Reproductive Biology of *Tuta absoluta* on Four Solanaceous Host Plants

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Abstract: Since first recorded in Egypt in 2009, the tomato leafminer, *Tutaa bsoluta*, remains the most important biotic constraint to tomato and other solanaceous species production in Egypt and Middle East. The effect of solanaceous plant species on the biological attributes of tomato leaf miner (TLM) was studied under laboratory conditions. Results indicated that TLM females prefer tomato plants for their offspring to other tested solanaceous species. The tested host plant species had a profound and significant effect on the development of all immature stages of TLM. Data further indicated that TLM cannot complete its development on pepper in all developmental stages. The percentages of immature survival were 83.33, 86.67 and 86.67% on tomato, potato and eggplant, respectively. Longevities of TLM females reared on tomato, potato and eggplant lasted 13.75, 12.83 and 15.38 days, respectively. As for the oviposition period, the longest period was recorded on eggplant, whereas the shortest was on tomato and potato. Lifetime fecundity was the highest in TLM females reared on tomato plants at 262 eggs/female compared to 198 eggs on eggplant.

Keywords: *Tuta absoluta*, biological attributes, immature stages, oviposition period, fecundity, solanaceous plants

INTRODUCTION

The tomato leaf minor (TLM), *Tuta* (*Scrobipalpuloides*) *absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is one of the most devastating pest of tomatoes in tomato-producing regions worldwide. Recently, it has become a serious threat of tomato crop either in open fields or in greenhouses at Ismailia Governorate and elsewhere in Egypt. The damage caused by TLM is mainly through feeding on all the aerial parts of tomato plants in forms of larval galleries on leaves and fruits. Inflorescences, terminal buds and stems can also be affected (Haji *et al.,* 1988; Lopes-Filho, 1990). Larvae of TLM feed on the mesophyll of the leaf leaving only the epidermis intact with its feces, which subsequently widens and then the damaged tissue dries. Under intense attack, the leaves turn yellow, wither, and senesce; the fruits are destroyed; and the plant is ultimately died (Maluf *et al.,* 1997). Severe infestation with TLM is the result of greatest population growth in spring/early summer and in late summer/autumn with a period of respite in mid-summer (Jacobson, 2012; Awad *et al.,* 2018). The potential yield losses in tomatoes due to this pest are considerable and can be up to 80-100%, if the pest is not properly controlled (Desneux *et al.,* 2010).

Although, tomato is known as the main host of TLM, it also feeds, develops and reproduces on other solanaceous plants such as potato, tobacco, eggplant, pepper, aubergines, black nightshade and several related weeds such as jimsonweed (EPPO, 2005; Pereyra and Sanchez, 2006; Viggiani *et al.*, 2009; Desneux *et al.*, 2010; Abd El-Hady *et al.,* 2014).

Host plants and the insect herbivores are of ecological importance due to their relationships in understanding trophic specificity and plants-insects interactions. The host plant range of herbivores determines their resource base, which in turn is an important factor influencing their population dynamics and interactions with other herbivorous species and carnivorous natural enemies. Study of the effects of host plants on the biology of insects is important in understanding host suitability of plant-infesting insect species.

There have been a number of studies on the biological parameters of TLM on different host plants, where TLM has been an important pest on various solanaceous vegetables. However, not all of these studied the effects of the same host plants on development, survival, longevity and oviposition of TLM under the same environmental conditions.

Therefore, the main objective of the current research is to investigate the development and other biological aspects of the TLM on four host plant species of family solanaceae, for population increase of this insect pest on the different host plants to guide pest management decisions. The selected host plant represents some of the most common vegetable crops in Egypt.

MATERIALS AND METHODS

The laboratory culture of TLM was established from infested tomato plant leaves and fruits, collected from tomato fields around Ismailia city. The infested leaves or fruits harboring the immature stages of TLM, were kept in rearing cages (40 cm in width × 60 cm in length × 80 cm in height), and provided with fresh tomato plants to complete TLM immature stages development. Newly formed TLM pupae were regularly collected and kept in 12 cm Petri dish until emergence. Emerged adults were collected by an aspirator and confined in an ovipositional cage (40 cm in width × 60 cm in length × 80 cm in height). Inside each cage, a piece of cotton moistened with 10% honey solution was introduced for moth feeding and intact tomato plants (20-30 cm height) were provided for egg laying. Tomato plants harboring eggs of TLM were transferred daily to rearing cage and replaced by another fresh batch of tomato plants and so on until the death of all TLM adults. Rearing cages were kept at room temperature of 25±2°C and 60±10% R.H.

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Effect of plant species on the biological attributes of TLM

Effect on immature development

The effect of four solanaceous plant species (tomato, eggplant, pepper and potato) on the development and biological attributes of TLM immature stages was studied under laboratory conditions of 25±2ºC, 60±10% RH and 16:8 L/D photoperiod. Thirty eggs of TLM (newly deposited, < 6 hours) were collected from the laboratory culture. Eggs were separated individually and each egg was placed in a clean Petri dish (5 cm) and closed with a rubber band and considered as a replicate. Upon hatching, the newly hatched larvae were transferred for rearing on small, healthy un-infested solanaceous seedling. The development of TLM was monitored and data were recorded twice a day in terms of incubation period, larval duration, pupal stage as well as the survival of each stage throughout the experimental period.

Effect on adult stage

The effect of different solanaceous plant species on the longevity, ovipositional periods, survival and fecundity of TLM adults were studied. Twelve pairs of adults in each experiment were tested under the previously mentioned laboratory conditions. Adults were paired and each couple was left for mating. Each couple (as a replicate) was placed in a glass tube 3×10 cm covered with piece of cotton cloth and held in place by rubber band. These tubes were provided by small droplets of honey solution on the inner wall for TLM adults feeding. Fresh leaf of each solanaceous species was provided for each couple as an ovipositional substrate. Adults were checked daily and the number of deposited eggs, alive and dead adults was recorded until the death of all tested TLM females or males.

RESULTS

Effect of four solanaceous species on the biological attributes of TLM

Effect on immature stages

Generally, immature stages of TLM couldn't develop, or survive on pepper plants therefore; the obtained data associated with pepper plant on both immature and adult stages of TLM were excluded from statistical analysis and were not tabulated. As shown in Fig (1), the effect of the tested plant species on the incubation period of TLM eggs differed significantly (F= 13.909; *P*= 0.000). The longest incubation period (4.63 days) was recorded on tomato plants. The incubation period was intermediate in the other tested plant species; being 4.2 and 4.28 days on potato and eggplant, respectively.

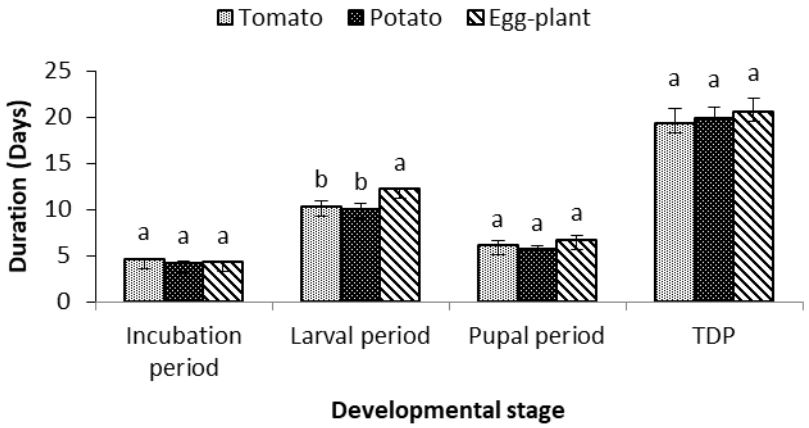

Fig (1): Effect of three solanaceous species on the development of TLM immature stages
Bars with different letters indicate significant differences

As for the total larval developmental period, there was also a significant difference among plant species on this stage (F= 135.07; *P*= 0.000). The total larval period was shortest at 10.03 and 10.32 days on potato and tomato plants, respectively. The longest larval duration was recorded in TLM larvae reared on the eggplant at 12.18 days (Fig 1). Data also indicated that significant differences were not existed among the tested plant species on the TLM pupal period (F= 55.909; *P*= 0.000). The TLM pupal periods lasted about 6.10, 5.65 and6.70 days on tomato, potato and eggplant, respectively.

Statistical analysis also showed that there were no significant differences among the tested solanaceous plant species in terms of total developmental periods of TLM (from egg to adult) (F= 0.157; *P*= 0.855). No significant differences were observed between tomato, potato and eggplant with a total developmental period of 19.37, 19.83 and 20.53 days, respectively.

Effect on immature stages survival

Percentages of the survival of each TLM immature stages as well as generation survival are shown in Fig (2). Data showed that the highest percentage of egg hatching (100%) was observed on eggplant and tomato followed by 90% on potato plants. Moreover, the larval survival also varied among tested species being greatest (100%) on eggplant and potato. The overall generation survival (eggs-adults) was greatest (100%) on potato plants and lowest (83.33%) on tomato. For total developmental period, data indicated that TLM cannot survive or complete the development when feed on pepper in all developmental stages. The percentages of overall immature survival (Generation survival) were 83.33, 86.67 and 86.67% on tomato, potato and eggplant, respectively.

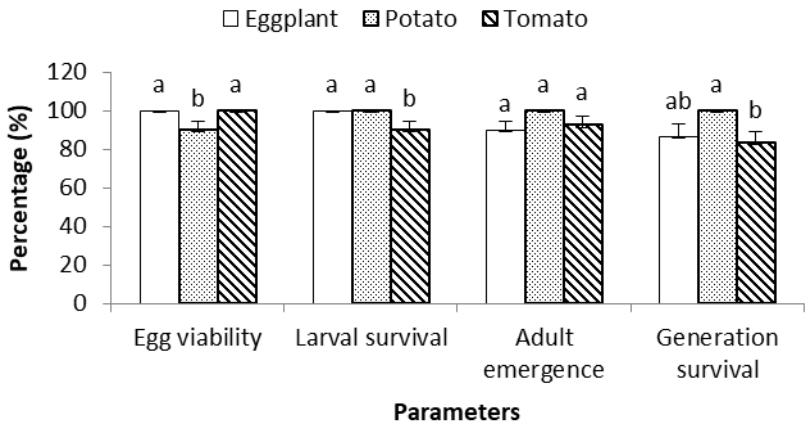

Fig (2): Effect of three solanaceous species on the survival of TLM different stages
Bars with different letters indicate significant differences

Effect on adult stage

Effect on ovipositional periods

TLM couldn't lay eggs or survive when immature stages were reared on pepper plants. Therefore, the effect of pepper plant on the adult stage of TLM has not been evaluated.

The obtained data indicated that the tested plant species elicited significant effect on the pre-oviposition period of TLM. The pre-oviposition period lasted 4.33, 3.54 and 2.92 days on eggplant, tomato and potato plants, respectively (Fig 3).

As for the oviposition period, the longest period was 9.21 days for adults fed on eggplant, whereas the shortest was 7.88 and 7.79 days on tomato and potato, respectively (Fig 3).

Regarding the post-oviposition period, this interval was very short (1.83 days) on eggplant increased to 2.13 and 2.33 days on potato and tomato plants, respectively (Fig 3).

Statically, there were significant differences among treatments in terms of pre-ovipositional periods (F= 8.382; *P*= 0.001), ovipositional periods (F= 3.879; *P*= 0.030), but this was not the case in form of post-ovipositional periods (F= 1.091; *P*= 0.348).

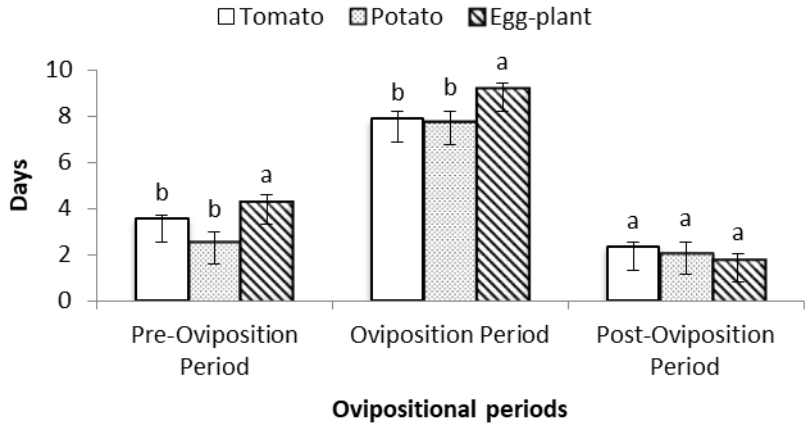

Fig (3): Mean ovipositional periods (days) of TLM females reared under laboratory conditions
Bars with different letters indicate significant differences

Effect on longevity

Generally, females of TLM lived longer than males irrespective of rearing plant species and holding conditions. Longevities of TLM females reared on tomato, potato and eggplant lasted 13.75, 12.83 and 15.38 days, respectively. Apparently, there were significant differences among tested plant species in terms of female longevity (F= 6.836; *P*= 0.003). Pertaining to males, the respective values of longevities were 6.29, 4.5 and 4.67 days (Table 1). Significant differences were also observed in male longevities among the tested host plants (F= 5.843; *P*= 0.007).

Table (1): Mean longevities (days± SE) and total lifetime fecundity of TLM adults reared on solanaceous plant species under laboratory conditions

Plant species	♂ Longevity	♀ Longevity	Total Fecundity
Tomato	6.29 ± 0.28 **a**	13.75 ± 0.31 **b**	262.00 ± 10.07 **a**
Potato	4.50 ± 0.35 **b**	12.83 ± 0.57 **b**	255.75 ± 11.21 **a**
Egg-plant	4.67 ± 0.55**b**	15.38 ± 0.55 **a**	198.00 ± 8.50**b**
P	0.007	0.003	0.000

Means within a column followed by different letter are significantly different: P<0.05.

Effect on lifetime fecundity

As shown in Table (1), TLM females oviposited only on three tested plant species. However, no eggs were laid by TLM females on pepper plants. Lifetime fecundity was the highest in TLM females reared during their immature stages on tomato and potato plants at 262 and 255.57 eggs/female, respectively compared to 198 eggs for females reared on eggplant. Clearly, plant species elicited significant effect on the total lifetime fecundity per TLM female (F= 12.437; *P*= 0.000).

DISCUSSION

Tuta absoluta (TLM) is a widespread devastating pest on many economically important crops. Various solanaceous plant species have been recorded as host plants for TLM (Colomo *et al.,* 2002; Siqueira *et al.,* 2001). However, there are few studies on the trophic relationship between *T. absoluta* and its potential host-plants, therefore; the host range of TLM is not determined well and its impact on production of host plants is still unknown (Colomo *et al.,* 2002; Siqueira *et al.,* 2001).

In Egypt, since the TLM was first recorded as invasive pest in 2009, it was found to be severely attacking tomatoes (Moussa *et al.,* 2013; Salama *et al.,* 2015). The current study revealed that although tomato was the most favorable host plant, it also demonstrated that *T. absoluta* populations could develop on other solanaceous plant species as potato and eggplant. These results were in agreement with those earlier reported (Vargas, 1970; Mallea *et al.,* 1972; Campos, 1976; Mohamed *et al.,* 2015) who concluded that potato and eggplant are potential host plants of TLM. Similarly, earlier results supports the potential of potato as host plant for TLM in Peru (Campos 1976; Cisneros and Mujica 1998), Morocco (Ouardi *et al.,* 2012), Sudan (Mohamed *et al.*, 2012), and Argentina (Pereyra and Sanchez, 2006).

Results in this study also proved that TLM adults refrain laying eggs on pepper as well its immature stages couldn't feed or survive on pepper plants. Such results are in harmony with those reported earlier in Tanzania by Smith *et al.* (2018) who found that pepper was not infested by TLM and no mines were detected in tissues or fruits of pepper plants. Thus this crop is sometimes omitted from lists of TLM host plants (*e.g.,* EPPO 2005; Desneux *et al.*, 2010). On contrast, Bayram *et al.* (2015) reported that TLM infested pepper in Turkey, but the impact of TLM on production of pepper was economically less considered.

Results obtained showed that TLM has a shorter total developmental period of 19.37 days and higher percentage of immature survival on tomato compared to potato and eggplant. These results are in line with those obtained in Tunisia by Cherif *et al.* (2018) who reported that TLM was found on potato, eggplant or tomato (mainly) with a shorter developmental time on tomato compared to the two other host plants (Cherif *et al.,* 2018).

The current study showed also that the adult longevity, oviposition and post-ovipositional periods, total fecundity were not statistically different between the three tested host plants. Such results were in consistency with those obtained by Pereyra and Sanchez (2006).

CONCLUSION

The obtained results in this study clearly demonstrated that plant species play a crucial role in the development, survival and reproduction of *T. absoluta*. TLM immatures and adult stages could complete its life cycle on tomato, potato and eggplant but females refrain laying eggs and immatures couldn't survive when offer pepper as host plants, that may shed the light on studying the repellent compounds that might pepper contains. Results proved that plant species is an important factor that effectively influence the attraction response of TLM. Results also obtained that TLM females prefer tomato as host plant, also that *T. absoluta* populations could develop on other solanaceous plant species as potato and eggplant.

REFERENCES

Abd El-Hady, M. A., A. A. Sarhan, N. S. Mandour and M. A. Osman (2014). Biological control studies on some insect pests infesting tomato plants at Ismailia governorate. M.Sc. thesis, Faculty of Agriculture, Suez Canal University.

Awad, H. A., A. Z. El-Naggar and H. M. EL-Bassouiny (2018). Monitoring population of tomato leaf miner, *Tuta absoluta* during winter and summer evergreens of potato filed in Egypt. Egyptian Academic Journal of Biological Sciences, 11(1): 27–32.

Bayram, Y., M. Büyük, C. Özaslan, Ö. Bektaş, N. Bayram, Ç. Mutlu, E. Ateş and B. Bukun (2015). New host plants of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Turkey. Journal of Tekirdag Agricultural Faculty, 12: 43-46.

Campos, R. G. (1976). Control químicodel "minador de hojas y tallos de la papa" (*Scrobipalpula absoluta* Meyrick) en el valle del Cañete. Revista Colombiana de Entomología, 19: 102-106.

Cherif, A., K. Harbaoui, L. Zappalà and K. Grissa-Lebdi (2018). Efficacy of mass trapping and insecticides to control *Tuta absoluta* in Tunisia. Journal of Plant Diseases and Protection, 125: 51-61.

Cisneros, F. and N. Mujica (1998). The leaf miner fly in potato plant reactions and natural enemies as natural mortality factors. CIP (Peru) Program report, 1997-98: 129-140.

Colomo, M. V., D. C. Berta and M. J. Chocobar (2002). El complejo de himenópteros parasitoides que atacan a la "polilla del tomate" *Tuta absoluta* (Lepidoptera: Gelechiidae) en la Argentina. Acta Zoologica Lilloana 46: 81-92.

Desneux, N., E. Wajnberg, K. Wyckhuys, G. Burgio, S. Arpaia, C. Narváez-Vasquez, J. Gonzalez-Cabrera, D. Ruescas, E. Tabone, J. Frandon, J. Pizzol, C. Poncet, T. Cabello and A. Urbaneja (2010). Biological invasion of European tomato crops by *Tuta absoluta*: Ecology, geographic expansion and prospects for biological control. Journal of Pest Science, 83: 197-215.

European and Mediterranean Plant Protection Organization (EPPO) (2005). 35(3): 434-435.

Haji, F. N. P., J. R. P. Parra, J. P. Silva and J. G. D. Batista (1988). Biology of the tomato leafminer under laboratory conditions. PESQUISA AGROPECUARIA BRASILEIRA, 23: 107–110.

Jacobson, R. J. (2012). Rob Jacobson Consultancy Ltd.; Leeds, UK, personal communication.

Lopes-Filho, F. (1990). Tomate industrial no submedio São Francisco e as Pragas que limitam sua producao (in Portuguese) Pesquisa Agropecuaria Brasileira, 25: 283–288.

Mallea A. R., G. S. Macola, S. J. G. Garcia, L. A. Bahamondes and J. H. Suarez (1972). *Nicotiana tabacum* var. *virginica*, a new host of *Scrobipalpula absoluta* Revista de la Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, 18: 13–15.

Maluf, W. R., L. V. Barbosa and L. C. Santa-Cecilia (1997). 2-tridecanone-mediated mechanisms of resistance to the South american tomato pinworm *Scrobipalpuloides absoluta* (Meyrick, 1917) (Lepidoptera - Gelechiidae) in *Lycopersicon* spp. Euphytica, 93: 189-194.

Mohamed, E. S. I., M. E. Mohamed and S. A. Gamiel (2012). First record of the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Sudan. Bulletin OEPP/EPPO Bulletin, 42: 325–327.

Mohamed, E. S. I., M. E. Mahmoud, M. Elhaj, S. Mohamed and S. Ekesi (2015). Host plants record for tomato leaf miner *Tuta absoluta* (Meyrick) in Sudan. EPPO Bulletin, 45(1): 108-111.

Moussa, S., A. Sharma, F. Baiomy and F. El-Adl (2013). The status of tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Egypt and potential effective pesticides. Academic Journal of Entomology, 6: 110-115.

Ouardi, K., M. Chouibani, M. A. Rahel and M. El Akel (2012). Stratégie Nationale de lutte contre la mineuse de la tomate T uta absoluta Meyrick. *EPPO bulletin*, *42*(2), 281-290.

Pereyra, P. C. and N. E. Sánchez (2006). Effect of two solanaceous plants on developmental and population parameters of the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Neotropical Entomology, 35(5):671-676.

Salama, H. S. A., I. A. Ismail, M. Fouda, I. Ebadah and I. Shehata (2015). Some ecological and behavioral aspects of the tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Journal of Balkan Ecology, 7: 35–44.

Siqueira, H. A., R. N. Guedes and M. C. Picanço (2001). Insecticide resistance in populations of *Tuta absoluta* (Lepidoptera: Gelechiidae). Agricultural and Forest Entomology, 2(2): 147-153.

Smith, J., T. Dubois, R. Mallogo, E. Njau, S. Tua and S. Ramasamy (2018). Host range of the invasive tomato pest *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on solanaceous crops and weeds in Tanzania. Florida Entomologist, 101: 573-579.

Vargas, H. C. (1970). Observaciones sobre la biología y enemigos naturales de la polilla del tomate, *Gnorimoschema absoluta* (Meyrick). Departamento de Agricultura, Universidad del Norte-Arica, 1:75-110.

Viggiani, G., F. Francesco, G. Delrio, R. Wilson and C. Foxi (2009). *Tuta absoluta*, nuovo lepidottero segnalato anche in Italia. L'Informatore Agrario, 65(2): 66-68.

بيولوجي تكاثر *Tuta Absoluta* على أربعة عوائل نباتية من العائلة الباذنجانية

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منذ تسجيلها لأول مرة في مصر في عام ٢٠٠٩، تظل حشرة الطماطم *Tutaa bsoluta* أهم معوق حيوي لإنتاج الطماطم وأنواع العائلة الباذنجانية الأخرى في مصر والشرق الأوسط. تم دراسة تأثير أنواع العوائل النباتية من العائلة الباذنجانية على الصفات البيولوجية لصانعة أنفاق أوراق الطماطم (TLM) تحت الظروف المعملية. وقد أشارت النتائج إلى أن إناث صانعة أنفاق الطماطم تفضل نباتات الطماطم لنسلها على باقي أنواع العوائل من نباتات الباذنجانية المختبرة. وكان لأنواع العوائل النباتية المختبرة تأثير معنوي على تطور جميع الأطوار غير الكاملة لحشرة صانعة أنفاق الطماطم. أشارت النتائج كذلك إلى أن صانعة أنفاق الطماطم لا يمكنها إكمال دورة حياتها على الفلفل في جميع أطوار النمو. وكانت النسب المئوية لبقاء الأطوار غير الكاملة ٨٣.٣٣ و ٨٦.٦٧ و ٨٦.٦٧٪ على الطماطم والبطاطس والباذنجان على الترتيب. وبلغت أعمار إناث صانعة أنفاق الطماطم التي تم تربيتها على الطماطم والبطاطس والباذنجان ١٣.٧٥ و ١٢.٨٣ و ١٥.٣٨ يومًا على الترتيب. بالنسبة لفترة البيض، سجلت أطول فترة وضع بيض على نبات الباذنجان، بينما سجلت أقصر فترة على الطماطم والبطاطس. كما كانت خصوبة الإناث هي الأعلى في الإناث المرباة على نباتات الطماطم بواقع ٢٦٢ بيضة/أنثى مقارنة بـ ١٩٨ بيضة على نبات الباذنجان.