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Induction of Systemic Resistance in Tomato Plants against Root-Knot Nematode, *Meloidogyne incognita* (Passe-Muraille) with β, Amino Butyric Acid

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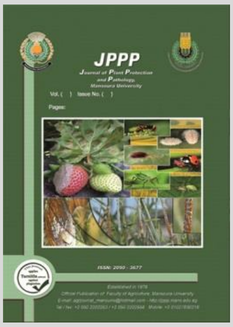

ABSTRACT

In this study, the efficiency of β amino butyric acid (BABA) on induction of resistance against root-knot nematode (*Meloidogyne incognita*, PM) infection of tomato plants were evaluated. The effects of treatments were estimated by counting the number of galls, egg masses / root system and juvenile per 250 g soil. In addition, tomato plants growth parameters were estimated. Results showed that the plants which sprayed with BABA at 32 and 16 Mm gave the highest reduction in gall numbers, egg masses formation and juveniles, (57.87- 55.85, 60-59.48 and 49.8- 47.25 % respectively). Concerning the soil drench of BABA with 32 and 16 Mm the highest reduction in gall numbers, egg masses formation and juveniles were recorded (61.92- 60.05, 63.99-61.85 and 55.65- 53.38 % respectively). Treatments as well enhance both fresh and dry shoot and root system compared with inoculated control. Also, results showed that application of BABA interior to nematode inoculation were outstanding in inducing acquired resistance for *M. incognita* than application at the same time or next nematode infection.

Keywords: *Meloidogyne incognita*, β amino butyric acid, *Solanum lycopersicum.*

INTRODUCTION

The tomato (*Solanum lycopersicum*) industry is one of the most progressing, innovative and globalized horticultural industries, Tomato ranks second in priority after Potato in the world. Egypt ranks fifth in the production of Tomato, China, USA, Italy, Turkey, India and Egypt are the important tomato production countries (FAO, 2019). Plant-parasitic nematodes can act as pests on a wide range of remarkable agricultural crops. The root-knot nematodes (*Meloidogyne spp*.) are among the most devastating agricultural pests globally. They damage a wide range of plants, causing a great losses in yield both tropical and sub-tropical agriculture (Sikora and Fernandez 2005). Newly, *Meloidogyne* has an important role as determination factor for many crop cultivation. Also, root-knot nematode (*Meloidogyne* spp.) is one of the gravest nematode in greenhouse and field (Bakr *et al* 2011). Control of plant-parasitic nematodes always has been complicated, and the use of toxic fumigant nematicides for many years has been the most effective strategy, like the most notorious methyl bromide (Oka *et al.*, 2000b). Furthermore, efficient nematicides such as dibromochloropropane (DBCP) and ethylene dibromide (EDB) have been outgoing from the market due to the fact their harmful effects on both humans and environment (Oka *et al.*, 2000b). The use of chemical nematicides, not only the expenses incurred, but also, can result in chemical residues deleterious for humans and the environment as well as pick out resistance for nematodes (Ghini and Kimati, 2000). Nematode control is complex and also needs integrated management practices. The greatest used methods include chemical and biological control and resistant cultivars. Consequently, late strategies for the management of nematodes have actively been examined in a few years ago, and seeking has focused on organic and inorganic amendments, biological control, naturally nematicides and induced acquired resistance (Oka *et al*., 2000a). Chemical inducers have been among the alternative methods developed for management of the nematode, a number of defense mechanisms in the plants have been found against pathogens. In addition to constituent resistance, plants infection with widely different pathogens can be activate protective mechanisms. The pathogen induced resistance can be setup in the tissue surrounding the site of premier infection (localized acquired resistance, LAR) however in the distant, uninfected parts of the tissue (systemic acquired resistance, SAR) (Hammerschmidt, 2009). Applying SA and also its functional analogs, such as 2,6-dicholoroisonicotinic acid (INA) and acibenzolar-Smethyl (ASM) (Oostendorp *et al*., 2001). SAR elicitors do not display any direct antimicrobial action and seem to have environmentally benign, diverse traditional pesticides. In many cases SAR protects plants from a wide spectrum of pathogens and have systemic action (Klessig and Malamy, 1994; Schneider *et al*., 1996). The use of SA to inducing resistance for nematodes is particularly motivating as it is non-phytotoxic and a natural compound at the convenient dosage (Molinari, 2008). Accumulation of plant defense metabolites and activation of enzymes related to plant defenses against pathogens are the most significant mechanisms of chemical inducers in plants. In many plants these compounds stimulate resistance against plant diseases that are caused by a diversity of pathogens including, fungi, viruses, bacteria, and nematodes (Kessmann *et al.* 1994; Cohen 1994; Oostendorp and Seikora 1990). Plant molecules thought to be plant defense signals, such as ethylene,

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systemin, jasmonic acid (JA) and methyl jasmonate (MeJA) as well have been reported to induce local and systemic resistance to spectrum range of pathogens in plants (Oka *et al*., 1999). BABA is a nonprotein amino acids have been used as chemical inducers against a wide spectrum of pathogens in various plants (Oka *et al*., 1999; Lee *et al*., 2000). Applied the BABA as a resistance chemical inducer in tomato plants as soil drenching and foliar spray with BABA causes both local and systemic induction of plant defense mechanisms and decreases the root galls, number of eggs (Oka *et al*., 1999). Also, Ton *et al*., 2005 illustrated that plants applied with BABA develop a promote capacity to resist biotic and abiotic stresses. They have cleared that induced resistance miss at low BABA concentration while female sterility happen at high BABA concentrations. Ji *et al*., 2015 illustrated that BABA induced resistance against M. graminicola in rice crop although, it has'nt toxicity to nematode. BABA inhibited penetration of nematode, delaying development of giant cell formation. Foliar spray and root drench with BABA to tomato and cucumber induced systemic resistance against M. javanicum (Oka *et al.*, 1999 and Oka et al., 2001) as well against the M. marylandi in wheat (Oka *et al.*, 2001). BABA reduced *M. incognita* in tomato plants (Anter *et al.*, 2014). Fatemy *et al.* (2012 sowed that tomato seed treated with BABA protected them aganist M. javanica. Ahmed *et al.* (2009) cleared the effectively of BABA in mung bean plants against *M. javanica*. Mongae and Moleleki, 2015 showed that potato plants treated with of BABA protected them from *M. incognita.* So, the aim of this work was to determine the effect of foliar spray and/or soil drench of BABA as a chemical inducer at five concentration with three different time of application on tomatoes plants against *M. incognita* plants under greenhouse condition.

MATERIALS AND METHODS

Nematode Inoculation:

Eggs of root-knot nematode, *M. incognita* was isolated from heavily infested roots of eggplant (*Solanum melongena L*) which were obtained from El-Bostan region, EL-Beheira Governorate. Roots were used for egg extraction methods using sodium hypochlorite (NaOCl) technique (Hussey and Baker 1973)

Egg-masses staining and counting:

For 20-30 minutes egg-masses of *M. incognita* were stained by placed them in an aqueous solution of Phloxine B (0.15g per liter tap water). Root systems were rinsed in tap water, to remove residual stain on the roots. Phloxine B primarily stains the gelatinous egg sac and naked viable eggs (Barker *et al.*, 1985)

Nematode extraction:

Through 100, 200 and 325 mesh-sieves 250 g of soil was successively wet-sieved. The active nematode present in the fine sieve were extracted by Baermann-plate technique (Goodey, 1963). A counting slide was used for counting second stage juveniles (J_2) of *M. incognita* microscopically.

β, amino butyric acid preparation (BABA):

Stalk solution of BABA, molar mass103.121 g·mol−1 (purchased from Gomhoria Company, Egypt) was prepared by dissolving 164.8 mg in 50 ml of distilled water.

Foliar spraying with β, amino butyric:

Plastic pots (20 cm in diam. and 25 cm in depth) were filled with 3 kg mixture of autoclaved sand: peat moss (3:1, V: V). One of tomato seedling (CV. 023 f1) of 35 days old was transplanted in each pot and watered every two days and fertilized as needed. After one week from transplanting time, suspension containing near to 5000 eggs and newly hatching second stage juveniles was used to inoculate each pot after seven days from transplanting around the plant stem. Five concentrations of BABA, 2, 4, 8, 16 and 32 mM were used as a foliar spray application. The experiment was consisted of 17 treatments (untreated control inoculated with *M. incognita*; non-inoculated control and 15 combination of the 5 concentrations of BABA 5-d before, during and 5-d after nematode inoculation). Plants were accurately sprayed until complete wetness using 2 L hand sprayer. In the greenhouse, each treatment was replicated 4 times and arranged in randomized complete design. Fifth days after inoculation, plants were removed, the fresh and dry weights of shoots and roots were determined. Also, egg-masses, number of galls and juveniles per 250 g soil were counted

Soil drenching with β, amino butyric:

One of tomato seedling (CV. 023f1) of 35 days old was transplanted, in plastic pots (20 cm in diam. and 25 cm in depth), which was filled with 3 kg mixture of autoclaved sand: peat moss (3:1, V: V). Suspension containing around 5000 eggs and newly hatching second stage juveniles were add around the plant stem after one week from transplant. 3 mL of 2, 4, 8, 16 and 32mM of BABA were added around the root of each tomato plants as soil drenching. Seventeen treatments (untreated control inoculated with *M. incognita*; non-inoculated control and 15 gathering s of the five concentration of BABA applied 5-days before, during and 5-days after nematode inoculation. Plants were watered every two days and fertilized as needed. In the greenhouse each treatment was replicated 4 times and arranged in randomized complete design. Fifth days after inoculation plants were removed, the fresh and dry weights of shoots and roots were determined. As well, number of galls egg-masses and number of juveniles / 250 g soil were counted

Statistical analysis:

As a factorial arrangement in a complete randomized design (CRD) data were analyzed. The least significant differences (LSD) were used for comparisons among means at 0.05 levels according to Sendecor and Cochran (1980). SAS (2000) were used to analyze the data.

RESULTS AND DISCUSSION

Results:

Foliar spraying application:

Effect of foliar spraying with β, amino butyric on *M. incognita* gall numbers

The resulted in Table (1) clear that, treatments significantly ($p \leq 0.05$) decreased the number of galls compared to untreated inoculated control at the five concentration, and the three time. However, 32, 16, 8, 4 and 2 mM of BABA treated plants registered reduction gall number by 57.78, 55.85, 45.49, 42.9 and 34.15 % respectively. BABA at 32 mM achieved the highest significant reduction. While, spraying BABA five days before inoculation gave the highest heist significant reduction on gall number. Otherwise spraying after five days from inoculation with BABA gave the lowest significant reduction.

Table 1. Effect foliar spray of β, amino butyric acid on the number of galls on tomato plants infected with *M. incognita* under greenhouse conditions

Conc.	Nematode inoculation						Mean	Reduction %
	5 days after		During		5 days before			
	Mean of galls / plant	Reduction %	Mean of galls / plant	Reduction %	Mean of galls / plant	Reduction %		
32mM	140	65.47	170.25	58.01	202.25	50.12	170.83	57.87
16 mM	150	63	172.25	57.39	214.75	47.04	179	55.85
8 mM	190.25	53.08	209.75	48.27	263	35.14	221	45.49
4 mM	204	49.62	245.25	39.58	245.25	39.51	231.5	42.9
2 mM	216	46.79	272.25	32.86	313	22.81	267	34.15
Inoculated Control	405.5		405.5		405.5		405.5	
Mean	217.62		245.87		273.95			

LSD (P≤ 0.05) = Concentration = 7.55, Treatments = 5.34, Interaction = 1.64. Each number is a mean of four replicates and one plant.

Nematicidal activity of foliar Spraying with β, amino butyric on *M. incognita* egg masses formation:

All treatments significantly (p ≤ 0.05) reduced number of egg masses compared to untreated inoculated control as showed in Table (2), the highest effect was obtained by BABA at 32 mM (60%), followed by BABA at 16 mM (59.48) without significant difference between them. otherwise, treatment with BABA at n mM gave the lowest effect (34.15) However, treatments five days before inoculation reduced number of egg masses significantly (p ≤ 0.05) compared with treatment during inoculation and five days after inoculation.

Table 2. Efficiency of spraying β, amino butyric on tomato plants, on rate egg masses formation of *M. incognita* under greenhouse condition.

Conc.	Nematode inoculation						Mean	Reduction %
	5 days after		During		5days before			
	Mean of egg masses/ plant	Reduction %	Mean of egg masses/ plant	Reduction %	Mean of egg masses/ plant	Reduction %		
32 mM	119.75	68.61	151	60.41	186.5	51.11	152.41	60
16 mM	123.25	67.69	152	60.15	188.5	50.58	154.58	59.48
8 mM	170.5	55.3	189	50.45	242.5	36.43	200.67	47.39
4 mM	187.5	50.58	219.75	42.39	219.75	42.39	209	45.21
2 mM	195	48.88	250.75	34.27	281.25	26.27	242.33	36.47
Inoculated control	381.5		381.5		381.5		381.5	
Mean	196.25		224		250			

LSD (P ≤ 0.05) = Concentration = 6.84, Treatments = 4.62, Interaction = 1.42. Each number is a mean of four replicates and one plant.

Nematicidal activity of foliar spraying with β, amino butyric on *M. incognita* 2nd juveniles

The results in Table (3) illustrated that treatments were significantly (p ≤ 0.05) different compared to untreated inoculated control. Treatment with BABA at 32 mM and at 16 mM had the highest reduction reduced the number of J2 by 49.8 and 47.25 % respectively, without significant difference between them. Otherwise, Treatment with BABA at 2 mM had the lowest reduction reduced the number of J2 by 28 %. Furthermore, application BABA five days before inoculation had the highest effect, compared with the treatment of BABA five days after inoculation that gave the lowest reduction.

Table 3. Efficacy of spraying β, amino butyric on number 2nd juvenile's under greenhouse conditions on tomato plants infected with *M. incognita*.

Conc.	Nematode inoculation						Mean	Reduction %
	5 days after		During		5 days before			
	Mean juveniles 2nd /250 g of soil	Reduction %	Mean juveniles 2nd / 250 g of soil	Reduction %	Mean juveniles 2nd/ 250 g of soil	Reduction %		
32 mM	114	59.02	139.25	49.95	165.75	40.43	139.67	49.8
16 mM	126.75	54.52	144	48.24	169.5	38.41	146.75	47.25
8 mM	151.5	45.55	166	40.34	208.5	25.06	175.33	43.45
4 mM	159.5	42.67	190.75	31.44	190.75	31.44	180.33	35.19
2 mM	164.75	40.79	216.25	22.28	220	20.93	200.33	28
Inoculated control	278.25		278.25		278.25		278.25	
Mean	165.79		189.08		205.45			

LSD (P ≤0.05) = Concentration = 9.82, Treatments = 6.94, Interaction = 2.13. Each number is a mean of four replicates and one plant.

Effectively of spray β, amino butyric on Fresh and Dry Weight of Shoot.

The data in Table (4) cleared that, tomato plants spraying with BABA significantly (p = 0.05) increased both shoot fresh weight and shoot dry weight compared with untreated inoculated control, but less significantly (p = 0.05) compared with non-inoculated control. The 32 mM recorded the height average fresh and dry shoot weights, 62.82 and 17.24g. Spraying with BABA 5 days interior nematode inoculation gave the height fresh and dry shoot weight 57.82 and 16.45 g respectively. Furthermore both treatment of BABA during inoculation and five days after inoculation gave the lowest weight of fresh and dry shoot weight 55.71, 15.18 and 55.51, 14.95 g respectively, without significant difference between them.

Table 4. Effectively of foliar spraying with β, amino butyric on shoot fresh and dry weights of tomato plants infected with *M. incognita* under greenhouse conditions

Conc.	Shoot weight of infected plants							
	Nematode inoculation							
	5 days after		During		5 days before		Mean	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
32 mM	63.59	17.72	64.96	16.82	59.9	17.19	62.82	17.24
16 mM	62.29	17.32	63.65	17.45	63.3	15.57	57.41	16.78
8 mM	56.52	15.57	55.29	14.55	56.5	14.85	56.1	15
4 mM	57.38	16.52	53.28	13.51	53.28	13.51	54.56	14.51
2 mM	55.58	17.19	53.41	13.08	53.24	12.63	54.07	14.3
Inoculated control	40.43	11.25	40.43	11.25	40.43	11.25	40.43	11.25
Non-inoculated Control	68.59	19.62	68.95	19.62	68.95	19.62	68.95	19.62
Mean	57.82	16.45	55.71	15.18	55.51	14.95		

LSD ($P \leq 0.05$) Fresh weight: Concentration = 2.83, Treatments = 1.85, Interaction = 0.60. LSD ($P \leq 0.05$) Dry weight: Concentration = 1.45, Treatments = 0.95, Interaction = 0.3. Each number is a mean of four replicates and one plant.

Efficacy of spray β, amino butyric on Fresh and Dry Weight of root system

Data obtained in Table (5) illustrated that tomato plants spraying with BABA significantly (p = 0.05) increased both fresh and dry root weight compared with untreated inoculated control (10.22 and 2.6 g respectively), but less significantly (p = 0.05) compared with non-inoculated control (17.81 and 4.37 g respectively). Spraying BABA 32 mM and 16 mM recorded the height average weight of fresh and dry root weights, 15.17, 3.44 and 14.97, 3.19 g, without significant difference between them. While, spraying BABA 5 days before nematode inoculation gave the height fresh and dry root weight 14.57 and 3.31 g respectively. Moreover, both treatment of BABA during inoculation and five days after inoculation gave the lowest weight of fresh and dry root weight 13.42, 3.04 and 13.51, 3.05 g respectively, without significant difference between them.

Table 5. Efficiency of foliar spraying with β, amino butyric on root fresh and dry weights of tomato plants infected with *M. incognita* under greenhouse conditions

Conc.	Shoot weight of infected plants							
	Nematode inoculation							
	5 days after		During		5 days before		Mean	
	Fresh	dry	Fresh	Dry	Fresh	Dry	fresh	Dry
32 mM	16.79	4.14	14.01	4.15	14.7	3.04	15.17	3.44
16 mM	16.17	3.77	13.9	2.99	14.85	2.82	14.97	3.19
8 Mm	14.07	2.81	13.34	2.73	12.52	2.9	13.31	2.81
4 mM	13.59	2.8	12.26	2.69	12.26	2.69	12.7	2.8
2 mM	13.35	2.69	12.4	2.78	12.19	2.94	12.64	2.72
Inoculated control	10.22	2.6	10.22	2.6	10.22	2.6	10.22	2.6
Non-inoculated Control	17.81	4.37	17.81	4.37	17.81	4.37	17.81	4.37
Mean	14.57	3.31	13.42	3.04	13.51	3.05		

LSD ($P \leq 0.05$) Fresh weight: Concentration = 1.15, Treatments = 0.99, Interaction = 0.32. LSD ($P \leq 0.05$) Dry weight: Concentration = o.31, Treatments = 0.2, Interaction = 0.068. Each number is a mean of four replicates and one plant.

The results in Table (6) cleared that, all treatments significantly ($p \leq 0.05$) decreased the number of galls compared to untreated inoculated control at the five concentration, and the three time. While 32, 16, 8, 4and 2 mM of BABA treated plants registered reduction gall number by 61.29, 60.05, 46.34, 37.53 and 55.69 % respectively. BABA at 32 mM and 16 mM achieved the highest significant reduction, without significant difference between them. Moreover, soil drench of BABA five days before inoculation gave the highest significant reduction on gall number compared with the other two time of application.

Table 6. Effects of soil drench with β, amino butyric on numbers of galls under greenhouse conditions of tomato plants infected with *M. incognita*.

Conc.	Nematode inoculation						Mean	Reduction %
	5 days after		During		5 days before			
	Mean of galls / plant	Reduction %	Mean of galls / plant	Reduction %	Mean of galls / plant	Reduction %		
32 mM	87	75.37	141.5	59.94	175	50.46	134.5	61.92
16 mM	102.75	70.91	138.75	60.72	181.75	48.54	141.1	60.05
8 mM	140.75	60.15	201.25	43.02	225.75	36.18	189.25	46.34
4 mM	192	45.64	224.75	36.37	245.25	30.57	220.66	37.53
2 mM	210	40.55	210	40.55	261	26.11	227.16	35.69
Inoculated control	353.25		353.25		353.25		353.25	
Mean	180.95		211.58		240.41			

LSD ($P \leq 0.05$) = Concentration = 11.17, Treatments = 7.89, Interaction = 2.43. Each number is a mean of four replicates and one plant.

All treatments significantly (p ≤ 0.05) decreased number of egg masses compared to untreated inoculated control in Table (7), the highest effect was obtained with BABA at 32 mM (63.99%), followed by BABA at 16 mM (61.85) without significant difference between them. Otherwise the lowest effect was obtained with both BABA at 2 and 4 Mm (37.06 and 39.71 % respectively) without significant difference between them. However, treatments with BABA as five days before inoculation reduced number of egg masses significantly (p ≤ 0.05) compared with treatment with BABA during inoculation and five days after inoculation.

Data presented in Table (8), revealed that, treatments reduced number of J2 significantly (p ≤ 0.05) compared with untreated inoculated control, the highest effect was recorded with BABA at 32 mM (55.65%), followed by BABA at 16 mM (53.38) without significant difference between them. Otherwise the lowest effect was obtained with both BABA at 2 and 4 Mm (31.14 and 33.67 % respectively) without significant difference between them. However, treatments with BABA as five days before inoculation reduced number of J2 significantly (p ≤ 0.05) compared with treatment by BABA during inoculation and five days after inoculation.

Table 7. Effects of soil drench with β, amino butyric on egg masses formation under greenhouse conditions of tomato plants infected with *M. incognita*.

Conc.	Nematode inoculation						Mean	Reduction %
	5 days after		During		5 days before			
	Mean of egg masses/ plant	Reduction %	Mean of egg masses/ plant	Reduction %	Mean of egg masses/ plant	Reduction %		
32 mM	62.5	80.15	121.5	61.42	156.25	50.39	113.41	63.99
16 mM	83.25	73.57	121	61.58	156.25	50.39	120.16	61.85
8 mM	117.25	62.77	186	40.95	198.25	37.06	167.16	46.93
4 mM	162.75	48.33	198	37.14	212.75	32.46	191.16	39.17
2 mM	184.25	41.5	184.25	41.5	226.25	28.17	198.25	37.06
Inoculated control	315		315		315		315	
Mean	154.16		187.62		210.79			

LSD (P ≤0.05) = Concentration = 9.04, Treatments = 6.65, Interaction = 2.04. Each number is a mean of four replicates and one plant.

Table 8. Effects of soil drench with β, amino butyric on numbers J2 under greenhouse conditions of tomato plants infected with *M. incognita*.

Conc.	Nematode inoculation						Mean	Reduction %
	5 days after		During		5 days before			
	Mean juveniles 2nd / 250 g of soil	Reduction %	Mean juveniles 2nd / 250 g of soil	Reduction %	Mean juveniles 2nd / 250 g of soil	Reduction %		
32 mM	50	71.13	77.25	55.41	103.25	40.4	76.83	55.65
16 mM	58.5	66.23	81	53.24	102.25	59.01	80.58	53.38
8 mM	75	56.7	97	44.01	121	30.15	97.66	43.63
4 mM	104	39.97	114.25	34.05	126.5	26.98	114.91	33.67
2 mM	115	33.62	115	33.62	126.5	26.98	118.83	31.41
inoculated control	173.25		173.25		173.25		173.25	
Mean	95.95		109.62		125.45			

LSD (P ≤ 0.05) = Concentration = 6.35, Treatments = 4.42, Interaction = 1.38. Each number is a mean of four replicates and one plant.

Effect of soli drench with β, amino butyric on Fresh and Dry Weight of Shoot

The obtained results in Table (9), indicated that tomato plants treated as a soil drench with BABA significantly (p = 0.05) increased both fresh and dry shoot weight compared with untreated inoculated control (42.63 and 11.07 g respectively), but less significantly (p = 0.05) compared with non-inoculated control (74.27 and 20.72 g respectively). Soil drench with BABA 32 mM and 16 mM recorded the height average weight of fresh shoot weights, 67.07 and 61.66 g, with significant difference between them. Furthermore, they did not have a significant difference between them on the shoot dry weight. Soil drench with BABA 5 days before nematode inoculation gave the height fresh and dry shoot weight, 61.93 and 17.33 g respectively. Moreover, both treatment of BABA during inoculation and five days after inoculation gave the lowest weight of fresh and dry root weight 59.82, 16.06 and 59.77, 15.72 g respectively, without significant difference between them.

Table 9. Effects of soil drench with β, amino butyric shoot fresh and dry weights of tomato plants infected with *M. incognita* under greenhouse conditions

Conc.	Shoot weight of infected plants							
	Nematode inoculation							
	5 days after		During		5 days before		Mean	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
32 mM	67.84	18.64	69.21	17.74	64.15	18.11	67.07	18.16
16 mM	66.54	18.24	57.9	18.37	60.55	16.49	61.66	17.7
8 mM	60.77	16.49	59.54	15.47	60.75	15.81	60.35	15.92
4 mM	61.63	17.44	57.53	14.43	58.59	13.67	59.25	15.22
2 mM	59.83	18.11	57.66	14	57.45	13.55	58.32	15.18
Inoculated control	42.63	11.7	42.63	11.7	42.63	11.7	42.63	11.7
Non-inoculated Control	74.27	20.72	74.27	20.72	74.27	20.72	74.27	20.72
Mean	61.93	17.33	59.82	16.06	59.77	15.72		

LSD (P ≤ 0.05) Fresh weight: Concentration = 2.91, Treatments = 1.91, Interaction = 0.63. LSD (P ≤0.05) Dry weight: Concentration = 1.48, Treatments = 0.97, Interaction = 0.32. Each number is a mean of four replicates and one plant.

Effect of soil drench with β, amino butyric on Fresh and Dry root system

As shown in Table (10) treatments significantly (p = 0.05) increased both fresh and dry root weight compared with untreated inoculated control (10.38 and 2.72 g respectively), but less significantly (p = 0.05) compared with non-inoculated control (19.37 and 4.62 g respectively). Spraying BABA 32 mM and 16 mM recorded the height average weight of fresh and dry root weights, 17.38, 3.76 and 17.18, 3.51 g, without significant difference between them. While, soil drenching of BABA 5 days before nematode inoculation gave the height fresh and dry root weight, 16.54 and 3.59 g respectively. Moreover, both treatment of BABA during inoculation and five days after inoculation gave the lowest weight of fresh and dry root weight 15.5, 3.35 and 13.39, 3.27 g respectively, without significant difference between them

Table 10. Effects of soil drench with β, amino butyric on root fresh and dry weights of tomato plants infected with *M. incognita* under greenhouse conditions

Conc.	Shoot weight of infected plants							
	Nematode inoculation							
	5 days after		During		5 days before		Mean	
	Fresh	Dry	fresh	Dry	Fresh	Dry	Fresh	Dry
32 mM	19	4.46	16.22	3.47	16.91	3.36	17.38	3.76
16 mM	18.38	4.09	16.11	3.31	17.06	3.14	17.18	3.51
8 mM	16.28	3.13	15.55	3.05	14.73	3.22	15.52	3.13
4 mM	15.8	3.12	14.47	3.01	14.65	3.15	14.97	3.12
2 mM	15.56	3.01	14.61	3.1	14.4	3.26	14.85	3.09
Inoculated control	11.38	2.72	11.38	2.72	11.38	2.72	11.38	2.72
Non-inoculated Control	19.37	4.62	19.37	4.62	19.37	4.62	19.37	4.62
Mean	16.54	3.59	15.5	3.35	15.39	3.27		

LSD (P ≤0.05) Fresh weight: Concentration = 1.53, Treatments = 1, Interaction = 0.34. LSD (P≤0.05) Dry weight: Concentration = 0.32, Treatments = 0.22, Interaction = 0.7. Each number is a mean of four replicates and one plant.

Discussion

Induced acquired resistance of plants exploiting natural defense that could be consider as important alternative program for crop protection. This study estimate the effects of BABA on tomato plants infection with *meloidogyne* incognita. BABA is a recognized chemical plant defense activator, so it has been used successfully complete to induce resistance against pathogens. Results from this work illustrate that foliar spray as well as soil drench application of BABA induced systemic resistance against *M. incognita* in tomato plants. This was demonstrated by the reduction of galls and egg masses on roots as well as numbers of J2 in soils. Also, application of BABA enhance plants growth criteria. Likewise, (oka et al 1999; Chinnasri et al 2006 and Sahebani & Hadavi 2011) support the preceding results, consequently the treatments with β,amino butyric acid decreased root knot disease during reduced penetration of J2, galls number and the development of nematode. Plants treated with the high concentration of BABA increase fresh and dry shoot weight, also increase fresh and dry root weight compared with untreated inoculated control. This is at most due to the fact that infection with nematode embed chlorophyll synthesis and photosynthesis which negatively effects on plant growth (Melakeberhan 2004).

It was obvious from this work, the treatments with BABA before nematode inoculation was more effective likely due to the technique of induce acquired resistance of this inducer. In tomatoes induce resistance mechanism to *Meloidogyne* by BABA is not perfectly understood. Oka *et al* 1999 showed that treatments with this chemical inducer gave roots less attractive to J2 during converted plant nutrient intake or provide cell walls of plant harder to penetrate by J2 or produce giant smaller cells or affect the nutrients for the developing nematodes. Treatments with BABA were notified to increase scale of salicylic acid (SA) and pathogenesis related proteins (PRP) (Hwang *et al* 1997), and enzymes such catalase (CAT), guaiacol peroxidase (GPOX) and polyphenoloxidase (PPO) (Sahebani,. and Hadavi 2011; Sahebani and Hadavi 2009) and phenolic compounds. BABA was also reported to induce the accumulations of PPO, GPOX, H2O2, CAT and phenols in *M. javanica* infected cucumber plants (.M'Piga *et al.* 1997)

From this work and from endow former reports we concluded that the use of *β*, amino-butyric acid was efficiency as a chemical inducer to induced resistance and eco-friendly sound alternative for controlling of *M. incognito* on tomato plants.

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تحفيز مقاومة نباتات الطماطم ضد نيماتودا تعقد الجذور (Passe-Muraille) *Meloidogyne incognita* باستخدام مركب β, amino butyric acid

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في هذا البحث تم دراسة تاثير حامض بيتا امينو بيتوريك اسيد لحث نبتات الطماطم على مقاومة نيماتودا تعقد الجذور. تم تطبيق المركب بطريقتين الرش الورقى واضافتة الى التربة وذلك بخمس تركيزات فى ثلاث مواعيد مختلفة. وقد تم عد العقد الجذرية وكتل البيض لكل مجموع جذري وكذلك تم عد اليرقات لكل 250 جرام تربة وتقدير مقايس النمو لنباتات الطماطم لمعرفة كفاءة هذه المعاملات. وقد تبين من خلال النتائج المتحصل عليها أنه فى حالة الرش الورقي تطبيق بيتا امينو بيوتريك اسيد بالتركيزات 32 و 16 ميللي ومولار كان لهما التاثير الاكبر فى خفض عدد العقد وكتل البيض وكذلك عدد يرقات الطور الثانى حيث سجلا خفض فى نسبة الاصابة الى (57.87- 55.85 % و60- 59.48 % و49.8 – 47.25 % ، على التوالى. وايضا فى حالة الاضافة الى التربة وجد ان تطبيق بيتا امينو بيوتريك اسيد بالتركيزان 32 و 16 ميكرومولار كان لهما التاثير الاكبر فى خفض عدد العقد وكتل البيض وكذلك عدد يرقات الطور الثانى حيث سجلا خفض فى نسبة الاصابة الى (61.92- 60.05 % و63.99- 61.55 % و55.65 – 53.38 % ، على التوالى. و قد وجد أن المعاملات حسنت ايضا من الوزن الطازج والجاف لنمو المجموع الخضرى والجذور. وكذلك وجد ان تطبيق المركب قبل العدوى كان لة التاثير الاكبر فى حث النبات على مقاومة النيماتودا بالمقارنة مع المعاملة اثناء العدوى او بعد العدوى.