Controlling *Tuta absoluta* (Lepidoptera: Gelechiidae) and *Aphis gossypii* (Hemiptera: Aphididae) by aqueous plant extracts

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Abstract: Effects of basil, geranium, chinaberry, onion and garlic aqueous extracts against the tomato leafminer, *Tuta absoluta* Meyrick and the cotton aphid, *Aphis gossypii* (Glover) in laboratory and greenhouse were evaluated. In laboratory, Chinaberry, geranium, onion and garlic showed the highest effects on *T. absoluta* second instar larvae. While, basil leaves extract exhibited the least effect. In greenhouse, chinaberry exhibited the highest effects on *T. absoluta* population, while geranium and coragen® insecticide had the second rank of the effects. Onion showed the lowest effects on *T. absoluta* population. For *A. gossypii*, chinaberry and geranium showed the highest mortality percentages in laboratory. Basil leaves exhibited the lowest effect while onion and garlic had a moderate result. In greenhouse, reduction percentages of *A. gossypii* population were highest with geranium, chinaberry, basil, onion and garlic, respectively. Washing the treated tomato fruits by water reduced the toxic effects using *T. absoluta* larvae as a bio-instrument.
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1. Introduction

Tomato leafminer, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) is originated from South America and occurs in many parts of the world (Clarke, 1962; Garcia and Espul, 1982; Notz, 1992). It is an oligophagous serious pest of outdoor and greenhouse tomatoes and it also attacked potato, egg-plant and pepper (Notz, 1992; Suinaga et al. 1999). *T. absoluta* larvae cause losses of up to 100% by attacking tomato leaves, flowers, stems, and especially fruits (Lopez, 1991; Apablaza, 1992; Picanco et al., 2007). The cotton aphid, *Aphis gossypii* (Glover) is considered to be a serious pest to almost all agricultural crops and alternative host plants because of its polyphagous feeding habits (Minks and Harrewijn, 1987). *Aphis gossypii* is a direct plant-sucking pests and it can cause serious problems on vegetable crops even at low densities, since it can transmit plant viruses (Sharma and Joshi 2010). It attack various plants, infesting leaves stems, fruits (Blackman and Eastop 2000) and also causing damage indirectly by secreting honeydew that cause development of sooty mold.

Commercially available synthetic pesticides are currently the most effective means of pest control. However, the unceasing and indiscriminate uses of these substances have not only caused adverse effects on mammals' health, but have also affected many other non-target organisms (Bughio and Wilkins, 2004). They are also responsible for the development of insecticide-resistance phenomenon (Suinaga et al., 1999; Lietti et al., 2005). These drawbacks evoked the scientific community to exploring new ways of insect control. Also, synthetic pesticides cannot be tolerated in organic farming situation (Wallace 2001). Plant extracts can provide a safe control method under organic agriculture conditions. Today, there is an urgent need of finding new "weapons" for controlling insect attack on plants which are the basis of our food in a direct or indirect way. However, extracts and pure compounds isolated from different plants could be used for controlling insect pests showing effectiveness, availability and seemingly no adverse effects on human and animal health (Carpinella et al., 1999) or on the environment.

Considerable efforts have been focused on plant-derived materials that are potentially useful as commercial insecticides. Natural product-based pesticides can sometimes be specific to the target species and have unique modes of action (Duke et al., 2003) making them less toxic or nontoxic to mammals, other vertebrates, and invertebrates. Plant products have several uses in insect control (Trindade et al., 2000; Moreira et al., 2004; Farghaly et al., 2009; Moreno et al., 2011; Salari et al., 2012). These products have also been studied for acute toxicity, antifeedant, or repellent, and fumigant effects, as well as inhibiting reproduction of many pest species (Cox, 2004; Kubo, 2006). Tropical and subtropical plants t less than 1% has been chemically investigated (Balick et al., 1995). Plant extracts can be used per se or as a starting point for synthesis.

The present study aimed to investigate the anti-insect activities of 5 plant aqueous extracts in order to introduce practical, effective and safe natural insecticides that can be integrated in pest management program from local and available plants. Two common and aggressive pests (i.e. tomato leafminer *T. absoluta* and cotton aphid *A. gossypii*) were selected for that purpose.

2. Materials and Methods

Laboratory work was performed in Plant Production and Protection Department, Faculty of Agriculture and veterinary medicine, Qassim University. Field trials were carried out either in faculty experimental farm or at greenhouse field in the Qassim region, Saudi Arabia. Field and laboratory work was conducted during the tomato growing season period from August to December 2013.

2.1. Plant collection and extraction

Basil, *Ocimum basilicum* L.; geranium, *Pelargonium zonale*; chinaberry and *Melia azedarach* L. plants were collected from Qassim area, Saudi Arabia. Required plant parts were dusted off and left to dry indoors. Air dried parts were ground in an electrical mill to obtain fine powder. To prepare the concentration of 6%, 60 g of each plant part powder were added to one liter of distilled water and left on a mechanical shaker for 24 h for extraction at ambient. Onion, *Allium cepa* L. and garlic, *Allium sativum* L. plants were obtained from a local farm in Qassim and were used as fresh extract. Fresh onion or garlic (60 g) was blended in one liter of distilled water using a high speed blender to make the 6% concentration. All water extracts were filtered through cotton wool plug to eliminate particulates. Tween® 20 (SigmaAldrich) was added to all extracts to make up 0.1%. Concentration of 2% was made by addition of distilled water to the 6% stock.

2. 2. Bioassay under laboratory conditions:

2.2.1. *Tuta absoluta*:

The stock culture of *T. absoluta* was prepared by obtaining insect larvae from an infested greenhouse. The larvae were put on seedlings of tomato inside large breading cages (60 × 50 × 40 cm). The cages containing the seedlings were maintained at 27 ±2 ºC and 70 ±5% RH. The pupae were collected and laid in glass jars which were lined with filter paper. Jars were covered with muslin fixed with a rubber band. When moths emerged, a piece of cotton wool soaked in a 10% honey solution was provided as a source of food for the moths in addition are recognized sources of bioactive compounds, bu to new seedlings for egg laying. Newly deposited eggs were collected daily with its seedlings and maintained till reached the second instar larval stage.

Bioassay was performed with second instar larvae of *T. absoluta* using 2 and 6% concentrations of each plant extract. Second instar larvae (20 larvae) were carefully got out from their mines by using zero brush and then transferred on newly uninfested tomato leaves in a Petri-dish (15 cm in diameter). Tomato leaves were soaked in extract solution for 1 min then left to dry before introducing to larvae. Petri-dishes were provided with filter paper to protect larvae from excessive humidity. Petri-dishes were maintained at the previously mentioned laboratory conditions. Control experiment was performed using 0.1% Tween® 20 in distilled water. Each treatment was replicated five times. Number of live and dead larvae of each treatment as well as control was recorded after 1, 3 and 5 days of treatment. At every investigation, leaves were removed and replaced with fresh untreated leaves for control and treated leaves for treatments.

2.2.2. *Aphis gossypii*:

Naturally infested egg-plants with *A. gossypii* were obtained from unsprayed greenhouse with pesticides in the season. It is located in the experimental farm of Faculty of Agriculture and Veterinary Medicine, Qassim University at Qassim region, Saudi Arabia. One hundred individuals of *A. gossypii* were counted on an infested leaf and then put in a Petri-dish (15 cm in diameter). Each infested leaf was treated by spraying the leaves with hand atomizer. Control treatment was sprayed with 0.1% Tween® 20 in distilled water. Each treatment was replicated five times. Mortality was recorded after 1 and 3 days.

2.3. under greenhouse conditions:

2.3.1. *Tuta absoluta*:

To evaluate the effect of the plant extracts against *T. absoluta* population, a naturally infested tomato greenhouse (9 × 30 m^2) in Qassim area, Saudi Arabia was selected. The greenhouse has not been sprayed with any pesticide during the season. It was divided into nine plots (each plot was 30 m^2). Pretreatment larval count was carried out by sampling 75 leaves randomly taken from each plot as 3 replicates of 25 each. The 6% concentration was used in all field experiments. Seven different plant extracts were applied against seven plots. The eighth one was sprayed with Coragen® (DuPont Crop Protection) with the concentration 20 ml/100 L. Coragen® (Chlorantraniliprole, 20% soluble concentrate) is active against Lepidoptera and Coleoptera. Control plot was sprayed with 0.1% Tween® 20 in water. Larval count was performed after 2, 4, 6 and 8 days of treatment, 75 tomato leaves (25 × 3 replicates) were randomly taken from each plot. Number of *T. absoluta* larvae per sample in each treatment was counted and recorded.

2.3.2. *Aphis gossypii*:

An *A. gossypii* infested eggplant cultivated greenhouse, was designated, Faculty of agriculture and veterinary medicine experimental farm, Qassim University. It was divided into eight plots. Each plot was sprayed with 6% concentration of one plant extract. Control treatment received 0.1% Tween® 20 in water. Samples (10 leaves) were taken after 2, 4, 6 and 8 days after treatment. Number of *A. gossypii* individuals per leaf in each treatment was recorded.

2.4. Effect of washing treated fruits in removal of plant extract and insecticide residues

Tomato fruits were sprayed with 6% concentration of each extract and coragen® insecticide with the recommended dose (0.2 ml/L) using hand atomizer. Tomato fruits were left to dry before dividing into two groups. First group was placed as a single fruit in a lidded plastic cup (10 cm height and 15 cm diameter) then 10 *T. absoluta* larvae were transferred to each cup. Control was conducted using 0.1% Tween® 20 in distilled water. The second group of fruits was left for 24 hours before washing with tap water, then placed individually in the cups and ten larvae were put in each cup. Each treatment was replicated five times. The first group of fruits was examined after 24 and 48 hours of treatment and the washed group was examined after 24 hours only. Number of formed bores was recorded in each treatment.

2.5. Statistical analysis:

Data were analyzed by using one way ANOVA. Means comparison was conducted according to Duncan's Multiple Range Test (LSD) at the probability of 5% (CoHort Software 2004). Under laboratory conditions, the average of mortality percentages was corrected using Abbott's formula (Abbott, 1925). While, reduction percentages under greenhouse conditions were estimated according to Henderson & Tilton formula (Henderson and Tilton, 1955).

Table 1. Mortality percentages of *T. absoluta* 2nd instar larvae caused by aqueous extracts of some plants in laboratory

Treatment	Conc.	After 1 days	After 3 days	After 5 days
Basil leaves	2%	16.7±2.3 e	34.8±2.0 f	45.1±3.5 f
	6%	25.0±3.9 de	48.7±2.7 e	53.8±2.2 ef
Basil flowers	2%	27.1±3.3 cde	34.8±3.1 f	64.8±5.3 de
	6%	33.3±2.5 cd	54.4±2.1 de	73.6±2.7 bcd
Geranium	2%	37.5±3.3 bc	47.6±4.3 e	83.8±5.3 ab
	6%	39.5±3.3 bc	61.5±2.0 cd	86.8±4.5 ab
Chinaberry leaves	2%	47.9±3.3 ab	58.3±2.0 cd	69.2±5.3 cd
	6%	56.2±3.5 a	61.5±2.0 cd	91.2±4.0 a
Chinaberry fruits	2%	54.1±6.2 a	65.8±4.3 bc	78.0±3.5 abc
	6%	58.3±4.6 a	74.3±3.9 a	91.2±4.1 a
Onion	2%	29.2±2.6 cd	54.0±3.1 de	78.0±4.9 abc
	6%	31.3±2.5 cd	58.3±3.1 cd	80.2±5.3 abc
Garlic	2%	31.3±2.5 cd	54.0±2.1 de	82.4±2.7 abc
	6%	35.4±3.5 cd	70.1±1.3 ab	84.6±2.7 ab
LSD		10.0	7.8	11.8
F		12.5	17.4	10.8
df		13 , 56	13 , 56	13 , 56
P		0.0000	0.0000	0.0000

Letters are indices to show statistical similarities. Values with the same letter are not significantly different at $p \geq 0.05$.

3. Results

3.1. Effect of the extracts on *T. absoluta*

3.1.1. Under laboratory conditions

Leaves and fruits extracts of chinaberry showed the significantly highest initial kill 47.9- 58.3 % (after 1 day) and geranium came second to it 39.5 (Table 1). Basil leaves exhibited the significantly lowest initial kill. After 3 days, the concentration 6% of all tested plants exhibited significantly higher effects than those of 2%. Chinaberry, geranium, onion and garlic showed the highest effects on *T. absoluta* larvae after 5 days. While, basil leaves extract exhibited the lowest effect on the larvae.

3.1.2. Under greenhouse conditions

Both chinaberry extracts exhibited the highest reduction effects on *T. absoluta* population larvae numbers decreased from 45 to 14.0 after 2 days of treatment in chinaberry fruit treatment before it gradually reaches 74 in the eighth day (Table 2). Both geranium and pesticide treatment had the second rank of the effects on *T. absoluta*. Onion showed the significantly lowest effect for entire treatment time course. In general, population of *T. absoluta* was significantly higher in control treatment than other treatments.

The residual effect of the tested treatments on *T. absoluta* population comparing to the insecticide Coragen® is illustrated in Figure 1.

Table 2. Effect of plant extracts (6 %) on *T. absoluta* larvae population in greenhouse

Treatment	N. of *T. absoluta* larvae/sample				
	Pre-treatment	After 2 days	After 4 days	After 6 days	After 8 days
Basil leaves	40.0±2.9 a	25.0±1.7 c	47.7±1.5 c	52.3±2.6 c	84.7±4.3 bc
Basil flowers	38.7±3.5 a	28.0±4.0 c	37.0±2.9 de	49.7±2.6 cd	87.0±5.8 bc
Geranium	42.0±2.9 a	25.0±4.0 c	32.3±1.5 ef	44.7±1.5 cde	53.0±3.8 e
Chinaberry leaves	45.0±4.0 a	22.7±1.5 cd	25.0±1.7 fg	34.7±4.3 e	74.0±3.8 cd
Chinaberry fruits	45.0±2.9 a	14.0±2.1 d	22.3±1.5 g	38.0±2.1 de	60.7±5.2 de
Onion	41.7±8.7 a	52.0±4.0 ab	66.3±5.2 b	77.3±4.3 b	89.7±4.9 b
Garlic	35.0±1.2 a	43.3±3.2 b	45.0±2.3 cd	53.0±4.9 c	82.7±4.6 bc
Coragen®	39.7±4.3 a	27.7±2.6 c	32.7±1.5 ef	36.0±3.8 e	49.3±1.3 e
Control	32.3±5.5 a	60.3±4.3 a	95.0±4.0 a	102.7±5.5 a	110.7±6.4 a
LSD	13.3	9.6	8.2	11.1	13.9
F	0.9	22.3	69.8	35.4	17.9
df	8 , 18	8 , 18	8 , 18	8 , 18	8 , 18
P	0.5445	0.0000	0.0000	0.0000	0.0000

Letters are indices to show statistical similarities. Values with the same letter are not significantly different at p ≥ 0.05.

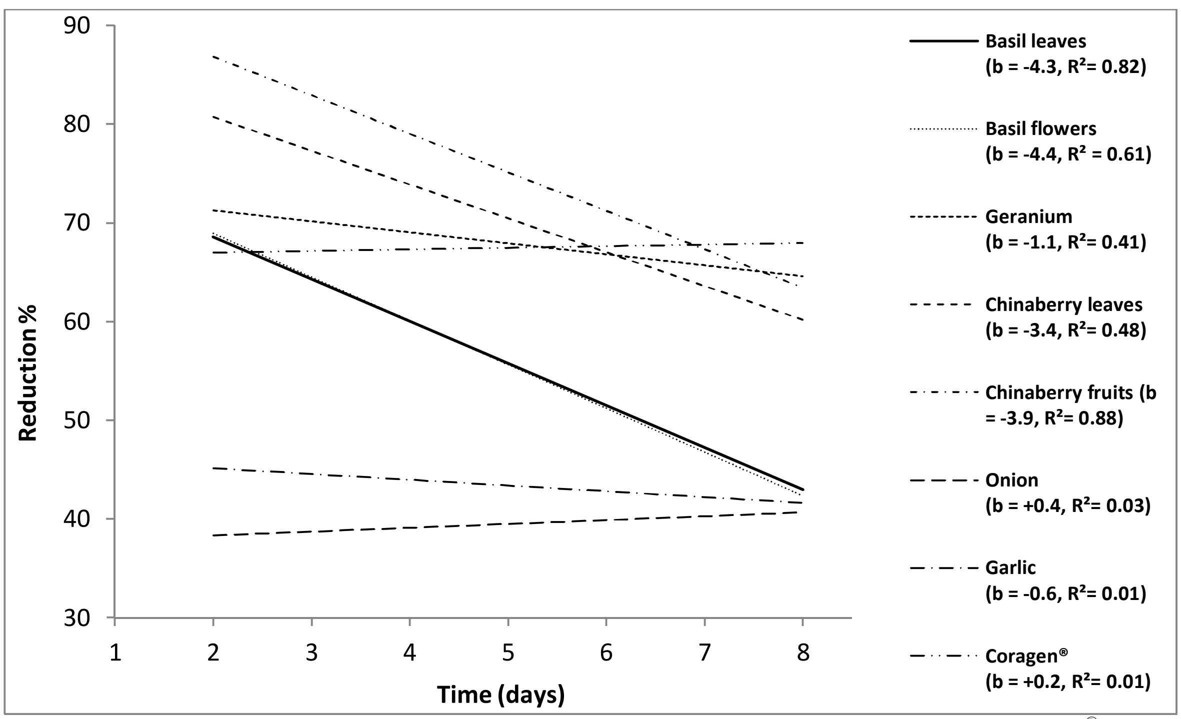

Figure 1. Residual effect of plant extracts in comparison with the recommended insecticide Coragen® against *T. absoluta* population in greenhouse

Both basil treatments were the most declined treatments against time. Slope (b) values were -4.3 and -4.4 for basil leaves and flowers, respectively. The daily decreasing of chinaberry had the second rank; however, b values of leaves and flowers were -3.4 and -3.9. Coragen® was the most stable treatment (b = 0.2) affecting on *T. absoluta* population. Both of garlic and onion had the least effects on the pest population throughout the experiment time.

3.2. Effects of the extracts on *A. gossypii*:

3.2.1. In laboratory

Both chinaberry extracts and geranium showed the significantly highest mortality percentages of *A. gossypii*, 46.9- 56.4 (Table 3). Basil leaves exhibited the significantly lowest mortality of *A. gossypii*. Onion and garlic effects had a moderate effect.

3.2.2. Under greenhouse conditions:

Chinaberry and geranium exhibited the highest effects on *A. gossypii* population starting from 27 individuals before treatment reaching 6, 7.5, 12, 13.4 individuals after 2, 4, 6 and 8 days of treatment, respectively, in chinaberry fruit treatment (Table 4). While, both of basil extracts, onion and garlic showed the significantly lowest effects.

Table 3. Mortality percentages of *A. gossypii* caused by tested aqueous plant extracts in laboratory

Treatment	Conc.	After 1 day	After 3 days
Basil leaves	2%	29.3±1.4 h	54.1±1.3 f
	6%	31.1±2.7 h	56.3±4.3 f
Basil flowers	2%	30.9±2.5 h	58.3±3.5 ef
	6%	42.2±1.0 def	75.6±1.0 cd
Geranium	2%	46.0±1.8 cde	86.2±4.0 ab
	6%	56.0±1.6 a	96.0±1.6 a
Chinaberry leaves	2%	46.9±1.8 bcd	84.5±4.7 bc
	6%	50.7±2.9 abc	88.1±0.9 ab
Chinaberry fruits	2%	52.0±2.4 ab	88.8±4.6 ab
	6%	56.4±2.1 ab	91.8±2.5 ab
Onion	2%	34.5±1.2 gh	67.3±4.5 de
	6%	38.6±0.9 fg	69.2±1.5 d
Garlic	2%	29.7±2.0 h	52.5±3.8 f
	6%	40.6±0.9 ef	75.2±1.0 cd
LSD		5.4	9.0
F		24.1	22.5
df		13 , 56	13 , 56
P		0.0000	0.0000

Letters are indices to show statistical similarities. Values with the same letter are not significantly different at p ≥ 0.05

Table 4. Effect of plant extracts on *A. gossypii* population in greenhouse

Treatment	No. of *A. gossypii* / leaf				
	Pre-treatment	After 2 days	After 4 days	After 6 days	After 8 days
Basil leaves	25.6±1.8 a	20.3±1.3 b	25.4±2.0 b	43.1±2.2 bc	53.0±2.9 b
Basil flowers	25.8±2.6 a	18.2±1.4 b	24.3±1.8 b	35.1±1.8 c	50.5±2.4 b
Geranium	25.5±2.5 a	3.7±0.4 c	5.3±0.6 d	7.6±0.7 e	9.8±1.7 d
Chinaberry leaves	26.3±2.8 a	8.4±1.1 c	14.4±1.3 c	22.1±1.4 d	23.9±1.7 c
Chinaberry fruits	27.0±2.7 a	6.0±0.9 c	7.5±0.8 cd	12.0±1.1 e	13.4±1.1 cd
Onion	24.0±2.2 a	21.1±1.4 b	28.2±2.6 b	47.8±3.1 b	62.5±3.6 b
Garlic	23.9±2.2 a	18.3±1.3 b	26.8±2.8 b	39.1±3.2 bc	50.5±4.2 b
Control	25.7±2.0 a	43.2±2.7 a	54.0±3.5 a	76.0±4.7 a	77.5±4.7 a
$LSD_{(P=5\%)}$	9.2	5.6	8.2	10.0	11.8
F	0.1	44.2	30.9	43.0	37.9
df	7 , 16	7 , 16	7 , 16	7 , 16	7 , 16
P	0.9959	0.0000	0.0000	0.0000	0.0000

Letters are indices to show statistical similarities. Values with the same letter are not significantly different at p ≥ 0.05.

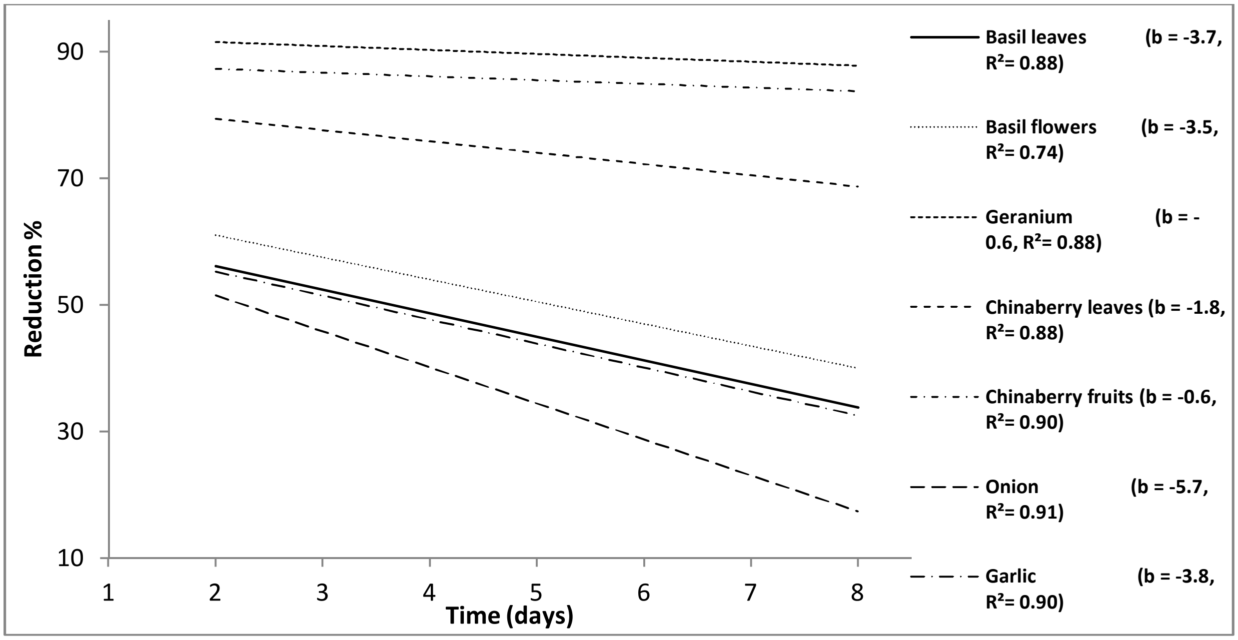

Figure 2. Residual effect of plant extracts against *A. gossypii* population in greenhouse

Population of *A. gossypii* was significantly high in control treatment. As shown in Figure 2, the effect of all tested treatments has diminished as the time pass after treatment. The highest daily decline was noticed in onion treatment (b = -5.7) followed by garlic (b = -3.8), basil leaves (b = -3.7), basil flowers (b= -3.5), chinaberry leaves (b = -1.8), chinaberry fruits (b = -0.6) and geranium (b = -0.6).

3.3. Effects of washing treated fruits on the efficiency of plant extracts:

All treatments were able to protect treated tomato fruits from *T. absoluta* larvae to drill into for 48 hours (Table 5). Washed fruits treated with plant extracts were infested by larvae in different frequencies. In case of basil, geranium and chinaberry leaves from 60 to 80 % of larvae were able to bore into the fruits. For chinaberry fruits, onion and garlic 40% of larvae perforated fruit flesh. Coragen® insecticide residue was not removed by washing as none of the larvae was capable to bore the fruit and it's noteworthy that all larvae were killed.

4. Discussion

Basil extracts exhibited the least activity against tested pests, *T. absoluta* and *A. gossypii*, Kim and Lee 2013 reported the activity of basil essential oils against stored products insect pests (*Sitophilus zeamais* and *Tribolium castaneum*). Plant extracts may have different potentials of activity against different pests (Rizvi et al., 2012). Also, Salari et al. (2012) demonstrated that the differences in insect mortality to plant extract are perhaps related to its penetration and detoxification mechanisms.

Geranium, *P. zonale* extract was effective against *T. absoluta* and *A. gossypii* in laboratory and under greenhouse field conditions at 6% concentration. Jeyabalan et al. (2003) reported that the geranium leaf aqueous extracts exhibited anti-larval, repellency, growth regulation activities and interfered with oviposition and egg hatchability against *Anopheles stephensi* at 4% concentration. Essential oils from *p. roseum* showed acaricidal activity against *Rhipicephalus* (*Boophilus*) *annulatus* (Pirali-Kheirabadi et al., 2009). Plants belong to the genus *Pelargonium* possess many active compounds in their essential oil complex (e.g. citral, geraniol, citronellol and linalool) (Abbas et al., 2013).

Our results rationalize more studies to be conducted to isolate the active principals in *P. zonale*. Toxicity also might vary depending on the plant parts used, solvent used geographical origin, and photosensitivity of compounds in the extract. Also, other variations were noted due to responses by species and developmental stages of species to the specified extract (Jeyabalan et al., 2009, Sukumar et al., 1991). With respect to *A. gossypii*, the present results are in agreement with those obtained by Singh et al. (2012) who reported the use of geranium extract to control the population of *A. gossypii* in an environmentally friendly way. The present results showed that aqueous plant extracts of chinaberry leaves and fruits were effective in controlling *T. absoluta* and *A. gossypii*. Bioactivities of chinaberry have been reported against many pests (Sengottayan et al., 2006, Hu et al., 1998, Bashir et al., 2013, Abou-fakhr Hammad and Mcauslane, 2006; Abou-fakhr

Hammad et al., 2000; Abou-Fakhr Hammad et al., 2001). Chinaberry is very much related to the known tree neem. These two species contain chemically similar secondary metabolites (Hu et al., 1998). Dos Santos et al. (2004) mentioned that the aqueous extract of neem seeds is efficient against *A. gossypii* causing considerable mortality. Singh et al. (2012) reported the use of neem extract to control the population of A. gossypii. Hu et al. (1998) reported the low activity of chinaberry seed extract against aphids using soil drench technique as their bioassay method. They interpret the results as either the extract constituents are not active or not systemic. We found that chinaberry extracts were effective against *T. absoluta* and *A. gossypii*. We used spraying as the application method. The activity can be interpreted as these active compounds have a contact effect. Also, Brunherotto and Vendramim (2001) reported the activity of the aqueous extract of different parts of chinaberry against *T. absoluta* and suggested that the active principals in chinaberry extract have translaminar action since affecting the larvae and pupae inside mines while applied on the outer surface. Abou-Fakhr Hammad et al. (2000) have investigated the activity of methanolic and aqueous extracts of chinaberry. They reported that though the methanolic extract was little more effective against *Bemisia tabaci* than water extract with no significant difference.

Table 5. Numbers of larvae bored into tomato fruits treated with plant extracts and Coragen® insecticide with and without washing with water

Treatment	After washing	Without washing	
		After 24 h	After 48h
Basil leaves	6.0±0.4 c	0.0±0.0 c	0.0±0.0 d
Basil flowers	7.2±0.4 b	0.0±0.0 c	0.0±0.0 d
Geranium	8.0±0.4 b	0.0±0.0 c	0.0±0.0 d
Chinaberry leaves	8.0±0.4 b	0.0±0.0 c	0.0±0.0 d
Chinaberry fruits	4.0±0.4 d	0.0±0.0 c	0.0±0.0 d
Onion	4.0±0.2 d	0.8±0.4 b	2.0±0.4 b
Garlic	4.0±0.4 d	0.0±0.0 c	1.0±0.4 c
Pesticide	0.0±0.0 e	0.0±0.0 c	0.0±0.0 d
Control	9.6±0.2 a	8.4±0.5 a	8.8±0.7 a
LSD	1.1	0.6	0.9
F	82.7	200.8	71.6
df	8 , 36	8 , 36	8 , 36
P	0.0000	0.0000	0.0000

Letters are indices to show statistical similarities. Values with the same letter in each column are not significantly different at $p \geq 0.05$.

Onion and garlic extracts showed significant effects against the tested pests especially *T. absoluta* larvae under laboratory conditions. This may be attributed to the high levels of essential oils present in onion and garlic which evaporated inside the small area of the Petri-dishes (used in the laboratory experiments) and exhibited activity against the tested pests. On another hand, onion and garlic extracts showed significantly low efficiency against *T. absoluta* and *A. gossypii* populations under greenhouse conditions. This may be attributed to the vaporization of the active essential oils and removal through greenhouse ventilation system. The present results under laboratory conditions agree with that of Ramakrishnan et al. (1989) who mentioned that extracts of garlic have been shown to be toxic with 90% of *Culex* larvae dying after only 8 hours exposure at 50 ppm.

Under greenhouse conditions, the highest effects of the tested plant extracts against *T. absoluta* were obtained after four days of treatment and then their effects decreased time after treatment. While, the highest effect of these extracts on *A. gossypii* was recorded after two days of treatment. These results may be attributed to that *A. gossypii* was more sensitive to the tested plant extracts than *T. absoluta*. The effect of plant extract seems to be decreased with time after treatment. So, the tested pests tend to build up their populations again synchronized with the decrease of residual effects. Also, Salari et al. (2012) mentioned that *A. gossypii* is a susceptible to *P. harmala* extracts. On another hand, aphid tends to build up its population faster than *T. absoluta*; however, the developmental time of *T. absoluta* (Barrientos et al., 1998) is longer than A. g*ossypii* (Dos Santos et al., 2004). Sarmamy et al. (2011) mentioned that decreasing of the plant extract efficiency against *T. granarium* by the time passed may be due to that *T. granarium* can excrete the chemicals partially by the secretion system or because the onset exposure is more effective on the physiological activities of the pest. Moreira et al. (2004) added that the differences in plant extracts toxicity were probably due to differential susceptibility of insect species.

The second instar larvae of *T. absoluta* was used as a biological tool to explore the effect of washing the treated tomato fruits on the residues of plant extracts and the Coragen® insecticide. The experiment was performed on fruits as the eaten part. Coragen® was not removed totally may be attributed to the less solubility of the active ingredient Chlorantraniliprole (0.88 mg/L) and the other formulation components might allowed active ingredient to penetrate into fruit tissues that cannot be washed with water. All the tested plant extracts' residues can be eliminated by washing tomato fruits effortlessly at home. This may be due to the active compounds are water soluble and can be easily washed by water. Thus, indicating that the proposed extracts are safe for consumers. Carpinella et al. (2006) mentioned that plants treated with chinaberry extracts 10% before infestation received 90% fewer punctures than untreated ones.

Environmentally benign, solvent free, aqueous plant extract were investigated against two resistant and frequent pests, *T. absoluta* and *A. gossypii*. Under greenhouse conditions, Chinaberry and geranium extracts were efficient bio-insecticide in controlling *T. absoluta* and *A. gossypii*. Both bio-insecticides can be integrated in pest management program in conventional and organic farming. Chinaberry is a deciduous fruiting tree. It is cultivated in Africa as drought-resistant and shade tree (Abou-Fakhr Hammad et al., 2001). Its leaves can be used during summer and fruits can be stored and used during winter. Geranium is a perennial plant. Cultivation of these active containing plants should provide alternatives for synthetic insecticides. Residues of the proposed bio-insecticides are easily washed by water.

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