetyl salicylic (ASA) and γ-amino-n-butyric acids (GABA) as chemical resistance inducer at the concentrations of 5, 10 and 20 mM against nematodes and consequently on date palm yield. The results showed that number of *R. reniformis* in soil and roots and *Helicotylenchus* sp., were reduced in soil one month after application at the harvest according to the tested concentrations as compared with control significantly ($p \leq 0.05$). GABA achieved at the highest and moderate concentrations the highest dates yield (%) increases (25.4 and 17.8%) as compared to ASA (16.2% and 12.9%), respectively. The lowest concentration from each material achieved the lowest result.

Keywords: Resistance, date palm, plant parasitic nematodes, *Rotylenchulus reniformis*, *Helicotylenchus* sp.

Because of the lack of resistance in plants to the most species of plant parasitic nematode as well as the environmental restrictions on nematicidal use for controlling plant parasitic nematodes on date palm; other control measures have gained recently increasing interest (Bondok & Korayem, 2011; El-Nagdi *et al*., 2011). On the other hand, it has been suggested that the use of induced resistance in plants could offer a considerable potential for biological control (Deverall, 1995). A new strategy for controlling plant parasitic nematodes is based on the activation of the plant's own defense system via various biotic and abiotic agents.

Systemic acquired resistance (SAR) is plant defense mechanism present long lasting resistance against diffeent pathogens. SAR activated molecular changes including antimicrobial pathogenesis related (PR)-proteins (Dong *et al*., 2007). DL-B-amino-n-butyric acid (BABA) is a non protein amino acid still not reported in nature (Rosenthal, 1982). Treatment with (BABA) induces plant resistance to fungal pathogens as well and PR-proteins accumulate in tomato plants treated with this amino acid (Sunwoo *et al*., 1996; Hwang *et al*., 1997). Oka & Cohen (2001) reported that foliar sprays and soil drenches with (BABA) reduced the number of *Heterodera avenae* (pathotype, Ha 21) and *H. latipons* cysts on wheat (cv. Bet-Shita) and barley (cv. Ingrid).

Salicylic acid (SA) of which acetyl salicylic acid is an inducer of plant resistance to some pathogens (Kessmann *et al*., 1994 a&b). It has been thought that this inducer and its derivatives can act an important role in systemic acquired resistance because exogenous SA induces this resistance and accumulates in pathogen infected tissue (Malamy *et al*., 1990; Métraux *et al*.,

1990) and translocated to uninfected parts of the plant (Shulaev *et al*., 1995). Kim-Young *et al*., (1998) stated that reproduction of *Heterodera glycines* on the susceptible soybean cv. Lee 74 was significantly reduced by 60, 64 and 87% in pre, post and simultaneous treatments of acetyl salicylic acid (ASA, aspirin), respectively. ASA had insignificant effect on the survival of second stage juveniles (J_2) and their penetration into the soybean root tissues, but significantly inhibited the early stage nematode growth in the roots. Exogenous salicylic acid reduced *Meloidogyne incognita* infestation when it was sprayed on roots, suggesting that it could induce some resistant effect to nematode and improve plant growth (Nandi *et al*., 2000). Hence, the aim of this research to investigate the effect of two chemical inducers for managing root-knot, *Rotylenchulus reniformis* and spiral *Helicotylenchus* sp., nematodes infesting date palm cv. Zaghlool under field conditions.

Materials and Methods

Experiment was conducted on a date palm orchard (cv. Zaghlool) at Faculty of Agriculture Farm in Giza Governorate, Cairo University, Giza, Egypt on clay loam soil and infested with certain plant parasitic nematodes. Treatments were applied to 15 year old date palm trees during April, 2011. Acetyl salicylic acid and γ-aminobutyric acid were applied at the concentrations of 5, 10 and 20 mM/tree. The two materials at their rates were added as soil drench and applied in 500 ml water per tree and watered after treatment. There were five replicates for each treatment and all treatments were distributed in a completely randomized block design. Soil and root samples at a depth of 60-cm were taken one month after application and at harvest around root system. An aliquot of 200 g soil was extracted by sieving and decanting method for nematode assessment. An aliquot of 5 g roots were incubated in distilled water as described by Young (1954). Yield of dates per tree was determined and productivity was calculated per feddan by multiplying in 70 (70 trees per feddan).

Statistical Analysis: The data was statistically analyzed using general linear model (GLM) (SAS, 1999). Differences among means were determined by Duncan's Multiple Range Test (DMRT).

Results

Table 1 and 2 illustrated the effect of γ-aminobutyric and acetyl salicylic acids in inducing resistance in date palm against the reniform nematode, *Rotylenchulus reniformis* and the spiral nematode, *Helicotylenchus* sp. compared to untreated trees. It is noticeable that all treatment's concentrations significantly ($p \leq 0.05$) decreased the number of *R. reniformis* in soil and roots and *Helicotylenchus* sp. in soil. The percentages reductions were positively proportional to the tested concentration i.e. the highest concentration, the highest efficacy on nematodes. It is clearly noticed the reductions by using the two tested materials were higher regarding *R. reniformis* than those in relation to *Helicotylenchus* one month after application and vice versa at harvest stage.

The tested treatments improved date yield in kg per tree and productivity per feddan according to the tested concentrations, as the highest concentration, the highest date yield and productivity. GABA achieved the highest percentages date yield increases (25.4 and 17.8%), compared to ASA (16.2% and 12.9%), at the highest and moderate concentrations, respectively (Table 3). The lowest concentration from each material achieved the lowest result.

Table 1. **Effect of γ-aminobutyric acid (GABA) and acetyl salicylic acid (ASA) as chemical inducers on nematode densities associated with the date palm rhizosphere one month after application.**

Treatment	Concentration (mM)	Nematode densities/200 g soil and 5 g roots					
		Rotylenchulus reniformis (in soil + roots)			*Helicotylenchus* sp. (in soil)		
		Initial	Number	Reduction (%)	Initial	Number	Reduction (%)
γ-aminobutyric acid (GABA)	5	146	110 b	50.0	156	92 bc	30.3
	10	75	74 bc	66.4	130	74 c	43.9
	20	65	44 c	80.0	80	44 d	66.7
Acetyl salicylic acid (ASA)	5	165	96 b	56.4	234	130 a	01.5
	10	146	87 b	60.5	156	96 b	27.3
	20	120	78 bc	64.5	160	82 bc	37.9
Control	-	90	220 a	-	140	132 a	-

Initial population densities are not significantly different after Arcsin transformation (Snedecor & Cochran, 1980).
Figures in each column with different letter(s) are significantly different at $P \leq 0.05$.

Table 2. **Effect of γ-aminobutyric acid (GABA) and acetyl salicylic acid (ASA) as chemical inducers on nematode densities associated with the date palm rhizosphere at harvest stage.**

Treatment	Concentration (mM)	Nematode densities/200 g soil & 5 g roots					
		Rotylenchulus reniformis (in soil + roots)			*Helicotylenchus* sp. (in soil)		
		Initial	Number	Reduction (%)	Initial	Number	Reduction (%)
γ-aminobutyric acid (GABA)	5	146	110 c	35.3	156	95 bc	51.5
	10	75	53 e	68.8	130	92 c	53.1
	20	65	32 f	81. 2	80	64 c	67.3
Acetyl salicylic acid (ASA)	5	165	143 b	15.9	234	127 b	35.2
	10	146	80 d	52.9	156	80 c	59.2
	20	120	47 ef	72.4	160	71 c	63.8
Control	-	90	170 a	-	140	196 a	-

Initial population densities are not significantly different after Arcsin transformation (Snedecor & Cochran, 1980).
Figures in each column with different letter(s) are significantly different at $P \leq 0.05$.

Table 3. Effect of γ-aminobutyric acid (GABA) and acetyl salicylic acid (ASA) as chemical inducers in date palm yield and productivity.

Treatment	Concentration (mM)	Yield (kg/tree)	Production (ton/feddan)	Increase (%)
γ-aminobutyric acid (GABA)	5	148.0 bc	10. 360 bc	08.2
	10	161.2 ab	11. 284 ab	17.8
	20	171.6 a	12. 012 a	25.4
Acetyl salicylic acid (ASA)	5	150.6 bc	10. 542	10.1
	10	154.4 b	10. 808	12.9
	20	159.0 ab	11. 130	16.2
Control	-	136.8 c	9.576 c	-

Figures in each column with different letter(s) are significantly different at $P \leq 0.05$.

Discussion

It is suggested that the mechanism of amino acids in inducing nematode resistance in plants against nematodes results from high peroxidase activity, lignin formation at pathogen infection sites and by making the plant cell walls physically harder for nematodes to penetrate and render treated roots temporarily less attractive to nematodes due to changes in plant metabolism modification of plant cell wall. Different chemical compounds induced resistance tested for their ability to reduce the number of *H. avenae* cysts population on wheat. Only DL-B-amino-n-butyric acid (BABA) was an effective resistance inducer. Soil drench of wheat (cv. Prince) with 500 mg/l BABA reduced the number of egg-masses of *Meloidogyne* sp., (root-knot nematode) and inhibited development of this nematode inside the BABA-treated roots (Oka & Cohen, 2001).

Whereas, the statistical analysis in the present study revealed that, all concentrations of the tested materials decreased the number of nematodes and improved date palm yield. Also, in the present study, the differences in the effect of both materials on *R. reniformis* and *Helicotylenchus* sp. may be due to nature of their parasitism on plants, as they act as semi endo and ecto-parasites, respectively. Similar results were obtained by application acetyl salicylic acid (ASA) and γ-aminobutyric acid (Osman *et al*., 2008). These results agree with other investigations (Nandi *et al*., 2003a & b; Pankaj *et al*., 2005). Salicylic acid (SA) from acetyl salicylic acid plays significant role after pathogen attack in the activation of plant defense responses (Klessig *et al*., 2000) SA is considered as plant defense signal and has induced resistance in several plant species (Yang *et al*., 1997). Induced resistance has been obtained in numerous plant species with SA, by a mechanism, including induction of pathogenesis-related protein (PR-protein). Moreover, SA has been reported as an endogenous signal for the activation of certain plant defense responses by expression of genes for pathogenesis-related protein (PR-1) and enhanced resistance to pathogens (Green berg *et al*., 1994; Conrath *et al*., 1995; Nandi *et al*., 2003a & b). SA, in particular, has a biotic role in nematode susceptible plants. It has been regarded as resistance inducer in such susceptible plants. The role of SA inside plants has been explained by many workers (Nandi *et al*., 2002; Mahgoob & Zaghlool, 2002; Siddiqui & Shaukat, 2004; 2005).

In fact a network of sophisticated and interconnected mechanisms is developed in plants as a result of exposure to a variety of abiotic and biotic agents. Plant hormones are key players that interconnect and modulate responses to various external signals. Induced defenses play a strong role in plant disease resistance and controlled by Jasmonic acid (JA), ethylene (ET) and Salicylic acid (SA). Potential antagonism or synergism between defense pathways determined by recognition of pathogen or other environmental stress (Palva *et al*., 2007)

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