Pest Management in Horticultural Ecosystems
Vol. 29, No.1 pp 82-88 (2023)
DOI Number:10.5958/0974-4541.2023.00013.9

Studies on biology and host preference of South American Leaf Miner, *Phthorimaea absoluta* Meyrick (Lepidoptera: Gelechiidae)

S. JEYARANI*

*Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Kudumiyanmalai -622 104, India

***E-mail**: jeyarani.s@tnau.ac.in

ABSTRACT: The invasive South American Leaf miner, *Phthorimaea* (=*Tuta*) *absoluta* Meyrick (Lepidoptera: Gelechiidae) is now getting a status of key pest in India. Biology studies carried out on tomato revealed that the *P. absoluta* had four larval instars. The total life cycle of *P. absoluta* lasted for 20.62 ± 0.66 days with an egg, larval and pupal periods of 2.54 ± 0.15, 9.54 ± 0.31 days and 8.54 ± 0.20 days, respectively. The longevity of female (40.00 ± 0.49 days) was found longer than the males which lasted for 36.45 ± 0.21 days. The biology studies carried out at different temperature conditions revealed the lowest egg (3.00 ± 0.24), larval (10.00 ± 0.27), pupal (9.00 ± 0.27) period, high fecundity (211.00 ± 2.54/female), highest female (40.00 ± 0.49) and male (36.45 ± 0.21) longevity at 30°C. Studies on the spatial distribution of eggs by *P. absoluta* revealed that the *P. absoluta* adults mostly preferred to lay the eggs on upper leaf surface (6.07 eggs) followed by lower surface of leaves (5.79 eggs). Ovipositional preference studies on different solanaceous crops *viz.,* tomato, brinjal, potato*,* chilli and European black nightshade revealed that the adults of *P. absoluta* highly preferred tomato (233.70 and 326.00 eggs plant^{-1}) followed by potato (95.90 and 143.20 eggs plant^{-1}) both under free and no choice conditions, respectively. Biology of *P. absoluta* on other solanaceous crops revealed that the total life cycle was the shortest on tomato (22.00 ± 0.61) followed by European black nightshade (27.75 ± 0.84 days). However, no eggs hatched on chilli.

Key words: *Phthorimaea absoluta,* solanaceous crops, biology, host preference, spatial distribution

INTRODUCTION

The South American leaf miner*, Phthorimaea* (=*Tuta*) *absoluta* (Meyrick) (Lepidoptera: Gelechiidae), a key pest of tomato and native to the western part of South America, recently invaded India. It was initially observed in polyhouse and field grown tomato in Pune during 2014 (Shashank *et al.,* 2015) and at Indian Institute of Horticultural Research (IIHR), Bengaluru (13°8.12"N 77°29.45"E, altitude 890 m), Karnataka, India during the *rabi* season, 2014. It was also reported that the yield loss due to *P. absoluta* was 87 per cent in Shivakote, Karnataka (Sridhar *et al.,* 2014) and 14.4 to 97.9 per cent at Vegetable Research Station, Rajendranagar, Telangana (Kumari *et al.,* 2015) and is now getting a status of key pest in Tamil Nadu, India. *Phthorimaea absoluta* is a neotropical, oligophagous pest infesting many solanaceous crops. It mostly prefers tomato, but it can also feed, develop and reproduce on other cultivated solanaceous crops such as eggplant (*Solanum melongena* L.), potato (*S. tuberosum* L.) sweet pepper (*Capsicum annuum* L.), sweet cucumber (*S. muricatum* AiP.) and tobacco, *Nicotiana tabacum* L. (EPPO, 2005) as well as on non-cultivated solanaceous crops *viz., S. nigrum* L., *S. eleagnifolium* L., *S. bonariense* L., *S. sisymbriifolium* Lam., *S. saponaceum*, *Lycopersicum puberulum* Ph., *Lycopersicon hirsutum* (C.H.Mull.) Luckwill, *S. lyratum* Thunb, *S. nigrum*, *S. puberulum* NutP., *N. glauca*, Aubergine, *Datura ferox* L., *D. stramonium* L., *N. glauca* Grahamandon alfalfa, *Medicago sativa* L.*,* (Tosevski *et al.,* 2011).

In Europe, it was also reported in a Sicilian greenhouse of Cape gooseberry (*Physalis peruviana* L.) (Garzia *et al.,* 2009) and in Italy it was reported on *Lycium* sp. and *Malva* sp. which indicates that the *P. absoluta* shows a high propensity to use various plants as secondary hosts, notably species within the family Solanaceae. Ogur *et al.* (2014) also reported that *P. absoluta* mostly preferred tomato, but it also developed and reproduced on leaves of the weed, *Chenopodium album* L. and this paved way for its continuous existence in the absence of tomato.

Application of chemical insecticides is the most commonly recommended practice for the suppression of *P. absoluta*. Chemicals may provide sufficient control, but extensive use of these insecticides may lead to

Table 1. Biology of *P. absoluta* on tomato at ambient temperature

Stage	Period (in days ± SE)[#]
Egg	2.54±0.15
Larval period	
1st instar	1.74±0.11
2nd instar	2.20±0.10
3rd instar	2.47±0.03
4th instar	3.07±0.07
Total larval period	9.54±0.31
Pupal period	8.54±0.20
Adult longevity	
Male	36.45±0.21
Female	40.00±0.49
Total life cycle of *P. absoluta*	20.62±0.66
Total life span of *P. absoluta*	60.62±1.15

[#] Mean of twelve replications

development of resistance, as previously reported in South America (Lietti *et al.,* 2005). Hence, the study on the bioecology and host preference of this new invasive pest is the need of the hour to provide information for its ecofriendly managemenP. Keeping this in view, the present investigations were carried out on the bioecology and host preferences of *P. absoluta.*

MATERIALS AND METHODS

Culturing of *P. absoluta*

The population of *P. absoluta* required for the laboratory experiments were mass cultured in the Insectary, Department of Agricultural Entomology, Tamil Nadu Agricultural University (TNAU), Coimbatore. Mined leaves with *P. absoluta* larvae collected from tomato fields were kept in plastic trays (60 x 45 x 15 cm) lined with filter paper. When the leaves were fully mined fresh tomato leaves were provided for the larvae until pupation.

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 ten per cent 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 pro-tray 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. Freshly emerged adults from these cultures were utilized for various experiments outlined below.

Experimental design for the bioecology studies

To study the biology of *P. absoluta*, a freshly mated adult female was released individually on to twelve tomato seedlings (20 days old) kept in separate cages (30 x 30 x 30 cm). Twenty four hours after release, the seedlings with fresh eggs were taken and observed under stereo zoom microscope (Model: MZ16). Single egg was left and the remaining was brushed off from each seedling and kept separately in individual cages (30 x 30 x 30 cm). Observations on egg incubation, larval (different instars), pupal period and total life cycle were recorded periodically. The temperature and the RH prevailed during the study period ranged from 28 to 32^{o}C and 65 to 88 %.

Biology of *P. absoluta* was also studied at different temperature conditions *viz.,* 20^{o}C (80% RH), 25^{o}C (75% RH), 30^{o}C (60% RH) and 35^{o}C (50% RH) to find out the optimum temperature for its growth and developmenP. The experiment was conducted in completely randomized design (CRD) with twelve replications. For each temperature conditions, 12 eggs each representing one replication were used and the observations on egg incubation, larval, pupal period and total life cycle were recorded periodically.

Spatial distribution of *P. absoluta* eggs on tomato

Experiment was also carried out to study the spatial distribution of eggs within the tomato plant by the *P. absoluta* adulP. Twelve (45 days old) tomato plants grown in tubular mud pots (15 x 10 x 10 cm) each representing one replication were used for the study. The plants were kept in separate cages and freshly mated female was released into each cages. After 24 h of egg laying the number of eggs in upper and lower surface of leaves, stem, buds and calyx were counted and the spatial preference for egg laying by the adults were worked ouP.

Table 2. Biology of tomato leaf miner, *P. absoluta* at different temperature conditions

Temperature	Days ± SE#					
	Egg period	Larval period	Pupal period	Total life cycle	Male adult longevity	Female adult longevity
20°C	5.50±0.15	15.75±0.32	14.00±0.24	35.25±0.71	23.00±0.25	26.50±0.19
25°C	4.75±0.35	14.75±0.13	10.50±0.18	30.00±0.66	26.50±0.21	29.50±0.39
30°C	3.00±0.24	10.00±0.27	9.00±0.27	21.00±0.78	36.45±0.21	40.00±0.49
35°C	2.75±0.13	10.00±0.24	10.75±0.28	23.50±0.65	28.75±0.18	31.50±0.19

Mean of twelve replications

Ovipositional preference and biology of *P. absoluta* on selected solanaceous crops

Five solanaceous hosts *viz.,* tomato (*Solanum lycopersicum*), brinjal (*S. melongena)*, potato (*S. tuberosum),* chilli *(Capsicum annum*) and European black nightshade (*S. nigrum)* was used to study the ovipositional preference of *P. absoluta.* The host plants were grown in mud pots (30 x 30 x 30 cm) at Insectary, Department of Agricultural Entomology, TNAU, Coimbatore. Single leaf of brinjal and compound leaves of other four host crops were kept separately in a glass vial with water and secured with cotton. The vials were randomly arranged in a circular manner inside a (60 × 60 × 60 cm) rearing cage (Fekri *et al.,* 2013). Ten pairs of freshly emerged adults were released at the centre of the cage. Adults were provided with ten per cent sugar solution fortified with multivitamin (ABDEC®) in 5 ml glass vial with cotton swab to prevent moths from drowning. The host leaves were changed daily until the completion of oviposition period of seven days. The number of eggs laid in each hosts were counted daily and the total number of eggs laid per host were worked out with the help of stereo zoom microscope (10x). The experiment was conducted in CRD with five replications. Similar procedure was also followed for no choice tesP. Instead of five host crops, each crop was kept separately in individual cages and the number of eggs laid per host crop was assessed daily until the completion of oviposition period of seven days and the total number of eggs laid per host was worked ouP. The experiment was conducted in CRD with five replications.

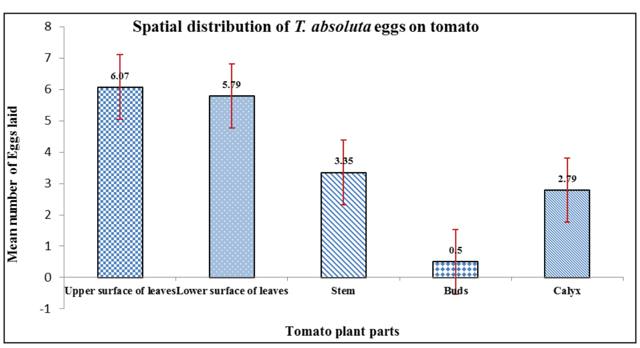

Fig. 1 Spatial distribution of eggs by *P. absoluta* on tomato

To study the biology of *P. absoluta* on different solanaceous crops *viz.,* brinjal, potato,, chilli, and European black nightshade, freshly mated adult female was released individually on to twelve seedlings of each hosts kept in separate cages (30 x 30 x 30 cm). Twenty four hours after release, the seedlings with fresh eggs were taken and observed under stereo zoom microscope (Model: MZ16). Single egg was left and the remaining was brushed off from each seedling and kept separately in individual cages (30 x 30 x 30 cm). Tomato, the most preferred crop was also included along with other host crops for comparison of biology. The experiment was conducted in CRD with twelve replications. Observations on egg incubation, larval, pupal period and total life cycle were recorded periodically. The temperature and the RH prevailed during the study period ranged from 28 to 32°C and 65 to 88 per cent.

Data analysis

The data obtained in percentages from various experiments were transformed to square root (X+0.5). The analysis of variance for different experiments were carried out in AGRES and the means were separated by least significant difference (LSD) available in the package.

RESULTS AND DISCUSSION

Knowledge on the bioecology of insect pests is the pre-requisite for evaluating methods compatible with Integrated Pest Management. The research works carried out on the biology of *P. absoluta* under different temperature conditions and host crops were scanty. In view of limited availability of information, the present

Table 3. Ovipositional preference of *P. absoluta* under free choice condition

Crop	No. of eggs laid plant^{-1} (DAR*)#							Total no. of eggs laid plant^{-1}
	1	2	3	4	5	6	7	
Tomato *(S. esculentum)*	22.10 (4.70)^{a}	28.90 (5.38)^{a}	45.50 (6.75)^{a}	34.30 (5.86)^{a}	36.90 (6.07)^{a}	33.30 (5.77)^{a}	32.70 (5.72)^{a}	233.70 (15.29)^{a}
Brinjal (*S. melangena)*	1.50 (1.22)^{b}	2.50 (1.58)^{b}	7.10 (2.66)^{bc}	4.90 (2.21) bc	6.90 (2.63)^{b}	1.50 (1.22)^{b}	2.10 (1.45)^{b}	26.50 (5.15)^{cd}
Potato (*S. tuberosum)*	14.50 (3.81)^{a}	15.90 (3.99)^{a}	16.10 (4.01)^{b}	14.50 (3.81) ab	16.10 (4.01)^{ab}	12.10 (3.48) ab	6.70 (2.59)^{b}	95.90 (9.79)^{b}
Chilli (*C. annum)*	0.50 (0.71)^{b}	0.50 (0.71)^{b}	0.80 (0.89)^{c}	0.50 (0.71)^{c}	1.80 (1.34)^{b}	1.70 (1.30)^{b}	0.80 (0.89)^{b}	6.60 (2.57)^{d}
European black nightshade (*S. nigrum)*	2.70 (1.64)^{b}	2.70 (1.64)^{b}	3.90 (1.97)^{c}	7.10 (2.66)^{b}	11.50 (3.39)^{b}	6.1 (2.47)^{b}	5.30 (2.30)^{b}	39.30 (6.27)^{c}
SE (d)	0.62	0.70	0.86	0.82	1.05	1.29	1.10	1.33
CD (0.05)	1.30	1.48	1.80	1.71	2.19	2.75	2.29	2.77

* Days after release
\# Mean of five replications
Figures in the parentheses are $\sqrt{x+0.5}$ transformed values
Means followed by the common letter (s) are not significantly different at P=0.05 level by LSD

Table 4. Ovipositional preference of *P. absoluta* under no choice condition

Host plant	No. of eggs laid plant^{-1} (DAR*)#							Total no. of eggs laid plant^{-1}
	1	2	3	4	5	6	7	
Tomato *(S. esculentum)*	60.20 (7.76)^{a}	51.40 (7.17)^{a}	45.80 (6.77)^{a}	44.00 (6.63)^{a}	60.80 (7.80)^{a}	39.40 (6.28)^{a}	24.40 (7.80)^{a}	326.00 (18.06)^{a}
Brinjal (*S. melangena)*	11.60 (3.41)^{c}	14.80 (3.85)^{bc}	12.20 (3.49)^{c}	10.20 (3.19)^{bc}	10.60 (3.26)^{c}	10.40 (3.22)^{bc}	8.20 (2.86)^{b}	78.00 (7.71)^{c}
Potato (*S. tuberosum)*	20.40 (4.52)^{b}	28.80 (5.37)^{ab}	26.40 (5.14)^{b}	21.80 (4.67)^{ab}	23.20 (4.82)^{b}	13.60 (3.69)^{b}	9.00 (3.00)^{b}	143.20 (11.97)^{b}
Chilli (*C. annum)*	1.00 (1.00)^{d}	1.20 (1.10)^{d}	1.00 (1.00)^{d}	1.20 (1.10)^{d}	1.20 (1.10)^{d}	1.20 (1.10)^{d}	1.20 (1.10)^{d}	8.00 (2.83)^{e}
European black nightshade (*S. nigrum)*	2.60 (1.61)^{d}	3.40 (1.84)^{cd}	8.80 (2.97)^{c}	9.00 (3.00)^{ab}	9.60 (3.10)^{c}	6.80 (2.61)^{c}	3.20 (1.79)^{d}	43.40 (6.59)^{d}
SE (d)	0.65	0.96	0.61	0.75	0.68	0.40	0.38	0.59
CD (0.05)	1.35	2.00	1.27	1.57	1.42	0.84	0.78	1.23

* Days after release
\# Mean of five replications
Figures in the parentheses are $\sqrt{x+0.5}$ transformed values
Means followed by the common letter (s) are not significantly different at P=0.05 level by LSD

Table 5. Life cycle of *P. absoluta* on other solanaceous hosts

Host plant	Developmental period (in days ± SE)#			
	Egg	Larva	Pupa	Total life cycle
Brinjal (*S. melangena)*	5.50±0.15	14.75±0.13	9.75±0.13	30.00±0.41
Potato (*S. tuberosum)*	4.00±0.24	11.75±0.35	12.75±0.13	28.50±0.72
Chilli (*C. annum)*	No egg hatching	-	-	-
European black nightshade (*S. nigrum)*	3.50±0.15	12.50±0.34	11.75±0.35	27.75±0.84
Tomato (*S. esculentum*)	3.25±0.22	10.25±0.28	9.25±0.26	22.00±0.61

Mean of twelve replications

study was carried out and the results obtained were discussed with the available literatures.

Biology of *P. absoluta* on tomato

The female *P. absoluta* laid the eggs singly on both upper and lower surface of leaves, stems, calyx and buds. The eggs were small, oblong or oval, microscopic, light yellow or creamy in colour. The incubation period of an egg lasted for 2.54 ± 0.15 days (Table 1) which is in agreement with the findings of Estay (2000) who documented an incubation period of 3.90±0.91 days. *Phthorimaea absoluta* had four larval instars, of which, the first and second instars were white or cream with a black head with a developmental period of 1.74 ± 0.11 days and 2.20 ± 0.10 days, respectively. Third and fourth instars turned greenish to pink with a brown head with a pale prothoracic shield and the larval period lasted for 2.47 ± 0.03 days and 3.07 ± 0.07 days, respectively and the total larval period lasted for 9.54 ± 0.31 days (Table 1). Estay (2000) also documented four well-defined larval instars with different size and colour in *P. absoluta*. The present finding was also in accordance with Erdogan and Babaroglu (2014) who reported four larval instars with a developmental period of 2.49 ± 0.09, 2.32 ± 0.07, 2.57 ± 0.07 and 3.79 ± 019 days, respectively with a total larval period of 10.97 days.

Newly formed pupae were greenish and turned to dark brown as they mature which was in line with the reports of Estay (2000). The present observation on the pupal period (8.54 ± 0.20 days) was in consonance with Erdogan and Babaroglu (2014) who observed mean pupal period of 9.53±0.25 days.

The mean longevity of female (40.00 ± 0.49 days) was found to be longer than the males (36.45 ± 0.21 days). Estay (2000) also reported similar results, however, he reported comparatively less longevity of 10 to 15 days for females and 6 to 7 days for males which is in contrary with our results. The variation in the duration observed in the present study may be attributed to the geographical variation in the population.

In the present investigation, the total life cycle of *P. absoluta* lasted for 20.62 ± 0.66 days on tomato. This corroborates with the results of Barrientos *et al.* (1998) who reported a total life cycle of 23.8 days for *P. absoluta* on tomato.

Biology of *P. absoluta* on tomato plants at different temperature indicated a profound impact on the biology. Among the temperatures studied, the life cycle was shortest (21.00 ± 0.78) at 30^{o}C and this was in close agreement with Attwa *et al.* (2015) who reported the life cycle of *P. absoluta* as 24.1 ± 1.1 days at 28°C. The total life cycle was observed to be 4.75 30.00 ± 0.66 days at 25^{o}C. This was in close agreement with the findings of Erdogan and Babaroglu (2014) who reported the total life cycle of 30.18 ± 1.70 days at 25^{o}C.

The life cycle of *P. absoluta* was determined as 35.25 ± 0.71 days at 20^{o}C which was in agreement with the findings of Barrientos *et al.* (1998) and Cuthbertson *et al.* (2013) who reported the developmental period of 39.8 and 37 days, respectively at 19°C. The total life cycle of *P. absoluta* was longest at lowest temperature and shortest at 30^{o}C on tomato plants. It may be due to the reason that the physiological age of insects increase more slowly at lower temperatures (Table 2).

Spatial distribution of *P. absoluta* eggs on tomato

Phthorimaea absoluta adults preferred to lay eggs on upper leaf surface (6.07 eggs) followed by lower surface of leaves (5.79 eggs) and least preferred to lay eggs on buds (0.50 eggs) (Fig. 1). This was in close agreement with Estay (2000) who reported that the *P. absoluta* females oviposited preferentially on leaves (73%) and to lesser extent on leaf veins and stem margins (21%), sepals (5%) or green fruits (1%).

The preference for oviposition by females may be determined by the volatiles released from host crops. Ovipositional preference studies carried out with different solanaceous crops *viz*., tomato, brinjal, potato, European nightshade and chilli both under free and no choice conditions revealed that the tomato was the most preferred host followed by potato. This was in accordance with the reports of Visser (2015) who reported that the *P. absoluta* preferred potato equal that of tomato for feeding. Several other workers have also documented many solanaceous crops as host for *P. absoluta* (Galarza, 1984 and EPPO, 2005). The variation in host preferences may be attributed to the biophysical and biochemical characters of the plants.

Ovipositional preference and biology of *P. absoluta* on selected solanaceous crops

Ovipositional preference of *P. absoluta* studied under free choice condition revealed that the *P. absoluta* adults could lay eggs in all the host crops. However, the total number of eggs (233.70 eggs plant^{-1}) laid per plant was maximum in tomato followed by potato, European black nightshade and brinjal which recorded 95.90, 39.30 and 26.50 eggs plant^{-1}, respectively. Chilli was found to be the least preferred host with 6.60 eggs plant^{-1} (Table 3).

Studies under no choice condition also revealed that the tomato was the most preferred host (326.00 eggs plant^{-1}) followed by potato, brinjal and European black nightshade. Chilli was the least preferred host with 8.00 eggs plant^{-1} (Table 4).

Among the hosts, tomato was the most preferred host and recorded shortest developmental period of 22.00±0.61 days followed by European black nightshade (27.75 ± 0.84 days), potato (28.50 ± 0.72 days) and brinjal (30.00 ± 0.41 days). However, not even a single eggs were hatched on chilli and hence, the biology could not be studied (Table 5).

Overall the biology of *P. absoluta* studied on other solanaceous crops *viz.,* brinjal, potato, chilli and European black nightshade in comparison with tomato revealed the shortest life cycle on tomato followed by European black nightshade, potato and brinjal. No such studies were reported earlier about the biology of *P. absoluta* on above mentioned solanaceous crops. Hence, this may be the first report on the biology of *P. absoluta* on other solanaceous crops.

Comparison of biology of *P. absoluta* on tomato and other solanaceous crops revealed the suitability of tomato over other hosts studied. Host preferences showed a strong heritable component and are found to represent the suitability of hosts for larval survival. Suitability can depend upon a number of factors such as nutritional quality, host plant defence chemicals, prevalence of natural enemies or microenvironment. However, completion of life cycle with minimum variation in the developmental days in the present finding may be due to the learning process which is gradual in insects and is reversible on encountering other most abundant host species. Further, studies on the biochemical or biophysical attributes of chilli that prevents the development of *P. absoluta* may render prospective results for resistance breeding and its sustainable management.

ACKNOWLEDGEMENT

The Authors acknowledge the facilities provided at the Department of Agricultural Entomology for carrying out the investigation.

REFERENCES

Attwa, W. A., Omar, N. A., Ebadah, I. M. A., Abd El-Wahab, P. E., Mowad, S. M. and Sadek, H. E. 2015. Life Table parameters of the Tomato Leaf Miner, *Tuta absoluta* (Meyrick) and Potato tuber moth *Phthorimaea operculella* Zeller (Lepidoptera : Gelechiidae) on tomato plants in *Egyptian Journal of Agricultural Research*, **5**: 1-5.

Barrientos, Z. R., Apablaza, H. J., Norero, S. A. and Estay, P. P. 1998. Threshold temperature and thermal constant for development of the South American tomato moth *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *Cienciae Investigacion Agraria*, **25**: 133-137.

Cuthbertson, A. G., Mathers, J. J., Blackburn, L. F., Korycinska, A., Luo, W., Jacobson, R. J. and Northing, P. 2013. Population development of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) under simulated UK glasshouse conditions. *Insects*, **4** (2): 185-97.

EPPO. 2005. EPPO datasheets on quarantine pests: *Tuta absoluta*. *PPO Bulletin*, **35**: 434-35.

Erdogan, P. and Babaroglu, N. E. 2014. Life Table of the Tomato Leaf Miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *JAFAG*, **31**(2): 80-89.

Estay, P. 2000. Polilla del tomate Tuta Absoluta (Meyrick) [en línea]. Santiago: Informativo INIA La Platina. no. 9. Disponible en: https://hdl.handle.net/20.500.14001/4505 (Consultado: 18 abril 2023).

Fekri, M. S., Samih, M.A., Imani, S. and Zarabi, M. 2013. Study of host preference and the comparison of some biological characteristcs of *Bemisia tabaci* (Genn) on tomato varieties. *Journal of Plant Protection Research*, **53** (2): 137-42.

Galarza, J. 1984. Laboratory assessment of some solanaceous plants as possible food plants of the tomato moth *Scrobipalpula absoluta*. *IDIA*, **421/424:** 30-32.

Garzia, G. P., Siscaro, G., Colombo, A. and Campo, G. 2009. Reappearance of *Tuta absoluta* in Sicily. Rinvenuta in Sicilia *Tuta absoluta*. *Informatore Agrario*, **65** (4):71-71.

Kumari, D. A., Anitha, G., Anitha, V., Lakshmi, B. K. M., Vennila, S. and Rao, N. H. P. 2015. New record of leaf miner, *Tuta absoluta* (Meyrich) in Tomato. *Insect Environment*, **20** (4): 136-38.

Lietti, M. M. M., Botto, E. and Alzogaray, R. A. 2005. Insecticide Resistance in Argentine Populations of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *Neotropical Entomology*, **34:** 113-19.

Ogur, E., Unluand, L. and Karaca, M. 2014. *Chenopodium album* L.: *Tuta absoluta* Povolny (Lepidoptera: Gelechiidae)'nın yeni bir konukçusu. *Turkish Bulletin of Entomology*, **4** (1): 61-65.

Shashank, P. R., Chandrashekar, K., Meshram, N. M. and Sreedevi, K. 2015. Occurrence of *Tuta absoluta* (Lepidoptera: Gelechiidae) an invasive pest from India. *Indian Journal of Entomology*, **77** (4): 323-29.

Sridhar, V., A. K. Chakravarthy and R. Asokan, Vinesh,L. S., Rebijith, K. B. and S. Vennila, S. 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.

Tosevski, I., Jović, J., Mitrović, M., Cvrković, P., Krstić,O. and Krnjajić, S. 2011. *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae): a new pest of tomato in Serbia. *Pesticidii Fitomedicina*, **26** (3):197-204.

Visser, D. 2015. Is the tomato leaf miner a threat to the potato industry in South Africa.Agricultural Research Council-Vegetable and Ornamental Plants (ARC-VOP). *CHIPS*. 36-38.

MS Received: 19 April 2023
MS Accepted: 25 May 2023