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Evaluation of bio-efficacy of botanicals against tomato pinworm, *Tuta absoluta* (Meyrick, 1917)

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ABSTRACT: Laboratory bio-assay of botanicals against South American pinworm, *Tuta absoluta* **(Meyrick, 1917)** larvae showed that neem oil @ 3% and Pungam oil @ 3% recorded the maximum per cent of larval mortality (82.65% and 79.33% respectively) followed by neem seed kernal extract (NSKE) @ 5% (77.67%).From the results of field experiment of botanicals against *T. absoluta* the maximum reduction in larval population was recorded with neem oil @ 3% (65.26 %) followed by Pungam oil @ 3% (62.30%) and NSKE @ 5% (61.15%). Fruit yield was higher in plots treated with neem oil @ 3% (17.55t/ha) followed by Pungam oil @ 3% (16.96t/ha) and NSKE @ 5% (16.77t/ha) coupled with cost benefit ratio of 1:1.65, 1:1.46 and 1:1.42 respectively.

Keywords: *Tuta absoluta*, botanicals, bio-efficacy, neem.

INTRODUCTION

The tomato pinworm, *Tuta absoluta* (Meyrick) (Gelechiidae: Lepidoptera) is native of neotropical region. It is oligophagous moth feeding on solanaceous crops and especially one of the key pests of tomato (Garcia and Espul, 1982). It is an invasive pest which was first reported in Spain during 2006 (Urbaneja *et al*., 2007) followed by India in 2014 (Sridhar *et al*., 2014; Ballal *et al*., 2016). It is considered as a key pest of tomato which affects both yield and fruit quality leading 80–100% crop loss in the field and in protected cultivation (Khanjani, 2013). Botanicals have been the oldest tool used for the control of insect pests. Several plants exhibit antifeedent properties against an array of insects. Among them neem is one of the important plant still find a place in modern pest management programmes. (Moreira *et al.,* 2004). Identification of plant based products with high efficacy may serve as an important component in the integrated management of *T. absoluta* in an ecofriendly manner. So the present study was formulated to evaluate the efficacy of some of the botanicals with insecticidal properties against *T. absoluta* under laboratory and field conditions.

MATERIALS AND METHODS

Maintenance of *T. absoluta* culture

The population of *T. absoluta* required for the laboratory experiments were mass cultured in the Insectary, Department of Agricultural Entomology, Tamil Nadu Agricultural University (TNAU), Madurai. Mined leaves with *T. absoluta* larvae collected from tomato fields were kept in a plastic tray (60 x 45 x 15 cm) lined with filter paper. The pupae collected from the tray were placed in a petri dish and kept in adult emergence cage (60 x 60 x 60 cm). Newly emerged adults were provided with 10% sugar solution fortified with multivitamin (ABDEC®) in 5 ml glass vial with cotton swab to prevent moths from drowning. Twenty days old tomato seedlings grown in 10 x 10 x 10 cm protray were kept in the adult emergence cage for oviposition. Fresh seedlings were provided on every 24 h until the completion of oviposition by the adults. The seedlings with eggs were kept in separate cages and observed for hatching. The larvae thus hatched were maintained by providing fresh seedlings as and when needed and the culture was maintained continuously. Second instar larvae were used for various laboratory experiments (Balaji, 2016).

Preparation of botanicals

Botanicals and their doses evaluated against *T.absoluta* under laboratory and field conditions were given in the table 1. 3% spray solution of Neem oil, Pungam oil, Mahua oil and Citrus peel oil were prepared by 30ml of oil in 1 liter of water. For 5% Neem Seed Kernel Extract (NSKE), 50 gm of Neem seeds were ground and soaked in 200 ml of water for overnight. Then the solution was filtered in muslin cloth and the volume was made to 1 liter. Aqueous solution of Vasambu rhizome extract and Notchi leaf extract were prepared by soaking the crushed powder of Vasambu rhizome and Notchi leaves in one-third quantity of spray fluid for 12 hours. The content was stirred often. After 12 hours of soaking, content was filtered through muslin cloth and the residue were soaked with remaining one third quantity of water for an hour and were filtered as above. The filtered solution extracts were collected and mixed with remaining quantity of water. Sticking agent was added @ 2.0 ml per liter of spray fluid for all the botanicals (Pavela, 2012; Ghanim and Abdel Ghani, 2014).

Table 1. Laboratory bio-assay of botanicals against *T. absoluta*

Plant product	Initial population of larva	Corrected mortality (%)			
		24hrs	48hrs	72hrs	96hrs
Neem oil @ 3%	15	46.35 (42.91)[a]	59.50 (50.48)[b]	73.67 (59.13)[a]	82.65 (65.38)[a]
Pungam oil @ 3%	15	45.33 (42.23)[a]	61.65 (51.74)[a]	68.75 (56.01)[b]	79.33 (62.96)[ab]
Mahua oil @ 3%	15	40.10 (39.29)[c]	54.15 (47.38)[c]	62.85 (52.45)[c]	74.45 (59.64)[cd]
Citrus peel oil @ 3%	15	31.33 (34.04)[d]	39.55 (38.97)[e]	54.15 (47.38)[e]	68.95 (56.14)[e]
Vasambu rhizome extract @ 3%	15	27.54 (31.65)[e]	38.73 (38.49)[e]	51.95 (46.12)[e]	63.33 (52.73)[f]
Neem seed kernel extract @ 5%	15	43.22 (41.10)[b]	58.75 (50.04)[b]	65.54 (54.05)[c]	77.67 (61.80)[bc]
Notchi leaf extract @ 5%	15	41.16 (39.91)[c]	51.67 (45.96)[d]	59.87 (50.69)[d]	71.75 (57.89)[de]
Untreated check	15	0.00 (0.00)[f]	0.00 (0.00)[f]	0.00 (0.00)[f]	0.00 (0.00)[g]
SE (d)	*NS	0.46	0.56	0.82	1.17
CD (P= 0.05)		0.99	1.20	1.74	2.49

*NS- Non significant. Values in parentheses are arc sine transformations. In a column, means followed by same letter are not significantly different at P = 0.05 as per LSD

Laboratory bio-assay of botanicals against *T. absoluta*

A laboratory bioassay was conducted to evaluate the bio-efficacy of botanicals against *T. absoluta* under Completely Randomized Design (CRD). Tomato leaves were soaked in botanical solution for 1min and shade dried. Fifteen second instar larvae of *T. absoluta* were starved for four hours and allowed to feed on treated tomato leaf in the petridish. For untreated check, the larvae were fed with untreated leaves. Each treatment was replicated thrice. The mortality of larvae was recorded at 24, 48, 72 and 96 hours after treatment and corrected per cent mortality was worked out (Abbott, 1925; Kona *et al*., 2014).

Field experiment

The field experiment was taken up in Kinnimangalam village (9°55'52.6"N, 77°59'27.8"E), Madurai district, Tamil Nadu. Experimental area was planted with tomato (*L. esculentum)* hybrid Sagar (Rasi seeds) during January 2017. The experimental block design was randomized with each treatment replicated three times. Each plot had five rows with 15 plants row-1 at 60 x 45cm spacing. Three foliar sprays of botanicals were applied on 45, 60 and 90 days after transplanting using a knapsack sprayer (Molla *et al*., 2011).Five plants of medium row were used for data collection from each replicate before spraying as well as 1, 3, 5, 7 and 14 days after spraying. Alive larvae in each replication were counted. Percent reduction in infestation was calculated using Abbott's formula (1925). To assess the effect of tested botanicals on reduction in fruit damage, numbers of infested and uninfested tomato fruits from 10 plants were randomly counted from each replicate and per cent of infested tomato fruits in different treatments was calculated. Subsequently data on tomato yield was also recorded.

Assessment of yield loss

The per cent fruit damage was recorded on weight basis and number basis at the time of each harvest. Per cent fruit damage was estimated as follows (Kalleshwaraswamy*et al*., 2015). The mean population data were subjected to square root transformation. The data obtained from field and laboratory experiments were subjected to Analysis of Variance (ANOVA). The significance of differences was tested by F-tests, while the significance of difference between the treatment mean values was compared by LSD at 5 per cent probability.

Table 2. Field evaluation of efficacy of botanicals against *T. absoluta* on tomato (Hybrid Sagar) – Trial I (January – April, 2017), Kinnimangalam, Madurai (First spray)

Treatment	Days after first spraying (No. of live larvae/ plant)						Mean no. of live larva/ plant	Per cent reduction over control
	PTC	1	3	5	7	14		
Neem oil @ 3%	8.92	5.88 (2.42)^{a}	5.10 (2.26)^{a}	3.25 (1.80)^{a}	5.67 (2.38)^{b}	7.25 (2.69)^{b}	5.43 (2.33)^{a}	49.63
Pungam oil @ 3%	9.67	7.52 (2.74)^{b}	5.85 (2.42)^{b}	4.33 (2.08)^{b}	5.25 (2.29)^{a}	7.33 (2.71)^{b}	6.06 (2.46)^{b}	43.82
Mahua oil @ 3%	10.11	8.25 (2.87)^{c}	7.33 (2.71)^{d}	5.72 (2.39)^{e}	5.15 (2.27)^{a}	6.95 (2.64)^{a}	6.68 (2.58)^{c}	38.04
Citrus peel oil @ 3%	9.67	8.10 (2.85)^{c}	7.30 (2.70)^{d}	6.10 (2.47)^{f}	7.05 (2.66)^{d}	8.35 (2.89)^{c}	7.38 (2.72)^{e}	31.54
Vasambu rhizome extract @ 3%	9.35	8.47 (2.91)^{d}	7.48 (2.73)^{e}	5.33 (2.31)^{d}	7.67 (2.77)^{e}	9.67 (3.11)^{d}	7.72 (2.78)^{e}	28.35
Neem seed kernel extract @ 5%	6.40	5.65 (2.38)^{a}	4.95 (2.22)^{c}	4.85 (2.20)^{c}	5.88 (2.42)$_{bc}$	6.90 (2.63)^{a}	5.65 (2.38)^{a}	47.63
Notchi leaf extract @ 5%	8.61	7.33 (2.71)^{b}	7.15 (2.67)^{d}	6.15 (2.48)^{f}	6.22 (2.49)$_{c}$	7.20 (2.68)^{b}	6.81 (2.61)^{d}	36.83
Untreated check	9.82	9.85 (3.14)^{e}	10.25 (3.20)^{f}	10.66 (3.26)^{g}	11.12 (3.33)$_{f}$	12.01 (3.47)^{e}	10.78 (3.28)^{f}	-
SE (d)		0.03	0.03	0.02	0.02	0.03	0.03	
CD (P= 0.05)		0.06	0.06	0.03	0.04	0.06	0.07	

PTC – Pre Treatment Count. Values in parentheses are √x+0.5 transformed values. In a column, means followed by same letter are not significantly different at P = 0.05 as per LS

RESULTS AND DISCUSSION

Among the seven botanical tested (Table 1) Neem oil @ 3%, and Pungam oil @ 3%, recorded the maximum per cent mortality of *T. absoluta* (82.65% and 79.33% respectively), which were statistically on par in their efficacy followed by NSKE@ 5% (77.67%) and Mahua oil @ 3% (74.45%) which were on par. Nochi leaf extract @ 5% and Citrus peel oil @ 3% recorded mortality of 71.755% and 68.95% respectively which were on par followed by Vasambu rhizome extract (63.33 %). All the botanicals tested showed a range of 63.33 to 82.65% mortality of *T. absoluta* larvae under laboratory condition. The present finding was in accordance with Sow and Diarra (2013) recorded 93 per cent mortality of *Plutella xylostela* by neem oil 10%. Apart from neem formulations, some other plant products effective against the larvae of *T. absoluta* were hexane extract of *Acmella oleracea* (Moreno *et al.,*2012), ethanolic leaf extracts of *Piper* (Brito *et al.,*2015) and essential oil from cardamom, *Elettariac ardamomum* (Goudarzvand and Abbasipour, 2017).

From the field evaluation of botanicals against *T. absoluta* after the first spraying, Neem oil @ 3% and NSKE @ 5% recorded lower mean larval population of 5.43 and 5.65nos./ plant respectively and significantly superior than other treatments (Table 2). They also showed high larval population reduction over control (49.63 and 47.63 per cent respectively). This was followed by Pungam oil @ 3% (43.82%) and Mahua oil @ 3% (38.04%). After the second round of spray (Table 4) Neem oil @ 3% showed higher larval population reduction (60.23%) followed by Pungam oil (56.51%) and NSKE @ 5% (53.72%). The results of third spray revealed that Neem oil and Pungam oil showed lower larval count of 3.55 and 3.64nos./per plant with higher reduction of larval population (78.39% and 77.82% respectively) over control (Table 5). They were

Table 3. Field evaluation of efficacy of botanicals against *T. absoluta* on tomato (Hybrid Sagar) – Trial I (January – April, 2017), Kinnimangalam, Madurai (Second spray)

Treatment	Days after second spraying (No. of live larvae/ plant)						Mean no. of live larva/ plant	Per cent reduction over control
	PTC	1	3	5	7	14		
Neem oil @ 3%	9.20	7.45 (2.73)^{a}	5.85 (2.42)^{a}	3.67 (1.92)^{a}	3.55 (1.88)^{a}	5.45 (2.33)^{a}	5.19 (2.28)^{a}	60.23
Pungam oil @ 3%	9.67	8.35 (2.89)^{b}	6.12 (2.47)^{a}	4.32 (2.08)^{b}	3.46 (1.86)^{a}	6.15 (2.48)^{b}	5.68 (2.38)^{b}	56.51
Mahua oil @ 3%	10.62	8.22 (2.87)^{b}	7.54 (2.75)^{c}	5.69 (2.39)^{d}	4.72 (2.17)^{b}	7.22 (2.69)^{d}	6.68 (2.58)^{d}	48.87
Citrus peel oil @ 3%	9.64	8.15 (2.85)^{b}	7.65 (2.77)^{c}	6.05 (2.46)^{e}	5.95 (2.44)^{cd}	8.80 (2.97)^{f}	7.32 (2.71)^{e}	43.94
Vasambu rhizome extract @ 3%	10.05	8.95 (2.99)^{c}	8.12 (2.85)^{d}	7.56 (2.75)^{g}	6.20 (2.49)^{d}	8.01 (2.83)^{e}	7.77 (2.79)^{f}	40.52
Neem seed kernel extract @ 5%	9.67	7.33 (2.71)^{a}	6.13 (2.48)^{a}	5.33 (2.31)^{c}	4.65 (2.16)^{b}	6.78 (2.60)^{c}	6.04 (2.46)^{c}	53.72
Notchi leaf extract @ 5%	9.49	8.15 (2.85)^{b}	6.54 (2.56)^{b}	6.89 (2.62)^{f}	5.86 (2.42)^{e}	7.88 (2.81)^{e}	7.06 (2.66)^{e}	45.91
Untreated check	11.55	12.33 (3.51)^{d}	12.85 (3.58)^{e}	13.50 (3.67)^{h}	13.67 (3.70)^{e}	15.67 (3.96)^{g}	13.60 (3.69)^{g}	-
SE (d)		0.02	0.03	0.03	0.03	0.02	0.02	
CD (P=0.05)		0.05	0.07	0.06	0.06	0.04	0.06	

PTC – Pre Treatment Count
Values in parentheses are √x+0.5 transformed values
In a column, means followed by same letter are not significantly different at P = 0.05 as per LSD

statistically on par with each other. It was followed by NSKE (74.68%).

Analyzing the overall reduction in larval population per plant (Table 6), plots sprayed with Neem oil @ 3% was superior over other botanicals showing lowest larval population of 4.72 nos./ per plant coupled with 65.26 % reduction in larval population. It was followed by Pungam oil @ 3% and NSKE @ 5% having 5.13 and 5.28 larva/plant with 62.30% and 61.15% reduction in larval population respectively, and they were on par with each other. Other treatments exhibited moderate reduction in larval population per plant as follows Mahua oil @ 3% (6.05) <Nochi leaf extract @ 5% (6.40) <Citrus peel oil @ 3% (6.94) <Vasambu rhizome extract @ 3% (7.26). All the botanical tested ranged 65.26% - 46.65% reduction in larval population of *T. absoluta* under field conditions. With respect to fruit damage, Neem oil @ 3% had significantly lowest fruit damage with 69.79 % reduction in fruit damage over untreated check. It was followed by Pungam oil @ 3% and NSKE @ 5% showing 66.70 and 65.17% reduction in fruit damage and they were on par with each other. Other treatments exhibited moderate reduction in fruit damage percentage as follows: Mahua oil @ 3% (62.18%) <Nochi leaf extract @ 5% (59.82%) <Citrus peel oil @ 3% (55.20%) <Vasambu rhizome extract @ 3% (52.55%). All the botanical extracts tested registered 69.79% to 52.55% reduction in fruit damage by *T. absoluta* over untreated check under field condition.

With regard to yield, highest per cent increase in fruit yield was recorded in case of Neem oil @ 3% (27.08%) with maximum cost benefit ratio of 1:1.65 which was significantly superior over all other treatments. It was followed by Pungam oil @ 3%, NSKE @ 5% and

Table 4. Field evaluation of efficacy of botanicals against *T. absoluta* on tomato (Hybrid Sagar) – Trial I (January – April, 2017), Kinnimangalam, Madurai (Third spray)

Treatments	Days after third spraying (No. of live larvae/ plant)						Mean no. of live larva/ plant	Per cent reduction over control
	PTC	1	3	5	7	14		
Neem oil @ 3%	6.23	4.95 (2.22)^{b}	3.65 (1.91)^{b}	2.68 (1.64)^{a}	2.25 (1.50)^{a}	4.22 (2.05)^{a}	3.55 (1.88)^{a}	78.39
Pungam oil @ 3%	6.92	3.84 (1.96)^{a}	3.22 (1.79)^{a}	2.88 (1.70)^{b}	3.30 (1.82)^{b}	4.98 (2.23)^{b}	3.64 (1.91)^{a}	77.82
Mahua oil @ 3%	7.91	6.22 (2.49)^{d}	5.48 (2.34)^{c}	3.55 (1.88)^{d}	4.22 (2.05)^{d}	4.52 (2.12)^{a}	4.80 (2.19)^{c}	70.80
Citrus peel oil @ 3%	8.66	7.33 (2.71)^{e}	6.57 (2.56)^{e}	5.22 (2.28)^{f}	3.45 (1.86)^{c}	7.98 (2.82)^{d}	6.11 (2.47)^{e}	62.81
Vasambu rhizome extract @ 3%	8.22	7.45 (2.73)^{e}	5.96 (2.44)^{d}	5.45 (2.33)^{f}	4.68 (2.16)^{e}	7.84 (2.80)^{d}	6.28 (2.51)^{e}	61.80
Neem seed kernel extract @ 5%	6.51	5.95 (2.44)^{c}	4.23 (2.06)^{b}	3.22 (1.79)^{c}	3.25 (1.80)^{b}	4.15 (2.04)^{a}	4.16 (2.04)^{b}	74.68
Notchi leaf extract @ 5%	7.79	6.15 (2.48)^{d}	5.33 (2.31)^{c}	4.87 (2.21)^{e}	4.22 (2.05)^{d}	6.10 (2.47)^{c}	5.33 (2.31)^{d}	67.53
Untreated check	15.00	15.10 (3.89)^{f}	15.67 (3.96)^{f}	16.20 (4.02)^{g}	16.95 (4.12)^{f}	18.22 (4.27)^{e}	16.43 (4.05)^{f}	78.39
SE (d)		0.03	0.02	0.02	0.01	0.03	0.02	
CD (P= 0.05)		0.06	0.06	0.05	0.03	0.06	0.06	

PTC – Pre Treatment Count. Values in parentheses are √x+0.5 transformed values. In a column, means followed by same letter are not significantly different at P = 0.05 as per LSD

Mahua oil @ 3% with 22.81, 21.43 and 19.70 per cent increase in fruit yield coupled with cost benefit ratio of 1:1.46, 1:1.42 and 1:1.37 respectively and they were on par with each other. Other treatments *viz.*,Nochi leaf extract @ 5%, Citrus peel oil @ 3%, Vasambu rhizome extract @ 3% showed 17.38%, 16.15% and 14.70% increase in fruit yield with cost benefit ratio of 1:1.32, 1:1.25 and 1:1.19 respectively. The present finding was in agreement with Goncalves and Vendramim (2007) who reported that the plant extracts such as Neem acted as contact and systemic insecticides against *T. absoluta* and caused 57 to 100 per cent larval mortality. Also Cunha *et al.* (2006) reported that the leaf, twig freeze dried aqueous (FDA) and organic extracts of a Neem tree, *Trichilia pollens* was higher effective against *T. absoluta.* Findings of Kona *et al.* (2014) was in line with our findings. He reported around 25 and 18 per cent of egg mortalities were obtained with the different concentrations of neem and Jatropha extracts respectively. On the other hand, larval mortalities ranging between 33- 46.7 and 23.5 - 48.5 per cent were obtained after 24 hours with Neem and Jatropha seed extracts respectively. Also, higher larval mortalities, upto 100%, were obtained with the two extracts after 4 days of treatments. And also our finding was supported by Yankova *et al.* (2014) who reported that Neem Azal T/S®at 0.3% was found to be very effective after 14 days of treatment against 1st and 2nd instar larvae of the *T. absoluta*.

From the present study it is clear that from the studied botanicals Neem oil @ 3% is proven to be effective in controlling *T. absoluta* under both laboratory and field conditions. Following this NSKE @5% and Pungam oil @ 3% were also been effective.

Table 5. Impact of botanicals on reduction of active mines, fruit damage by *T. absoluta* and yield of tomato

Botanicals	No. of live larvae/ plant (Pooled mean)	Cumulative per cent reduction over control	Mean no. of damaged fruits/ plant	Per cent decrease over control	Yield (t/ha)	Per cent increase in yield over control	C:B ratio
Neem oil @ 3%	4.72 (2.17)[a]	65.26	8.69 (2.95)[a]	69.79	17.55 (4.19)[a]	27.08	1:1.65
Pungam oil @ 3%	5.13 (2.26)[b]	62.30	9.58 (3.10)[b]	66.70	16.96 (4.12)[ab]	22.81	1:1.46
Mahua oil @ 3%	6.05 (2.46)[c]	55.50	10.88 (3.30)[c]	62.18	16.53 (4.07)[bcd]	19.70	1:1.37
Citrus peel oil @ 3%	6.94 (2.63)[e]	48.99	12.89 (3.59)[e]	55.20	16.04 (4.00)[d]	16.15	1:1.25
Vasambu rhizome extract @ 3%	7.26 (2.69)[f]	46.65	13.65 (3.69)[f]	52.55	15.84 (3.98)[d]	14.70	1:1.19
Neem seed kernel extract @ 5%	5.28 (2.30)[b]	61.15	10.02 (3.17)[b]	65.17	16.77 (4.10)[bc]	21.43	1:1.42
Notchi leaf extract @ 5%	6.40 (2.53)[d]	52.92	11.56 (3.40)[d]	59.82	16.21 (4.03)[cd]	17.38	1:1.32
Untreated check	13.60 (3.69)[g]	-	28.77 (5.36)[g]	-	13.81 (3.72)[e]	-	
	0.02		0.03		0.04		
	0.05		0.07		0.08		

Values in parentheses are √x+0.5 transformations. In a column, means followed by same letter are not significantly different at P = 0.05 as per LSD

REFERENCES

Abbott, W. S. 1925. A method for computing the effectiveness of an insecticide. *Jornal Economic Entomology*,**18**: 265-267.

Balaji, D. R. 2016. Bio-ecology and management of South American tomato pinworm *Tuta absoluta* (Meyrick).Unpublished thesis, Tamil Nadu Agricultural University, Coimbatore, India. 169p.

Ballal, C.R., A. Gupta, M. Mohan, Y. Lalitha and A. Verghese. 2016. The new invasive pest *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in India and its natural enemies along with evaluation of Trichogrammatids for its biological control. *Current Science*, **110** (11):2155-2159.

Brito, E.F.D., E.L.L.Baldin, R.D.C.M.Silva, L.D.P.Ribeiro and J.D. Vendramim. 2015. Bioactivity of Piper extracts on *Tuta absoluta* (Lepidoptera: Gelechiidae) in tomato. *Pesquisa Agropecuaria Brasileira,* **50**(3):196-202

Cunha, U. S. D., J. D. Vendramim, W. C. Rocha and P. C. Vieira. 2006. Fractions of *Trichiliapallens* with insecticidal activity against *Tuta absoluta***.** *Pesquisa Agropecuaria Brasileira***, 41**(11): 1579-1585.

Garcia, M.F. and Espul, J. C. 1982. Bioecolog'ia de la polilladeltomate (*Scrobipalpula absoluta*) en Mendoza, Repu'blica Argentina. *Rev. Invest Agropecuarias INTA (Argentina)*, **18**: 135-146.

Ghanim, N.M. and Abdel Ghani, S.B. 2014. Controlling

Tuta absoluta (Lepidoptera: Gelechiidae) and *Aphis gossypii* (Hemiptera: Aphididae) by aqueous plant extracts. *Life Science Journal*, **11**(3): 299-307.

Goncalves, G.R.D.R. and Vendramim, J.D. 2007. Bioactivity of aqueous neem seeds extraction the *Tuta absoluta* (Meyrick, 1917) (Lepidoptera:Gelechiidae) in three ways of application. *Cienc.Agrotec.,***31**: 28-34.

Goudarzv and Chegini, S. and Abbasipour H. 2017. Chemical composition and insecticidal effects of the essential oil of cardamom, *Elettaria cardamomum* on the tomato leaf miner, *Tuta absoluta*. *Toxin Reviews*, **36**(1): 12 – 17.

Kalleshwaraswamy, C.M., M. S. Murthy, C. A. Viraktamath and Kumar, N. K. 2015. Occurrence of *Tuta absoluta* (Lepidoptera: Gelechiidae) in the Malnad and Hyderabad-Karnataka Regions of Karnataka, India. *Florida Entomologist*, **98**(3): 970-971.

Khanjani, M. 2013.Vegetable pest in Iran, 5nd Edition, Bu-Ali Sina University Press Center, Iran, 467p.

Kona, N.E.M., A. K. Taha and Mahmoud, M. E. 2014. Effects of Botanical Extracts of Neem (*Azadirachta indica*) and Jatropha (*Jatropha curcus*) on eggs and larvae of tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *Persian Gulf Crop Protection*, **3**(3): 41-46.

Molla, O., J. Gonzalez-Cabrera and A. Urbaneja. 2011. The combined use of *Bacillus thuringiensis* and *Nesidiocoris tenuis* against the tomato borer, *Tuta absoluta.Bio. Control*, **56**: 883-891.

Moreira, M.D., M.C. Picanco, L.C.D. Barbosa, R.N.C. Guedes and L.M. daSilva. 2004. Toxicity of leaf extracts of *Ageratum conyzoides*to Lepidoptera pests of horticultural crops. *Biol. Agric. Hortic.,***22**: 251-260.

Moreno, S. C., G. A. Carvalho, M. C. Picanco, E. G. Morais and Pereira, R. M. 2012. Bioactivity of compounds from *Acmella oleracea* against *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and selectivity to two non-target species. *Pest management science*, **68**(3): 386 – 393.

Pavela, R. 2012. Efficacy of three newly developed botanical insecticides based on pongam oil against *Plutella xylostella* L. larvae. *Journal of Biopesticides*, **5**(1): 62-70.

Sow, G. and Diarra, K. 2013. Laboratory evaluation of toxicity of *Bacillus thuringiensis*, neem oil and methamidophos against *Plutella xylostella* L.(Lepidoptera: Plutellidae) larvae. *International Journal of Biological and Chemical Sciences*, **7**(4): 1524 – 1533.

Sridhar, V., A.K. Chakravarthy and Asokan, R. 2014. New record of the invasive South American tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in India. *Pest Management in Horticultural Ecosystems*, **20**(2): 148-154.

Urbaneja, A., R. Vercher, V. Navarro, M. F. Garcia and Porcuna, J. L. 2007. La polilladeltomate, *Tuta absoluta*. *PhytomaEspaña*, **194**: 16 – 23.

Yankova, V., N. Valchev and D. Markova. 2014. Effectiveness of phytopesticide Neem Azal T/S® against tomato leaf miner *Tuta absoluta* (Meyrick) in greenhouse tomato. *Bulgarian Journal of Agricultural Science (Bulgaria),***8**:22- 29.

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