ECOLOGICAL AND BIOLOGICAL ASPECTS OF THE TOMATO LEAF MINER *Tuta absoluta* (LEPIDOPTERA: GELECHIIDAE) ON TOMATO PLANTS

BY

EMAN MOHAMED MOHAMED ABD-ELMAKSOUD
B.Sc. Agric. Sc. (Entomology), Ain Shams University, 2010

A Thesis Submitted in Partial Fulfillment

Of

The Requirements for the Degree of

MASTER OF SCIENCE
in
Agricultural Sciences
(Economic Entomology)

Department of Plant Protection
Faculty of Agriculture
Ain Shams University

2016

Approval Sheet

ECOLOGICAL AND BIOLOGICAL ASPECTS OF THE TOMATO LEAF MINER *Tuta absoluta* (LEPIDOPTERA: GELECHIIDAE) ON TOMATO PLANTS

BY

EMAN MOHAMED MOHAMED ABD-ELMAKSOUD

B.Sc. Agric. Sc. (Entomology), Ain Shams University, 2010

This thesis for M.Sc. degree has been approved by:

Dr. Mohamed Abd El-Ghaffar Mahmoud ……….……….

Prof. Emeritus of Economic Entomology, Faculty of Agriculture, Al-Azhar University.

Dr. Ahmed Ahmed Abd El-Rahman Salem ....

Prof. Emeritus of Economic Entomology, Faculty of Agriculture, Ain Shams University.

Dr. Shokry Ahmed El-Sayed El-Refai ....

Prof. Emeritus of Economic Entomology, Faculty of Agriculture, Ain Shams University.

Date of Examination: 7 / 9 / 2016

ECOLOGICAL AND BIOLOGICAL ASPECTS OF THE TOMATO LEAF MINER *Tuta absoluta* (LEPIDOPTERA: GELECHIIDAE) ON TOMATO PLANTS

BY

EMAN MOHAMED MOHAMED ABD-ELMAKSOUD
B.Sc. Agric. Sc. (Entomology), Ain Shams University, 2010

Under the supervision of:

Dr. Shokry Ahmed El-Sayed El-Refai
Prof. Emeritus of Economic Entomology, Faculty of Agriculture, Ain Shams University (Principal Supervisor).

Dr. Ashraf Helmi Fathi
Associate Professor of Economic Entomology, Faculty of Agriculture, Ain Shams University.

ABSTRACT

Eman Mohamed Mohamed Abd El-maksoud: Ecological and biological aspects of the tomato leaf miner *Tuta absoluta* (Lepidoptera: Gelechiidae) on tomato plants. Unpublished M. Sc. Thesis, Department of Plant Protection, Faculty of Agriculture, Ain Shams University, 2016. The tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) became a serious pest to tomato cultivations in Egypt since 2009. It causes great damage in the crop. The present study was carried out to estimate some biological and ecological studies on this pest. *T. absoluta* reared on artificial diet on at four constant temperatures 20, 24, 28 and 32°C and 60-70 % RH. Data obtained indicated that incubation period were 6.8, 5.0, 4.0 & 3.5 days at 20, 24, 28 & 32°C, respectively. Percentages of hatchability were 72, 97, 89 & 95% on the same degree of temperature, respectively. Zero of development for egg stage was 7.0°C, thermal units for the egg were 88.4, 85.0, 84.0 & 87.5 DD's at 20, 24, 28 and 32°C, respectively. Durations of larval stage were 30.9, 21.9 & 15.7days at 20, 24 & 28°C, respectively. Zero of development was 10.0°C, while thermal of constant were 309.0, 306.6 & 316.8 DD's at 20, 24 & 28°C, respectively. Percentages of mortality of larval stage were 52, 74, 74 & 100% at 20, 24, 28 and 32°C, respectively. For pupal stage, durations were 15.8, 9.5, 8.1days at 20, 24 & 28°C, respectively. Zero of development was 11.2°C, thermal constant were 138.6, 121.5 & 136.6 DD's at 20, 24 & 28°C, respectively. Percentages of mortality were 10.0, 5.0 & 1.0% at 20, 24 & 28°C, respectively. For adult, male longevity was 12.8, 12.0 &7.0 days at 20, 24 & 28°C, respectively. Zero of development was 9.8°C, thermal constant were 130.6, 144.8 & 134.7 DD's at 20, 24 & 28°C, respectively. Female longevity was 15.6, 11.8, 7.0 at 20, 24 & 28°C, respectively. Zero of development was 11.2°C, thermal constant were 137.3, 151.0 & 137.8 DD's at 20, 24 & 28°C, respectively. The mean numbers of eggs laid by female were 57.8, 79.3 & 145.3eggs at 20, 24 & 28°C, respectively. Fertility of female was 72.0, 97.0 & 89.0% at 20, 24 & 28°C,

respectively. Durations of generation were 56.1, 38.6 & 30.7 days at 20, 24 & 28°C, respectively.

The life table parameters, net reproduction rate ($R_{\circ}$), mean generation time (Gt), intrinsic rate of increase (r_m), finite rate of increase (λ) and population double time (Dt) were: 2.85, 59.58, 0.02, 1.02 and 43.43 at 20 ºC; 6.29, 41.37, 0.07, 1.07 and 12.41 at 24 ºC; 10.03, 33.92, 0.13, 1.14 and 6.68 at 28 ºC; 3.15, 33.97, 0.04, 1.04 and 21.71 under laboratory conditions, respectively.

According to susceptibility of eight tomato cultivars to the infestation degree by *T. absoluta*, the eight cultivars could be arranged as follows; Red sun, Hybrid Super strain B and Castle rock were the more susceptible cultivars followed by Riogrande, Baladi and Nemaguard with a moderate infestation. Finally the Super set and Hybrid Bito86 cultivars were considered the most resistible ones.

The highest of *Tuta absoluta* mines occurred on the leaflets of Red sun was corresponding to the high level of N.P.K. On the other hand Hybrid Bito86 cultivar contained on the lowest infestation with corresponding to least values N.P.K. The same trend obtained for amino acid, total protein, total carbohydrate, α and β-esterases and peroxidase enzyme. The highest *T. absoluta* mines occurred on Red sun cultivars with corresponding to low level of total phenol while the highest content of phenol was found in Hybrid Bito86 cultivar. There are positive significant between the infestation by *T. absoluta* and density of non-glandular tricome/cm^2 in the upper surface.

When tomatoes plant treated by plant growth regulators induced it's resistance to infestation by *T. absoluta*. This treatments could be divided to into three groups; 1st group: Benzyle adenin and Kinetin, 2nd group: Salcylic acid, 3rd group: Control.

The normal distribution curve was used to determine the number of generation of *T. absoluta*, data obtained indicated that *T. absoluta* had 10.0 generations in the field per the year (From May 2015 to May 2016). When using linear method to determine the number of generations for *T. absoluta,* it could be found that this pest had 10.0 generations per the year. When using thermal units to determine the number of generations for *T. absoluta*, results revealed that this pest had 14.0 generations. There are a difference between 3rd method (thermal units) and the other previous methods. This pest certainly enters aestivation from end of July to half of October (about72.0 days) and emphasize that 32°C is considered as a fetal degree temperature for the first instars larvae of *T. absoluta*. During this period, there are four predicted peaks. Therefore, the chemical control was not obligatory and natural enemies are enough.

To find parasitoids and predators for biological control of this pest, samples of tomato leaves infested with *T. absoluta* were collected from Qualiobya and Giza Governorates. Three genera of hymenopterous parasitoids, *Diglyphus* sp. (Eulophidae), *Elasmus* spp. (Elasmidae) and *Telenomus* sp. (Scelionidae) are the first record in Egypt. The predatory bug, *Nesidiocoris tenuis* Reuter (Heteroptera: Miridae) was also recorded. *T. absoluta* showed two peaks of 30.3 and 25.0 leaf mines/10 leaflets on 7th and 28th of May, 2013, respectively. *N. tenuis* also recorded two peaks of 58.8 and 73.3 nymphs & adults/plant on the same previous dates, respectively. *N. tenuis* was mass reared to evaluate the predatory efficiency of nymph and adult stages on *T. absoluta* eggs. The nymph, adult male and female consumed 113.3, 81.5 and 125.3 eggs of *Tuta absoluta*, respectively. The 4thnymphal instars devoured the highest number (30.6 eggs), while the 1stnymphal instars ate the lowest (7eggs). Therefore, *Nesidiocoris tenuis* was highly effective in controlling *T. absoluta* eggs under laboratory conditions.

Key words: Tomato, *Lycopersicon esculentum*, *Tuta absoluta*, Developmental threshold, Thermal units, Life table, Susceptibility of Tomato, Cultivars, N, P , K, Total Protein, Total Carbohydrate, Total phenol, Total amino acid, Peroxidase enzyme, α, β Esterase enzymes, Tricomes, Seasonal abundance, Plant growth regulator, Generations, Parasitoids, *Digluphus*, *Elasmus*, *Telenomus*, *Nesidiocoris tenuis*, predatory efficiency.

ACKNOWLEDGEMENT

First at all great thanks and gratitude to Allah, who guides me to this way and assist me in all my life. All words, all feelings and all praise will not be enough to thank Allah.

I would like to express the deepest gratitude to my Principal Supervisor, **Dr. Shokry Ahmed El-Sayed El-Refai,** Professor Emeritus of Economic Entomology, Department of Plant Protection, Faculty of Agriculture, Ain Shams University who introduced me to the wonderful world of entomology and valuable advices, preparation of the manuscript and overcoming difficulties throughout the whole period of study.

I'm grateful to **Dr. Ashraf Helmi Fathi,** Associate Professor of Economic Entomology, Department of Plant Protection, Faculty of Agriculture, Ain Shams University for valuable advices, encouragement and guidance during the experimental work.

My deepest thanks and gratitude are also to **Dr. Rania Salah El-Din Adly Rashwan,** Associate Professor of Economic Entomology, Department of Plant Protection, Faculty of Agriculture, Ain Shams University for her great help, valuable advices, encouragement and guidance during this study.

Thanks also are due to Prof. **Dr. Nevin Sami Gadallah** Department of Entomology, Faculty of Science, Cairo University and to **Dr. Abd El-Mohsen Hekal**, Professor Emeritus of Economic Entomology, Department of Plant Protection, Faculty of Agriculture, Ain Shams University for identifying specimens of parasitoid genera.

I could never have reached this point without the love and support from my family for their great help and assistance during the study also I would like to express my immeasurable thanks to my husband **Dr. Ahmed Nagib Amin.**

Finally, the writer would like to thank all the staff numbers in Plant Protection Department of Faculty of Agriculture, Ain Shams University for helping and real cooperation.

CONTENTS

	Page
LIST OF TABLES……………………………………………..	**III**
LIST OF FIGURES…………………………………………	**VI**
I. INTRODUCTION……………………………………….…	**1**
II. REVIEW OF LITERATURE………..………………..…	**4**
1. The developmental parameters of tomato leaf miner pest *Tuta absoluta* as explained by thermal accumulated units…………………………………..	**8**
2. Life Table parameters of *Tuta absoluta*…..………….	**11**
3. Susceptibility of certain tomato genotypes to the infestation degree by *Tuta absoluta*……………….…	**12**
3.1. Field experiment……..………………………………	**12**
3.2. Effect of plant growth regulator on sensitive cultivars on infestation by *Tuta absoluta*……………	**15**
4. Seasonal abundance and generations in relation to phermone trap catches………………………………..	**16**
5. Natural enemies associated with tomato leaf miner *Tuta absoluta* and Biological control………………..	**19**
III. MATERIAL AND METHODS……………….…..……	**31**
1. The developmental parameters of tomato leaf miner pest *Tuta absoluta* as explained by thermal accumulated units……………………………………...	**31**
1.1. Experimental design……..……………………………	**31**
1.1.1. Egg stage……………………………………….…	**31**
1.1.2. Larval stage……………………………………	**31**
1.1.3. Pupal stage……………………………………..	**32**
1.1.4. Adult stage……………………………………...	**32**
1.2. Rearing technique …………………………………	**33**
1.3. Development of different stages at three constant temperatures for the tested insect *Tuta absoluta*	**33**
1.3.1. Linear regression method……………..……..	**33**

Page

2. Life table parameters of *Tuta absoluta*………………. 35
2.1. Construction of life table…………………………... 35
3. Susceptibility of certain tomato genotypes to the infestation degree by *Tuta absoluta*………………… 36
3.1. Field experiment…………………………………..… 36
3.2. Effect of different leaf chemical components on rate infestation by *T. absoluta*……………………………. 37
3.2.1. Nitrogen determination……………………… 38
3.2.2. Inorganic Phosphorus (P) determination…… 39
3.2.3. K^+ determination……………………………….. 39
3.2.4. Free amino acids determination…………..…… 39
3.2.5. Total proteins…………………….……………... 40
3.2.6. Determination of total carbohydrates……..…... 40
3.2.7. Determination of Phenols……………………… 41
3.2.7.1. Extraction procedure……………………….. 41
3.2.7.2. Quantification of total phenolics…………... 42
3.2.8. Nonspecific esterases………………….……….. 43
3.2.9. Quantitative Determination of Peroxidase…… 43
3.3. Preparation of tissue samples for scanning electron microscope examination………………… 44
3.4. Effect of three plant growth regulator on *Tuta absoluta* infestations……………………….………….. 45
3.5. Effect of the interaction between physical factors and cultivars on rate of infestation by *Tuta absoluta*…….. 45
4. Seasonal abundance and generations in relation to pheromone trap catches…………...………………… 46
4.1. Experimental locality…………………………… 46
4.2. Predicting the changes in the population dynamics of *Tuta absoluta* based on accumulated heat units 48
4.2.1. Heat unit accumulations……………………….. 48

	Page
4.2.2. Using Degree-Days to predict pest activity……	**49**
4.2.2.1. The averaged method…………………….	**49**
5. Natural enemies associated with tomato leaf miner *Tuta absoluta* and Biological control…………….………	**49**
5.1. Survey of parasitoids and predators…………….….	**49**
5.2. Seasonal abundance of *Nesidiocori stenuis* associated with *Tuta absoluta*………………………..	**50**
5.3. Predatory efficiency of *Nesidiocoris tenuis* on *Tuta absoluta* eggs…..……………………………………	**51**
5.3.1. Prey culture………………………………………	**51**
5.3.2. Predator culture………………………………….	**51**
5.3.3. The experiment……………………………………	**51**
IV. RESULT AND DISCUSSION……….………………...	**53**
1. The developmental parameters of tomato leaf miner *Tuta absoluta* as explained by thermal accumulated units……………………………………………….........	**53**
1.1. Egg stage……………………………………………	**53**
1.1.1. Incubation period……………………………….	**53**
1.1.2. Percentage of hatchability…………………….....	**54**
1.1.3. Zero of development for egg stage……………..	**55**
1.1.4. Rate of development and thermal units of egg stage……………………………………………	**56**
1.2. Larval stage……………………………………….…..	**57**
1.2.1. Duration of larval stage…..…………………….……	**57**
1.2.2. Zero of development of larval stage ……………….…	**58**
1.2.3. Rate of development and thermal constant units for larval stage……………………………………	**59**
1.2.4. Percentage of mortality of larval stage………..	**60**
1.3. Pupal stage…………………………………………	**62**
1.3.1. Duration of pupal stage……………………..	**62**
1.3.2. Zero of development of pupal stage …………	**63**

	Page
1.3.3. Rate of development and thermal constant units for pupal stage……………………………	63
1.3.4. Percentage of mortality of pupal stage………	64
1.4. Adult stage………….…………………..……………	66
1.4.1. Pre-oviposition period……………………..…….	66
1.4.2.Oviposition period…………………………….	68
1.4.3. Post-oviposition period………………………….	69
1.5. Longevity…….…………………………………….	72
1.5.1. Female longevity………………………………	72
1.5.2. Male longevity…..………………………………	74
1.6. Fecundity……...………………………………………	75
1.7. Egg fertility……...…………………………………	78
1.8. Total generation duration……...…………………….	78
2. Life table parameters of *Tuta absoluta*…………….	82
2.1. Percentage of apparent and real mortalities……	82
2.1.1. Percentage of apparent and real mortalities under constant temperature…..	82
2.1.2. Percentage of apparent and real mortalities under laboratory conditions………………...	85
2.2. Survival and fecundity of adults………………..	86
2.3. Net reproduction rate (R_o)……….…………….	86
2.4. Mean generation time (Gt)…………………...….	87
2.5. Intrinsic rate of increase (r_m)…………….…….	87
2.6. Finite rate of increase (λ)……………………..…	87
2.7.Population double time (Dt)……………………….	88
3. Susceptibility of certain tomato genotypes to the infestation degree by *Tuta absoluta*…………………	90
3.1. Field experiment…………………………….………	93
3.2. Effect of different leaf chemical components on rate infestation by *T. absoluta*……………………	98
3.2.1. N. P. K………………………………………….……..	98

	Page
3.2.2. Amino acid and Total protein…………………	100
3.2.3. Total phenol………………………………….....	102
3.2.4. Total carbohydrate…………………………..…	103
3.2.5. α and β-esterases……………………………...	104
3.2.6. Peroxidase……………………………………	104
3.3. Effect of physical features of tomato leaflet surface……..	106
3.4. Effect of the interaction between physical factors and tomato cultivars on infestation rate by *Tuta absoluta*………………………………………………..	109
3.4.1. Red sun cultivar…………………….………...	111
3.4.2.Hybrid Super strain B cultivar…………………	112
3.4.3. Castle rock cultivar…………………………...	113
3.4.4. Riogrande cultivar………………………………	113
3.4.5. Baladi cultivar…………………………………...	114
3.4.6. Nemaguard cultivar…………………………......	115
3.4.7. Super set cultivar………………………………..	116
3.4.8. Hybrid Bito86 cultivar…………………………..	117
3.5. The effect of three plant growth regulator on the pest infestation…………………………………...........	130
4. Seasonal abundance and generations in relation to phermone trap catches………………………………..	135
4.1. Monitoring the changes in *Tuta absoluta* population activity based on adult occurrence expressed as actual data figures…………………	135
4.2. Field generation of tomato leaf miner, *Tuta absoluta* depending on linear method……………	142
4.3. Predicted dates of peak generations of *Tuta absoluta* according to degree-days………………	146
5. Natural enemies associated with tomato leaf miner *Tuta absoluta* and Biological control…………..........	151

	Page
5.1. Parasitoids……………………………………..……	**151**
5.1.1. *Diglyphus* sp……………………………………..	**151**
5.1.2. *Elasmus* spp……………………………………...	**152**
5.1.3.*Telenomus* sp.……………………………...…	**153**
5.2. Predator…………………………………….…….	**154**
5.3. Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*……..………………..	**155**
5.4. Predatory efficiency of *Nesidiocoris tenuis* on *Tuta absoluta* eggs………………………………………….	**157**
V. SUMMARY………..……………………………….……	**158**
VI. REFERENCES……………..…………………………….	**182**
ARABIC SUMMERY……………………………………..	

LIST OF TABLE

Table No.		Page
1.	*Tuta absoluta* current distribution outside the area of origin………………………………………...	**6**
2.	Parasitic species of *Tuta absoluta* recorded in literature………..	**24**
3.	Predator species of *Tuta absoluta* recorded in literature………..	**30**
4.	Artificial diet components of *T. absoluta*…………..	**33**
5.	Definition and formulae of life table parameters	**36**
6.	Mean incubation period (in days) of *Tuta absoluta* at four constant temperatures &60-70 % R.H……………………………………………...	**54**
7.	Mean duration of *Tuta absoluta* larvae at three constant temperatures and 60-70 % R.H………	**58**
8.	Effect of four constant temperatures on survival and mortality percentage of larval stage of *Tuta absoluta*………………………………………………..	**61**
9.	Mean duration of *Tuta absoluta* pupae under three constant temperatures and 60-70 % R.H. ……………………………………………………..	**62**
10.	Effectof three constant temperatures on mortality and survival percentage of pupal stage of *Tuta absoluta* ……………………...………	**65**
11.	Mean duration, rate of development and thermal units required for Pre-oviposition period for *Tuta absoluta* at three constant temperatures and 60-70 % R.H.…………………..……………..….	**67**
12.	Mean duration of Oviposition and Post-oviposition periods, Rate of development and Thermal units DD's for *Tuta absoluta* which reared at three constant temperatures and 60-70 % R.H……………………………………..……	**71**

Table No.		Page
13.	Mean of female longevity of *Tuta absoluta* at three constant temperatures and 60-70 % R.H…………………………………….………..	**73**
14.	Mean of male longevity of *Tuta absoluta* at three constant temperatures and 60-70 % R.H	**74**
15.	Zero of development for different stages of *Tuta absoluta* which reared under three constant temperatures……………………………….....	**75**
16.	Fecundity and fertility female of *T. absoluta* which reared on three constant temperatures…..	**77**
17.	Effect of three constant temperatures on durations of generation of *Tuta absoluta*….…	**79**
18.	Mean of generation, rate of development and constant temperature of *T. absoluta* at three constant temperatures and 60-70 % R.H………	**81**
19.	Some life table parameters of *Tuta absoluta* from egg stage to adults reared on three constant temperature …………………………………	**84**
20.	Some life table parameters of *Tuta absoluta* from egg stage to adults reared on tomato under Laboratory condition (24-28°C)……………...	**86**
21.	Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female at constant temperature 20°C………………………...	**89**
22.	Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female at constant temperature 24°C…………………..…………..…	**90**
23.	Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female at constant temperature 28°C………………………………..	**91**

Table No.		Page
24.	Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female under laboratory conditions…………….………………......	**92**
25.	Summary of life table parameters for *Tuta absoluta* reared under three constant temperatures (20, 24 & 28) and under laboratory conditions………..…………………………...……	**93**
26.	Average mean number of *T.absoluta* mines/10 leaflets on eight tomato cultivars during two successive seasons 2012&2013………..….….	**94**
27.	Weekly average mean of leaf mines of *Tuta absoluta* on eight cultivars during the first season (2012) at Shoubra Elkheima, Qaliubya Governorate………………………………	**96**
28.	Weekly average mean of leaf mines of *Tuta absoluta* on eight cultivars during the second season (2013) at Shoubra Elkheima, Qaliubya Governorate.……………………………………	**97**
29.	Relationships between the content of N.P.K. components in leaflets of eight tomato cultivars and mean number of *Tuta absoluta* leaf mines/ 10 leaflets during season, 2013…………...…...	**100**
30.	Relationships between the content of free amino acid and total protein components in leaflets of eight tomato cultivars and mean number of *Tuta absoluta* mines/10 leaflets during season, 2013..	**101**
31.	Relationships between the content of total phenol component in leaflets of eight tomato cultivars and mean number of *T.absoluta* leaf mines/10 leaflets during season, 2013………..…	**103**

Table No.		Page
32.	Relationship between the content of total carbohydrate component in leaflets of eight tomato cultivars and mean numbers of *T.absoluta* leaf mines/10 leaflets during season, 2013…………………………………………..	**104**
33.	Relationships between the content of Alpha, Beta esterases& peroxidase enzymes in leaflets of eight tomato cultivars and mean number of *T. absoluta* mines/10 leaflets during season, 2013…………………………………………..	**105**
34.	Effect of different leaflet surface physical features of non glandular trichomes 250X of different tomato cultivars on *Tuta absoluta* infestation ……………………………………...	**107**
35.	Effect of different leaflet surface physical features of glandular tricomes 250X of different tomato cultivars on *Tuta absoluta* infestation …	**109**
36.	Weakly mean temperature and relative humidity during experimental period in 2012 & 2013 seasons…………………………………...……...	**110**
37.	Weekly mean number of *Tuta absoluta* leaf mines/10leaflets and the main three weather factors (Max., Min.temp. and Mean R.H.%) at Qaliubya Governorate during seasons, 2012…	**118**
38.	Simple correlation and multiple regression values of the three main weather factors on *Tuta absoluta* mines and corresponding percentage of explained variance on eight tomato cultivars at Shoubra Elkheima, Qaliubya Governorate during season 2012……………………………	**119**

Table No. **Page**

Table No.		Page
39.	Weekly mean number of *Tuta absoluta* leaf mines/10leaflets and the main three weather factors (Max., Min. temp. and Mean R.H.%) at Qaliubya Governorate during seasons, 2013…….	**120**
40.	Simple correlation and multiple regression values of the three main weather factors on *Tuta absoluta* mines and corresponding percentage of explained variance on eight tomato cultivars at Shoubra Elkheima, Qaliubya Governorate during season 2013………………………………	**121**
41.	Number of *Tuta absoluta* for three tomato cultivars treated with three plant growth regulators during three weeks at Shoubra Elkheima, Qaliubya Governorate during season 2013……………………………………….……	**132**
42.	Analysis of variance for the effect of plant growth regulators on induced resistance to *Tuta absoluta* in certain tomato cultivars……..…….	**133**
43.	Fluctuation of the population of *Tuta absoluta* moths all over the year and the corresponding average of main weather forecasting factors during 2015/2016……………………………….	**137**
44.	Simple correlation and multiple regression values of the three main weather factors on population density of *Tuta absoluta* and corresponding percentage of explained variance on tomato plants at Shalakan, Qalyubia Governorate during season 2015/2016…………	**139**
45.	Accumulated days of sampling and number of *T.absoluta* moths during 2015/2016 season (Shalakan/Qalyubia)………………………………	**143**

Table No. **Page**

46. Number and duration of generations of *Tuta absoluta* moths on tomato plants at Shalakan, Qalyubia Governorate during 2015 season (according linear method)……………………… **146**

47. Predicted dates of peak generations of *Tuta absoluta* according to accumulated thermal units(DD's) and monitoring of moths by pheromone traps during 2015/2016 season (Shalakan, Qaliubya)…………………………... **149**

48. Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*………………….. **156**

49. Predatory efficiency and durations of nymphal instars and adults of *Nesidiocori stenuis* reared on *Tuta absoluta* eggs………...……………...… **157**

LIST OF FIGURES

Fig. No.		Page
1.	*Tuta absoluta* adult(♀ left + ♂ right) ……………	**32**
2.	Phermone trap………….……………………..………	**47**
3.	The two components of *Tuta absoluta* female sex pheromone: (**a**) (3E, 8Z, 11Z)-3,8,11-tetradecatrien-1-yl acetate or TDTA and (**b**) (3E, 8Z)-3,8-tetradecadien-1-yl acetate or TDDA………………..	**48**
4.	Rearing box…………………………………………	**52**
5.	Effect of four constant temperatures on the hatchability of *Tuta absoluta* eggs………………….	**55**
6.	Effect of three constant temperatures on mean durations of egg stage of *Tuta absoluta*…..…………	**56**
7.	Effect of three constant temperatures on mean durations of larval stage………………………………………..	**59**
8.	Effect of four constant temperatures on survival and mortality percentage of larval stage of *Tuta absoluta*	**61**
9.	Effect of three constant temperature on mean durations of pupal stage of *Tuta absoluta*………………………...	**63**
10.	Effect of three constant temperatures on mortality and survival percentage of pupal stage of *Tuta absoluta*……………………………………………...	**65**
11.	The regression line of the pre-oviposition period of *Tuta absoluta*at different constant temperatures……..………	**67**
12.	Effect of three constant temperatures on mean durations of *Tuta absoluta* oviposition period……..………………	**69**
13.	Effect of three constant temperatures on mean durations of *Tuta absoluta* post-oviposition period………………	**70**
14.	The regression line of female longevity of *Tuta absoluta* at three constant temperatures…………..…………	**73**
15.	The regression line of male longevity of *Tuta absoluta*at three constant temperatures……………………………	**75**

Fig. No.		Page
16.	Average number of eggs laid/female of *Tuta absoluta* at three different constant temperatures…..	**77**
17.	Effectof three constant temperatures on the hatchability of *Tuta absoluta* eggs………………….	**78**
18.	The regression line of the generation period of *Tuta absoluta*at constant temperatures……………………	**81**
19.	Total number of *T. absoluta* mines/80leaflets on tomato cultivars (irrespective of cultivars) during two successive seasons 2012&2013……….….....	**94**
20.	Weekly average mean of *Tuta absoluta* mines on eight cultivars during the first season (2012) at Shoubra Elkheima, Qaliubya Governorate ………..	**97**
21.	Weekly average mean of *Tuta absoluta* mines on 10leaflets per each cultivar during the second season (2013) at Shoubra Elkheima, Qaliubya Governorate…………………………………………...	**98**
22.	Non-glandular(typeI) on the left and Glandular tricomes(typeII) on the right……………………….	**106**
23.	Mean temperature and relative humidity during 2012&2013 seasons………………………………...	**111**
24.	Population fluctuations of *Tuta absoluta* leaf mines/ 10 leaflets occurred on tomato plants Red sun during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate………………….	**122**
25.	Population fluctuations of *Tuta absoluta* leaf mines/ 10 leaflets occurred on tomato plants Hybrid super strain B during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate………………	**123**
26.	Population fluctuations of *Tuta absoluta* leaf mines/ 10 leaflets occurred on tomato plants Castle rock during two summer seasons 2012 and 2013, at	**124**

Fig. No.		Page
	Shalakan, Qualiobya Governorate………………….	
27.	Population fluctuations of *Tuta absoluta* leaf mines/ 10 leaflets occurred on tomato plants Riogrande during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate…………………	125
28.	Population fluctuations of *Tuta absoluta* leaf mines/ 10 leaflets occurred on tomato plants Baladi during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate……………………………..	126
29.	Population fluctuations of *Tuta absoluta* eaf mines/ 10 leaflets occurred on tomato plants Nemaguard during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate…………….………	127
30.	Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Super set during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate……………...…..	128
31.	Population fluctuations of *Tuta absoluta* leaf mines/ 10 leaflets occurred on tomato plants Hybrid bito86 during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate…………….……	129
32.	Effect of three plant growth regulator (Benzyleadenin, Kinetin and Salsylic acid) on *Tutaabsoluta* infestation contracting to control…………………...	134
33.	Effect of sensitive cultivars (Hybrid super strain, Baladi and Castle rock) on *T. absoluta* infestation	134
34.	Effect of inspection dates on *Tuta absoluta* infestation…..……………….…...……………………	135
35.	Seasonal fluctuation of *Tuta absoluta* from May 2015 to May 2016 at Bahada village, Shalakan,	140

Fig. No.		Page
	Qualiubya Governorate……………………………..	
36.	Weekly mean number of *Tuta absoluta* moths and the main two weather factors (Mean temp. and Mean R.H.%) at Qaliubya Governorate during seasons, 2015/2016…………………………………	**141**
37.	The sequence of generations of *Tuta absoluta* on tomato plants at Shalakan, Qalyubia Governorate during 2015…………………….……………...	**145**
38.	Predicted dates of peak generations of *Tuta absoluta* according to degree-days and its relation to the number of moths captured by pheromone trap during 2015/2016 (Shalakan, Qalyubia)……………	**150**
39.	Adult of *Diglyphus* sp………………………………	**152**
40.	Adult of *Elasmus* spp……………….……………	**153**
41.	Adult of *Telenomus* sp…………………………...…	**154**
42.	Adult of *Nesidiocoris tenuis*………………………..	**155**
43.	Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*………………………	**156**

I- INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is the most important export crop in Egypt. The total cultivated area in Egypt is about 599.651 feddans at 2009 and the average production around 10,275,521 ton **(Mukhtar *et al.*, (2009).** The tomato leaf miner *Tuta absoluta* (Meyrick) became a serious pest to tomato cultivations in Egypt since 2009, whereas it causes great damage to the crop. Egypt has an appropriate climate for tomato cultivation and the annual production of the crop is 9,204,097 tons of tomato fruits from about 9,000 ha of the cultivated area **(Moussa *et al.*, 2013).** So, it is considered as the fifth largest tomato producer in the world **(WPTC, 2011).**There is more than 700 varieties of tomatoes all over the world. These varieties could be distinguished from each other by the form of leaves, size and color of fruits **(FAOSTAT, 2014).**The exceptional speed and extent of *T. absoluta* invasion have called for studies documenting its biology and ecology, while indicating an urgent need for efficient and sustainable management methods **(Desneux *et al*., 2010).**

Without any control measure the potential damage may be 100%, especially at high population densities at the end of the growing season **(Potting *et al.*, 2009).**

Tricomes are hair-like appendages that develop from cells of the aerial epidermis are produced by most plant species **(Werker, 2000).** Tricome production is an important component of resistance against herbivorous insects **(Traw and Dawson 2002)**, Also, one of the important defensive responses of plants against insect attack is the accumulation of oxidative enzymes such as peroxidase (POD), esterases **(Rani and Jyothsna 2010).** In addition, biochemical contents as N, P, K, protein, carbohydrate, amino acids are one of the most parameters in the relationships between plants and herbivores.

Natural enemies used successfully in biological control of *Tuta absoluta* such as parasitoids and predators. The parasitoids which recorded belong to different families as Eulophidae, Elasmidae, Scelionidae and

Tricogrammatidae. **Mahdi *et al.*, (2011)** in Algeria, recorded predatory bugs, *Nesidiocoris tenuis* on *Tuta absoluta*.

T. absoluta is generally controlled through an integrated pest management system. This concept of integrated pest management (IPM) implies using of present methods to control. Accurate prediction of insect development and emergence is essential for effective pest management. Monitoring based on degree-day accumulation is to be available tool for predicting population pest occurrence. The average method is the easiest for calculating the number of degree-day where Degree-days= {(max. temp. + min. temp.)/2}– base temp.

Degree-days can be valuable tools for predicting insect development and timing pest management practices. The easiest way to construct a degree-days model is to monitor a phonological event from one year to the next, and by noting on the total number of degree-days in addition.

Therefore, it is found rather fruitful to study the following points:

1- Bio-monitoring the changes in the developmental stage of *T. absoluta* under three constant temperatures and calculating the thermal units required for completing the different stages and also one generation to predict the number and duration of generations in the fields.
2- Biological studies to determine life table "Parameters"
3- Determine the susceptibility of eight tomato cultivars to *T. absoluta* infestation as evaluating the effects of the leaflet biochemical responses, defense mechanism and physical features to tomato cultivars after infestation, in addition studying the effect of plant growth regulators on induced resistance to *T. absoluta*.
4- Determine the beginning and the last dates of appearance of each generation by using actual data figures of methods captured by pheromone traps, linear method and degree-days method.

5- Survey available parasitoids and predators in some governorates in Egypt associated with tomato leaf miner *Tuta absoluta*. As well as studying seasonal abundance of *Nesidiocoris tenuis* as predator.

II-REVIEW OF LITERATURE

Taxonomic status and synonymy list of tomato leaf miner pest *Tuta absoluta*

Order: Lepidoptera

Super family: Gelechiidoidea

Family: Gelechiidae

Genus: *Tuta*

Species:*T.absoluta*

Synonymy list:

1873 *Gelechia operculella* Zeller

1874 *Bryotropha solanella* Boisd.

1875 *Lita solanella* Boisd.

1879 *Gelechia tabacella* Rag.

1881 *Parasia sedata* Butler

1885 *Lita tabacella* Rag.

1898 *Gelechia solanella* Boisd.

1902 *Phthorimaea operculella* Zeller

1917 *Phthorimaea absoluta* Meyrick

1962 *Gnorimoschema absoluta* Clarke

1964 *Scrobipalpula absoluta* Povolny

1987 *Scrobipalpuloides absoluta* Povolny

1994 *Tuta absoluta* Povolny

The scientific name of tomato leaf miner, *Tuta absoluta* changed 13 times during 121 years i.e. from 1873 to 1994 and still fixed from 1994 until now.

Host plants of *Tuta absoluta*

T. absoluta has major host, minor host and wild host. The tomato (*Lycopersicon esculentum*) is the main host plant for *T. absoluta* **(Desneux *et al.*, 2010).** It attacks other species of cultivated Solanaceae: potatoes(*Solanum tuberosum*), eggplants (*Solanum melongena*),pepinodulce (*Solanum muricatum*), peppers (*Capsicum*spp.) and wild Solanaceae such as

Lycopersicon hirsutum, *Solanum americanum*, *Solanum elaeagnifolium*, *Solanum hirtum*, *Solanum lyratum*, *Solanum nigrum*, *Solanum puberulum*, *Physalis angulata*, *Datura stramonium*, *Datura ferox* and *Nicotiana glauca*, etc. **(EPPO, 2009)**. Since becomingestablished in Europe, *Tuta absoluta* has also occasionallybeen found on several species of plants, such as thesweet pepper(*Solanum muricatum*), tobacco (*Nicotiana tabacum* L.), bean(*Phaseolus vulgaris*L.), capegooseberry (*Physalis peruviana* L.), green beans (*Physalis vulgaris*), *Lycium* sp. and *Malva* sp.**(Desneux *et al.*, 2010)**. In Sub-Saharan Africa, it is possible that *T. absoluta* attacks not just the cultivated Solanaceae butalso local species of the genus *Solanum*, such as Africaneggplants (*Solanum aethiopicum*, *Kumba* and *Gilo* group, *Solanum anguivi*, *Solanum americanum*, *Solanum macrocarpon*, *Solanum scabrum*and *Solanum villosum*).

Distribution of *Tuta absoluta*

T. absoluta is native to South America, where it is considered one of the key pests of tomato. Following its first detection in Eastern Spain in late 2006 **(Urbaneja *et al*., 2007)**, the pest has spread into Europe, North Africa and the Middle East at exceptional speed (Table 1). The first report of the pest in Russia is noteworthy because of its potential spread into China (currently the world's leading tomato producer, followed by the USA**(FAOSTAT, 2011).** Additionally, some other records, such as that reporting one specimen of the pest being caught in a light trap in Denmark (near Copenhagen), which is not a tomato-growing area **(Buhl *et al*., 2010)**, highlight the strict connection between this species' spread and human activities such as trading.

Table (1): *Tuta absoluta* current distribution outside the area of origin (old world)

Country	Year	Reference
Spain	2006	Urbaneja *et al.*, (2007); EPPO (2009)
Albania	2008	EPPO (2009)
Algeria	2008	Guenaoui (2008)
France (including Corsica)	2008	EPPO (2009)
Italy (including Sicily and Sardinia)	2008	Viggiani *et al.*, (2009); Tropea Garzia *et al.*, (2009)
Morocco	2008	EPPO (2008)
Tunisia	2008	EPPO (2009)
Bulgaria	2009	EPPO (2010)
Croatia	2009	EPPO (2011)
Cyprus	2009	EPPO (2010)
Germany	2009	EPPO (2010)
Greece (including Crete)	2009	Roditakis *et al.*, (2010)
Palestine	2009	EPPO (2010); Seplyarsky *et al.*, (2010)
Libya	2009	EPPO (2011)
Lithuania	2009	Ostraukas & Ivinskis (2010)
Malta	2009	EPPO (2009)
Portugal (including Azores)	2009	EPPO (2009)
Switzerland	2009	EPPO (2009)
The Netherlands	2009	EPPO (2009)
United Kingdom	2009	EPPO (2009, 2010)

Country	Year	Reference
[including Guernsey (2010)]		
Bosnia	2010	Uric & Hrncic (2010)
Egypt	2010	EPPO (2011)
Hungary	2010	EPPO (2010)
Iraq	2010	Abdul Razzak *et al.*, (2010)
Kosovo	2010	EPPO (2010)
Kuwait	2010	EPPO (2011)
Montenegro	2010	Hrnčić & Radonjić (2011)
Romania	2010	Keresi *et al.*, (2010)
Russia	2010	Izhevsky *et al.*, (2011)
Saudi Arabia	2010	Altmani (2010); EPPO (2011)
Serbia	2010	EPPO (2010)
Sudan	2010	EPPO (2011)
Syria	2010	Altmani (2010); EPPO (2011)
Turkey	2010	Kılıç (2010)
Bahrain	2011	EPPO (2011)
Iran	2011	Banamieri & Cheraghian (2011)
Jordan	2011	EPPO (2011)
Lebanon	2011	EPPO (2011)
Qatar	2012	EPPO (2011)

The tomato leaf miner, *Tuta absoluta* is cosmopolitan in distribution. It occurs in 38 countries throughout old world, in addition North and South America Table (1).

Biological studies:

1. **The developmental parameters of tomato leaf miner pest *Tuta absoluta* as explained by thermal accumulated units**

Uchoˆa-Fernandes *et al*., (1995) in Brazil, found that a maximum life time fecundity of 260 eggs per female.

Barrientos *et al*., (1998) recorded that the development of *T. absoluta* was 76.3 days at 14.0 degrees C, 39.8 days at 19.7 degrees C, and 23.8 days at 27.1 degrees C. The lower threshold temperature from egg to adult was 8.14 ºC, for the egg stage averaged 6.9ºC, for larval development 7.6 ºC and for pupae 9.2 ºC. The thermal constant for egg development was 103.8 DD, for larval development 238.5 DD and for pupal development 117.3 DD; all of these add 459.6 DD. This last amount of heat is close enough to that calculated directly for development from oviposition to adult emergence (453.6 DD).

Mihsfeldt and Parra (1999) in Spain, used the artificial diet which contained a protein source, wheat germ, casein, yeast, soyabean and common bean for rearing *T. absoluta*. The most suitable diet for rearing *T. absoluta* was leaves of 'Santa Clara' tomato and, among the artificial diet, the best diet was the one including 'Branco' common bean plus tomato leaf powder. This last diet had a phagostimulant effect, low larval mortality and promoted higher total viability. The number of larval instars was constant and equal to 4 for artificial diets as well as for tomato leaves, showing that the artificial diets are nutritionally suitable for rearing the insect.

Estay, P. (2000) mentioned that adult lifespan ranges between 10 and 15 days for females and6–7 days for males

Torrest *et al.*, (2001) reported that female fecundity ranged from 60 to 120 eggs and female longevity from 10 and 22 days.

Pires and Marques (2002) studied that the biology of the tomato pinworm (*Tuta absoluta*), reared on *Lycopersicon esculentum* cv. IPA5, under laboratory conditions at temperatures of 24.5&31.2 ºC and relative humidity of 45-100%. The incubation, larval and pupal periods were; 4.6±0.05, 11.9±0.15 and 6.5±0.33 days, respectively. The period from egg to adult emergence was 22.2±0.35 days.

Abolmaaty *et al.*, (2010) in Egypt, recorded that population of the *Tuta absoluta* in Qena governorate gave the highest number of generation as compared to other locations (EL Beheira, Giza and Fayoum governorates) under current climate.

Cherif*et al.*, (2013) in Tunis, mentioned that when using pheromone water traps during the period January-May, three flight peaks of *T. absoluta* males were recorded in Takelsa greenhouses, with the highest trap counts recorded in spring. The use of insect-proof screens significantly prevented *T. absoluta* infestations on host plants.

Cuthbertson *et al.*, (2013) in UK**,** mentioned that the optimum temperature for *T. absoluta* development ranged from 19 to 23°C. At 19 °C, there was 52% survival of *T. absoluta* from egg to adult. As temperature increased (23°C and above) development time of the moth would appear to decrease. Population development ceases between 7 and 10°C. Only 17% of eggs hatched at 10°C but no larvae developed through to adult moths. No eggs hatched when maintained at 7 °C. Under laboratory conditions the total lifespan of the moth was longest (72 days) at 13 °C and shortest (35 days) at both 23 and 25 °C. Development from egg to adult took 58 days at 13 °C; 37 days at 19 °C and 23 days at 25 °C.

Erdogan and Babaroglu (2014) in Turkey, studied that development and survival of immature stages, adult longevity, fecundity and ovipositon period of *T. absoluta* under laboratory conditions. The results indicated that duration of larval period was 10.97 days. The period of pupae development was 9.53 days. Fecundity of *T. absoluta* was found 141.16eggs/female. Pre-oviposition period was 1.28 days. Oviposition and post-oviposition periods were 7.88 and 5.52days respectively at a climate chamber at 25±1ºC, relative humidity 65±5% and under long daylight (16L:8D).

Krechemer and Foerster (2015) in Brazil, mentioned that *Tuta absoluta* required 416.7 degree-days to complete the cycle from egg to adult, and the lower temperature threshold was estimated to be 8.0°C. The upper temperature threshold estimated for the egg-adult cycle was 37.3°C. The pre-oviposition period was longer at 10°C, but the oviposition period was similar at all the temperatures tested. Fecundity was highest at 20 and 25°C, with averages of 134.8 and 149.1 eggs per female, respectively. The highest percentages of fertile eggs were recorded at 15, 20 and 25°C. At 10 and 30°C, only one egg clutch was laid by *T. absoluta*. No differences were recorded in the longevity of females and males of *T. absoluta*.

Mohamed*et al.*,(2015)in Egypt, recorded the effects of temperature on the biological attributes of *T. absoluta*at five constant temperatures(15, 20, 25, 30 and 35°C) combined with 60±10% R.H. Results indicated that *T. absoluta* failed to survive due to the high mortality in cohort reared at 35ºC. Total developmental time was negatively correlated to the increase of temperature; being longest (67.67 days) at 15°C and shortest (14.42 days) at 35°C. Longevity of either males or females decreased as temperature increased. The daily average fecundity of females was 15.78, 18.19, 34.65 and28.26 eggs at 15, 20, 25 and 30ºC, respectively. The mean total lifetime fecundity of *T. absoluta* females was 13.92, 211,244.17 and 177.83 eggs at 15, 20, 25 and 30°C, respectively. Adult survival rates were declined gradually to reach0% after 11 days post emergence at 30ºC, 17 days at 25ºC, 23 days at 20ºC, and 34 days at 15ºC.

Özgökce *et al.*, (2016) in Turkey, recorded that developmental threshold and thermal constant for total development of tomato leaf miner were estimated as 8.94°C and 419.46 degree-days respectively. Lower, optimum and upper temperature requests were estimated with different models and results obtained were in the range 8.9-12.5, 31.00-31.07 and 35.9- 38.5, respectively.

2. Life Table parameters of *Tuta absoluta*

Miranda *et al*., (1998) in Brazil, found that the total population mortality of tomato leaf miner was 92.3%. During the egg stage, the mortality was 58.7%, mainly due to egg non-viability. The mortality of the larval stage showed the highest apparent mortality (79.8%). The mortality at the pupal stage was low (0.6%) and was due to malformation.

Pereyra and Sanchez (2006) studied the effect of tomato plants on larval developmental time, pupal weight and mean fecundity was estimated. Age-specific survivorship and fecundity life tables were studied in the laboratory to evaluate the following populational parameters: net reproductive rate (Ro), intrinsic rate of increase (r) and generation time (T). Mean population parameters were: Ro=48.92; T=27.98, r=0.14.

Erdogan and Babaroglu (2014) in Turkey, found that the intrinsic rate of increase (r_m), finite population increase (λ), net reproductive rate (R_o) and mean generation time (T_o) of *T. absoluta* were 0.132 day -1 , 1.141day -1 , 42.01 and 28.25 days respectively. The life expectancy of a new born egg was 42.60 days. All of experiments were conducted in a climate chamber at 25±1ºC,relative humidity 65±5% and under long daylight (16L:8D).

Gharekhani and Salek-Ebrahimi (2014) in Iran, studied the life table parameters of *Tuta absoluta* on cut leaves of three greenhouse cultivars of tomato including 'Atabay', 'Cluse', and 'Perenses'. Data were analyzed based on the age-stage, two-sex life table analysis. Results showed differences in the duration of egg, larvae, pupae, and adults. Meanwhile, the life table parameters including intrinsic rate of increase (r), finite rate of increase (λ), net reproductive rate (R0), and gross reproductive rate (GRR) were categorized increasingly based on the feeding on Cluse, Atabay, and Perenses, respectively. The findings of the current study showed that the Cluse could be nominated as an unsuitable host for tomato leaf miner among cultivars because of its negative influences on the pest's biological parameters.

Mohamed *et al.*,(2015)in Egypt, recorded that Life table analysis of the population of *Tuta absoluta* reared at 30°C had the highest intrinsic rate of increase (0.75), net reproductive rate (28.28), shortest population doubling time (0.93 days) and mean generation time (4.49 days), comparing to populations reared at 15, 20 and 25°C. Thereupon, the optimum temperature for population growth of *T. absoluta* ranged between 20 to 30°C.

Ecological studies

3. Susceptibility of certain tomato genotypes to the infestation degree by *Tuta absoluta:*

3.1. Field experiment

Leite *et al*., (1998)in Brazil, mentioned that increasing N and K fertilization increased the *T. absoluta* oviposition rate on *Lycopersicon hirsutum*. Reduced oviposition was observed on leaves in the apical and mid parts of 4-month-old *L.hirsutum* plants. The greatest amount of oviposition was recorded on leaves in the apical and mid parts of *L. esculentum* plants. No significant effects of the treatments on adult mortality were observed.

Ecole *et al.*,(2000) in Brazil,recorded that *Lycopersicon hirsutum* f. typicum showed resistance to the tomato leaf miner in comparison with *Lycopersicon esculentum*, which was reflected by the smaller number of large mines/leaf and greater length of larval phase, mortality of larvae and number of small mines of *T. absoluta*.

Perveen *et al.*, (2001) reported that resistant and semi-resistant varieties of cotton attacked by insects possessed significantly greater phenolic content than susceptible varieties.

Leite *et al*., (2004)in Brazil, found that no significant effect of the trichomes and crystalliferous idioblasts densities of leaves were noted on *T. absoluta* and *Liriomyza* spp. populations. Apparently, the terpenes affected oviposition of *T. absoluta* while leaf potassium affected *Liriomyza* spp. attack.

Oliveira *et al.*, (2008) in Brazil, evaluated resistance to *Tuta absoluta* by antixenosis on 57 *Lycopersicon esculentum* and mentioned that the chemical causes of resistance, hexane extracts were analysed at day 90 by gas chromatography/mass spectrometry and the major peaks identified by a mass spectral database using similarity index. Nine hydrocarbons, viz., hexadecane, heptadecane, eicosane, tricosane, 2-methyltricosane, tetracosane, hexacosane, octacosane and triacontanewere identified in the hexane extracts in many samples. Tricosane, tetracosane and hexacosane presented significant correlations with the leavesmined. Only tricosane presented a negative correlation with the number of small mines (r= -0.28), total number of mines (r = -0.27) and hundred percentage of leaves mined (r=-0.22). However, tetracosane and hexacosane presented significant positive correlations (r=0.25 and 0.24, respectively) with the hundred percentage of leaves mined.

Antônio *et al.*, (2011) in Brazil, evaluated that the inheritance of resistance by antixenosis in tomatoplants (*Lycopersicon esculentum*) to *Tuta absoluta*. The inheritance of antixenosis resistance of genotype BGH-1497 is ruled by a gene of greater effect and polygenesin epistatic interactions, with a phenotypic proportion of 13:3 between susceptible and resistant genotypes, respectively.

War *et al.*, (2012)recorded that the three groundnut lines tested ICGV86699 (resistant for *Spodoptera litura*) showed greater elevation in peroxidase (POD) and polyphenol oxidase (PPO) activities and in phenolic and hydrogen peroxidase H2O2 contents at different time intervals as compared to TMV2 (susceptible line).

Glas*et al.*, (2012) in Spain, recorded that trichome density and physiology to facilitate customization of essential oil production or to tune biocide activity to enhance crop protection. They provide an overview of the metabolic diversity found within plant glandular trichomes, with the emphasis on those of the Solanaceae, and of the tools available to manipulate their activities for enhancing the plant's resistance to pest.

Assaf*et al.*, (2013) In Iraq, recorded that the average numbers of mines/ leaflet and larvae/ leaf during the study season were 1.36 and 0.42 respectively. The results showed a significant difference in number of mines/leaflet and number of males/trap among the two locations (Summel&Zawita). A maximum number of males/ trap/ week were 56.66 recorded on 10/9/2012 in Summel.

Cherif *et al.*, (2013)in Tunis, shown that the tomato cultivars Shams and Chebli were the least suitable under open-field conditions for egg-laying by *Tuta absoluta*, compared to the cultivar Ferrinz. The use of both insect-proof screens and tomato cultivars with lower suitability for pest'segg-laying might be a promising prophylactic control tactic against *T. absoluta*.

Han *et al.*, (2014) in France, found that an excess of N had no effect on both leaf N content and leaf C/N ratio. Sub-optimal nitrogen supplies, water treatments and their interactions significantly reduced the leaf miner survival rate and slowed down its development. Together with the findings from three recent companion studies, they assumed that a combination of changes in nutritional value and chemical defence could explain these observed effects. Furthermore, their findings supported both the "Plant vigor hypothesis" and "the nitrogen limitation hypothesis".

Salama*et al.*, (2015) in Egypt, mentioned that the larvae of *T. absoluta* are sensitive tolight and it prefers the dark zones. The larvae with its taste receptors are able to discriminate between host plants and other chemicals. For instance, it showed great sensitivity to various sugars in varying degrees.

Helmi and Mohamed (2016) in Egypt, evaluated that effects of tomato leaf biochemical components and leaflet surface physical features on the susceptibility of five tomato cultivars. Results clearly indicated significant differences among the five tested tomato cultivars according to their susceptibility to *Aphis gossypii* infestation. Photosynthetic pigments, biochemical components and antioxidant defense enzymes activity were negatively affected by infestation. Moreover, the density and length of leaflet non-glandular trichomes negatively effect on the population density of *A. gossypii*, while this was not the case with glandular trichomes.

Abd-Allah(2016)in Egypt**,** recorded that the highest mean seasonal abundance of Aphids &*Tetranychus urtica* occurred on leaves of Bahi (cucumber cultivar) were associated with high levels of total protein, carbohydrate, lipid, reducing suger & total amino acids and associated with low levels of total phenols.

3.2. Effect of plant growth regulator on sensitive cultivars to infestation by *Tuta absoluta*

Popova*et al.*, (1997) in Bulgaria, evaluated the effect of salicylic acid (SA) on different physiological processes. The role of SA on plant growth and development, flowering, ion uptake, stomata regulation and photosynthesis is analysed. SA as a natural inducer of thermogenesis and disease resistance in plants is described. Besides the physiological functions of SA, the general properties, biosynthesis and metabolism of this plant growth regulator are discussed.

Sakhabutdinova *et al.*, (2003) in Russia, found that the salicylic acid (SA) treatment reduced the damaging action of salinity and water deficit on seedling growth and accelerated a restoration of growth processes.Thus protective SA action includes the development of anti-stress programs and acceleration of normalization of growth processes after removal stress factors.

Javaheri *et al.*, (2012)in Iran, recorded that application of salicylic acid affected tomato yield and quality characters of tomato fruits so that tomato plants treated with salicylic acid 10 -6 M significantly had higher fruit yield (3059.5 g per bush) compared to non-treated plants (2220 g/bush) due to an increase in the number of bunch per bush. Results also indicated that application of salicylic acid significantly improved the fruit quality of tomato. Application of salicylic acid increased the amount of vitamin C, lycopene, diameter of fruit skin and also increased rate of pressure tolerance of fruits. Fruit of tomato plants treated with salicylic acid 10 -2 M significantly had higher vitamin C (32.5 mg/100 g of fruit fresh weight) compared to untreated plants (24 mg/100g fruit fresh weight).Salicylic acid concentration 10 -12 M also increased the diameter of fruit skin (0.54 mm) more than two fold compared to control (0.26 mm). Fruit Brix index of tomato plants treated with salicylic acid 10-12 M significantly increased (9.3) compared to non-treated plants (5.9). These results suggest that foliar application of salicylic acid may improve quantity and quality of tomato fruits.

Pacheco*et al.*, (2013) in Brazil, mentioned that the effects of Salicylic acid (SA) in marigold were evaluated by the following parameters: leaf gas exchange, number of leaves per plant, leaf dry mass, leaf area, chlorophyll content, number of inflorescences per plant, fresh and dry mass of inflorescences and total flavonoid content in inflorescences. Application of SA in this concentration range (0.0-1.00mM) resulted in linear increases on biomass accumulation, number of inflorescences and flavonoid content. Leaf gas exchange was not altered by SA application. These results showed that SA exogenous application before the reproductive stage resulted in higher biomass production of marigold plants and added significant value to the raw material by increasing total flavonoids content in the inflorescences.

4. Seasonal abundance and generations in relation to phermone trap catches:

Svatos *et al*., (1996) identified that *Tuta absoluta* in wind tunnel bioassays, a 10:1 mixture of synthetic (3E,8Z,11Z)-3,8,11-tetradecatrien-1-yl acetate and (3E,8Z)-3,8-tetradecadien-1-yl acetate was highly attractive to males of *T. absoluta*.

Vanderlei Carus Guedes *et al*., (1996) in Brazil, carried out an experiment in a plastic greenhouse during 1995 to evaluate the efficiency of 3 pheromone traps in capturing the tomato pests *Scrobipalpuloides absoluta* [*T. absoluta*]. The "Santa Maria" trap caught 25% more males than the "Cica-R" trap. The "Embrapa" trap was relatively ineffective.

Ferrara *et al*., (2001) in Brazil, found that the best trap, baited with 100 micro g. of the synthetic sex pheromone caught on average 1200 males per trap per night, while those baited with virgin females caught only 201 males. The male response to this pheromone is restricted to the same early morning time window during which female exhibit calling behaviour.

Salas (2004) in Venezuela, recorded that water traps had a greater number of captures with differences at 0.05 compared to Delta sticky traps.

Bavaresco *et al*., (2005) in Brazil, found that the monitoring process using sexual pheromone in delta traps was adequate to identify the time of tomato leafworm population increments, and has potential to be used to define thresholds for pest control.

EPPO (2005) reported that *Tuta absoluta*has a high reproductive potential. Larvae do not enter a diapause as long as food is available, and there may be 10–12generations per year (5 in Argentina). The biological cycle is completed in 29–38 days depending on environmental conditions.

Benvenga *et al*.,(2007) in Brazil, found that the relationship between tomato production and pest infestation on plants or pheromone traps was linear and negative. The adult occurrence on traps and plant infestation showed an influence on yield losses. The action level of *T. absoluta* with sex pheromone traps was 45±19.50 insect daily.

de Oliveira *et al*., (2008)in Brazil, evaluated the use of light traps for capture of adult *T. absoluta* specimens. The treatments used were: (1) black lamp; (2) BLB lamp; (3) Grolux lamp; and (4) fluorescent daylight lamp. The results showed that the BLB and ultraviolet lamps were the most efficient treatments based on the number of adult leaf miners trapped. Therefore, both can help to control the tomato leaf miner in integrated pest management programmes.

Korycinska and Moran (2009) in UK, found that generations of *Tuta absoluta* overlap, and there may be over 10 generations in a year if conditions are favourable in Europe, although only 5 generations per year have been observed in Argentina.

Abolmaaty *et al.*, (2010) in Egypt, recorded that population of the *T. absoluta* in Qena governorate gave the highest number of generation as compared to other locations (EL Beheira, Giza and Fayoum governorates) under current climate. Generation numbers of *T. absoluta* under climate change conditions increased especially in Qena governorates. However, the expected generation numbers of the pest at 2050 and 2100 are be 12-14 and 13-15 generations per year, respectively.

Taha *et al.*, (2014) in Egypt, recorded that attractiveness of the commercial sex pheromone formulations tested, except pheromone lure type Tuta san, remained highly attractive to male tomato borer for up to 4 weeks in tomato fields. The mean total number of males captured did not differ significantly among delta traps baited with: pheromone type, Tuta lure (292.33 average numbers of moths/ trap) baited with 0.5 mg of synthetic pheromone (E3.z8.z11 Tetradecatrieny acetate/ E3.z8. Tetradecatrieny acetate); pheromone type, Tutacap longlife (294.60 average numbers of moths/ trap) baited with 1.5 mg of synthetic pheromone ((E,Z,Z)- 3,8,11-Tetradecatrieny acetate) and pheromone type, Tryferron (269.47 average numbers of moths/ trap) baited with 0.6 mg of synthetic pheromone (E3Z8Z11-14AC (3,8,11- Tertacatrien-1-ylacetate-(E,Z,Z)). Data showed that there was significant degradation of lure performance (attractiveness) over the period of the experiment. The Tuta 100N commercial sex pheromone lure was the best dispenser for catching the *T. absoluta* males for long times post pheromone application. The high biological activity of the synthetic pheromone lures suggests that it could be useful for pest monitoring, in mating disruption and IPM of *Tuta absoluta* in tomato fields.

5. Natural enemies associated with tomato leaf miner *Tuta absoluta* and Biological control:

Arno*et al*., (2009)in Spain, found that *Macrolophus pygmaeus* and *Nesidiocoris tenuis* may be important predators of *T. absoluta* eggs but not of larvae.

Molla*et al*., (2009) in Spain, found that both predators *M. pygmaeus* and *N.tenuis* preyed actively on *T. absoluta* eggs and all larval stages, although they preferred first-instars larvae.

Urbaneja *et al*.,(2009) in Spain, examined prey suitability of *T. absoluta* eggs and larval instars under laboratory conditions to evaluate whether two indigenous predators, *M. pygmaeus* and *N. tenuis*, can adapt to this invasive pest. Both predators preyed actively on *T. absoluta* eggs and all larval stages.

Arnó and Gabarra (2011)in Spain, identified Predatory bugs such as *M. pygmaeus* (commercially available as *Macrolophus caliginosus*) and *N. tenuis* as the most promising natural enemies of *T. absoluta* in Europe as they are large consumers of eggs of the pest.

Boualem *et al*., (2011) in Algeria, studied the life cycle and longevity of *T. absoluta* and the natural predator *N. tenuis* in Mostaganem area in natural conditions in the laboratory, under an average temperature of 26±1.6 degrees C and 23.4±2 degrees C, relative humidity of 87±6.4% and 75±3% and a photoperiod of 16/8. The results showed a development cycle of 21.1±0.4 and 29.4±2 days for *T. absoluta* this depending on temperature and a cycle of 17.1±0.5 days for the predatory bug, *N. tenuis* at 26±1,6 º C.

Guenaoui *etal*., (2011) in Algeria**,** recorded some natural enemies on *T. absoluta* in the vicinity of Mostaganem, the mirid, *N. tenuis*, *M.*

caliginosus and *Dicyphus tamaninii* which had been evaluated in laboratory conditions.

Guenaoui and Bensaad (2011)in France, found in the galleries young nymphs of the mirid *Nesidiocoris tenuis* preying *Tuta absoluta* inside the fruit.

Lopez *et al.*,(2011) in Spain,reported that*Diglyphus isaea*is an ectoparasite of leafminers.

Mahdi*et al*., (2011) in Algeria,recorded that two species of predatory bugs,*N. tenuis* and *Macrolophus caliginosus*and a parasitoid wasp *Diglyphus* sp. as natural enemies of *T.absoluta*. Of the three native species, the predator *N. tenuis* was mass-reared in order to realize releases under greenhouses.

Molla*et al*., (2011) in Spain, mentioned that the predator *N.tenuis* can regulate *T. absoluta* populations, because it is able to prey efficiently on *T. absoluta* eggs.

Abbes and Chermiti (2012) in Tunis, Made many attempts to biologically control the tomato leafminer *T. absoluta* using the predator *N. tenuis* in nurseries, greenhouses and open field tomato crops.

Al-Jboory *et al*., (2012) in Jordan, recorded three hemipterans: *Orius albidipennis*, *Orius* sp. (Anthocoridae) and *N.tenuis* (Miridae) as natural enemies of *T. absoluta*.

Cabello *et al*., (2012)in Spain,recorded that predator, *N. tenuis* of *T. absoluta*, the mired,*N. tenuis*, but the young nymphs did not cause any mortality of the pest and tested the effectiveness of the predator *N.tenuis* (Reuter). This mirid species is commonly spread in Mediterranean greenhouse tomato crops for the control of the sweet potato whitefly, *Bemisia tabaci* (Gennadius). Tomato cultivars were also observed to influence the activity of natural enemies, mainly *N. tenuis* (whose average numbers ranged between 0.17±0.03 and 0.41±0.05 nymphs per leaf depending on the cultivar). This may be because of differences in plant nutrients in different cultivars, which may affect the feeding of omnivorous insects.

Calvo*et al*., (2012) suggested that release system developed for *Nesidiocoris tenuis* could provide a good control of *Tuta absoluta* in tomato..

El-Arnaouty and Kortam (2012)in Egypt, found that *N. tenuis* is a polyphagous predator widely distributed in the Mediterranean region, where it has been used as an augmentative biological control agent for several plant pests. *N. tenuis* was recorded for the first time in Egypt, associated with *T. absoluta* in aubergine and tomato plantations in Giza, Qaluobia and Fayoum Governorates.

Giorgini*et al.*, (2012)in Italy, found the species belong to 13 genera and 6 families (Ichneumonidae, Braconidae, Eulophidae, Elasmidae, Pteromalidae and Trichogrammatidae). In particular, the 16 identified species were: *Diadegma ledicola* Horstmann, *Diadegma pulchripes*Kokujev), *Agathis fuscipennis* (Zetterstedt), *Bracon hebetor* (Say), *Bracon osculator* (Nees), *Bracon* (Habrobracon) *nigricans Szepligeti*, *Chrysocharis pentheus* (Walker), *Diglyphus crassinervis* Erdös, *Necremnus artynes* (Walker), *Necremnus* sp. *Near artynes* (Walker), *Necremnus* sp. *near tidius* (Walker), *Neochrysocharis formosa* (Westwood), *Pnigalio soemius* s.l. (Walker), *Pnigalio cristatus* (Ratzeburg), *Pnigalio incompletus* (Boucek) and *Halticoptera aenea* (Walker). For 13 species, the findings represent the first host-parasitoid association report on *T. absoluta*. This survey suggests that indigenous natural enemies may have a potential role in reducing population of *T. absoluta*, and habitat management techniques should be considered in the development of integrated management strategy of the tomato borer in the Mediterranean area.

Nannini*et al*., (2012) in Italy, evaluated the efficacy of releasing two specimens of *Macrolophus pygmaeus* or *N. tenuis* per m2 for the control of tomato borer infestations. Both *M. pygmaeus* and *N. tenuis* failed to achieve the levels necessary for effective pest control.

Zappala*et al.*, (2012) in Italy, found species belong to 13 genera and 6 families (Ichneumonidae, Braconidae, Eulophidae, Elasmidae, Pteromalidae and Trichogrammatidae) as natural enemies of *Tuta absoluta*.

Al-Gerrawy*et al.*, (2013) in Iraq, identified on *Tuta absoluta*: two egg parasitoids *Trichogrammapintoi* (Trchogrammatidae) and *Telenomus* sp. (Platygastridae).

Biondi *et al.*, (2013) in France, found three species of mirid predators [*Marcrolophus pygmaeus* (Rambur), *Nesidiocoris tenuis* (Reuter) and *Dicyphus* sp.] preying on eggs and young larvae of T. absoluta.

Gabarra *et al.*, (2013)in Brazil, found other 13 larval/pupal parasitoid species occasionally parasitizing *T. absoluta*. Six of those were first reported to be able to parasitize this lepidopteran pest in this paper. These species are. *Elasmus phthorimaeae* Ferriereand *Diglyphus crassinervis* Erdo¨s(Hymenoptera: Eulophidae),*Dolichogenidea litae* (Nixon) (Hymenoptera: Braconidae), *Temelucha anatolica* (Sedivy) and *Zoophthorus macrops* (Bordera & Horstmann) (Hymenoptera: Ichneumonidae) and *Pteromalus semotus* (Walker) (Hymenoptera: Pteromalidae).

Oztemiz (2013) in Turkey, evaluated the population of tomato leafminer, *T.absoluta*and efficiency of natural enemies on tomato grown greenhouse, *Tricogramma evanescens*and *N. tenuis*were used for biological control of the pest. Both the egg parasitoid and predatory bug were released alone and combined. The decrease of egg and larva numbers of *T. absoluta* were higher in plots released *T. evanescens* with *N. tenuis* together than each one released separately. However, the decrease of eggs was higher than larvae in plots released *N. tenuis* and *T. evanescens* alone. Population of *T. absoluta* and fruit numbers were influenced by the treatments. The number of fruit directly affected negatively by increasing the population density of *Tuta absoluta*.

Payer *et al.*, (2015) in Spain, observed that females of *Diglyphus isaea* are able to predate larvae of *T. absoluta* but apparently they do not use this species as a host to parasitize.

Sohrabi and Hosseini (2015) in Iran,identified the indigenous predators of the tomato leafminer, associated with tomato. A predator species from the family Miridae was found, reared, and identified as *Nesidiocoris tenuis* (Reuter 1895).This species is reported for the first time on tomato leafminer in Iran. Identification of important natural enemies provides a scientific basis for including these predators in the biological programs against this pest.

Perdikis*et al.*, (2016)in Greece, used sticky traps (yellow, blue and transparent) to attract the two major natural enemies of the leaf miners, *Dacnusa sibirica* Telenga (Hymenoptera: Braconidae) and *D. isaea* (Walker) (Hymenoptera: Eulophidae) was recorded. In addition, they studied their efficacy to capture the effective predator *N. tenuis* which in high population levels may cause damage on tomato crop.

In other words, there are about 55 parasitoids belong to 7 families (Trichogrammatidae, Eulophidae, Braconidae, Ichneumonidae, Scelionidae, Chalcididae,Pteromalidae) and one order (Hymenoptera). As well as two predators belong to one family and order Heteroptera (Tables 2&3).

Table (2): Parasitic species of *Tuta absoluta* recorded in literature

Order	Superfamily	Family	Scientific Name	Stage	Country Outhers Host	
Hymenoptera Argentina	Chalcidoidea	Trichogrammatidae	*TrichogrammatoideabactraeNagaraja*	E		**Virgala and Botto (2010)**
Hymenoptera	Chalcidoidea	Trichogrammatidae	*Trichogramma sp.*	E	Algérie Spain Italy	**Boualem*et al.*, (2014)& Gabarra*et al.*, (2013) &Giorgini*et al.*, (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Dineulophusphtorimaeae (de Santis)*	L		**Luna *et al.*, (2010)**
Hymenoptera	Chalcidoidea	Eulophidae	*Closterocerus sp.*	L	Iraq	**Al-Gerrawy*et al.*, (2013)**
Hymenoptera	Chalcidoidea	Eulophidae	*Diglyphus sp.*	L	Algeria	**Mahdi *et al.*, (2011)**
Hymenoptera P	Chalcidoidea	Eulophidae	*DiglyphuscrassinervisErdo¨s, 1958*	L-	Spain Italy	**Gabarra*et al.*, (2013) &Giorgini*et al.*, (2012)**
Hymenoptera L	Chalcidoidea	Eulophidae	*Diglyphusisaea (Walker, 1838)*		Algeria, Spain Greece	**Boualem*et al.*, (2014)&Gabarra*et al.*, (2013)& Payer *et al.*, (2015)&Perdikis*et al.*, (2016)& Lopez *et al.*, (2011)**

Order	Superfamily	Family	Scientific Name	Stage Host	Country	Outhers
Hymenoptera	Chalcidoidea	Eulophidae	*Elasmus sp.*	L	Italy	**Zappala` *et al*., (2012a)&Giorgini*et al*., (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*ElasmusphthorimaeaeFerriere, 1947*	L-P	Spain	**Gabarra*et al*., (2013)**
Hymenoptera	Chalcidoidea	Eulophidae	*Neochrysocharissp.*	Not specified	Algeria	**Boualem*et al*., (2014)**
Hymenoptera	Chalcidoidea	Eulophidae	*Neochrysocharisformosa (Westwood, 1833)*	L/P	Spain Italy	**Gabarra*et al*., (2013)&Giorgini*et al*.,(2012)&Zappala*et al*., (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Sympiesis sp.*	L	Algeria Italy	**Boualem*et al*., (2014)&Giorgini*et al*., (2012)&Zappala*et al*., (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Necremnus sp.*	L/P	Spain Italy	**Gabarra*et al*.,(2013)&Giorgini*et al*., (2012)&Zappala*et al*.,(2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Necremnusartynes*	L/P	Algeria Spain Italy	**Boualem*et al*., (2014)&Gabarra*et al*.,**

Order	Superfamily	Family	Scientific Name	Stage	Country	Outhers Host
						(2013)&Giorgini*et* *al.*, (2012)
Hymenoptera	Chalcidoidea	Eulophidae	*Necremnus sp. near artynes*	L	Italy	**Giorgini*et al.*, (2012)&Zappala*et* *al.*, (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Necremnus sp. near tidius*	L	Italy	**Giorgini*et al.*, (2012)&Zappala*et* *al.*, (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Stenomesius cf. japonicus (Ashmead, 1904)*	L/P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Chalcidoidea	Eulophidae	*Pnigaliocristatus (Ratzeburg, 1848)* L/P		Spain Italy	**Gabarra*et al.*, (2013)&Giorgini*et* *al.*, (2012)&Zappala*et* *al.*, (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Pnigaliosoemius (Walker, 1839)*	L/P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Chalcidoidea	Eulophidae	*Pnigalioincompletus*	L	Italy	**Giorgini*et al.*, (2012)&Zappala*et* *al.*, (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Pnigalio sp. a gr. soemius*	L	Italy	**Giorgini*et al.*, (2012)&Zappala*et* *al.*, (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Pnigalio sp. b gr. soemius*	L	Italy	**Giorgini*et al.*,**

Order	Superfamily	Family	Scientific Name	Stage Host	Country	Outhers
						(2012)&Zappala*et al*., (2012)
Hymenoptera	Chalcidoidea	Eulophidae	*Pnigalio sp. c gr. soemius*	L	Italy	**Giorgini*et al*., (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Chrysocharis sp.*	L	Italy	**Giorgini*et al*., (2012)&Zappala*et al*., (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Chrysocharispentheus*	L	Italy	**Giorgini*et al*., (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Elachertus sp.*	L	Italy	**Giorgini*et al*., (2012)&Zappala*et al*., (2012)**
Hymenoptera	Chalcidoidea	Eulophidae	*Elachertusinunctus species group*	L	Italy	**Giorgini*et al*., (2012)&Zappala*et al*., (2012)**
Hymenoptera	Ichneumonoidea	Braconidae	*Pseudapanteles dingus (Muesebeck)*	L	Argentina, South America	**Luna *et al*., (2010) Sanchez *et al*., (2009)**
Hymenoptera	Ichneumonoidea	Braconidae	*Habrobracon sp.*	L	Iraq	**Al-Gerrawy*et al*., (2013)**
Hymenoptera	Ichneumonoidea	Braconidae	*Agathis sp.*	L	Italy	**Giorgini*et al*.,(2012)**
Hymenoptera	Ichneumonoidea	Braconidae	*AgathisfuscipennisZetterstedt*	L	Italy	**Loni*et al*., (2011) &Giorgini*et al*., (2012)**
Hymenoptera	Ichneumonoidea	Braconidae	*Apanteles sp.*	L-P	Spain	**Gabarra*et al*., (2013)**

Order	Superfamily	Family	Scientific Name	Stage Host	Country	Outhers
Hymenoptera	Ichneumonoidea	Braconidae	*Braconsp*	L	Tunisia Algeria	**Abbes *et al.*, (2012)&Boualem*et al.*, (2014)**
Hymenoptera	Ichneumonoidea	Braconidae	*Choerassemele (Nixon 1965)*	L-P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Ichneumonoidea	Braconidae	*Cotesia sp.*	L-P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Ichneumonoidea	Braconidae	*Dolichogenidealitae (Nixon, 1972)*	L-P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Ichneumonoidea	Braconidae	*Bracon (Habrobracon) sp. nr. nigricans (Sze´pligeti, 1901)*	L-P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Ichneumonoidea	Braconidae	*Chelonus sp.*	L-P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Ichneumonoidea	Braconidae	*Diolcogaster sp.*	L-P	Spain	**Gabarra*et al.*, (2013)**
Hymenoptera	Ichneumonoidea	Braconidae	*Braconosculator*	L	Italy	**Giorgini*et al.*, (2012) &Zappala` *et al.*, (2012)**
Hymenoptera	Ichneumonoidea	Braconidae	*Braconnigricans*	L	Italy	**Giorgini*et al.*, (2012) &Zappala` *et al.*, (2012)**
Hymenoptera	Ichneumonoidea	Braconidae	*Braconhebetor*	L	Italy	**Giorgini*et al.*, (2012**
Hymenoptera	Ichneumonoidea	Braconidae	*DacnusasibiricaTelenga*		Greece	**Perdikis*et al.*, (2016)**
Hymenoptera	Ichneumonoidea	Ichneumonidae	*Diadegma sp.*	L-P	Italy	**Zappala` *et al.*, (2012) &Giorgini*et al.*, (2012**
Hymenoptera	Ichneumonoidea	Ichneumonidae	*Diadegmapulchripes (Kokuje)*	L-P	Italy	**Zappala` *et al.*, (2012) &Giorgini*et***

Order	Superfamily	Family	Scientific Name	Stage Host	Country	Outhers
						***al*., (2012**
Hymenoptera	Ichneumonoidea	Ichneumonidae	*Diadegmaledicola*	L	Italy	**Giorgini*et al*., (2012**
Hymenoptera	Ichneumonoidea	Ichneumonidae	*Hyposoterdidymator (Thunberg)*	Not specified	Algeria	**Boualem*et al*.,(2014)**
Hymenoptera	Ichneumonoidea	Ichneumonidae	*Temeluchaanatolica (Sedivy,1959)*	L-P	Spain	**Gabarra*et al*., (2013)**
Hymenoptera	Ichneumonoidea	Ichneumonidae	*ZoophthorusmacropsBordera&Horstmann, 1995*	L-P	Spain	**Gabarra*et al*., (2013)**
Hymenoptera	Ichneumonoidea	Ichneumonidae	*Cryptinae gen. sp*	L	Italy	**Giorgini*et al*.,(2012) &Zappalà*et al*., (2012)**
Hymenoptera		Scelionidae	*Telenomus sp.*	E	Iraq	**Al-Gerrawy*et al*., (2013)**
Hymenoptera		Chalcididae	*Hockeria unicolor Walker, 1834*	L-P	Spain	**Gabarra*et al*., (2013)**
Hymenoptera		Chalcididae	*Proconura sp.*	P	Iraq	**Al-Gerrawy*et al*., (2013)**
Hymenoptera		Pteromalidae	*Pteromalussemotus (Walker, 1834)*	L-P	Spain	**Gabarra*et al*., (2013)**
Hymenoptera		Pteromalidae	*Halticopteraaenea*	L	Italy	**Giorgini*et al*., (2012)**

Table (3): Predator species of *Tutaabsoluta* recorded in literature

Order	Super family	Family	Scientific Name	Stage Host	Country	Outhers
Heteroptera	Miroidea	Miridae	*Nesidiocoristenuis*(Reuter)	E-L	Greece	**Perdikis*et al.*, (2016)**
Heteroptera	Miroidea	Miridae	*Macrolophus caliginosus*	E-L	Algeria	**Mahdi *et al.*, (2011)**

E= Egg L= Larvae P= Pupa

III- MATERIAL AND METHODS

Biological studies

1. **The developmental parameters of tomato leaf miner pest *Tuta absoluta* as explained by thermal accumulated units:**

1.1.Experimental design

This work was carried out at the ecological studies laboratory under controlled conditions (temperature and relative humidity). Four incubators were used to provide constant temperatures of 20, 24, 28 and 32ºC. All stages (from egg to adult) were kept under the constant temperature and 60-70% R.H. to determine the developmental rate and all biological aspects of each stage.

1.1.1. Egg stage

Eggs were collected from the breeding cages. The collected eggs were transferred to glass vials (2.0×7.5 cm), subsequently the incubation took place under the required combination of temperature and relative humidity. Five replicates of 20eggs/glass were used for each of the situation to be tested. Observations were recorded daily to determine the hatchability, the incubation period and embryo developmental rates.

1.1.2. Larval stage

To study the larval development of *T. absoluta*, 100 newly hatched larvae were reared on artificial diet divided into five replicates, larvae were reared in 5 glass tube (7.5 × 2.5 cm) which covered with absorbent cotton to prevent insects escaping and to allow ventilation (20 larvae/replicate). Daily observations were recorded to count the pupated larvae and calculate the percentage of pupation. Larval developmental rate and duration was recorded.

1.1.3. Pupal stage

New formed pupae were collected on the same day of pupation and placed individually, in a glass tube (2.0 × 7.5cm) five replicates were used (20 pupa/rep.) and plugged tightly with a piece of cotton, and observed daily till adult emergence.

1.1.4. Adult stage

Ten of newly emerged moths were sexed(female abdomen is width and male abdomen is narrow, Fig.1) and transferred on the same day of emergence to a glass mating-cage and also kept in the same conditions of temperature and %R.H. Five replicates were separated, each has 5 pairs of adult(5♀ + 5♂) glass cages were placed at the same tested temperature. Daily observations were recorded to calculate the adult longevity. Deposited eggs were collected from fresh leaflet and counted. Collected eggs were incubated at the same conditions in order to calculate the fecundity and fertility.

Fig. (1): *Tuta absoluta* adult (♀ left + ♂ right)

1.2.Rearing technique

The newly hatched larvae of *Tuta absoluta* were reared on artificial diet which mentioned by **(Mihsfeldt and Parra, 1999)**at three constant temperatures (20, 24 and 28ºC) and 60-70% R.H.

Table (4): Artificial diet components of *T. absoluta*

Ingredient	amount
White bean	75.0 g
Wheat germ	60.0 g
Soybean flour	30.0 g
Casein	37.5 g
Yeast	37.5 g
Ascorbic acid	3.6 g
Sorbic acid	1.8 g
Methyl- p- hydroxybenzoate	3.0 g
Tetracycline	113.0 mg
Formadehyde	3.6 mL
Vitaminic mixture	9.0 mL
Agar	23.0 g

* Add tomato leaves powder (5%) Modified from **Greene *et al.*, (1976).**

1.3. Development of different stages at four constant temperatures for the tested insect *Tuta absoluta*:

Effects of three different constant temperatures 20, 24 and 28ºC were tested on the different stages of insects. The fluctuations at each temperature were approximately ±1ºC.

1.3.1. Linear regression method:

The theoretical development threshold values were determined according to the following:

1- The points obtained when the time (t) in days is plotted against temperature (T) in degree centigrade so that the distribution of these points indicates the course of temperature time curve. The relationship is hyperbolic as commonly observed in many insect species **(Bean, 1961 and Hafez, 1961)**.
2- The point when the reciprocal for time (1/t) in days plotted against temperature (T) in degree centigrade, each of the reciprocals is multiplied by 100, so that the values on the ordinate (100/Y) represent the rate of average percentage development made by the stage per day, at the given temperature. Therefore, the distribution of the points indicates the course of temperature velocity curve, **(Davidson, 1944).** The values of the average percentage of development in one day which are presented within an effective normal zone of development are fitted to straight line by method of least square (Regression line). Theoretically, the point which the velocity line crosses the temperature axis is the threshold of development in degree centigrade (±ºC).

Thermal units required for complete development of each stage was determined according to the equation of thermal summation **(Blunk, 1923&Kajanshikov, 1946).**

$$K = y\,(T - t_0)$$

Where y= Duration of a given developmental stage

T= Prevailed temperature – K = Thermal units (degree-days)

t_0= Temperature threshold of development, in degree centigrade.

2. Life table parameters of *Tuta absoluta*

Life table was constructed according to (**Birch, 1984**) based on the data obtained from the effects of the three constant temperatures and under laboratory conditions as follows:

1) Insect numbers in different developmental stages (x).
2) Age specific and survival rates (lx).
3) Age specific fecundity (mx) within a generation (No. of eggs/female).
4) Apparent mortality percentage (A.M. %).

A.M. % = $\underline{dx_1}$ X 100, $\underline{dx_2}$ X 100, $\underline{dx_3}$X 100, ……….……etc.lx_1 $lx_2$$lx_3$

5) Real mortality percentage (R.M. %).

R.M. % = $\underline{dx_1}$ X 100, $\underline{dx_2}$ X 100, $\underline{dx_3}$X 100,...……….etc.lx_1 $lx_1$$lx_1$

2.1. Construction of life table

Life table for age specific survival (lx), number of dead individual (dx) during the age interval (x), rate of mortality (qx) during the age class (x to x+1) and for age specific fecundity (mx) were estimated. Symbols, definitions and formulae used to calculate these parameters were summarized in Table (4).

Table (5): Definition and formulae of life table parameters

Symbol	Definition	Formula
X	Age (in days)	
l_x	Age specific survival rates	
m_x	Female fecundity	
$R_\circ$	Net reproductive rate	$R_\circ = \sum lx*mx$
Gt	Generation time	$Gt = (\sum lx*mx*x) / R_o$
r_m	Intrinsic rate of increase	$r_m = \log e^{R_\circ} / Gt$
λ	Finite rates of increase	$\lambda = e^{rm}$
Dt	Population double time	$Dt = (\log e^2)/r_m$

Ecological studies

3. Susceptibility of certain tomato genotypes to the infestation by *Tutaabsoluta*

3.1. Field experiment

The experiment was carried out in the farm of Faculty of Agriculture at Shoubra Elkheima, Qualiobya Governorate. Seedlings obtained from a nursery in Dokki, Giza governorate. Six weeks after sowing date, seedlings of tomato cultivars were cultivated on 16thApril during two successive seasons 2012 & 2013 in pots in a randomized completed block design. This experiment contained eight tomato cultivars namely,Red sun, Hybrid Super strain, Castle rock ,Riogrande, Baladi,Nemaguard, Super set, Hybrid Bito 86. Each cultivar was replicated five times and each replicate contained eight pots (40 pots / cultivar) and each pot contains three seedlings i.e. the experiment contained on 320 pots. The experimental plot received the normal agricultural practices of mechanical weed control, irrigation and fertilizers and was kept free from any pesticide applications.

One week after cultivation, weekly randomized samples of 250 leaflets (10 leaflets x 5 plants x 5 replicates) for each cultivar were taken early in the morning during 10 weeks. Leaflets were kept in tightly closed paper bags and transferred to the laboratory. The pest mine was detected and counted by aid of a stereomicroscope. The average mean of mines were estimated per 10 leaflets in each cultivars. Statistical analysis procedures included the simple correlation coefficient and the regression coefficient. All calculations were carried out using **SAS program (1988).**

3.2. Effect of different leaf chemical components on rate infestation by *Tutaabsoluta*

The aim of this study to determine certain phytochemical componentsin dry leaves of the same previously eight tomato cultivarsto explain relationship between infestation by *T.absoluta* and leaf components of the tested cultivars during the plant growth period. Leaf samples were collected during the vegetative stage.

Plant sample preparation:

The plant samples (weighing 0.1-0.4 g) were weighed and stored at -20ºc, and then processed as described in **Ni *et al.*,(2001).**

The analysis of leaf samples were conducted in Department of Physiological, Plant Protection Institute, Agricultural Research Center. Statistical analysis was conducted by using **SAS Program (1988)**. F test used to evaluate the significant differences between treatments and mean separation was conducted using L.S.D. test to arrange the tested cultivars in groups according to their susceptibility to the infestation of the studied pests. The simple correlation was also used.

3.2.1. Nitrogen determination

The nitrogen in protein is converted to ammonium sulphate by H_2SO_4 during digestion. This salt, on steam-distillation, liberates ammonia which is collected in boric acid solution and titerated against standard acid. **Sadasivam and Manickam(1991**).

Since 1 ml of 0.1N acid is equivalent to 1.4 mg N, calculation is made to arrive at nitrogen content of the sample.

Procedure:

a- Weight 100 mg of the sample and transfer to a 30 ml digestion flask.
b- Add 1.9 g potassium sulphate and 80mg mercuric oxide and 2 ml conc. H_2SO_4 to the digestion flask.
c- Add boiling chips and digest the sample till the solution becomes colorless.
d- After cooling the digest, dilute it with a small quantity of distilled ammonia-free water and transfer to the distillation apparatus.
e- Place a 100 ml conical flask containing 5 ml of boric acid solution with a few drops of mixed indicator.
f- Add 10 ml of sodium hydroxide –sodium thiosulphate solution (Dissolve 600 g NaOH and 50 g $Na_2S_2O_3$.5H2O in1L. distilled water) to the test solution in the apparatus.
g- Distill and collect the ammonia on boric acid.
h- Rinse the tip of the condenser, and titrate the solution against the standard acid until the first appearance of violet color.

i- Run a reagent blank with an equal volume of distillied water and substract the titration volume from that of sample titre volume.

3.2.2. Inorganic Phosphorus (P) determination

Inorganic phosphate (po_4) was determined as described by **Rockstein and Herron (1951).**The phosphate ion was detected using acommercial kit of Quimicaclinicaapplicada S.A. (Spain). P reacts with molybdate to produce phosphor-molybdate, which is finally reduced to amolybdenum blue which is photometrically measured at 650 nm. Zero adjustment was against reagent blank, results obtained after comparison with a reference standard (conc. 4 mg %).

3.2.3. K^+ determination

Ion measurements were made on a radiometer FLM3 flame photometer as described by **Amin and El-Halafawy (2002).**The standard solution contained sodium chloride (14±1.4 mmol/L) and potassium chloride (5±0.5mmol/L) stored at aroom temperature (25ºC). Zero adjustment was against blank prepared by adding 5 ml of concentrated lithium chloride (300±5mmol/L) to 500 ml of distilled water.

3.2.4. Free amino acids determination

Total amino acids were colorimetrically assayed by ninhydrin reagent according to the method described by **Lee and Takabashi (1966).**The reaction mixture consists of 1 ml sample and 1.9 ml ninhydrin-citrate buffer-glycerol mixture that consists of 0.5 ml of 1% ninhydrin solution in 0.5 M citrate buffer (PH5.5); 0.2 ml of 0.5 M citrate buffer (PH5.5) and 1.2 ml glycerol. The mixture was heated in aboiling water bath 10 min and cooled in a tap water bath. The developed color was read at 570 nm. The aminc acids were expressed as ug alanine per gm body weight.

3.2.5. Total proteins

Extraction was carried out with buffers used for enzyme assay.Weight of 500 mg of the plant sample was grounded well with a pestle and mortar in 5 ml of 0.01 Mg phosphate buffer (pH 7), then centrifuged and used the supernatant for protein estimation. Total proteins were determined by the method of **Bradford (1976).**

Protein reagent was prepared by dissolving 100mg of Coomassie Brilliant blue G-250 in 50 ml 95% ethanol. To this solution 100 ml 85% (W/V) phosphoric acid were added. The resulting solution was diluted to a final volume of 1 liter.

Sample solution (50µl) or for preparation ofstandard curve 50 µl of serial concentrations containing 10 to 100µg bovine serum albumin were pipetted into test tubes. The volume in the test tube was aoteprdjusted to 1 ml with phosphate buffer (0.1M, pH 6.6). Five millimeters of protein reagent were added to test tube and the contents were mixed either by inverion or vortexing. The absorbance at 595 nm was prepared from 1 ml of phosphate buffer and 5 ml protein.

3.2.6. Determination of total carbohydrates

Total carbohydrates were estimated in acid extract of plant seedlings by the phenol-sulphuric acid reaction of **Dubois *et al.,* (1956)**.

Total carbohydrates were extracted from the plant and prepared for assay according to **Crompton and Birt (1967).**Weight of 100 mg of the plant sample was added into a boiling tube then hydrolyzed by keeping it in a boiling water bath for three hours after adding 10 ml of 2.5 N HCL and cooling at room temperature. The samples were neutralized it with sodium carbonate until effervescence, Centrifuge and the supernatant were used for analysis.

Seedlings (5-10 were homogenized in 0.3N HClO4 (5ml) at 0ºC for 1 min. The homogenate was kept in ice for further 10 min. Insoluble matter eas removed by centrifugation for 3 min. at 2000 r.p.m. and washed twice in ice-cold HClO4 (5ml) by redispertion and centrifugation. The three supernatant combined into acid extract.

Hundred microliters of the acid extract were added into a colorimetric tube to 0.5 ml of phenol (20 percent w/v). Then 5 ml of concentrated sulfuric acid were added rapidly with shaking.

The tubes were allowed to stand 10 min., then they were shaken and placed for 10-20min. in water bath at 25 to 30ºc before readings.

Blanks were prepared by substituting distilled water for the sugar solution. The absorbance of characteristic yellow-orange color is measured at 490 nm against blank. Total carbohydrate is expressed as: µg glucose/gm fresh weight.

3.2.7. Determination of Phenols

3.2.7.1. Extraction procedure

Ten plant leaves from each replicate (3 replicates for each treatment) were washed with Δ H_2O and placed in an oven to dry at 45ºC for 4 days. Then they were grounded in an electric grinder into fine powder. Extraction was performed as described by **Kâhkônen*et al*., (1999).** Grounded plant seedlings (5gm) were extracted with 2×10 ml of 80% aqueous methanol using electric homogenizer for 5 min. Samples were centrifuged (10 min, 3000 r.p.m) and combined extracts were poured into pre-weighed small conical flasks. Methanol was removed under reduced pressure. The solid residue (crude extract) was weight and dissolved in Δ H_2O to a 5 ml volume.

3.2.7.2. Quantification of total phenolics

The amount of total phenolics in extracts was determined by Folin – Ciocateu method as modified by **Singelton and Rossi (1965).**

TheFolin – Ciocateu reagent was prepared by adding 100 gm sodium tungstate, 25 gmphosphomolybdic acid, 100 ml HCL, and 50 ml orhphosphoric acid (85%) to 700 ml deionized water in conical flask. The flask was refluxed for 10 hours, cooled and then 150 gm lithium sulphate were added. Few drops of liquid bromine were added to make the solution yellow in color, then the final volume was completed by deionized water to 1 litre.

Two hundreds microliters of plant extracts were introduced into test tubes; 1 ml of Folin – Ciocateu reagent and 0.8 ml of sodium carbonate (7.5%) were added. The tubes were mixed and allowed to stand for 30 minutes. Absorption at 760 nm was measured against blank containing everything except the sample. Gallic acid standered (5 gm) was used, and the total phenolic content was expressed as mg gallic acid per gm dry weight of the original sample (mg GA/g dw).

3.2.8. Nonspecific esterases

Alpha esterases (α-esterases) and beta esterases (β-esterases) were determined according to **Van Asperen (1962)** using α-naphthyl acetate or β-naphthyl acetate as substrate, respectively.

The reaction mixture consisted of 5ml substrate solution (3× 10-4M α- or β- naphthyl acetate, 1% acetone and 0.1M phosphate buffer, pH 7) and 20 µl of larval homogenate.

The mixture was incubated for exactly 15 min at 27ºC, then 1 ml of diazoblue color reagent (prepared by mixing 2 parts of 1% diazoblue B and 5 parts of 5% sodium lauryl sulphate) was added. The developed color was read at 600 or 555 nm for α- and β- naphthol produced from hydrolysis of the substrate, respectively.

α- and β- naphthol standard curves were prepared by dissolving 20 mg α- and β- naphthol in 100 ml phosphate buffer, pH7 (stock solution). Ten milliliters of stock solution were diluted up to 100 ml by the buffer. Aliquots of 0.1,0.2,0.4,0.8 and 1.6 ml of diluted solution (equal to 2,4,8,16 and 32 µg naphthol) were pippeted into test tubes and completed to 5 ml by phosphate buffer. One milliliter of diazoblue reagent was added and the developed color was measured as mentioned before.

3.2.9. Quantitative Determination of Peroxidase

Peroxidase activity was determined according to **Vetter*(*1958).** To the sample (200µl), in which the color is to be formed, the following reagents are added:

1 ml of 1% o-phenylenediamine (in 95% ethyl alcohol; fresh every 4 hours) and 1 ml of 0.3% hydrogen peroxide (in distilled water). The reaction is allowed to proceed for 5 minutes at which time it is stopped by adding 2 ml of saturated sodium bisulfite. The reagent blank for each sample is prepared by adding the dye, followed by the sulphite, and then the hydrogen peroxide. The enzyme is inhibited by the sulfite so that it is inactive when the hydrogen peroxide is added.

The starch in the sample and the blank is flocculated by adding 25 ml of 95% ethyl alcohol. The starch suspention must be swirled continuously during addition of alcohol, so that good flocculation occurs.

The samples are then centrifuged at approximately 3000 r.p.m. for 5 minutes.

The clear supernatant is decanted into a colorimeter tube and its absorbance recorded at 430 mμ. The colorimeter is set at 100% transmittance with the corresponding blank for each sample.

The enzyme activity was expressed as the change in absorbancy at 430m(ΔOD_{430})/minute/gm fresh weight.

3.3. Preparation of tissue samples for scanning electron microscope examination

The mean number and mean length of the photographed trichomes were examined by using Scanning Electron Microscope. Samples of leaves were immediately fixed in glutaraldehyde (2.5) for 24 hours at 4° C then washed several times in phosphate buffer (pH 6- 8), then fixed in osmium tetraoxide (1% O_sO_4) for one hour at room temperature **(Millonig, 1961)**.

Sucrose was added to the washing and post fixation solutions to obtain the same osmolality as in the fixation solution. The samples were dehydrated with pathing through ascending concentrations of acetone, then dried until the critical point and, finally, the samples were divided into similar parts as regards surface area and sputter coated with gold. All observations, measurements and photographs were done through a Joel Scanning Electron Microscope (T.33A) at 30 Kv. linked with the SemAfore Software Program atthe Regional Center of Mycology and Biotechnology, Al-Azhar University, Cairo, Egypt.

The mean number and mean length of the photographed trichomes were counted by Compueye and Leaf Area Symptoms Program which made by **(Bakr,2005)**in an area of (0.1 cm^2= 1000 um^2) for each tested cultivars.

3.4. Effect of the interaction between physical factors and cultivars on rate of infestation by *Tuta absoluta*

The seasonal fluctuations of *T. absoluta* in relation to ecological properties involved certain weather factors i.e. the weekly mean of the weather factors, minimum temperature, maximum temperature and mean relative humidity (R.H.%) at the Central Laboratory for Agriculture Climate (CLAC), Agriculture Research Center, Dokki, Giza governorate were tested to clarify their effects on the population dynamics of *T. absoluta* throughout investigated period during 2013.

3.5. Effect of three plant growth regulator on *Tuta absoluta* infestation

The experiment was carried out in the farm of Faculty of Agriculture at Shoubra Elkheima,Qaliubya Governorate. Seedlings which obtained from nursery in Dokki, Giza governorate, were cultivated on 16thApril, 2016 in pots in a randomized completed block design. This experiment contained three tomato cultivars namely, Hybrid Super Strain B, Baladi, and Castle rock. Each cultivar treated with three plant growth regulator namely, Salcylic acid (2g/liter water), Benzyle adenin(0.1g/100ml water) and Kinetin (0.1g/100ml water). In addition fourth group treated with water as control i.e. each cultivar had 12 pots (4 plant growth regulator × 3 cultivars × 3replicates) each pot contained on three plants. In other words, all experiment contains on 36 pots. The experimental plot received the normal agricultural practices of mechanical weed control, irrigation and fertilizers and was kept free from any pesticide applications.

Two week after cultivation, weekly randomized samples of 120 leaflets (10 leaflets x 4treatments x 3cultivars) were taken early in the morning during three weeks. Leaflets were kept in tightly closed paper bags and transferred to the laboratory. The pest mine was detected and counted by aid of a stereomicroscope. To study the effect of plant growth regulators on host plant resistance to infestation by *Tuta absoluta.*The average mean of mines were estimated per 10 leaflets in each cultivars. Statistical analysis procedures included the simple correlation coefficient and the partial regression coefficient. All calculations were carried out using **SAS program (1988).**

4. Seasonal abundance and generations in relation to pheromone trap catches

4.1. Experimental locality

The present study was carried out at Bahada Village besides the Experimental station of the Faculty of Agriculture, Ain Shams University/ Shalakan/Qalyubiya ecosystem. Field trials were conducted throughout growing season on tomato 2015/2016. An area of about one feddan was sown with tomato. Delta pheromone traps are nearly pyramids shaped (18cm high) and made of plastic paper with two triangular openings at the two opposite ends to permit the release of the pheromones odor and the entrance of attracted methods (Fig.2). The inside surface of the trap was covered with an adhesive substance. The pheromone dispenser was hooked inside the trap in the centre at the same level of the two opposite openings. The sex pheromone traps were baited with the synthetic pheromone of *Tuta absoluta* formulated in polyethylene vials. Pheromone capsules were changed every 15 days. Two sex pheromone traps were used per feddan for *T. absoluta*, the sheets of moth were collected and recorded every week.

Fig. (2): Phermone trap

The pheromone which used obtained by **Svatos*et al*., (1996)** who indicated that 10:1 mixture of synthetic (3E,8Z,11Z)-3,8,11-tetradecatrien-1-yl acetate and (3E,8Z)-3,8-tetradecadien-1-yl acetate was highly attractive to males of *T. absoluta*. Thus the chemical structure of the mixture was as follow in Fig.3:

Fig. (3): The two components of *Tuta absoluta* female sex pheromone: (**a**) (3E, 8Z, 11Z)-3,8,11-tetradecatrien-1-yl acetate or TDTA and (**b**) (3E, 8Z)-3,8- tetradecadien-1-yl acetate or TDDA

4.2.Predicting the changes in the population dynamics of *Tuta absoluta* based on accumulated heat units

The role of temperature summations attempts to find an index for the heat energy required to complete a given stage or entire life cycle. So, temperature data could be transformed into heat units and serve as a useful tool for studying insect population dynamics and predicting the appearance of *T. absoluta*

4.2.1. Heat unit accumulations

This part of study was carried out to study the relationship between the thermal heat units expressed as day degrees(DD's) and the population dynamics of *T.absoluta* during season, 2015/2016.

Daily maximum and minimum temperatures were obtained and recorded by the Central Laboratory for Agriculture Climate (CLAC), Agriculture Research Center, Dokki, Giza. Degree-days (DD's) were calculated from the daily maximum and minimum temperatures (°C) with developmental threshold value which has been estimated as previously discussed. Hereinafter, the following formula was used for computing the heat units (DD) according to **Richmon*et al.*, (1983):**

$$H=\sum H_i$$

Where H_i= Number of heat units to emergence

$$H_i= (max. + min.)/2-C \qquad \text{if } max.t.>C.<min.t.$$

$$H_i= (max. - min.)^2/2(max.-min.) \qquad \text{if } max.t.>C.>min.t.$$

$$H_i=0 \qquad \text{if } max.t.<C.>min.t.$$

C= Threshold temperature

4.2.2. Using Degree-Days to predict pest activity

4.2.2.1.The averaged method

The averaged method is the easiest method for calculating the number of degree-days. Simply add the daily maximum temperatures and divide the sum by two to get the averaged temperature for the day. Then subtract the base temperature from the averaged temperature as the next formula:

Degree-days={(max. temp.+min. temp.)/2}-base temp.

If the maximum temperature for the day never rises above the base temperature, then no development occurs, and zero degree-days accumulate.

5. Natural enemies associated with tomato leaf miner *Tuta absoluta* and Biological control

5.1. Survey of parasitoids and predators

Samples of tomato leaves infested with *T. absoluta* were collected from fields at Qualiobya and Giza Governorates during 2012. Leaves were placed in rearing boxes covered with muslin cloth and secured with rubber bands. Emerging parasitoids were collected and kept in ethanol 70%. Parasitoids were identified in Department of Entomology, Faculty of Science, Cairo University. However, predators associated with *Tuta absoluta* were easily recognized and identified.

5.2. Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*

The experiment was carried out in the farm of Faculty of Agriculture at Shoubra Elkheima, Qualiubya Governorate. Seedlings of tomato cultivars were cultivated on 16thApril, 2013 in pots in a randomized completed block design. This experiment contained eight tomato cultivars namely, Hybrid Super Strain B, Super set, Hybrid Bito86, Nemaguard, Riogrande, Baladi, Red sun and Castle Rock. Each cultivar was replicated five times and each replicate contained eight pots (40pots/cultivar). The experimental plot received the normal agricultural practices of mechanical weed control, irrigation and fertilizers and was kept free from any pesticide applications.

One week after cultivation, weekly randomized samples of 250 leaflets (10 leaflets x 5 plants x 5 replicates) for each cultivar were taken early in the morning during 10 weeks. Leaflets were kept in tightly closed paper bags and transferred to the laboratory. The pest mine was detected and counted by aid of a stereomicroscope. The average mean of mines of *Tuta absoluta* and *Nesidiocoris tenuis* per 10 leaflets in each cultivars were estimated. Statistical analysis procedures included the simple correlation coefficient and the regression coefficient. All calculations were carried out using **SAS program (1988).**

5.3. Predatory efficiency of *Nesidiocoris tenuis* on *Tuta absoluta* eggs

5.3.1. Prey culture:

Tomato leaves infested with *T. absoluta* were collected from fields of Faculty of Agriculture, Ain Shams University at Shoubra Elkheima, Qualiobya Governorate. A laboratory stock of the prey was reared in wooden boxes measured (30×20 cm) with sides made of cloth screen, the top was made of glass to observe emerging insects as Fig. (3). Fresh tomato plants were transferred daily to boxes to allow *T. absoluta* laying its eggs on lower surfaces of leaves.

5.3.2. Predator culture:

The original culture of *N. tenuis* adults was collected from tomato fields infested with *T .absoluta*. *N. tenuis* adults were kept in rearing glass jars (20×10 cm) and daily provided with adequate numbers of *T. absoluta* eggs. Glass jars were then covered with muslin cloth tied with rubber bands to prevent insects from escaping and to allow ventilation. Small branches of tomato plants were provided daily as oviposition sites for the predator. Leaves bearing deposited eggs of *N. tenuis* were cut, transferred to clean jars and maintained until hatching under laboratory conditions. Newly hatched nymphs of *N. tenuis* were daily provided with adequate numbers of prey eggs until adult emergence.

5.3.3. The experiment

Twenty prey eggs were daily placed on a fresh leaf of tomato provided with a piece of absorbent cotton to avoid drying the eggs and were introduced into a glass tube(7×2.5cm) containing one nymph of *N. tenuis*.

Ten nymphs (replicates) of the predator were maintained to evaluate their predatory efficiency. Number of eggs consumed by *Nesidiocoris tenuis* nymph was recorded daily and replaced with other freshly deposited eggs. Durations of five nymphal instars of the predator were also estimated. This experiment was examined daily until adult emergence. The previous technique was also conducted on 10adults of *N. tenuis* until dead.

Fig. (4): Rearing box

IV- RESULTS AND DISCUSSION

Biological studies

1. The developmental parameters of tomato leaf miner pest *Tuta absoluta* as explained by thermal accumulated units

The study aimed to estimate the zero development temperature thresholds and the average of thermal units were required for completion of one generation of pests. These values were estimated through the laboratory work under constant conditions. The temperature is a limiting factor in development of the populations. Limitation of developmental requirements of this pest represents a trial to study the biological effects of constant temperatures on the developmental stages of *T. absoluta*.

1.1. Egg stage

1.1.1. Incubation period

Data in Table (6) indicated that required time for completion the embryonic development (incubation period) which decreased as the temperatures increased. The mean of incubation periods were 6.8, 5.0, 4.0 and 3.5 days at 20, 24, 28 and 32ºC. According to the analysis of variance it yielded significant "F" value in the incubation periods at the different treatments of 20, 24, 28 and 32ºC., whereas "F" value =96.8 sig. at 0.001 and L.S.D.=0.44day. The incubation period varied considerably to temperature. The longest mean incubation period i.e. 6.8 days was occurred at 20°C. On the contrary, the shortest i.e. 3.0 day was occurred at 32°C, while the other incubation periods come intermediate between them.

These results were in harmony with the obtained by **Pires and Marques (2002)** who recorded that the incubation period of *T. absoluta* egg was 4.6±0.05 days at (24.5 -31.2ºC)&(45-100 R.H.%) and **Erdogan and Babaroglu (2014)** in Turkey, who found that incubation period of *T. absoluta* egg was 4.1 days at 25±1ºC and 65±5 R.H. % under long daylight (16L: 8D).

Table (6): Mean incubation period (in days) of *Tuta absoluta* at four constant temperatures &60-70 % R.H.

Stage / Temp.	Egg			
	Incubation period(days) (mean ±s.e.)& Range	Hatchability %	Rate of development (1/t × 100)	Thermal units DD's
20	6.8±0.18 d (7.4-6.4)	72±0.39 c	14.7	88.4
24	5.0±0.0c (5.0-5.0)	97±0.39 a	20.0	85.0
28	4.0±0.0b (4.0-4.0)	89±0.38 b	25.0	84.0
32	3.5±0.0 a (3.0-3.4)	95±0.32 a	28.57	87.5
F. value	96.8 ***	36.8***		
L.S.D.(day)	0.44	1.12		

1.1.2. Percentage of hatchability

Table (6) and Fig.(5), demonstrated that the percentage of hatchability was 72%, 97%, 89% and 95% under 20, 24, 28 and 32ºC., respectively. Statistically, there are significant differences between the value of hatchability percent recorded at 20 and 24ºC, whereas there are no significant differences between the recorded values at 28 and 32ºC. It appears that favorable temperature for the egg hatching ranged from (24 to 32ºC).**Miranda *et al*., (1998)** found that during the egg stage, the mortality was 58.7%, mainly due to egg non-viability. **Cuthbertson *et al.*, (2013)** in UK, who mentioned that only 17% of *T. absoluta* eggs hatched at 10°C but no larvae developed through to adult moths. No eggs hatched when maintained at 7°C.

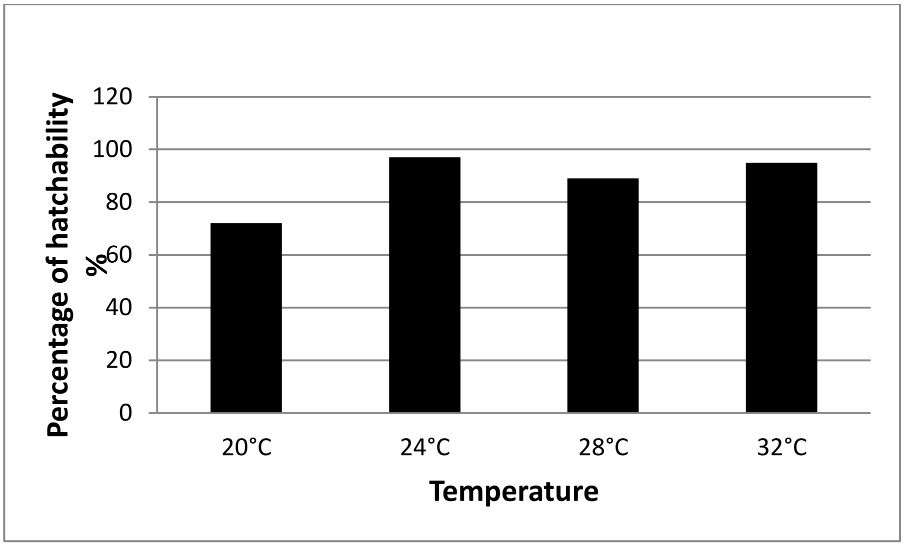


Fig. (5): Effect of four constant temperatures on the hatchability of *T. absoluta* eggs

1.1.3. Zero of development for egg stage

Data obtained for egg incubation period at the four constant temperatures 20, 24, 28 and 32°C were used to estimate zero of development for egg stage. Results obtained are graphically illustrated in Fig.6 and Table 5 and showed that the value of zero development for egg stage was 7.0°C.

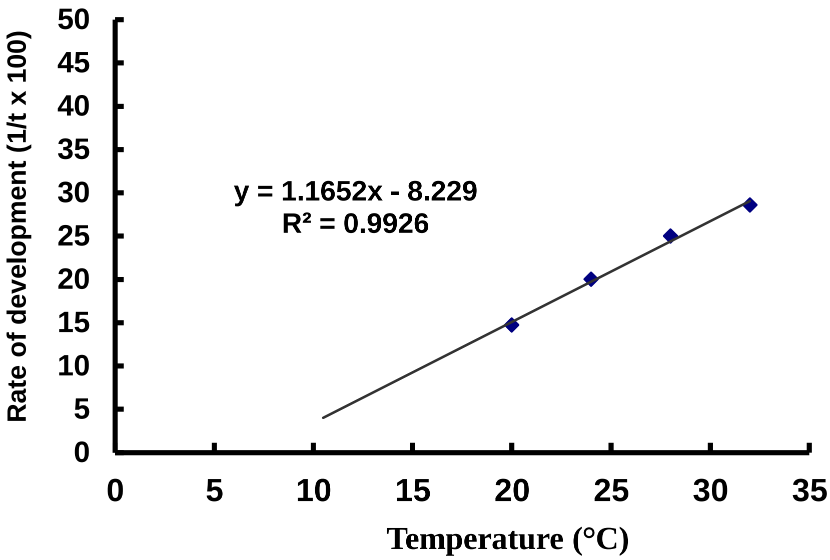


Fig. (6): Effect of three constant temperature on mean durations of egg stage.

1.1.4. Rate of development and thermal units of egg stage

Data tabulated in Table (6) showed that the effects of the three constant temperatures on the rate of egg development and thermal constant units (DD's) of egg incubation period of *Tuta absoluta*.

These results revealed that both of rates of development and thermal constant units for egg stage were obviously affected by the prevailing temperatures. Rate of development was increased gradually as the temperature increased from 20 to 32°C. The rates of development were 14.7, 20, 25 and 28.57 at 20, 24, 28 and 32˚C, respectively. Also, results revealed that thermal constant units required for development of egg stage of *T. absoluta* were greatly affected by prevailed temperature. The highest thermal units recorded was occurred at 20°C (88.4 DD's);while at 32°C (87.5DD's) &

at 24°C (85.0DD's) but the lowest thermal units recorded was occurred at 28°C being 84.0 DD's .

From these results it could be stated that 32°C seemed to be the optimum temperature for egg stage. At this degree, there are the highest percentage of hatchability and shortest incubation period.

As shown in Table (6) these results indicated that the rates of development were lower at 20ºC than the other degrees. The average of total thermal units were 86.2 DD's as determined by the thermal summation equation K= y (T- 7.0).

Also the average of thermal units in degree-days required for the completion of development of incubation period for the pest. They were 88.4, 85.0, 84.0 and 87.5 DDº at 20, 24, 28 and 32 ºC., respectively (Table 5).**Barrientos *et al*., (1998)** mentioned that the lower threshold temperature for *Tuta absoluta* egg was 6.9ºC., while the thermal constant for the same stage was 103.8 DD.

1.2. Larval stage

1.2.1. Duration of larval stage

Table (7) shown that the mean larval durations was recorded under three constant temperature only 20, 24 and 28 ºC, where it was 30.9, 21.9 and 17.6 days respectively. Statistically, there are significant differences between values of the mean durations under the tested constant temperature. Obviously the developmental rates increased with the increasing of temperatures.**Pires and Marques (2002)** mentioned that the larval period of *T. absoluta* was 11.9±0.15 days at 24.5 -31.2ºC & 45-100 R.H. %. **Erdogan**

and Babaroglu (2014) mentioned that total period of larvae instars of *Tuta absoluta* was 10.97 days on25ºC.

Table (7): Mean duration of *Tuta absoluta* larvae at three constant temperatures and 60-70 % R.H.

Stage / Temp.	Larvae		
	Larval duration(days) (mean ±s.e.)& Range	Rate of development (1/t×100)	Thermal units DD's
20	30.9± 0.9a (28.3-34.3)	3.2	309
24	21.9±0.3b (21.0-22.6)	4.6	306.6
28	17.6±0.7c (15.7-19.7)	5.7	316.8
F value **L.S.D.(day)**	83.29*** 2.29		

1.2.2. Zero of development of larval stage:

Data obtained from Table 6 duration of larval stage atthe three constant temperatures were used to estimate zero of development for the larval stage. Results obtained are graphically illustrated in Fig.(7) whereas, this value was 10°C. This result was disagree with **Barrientos *et al.*, (1998)** found that the lower threshold temperature for larval development of *T. absoluta* was 7.6ºC.

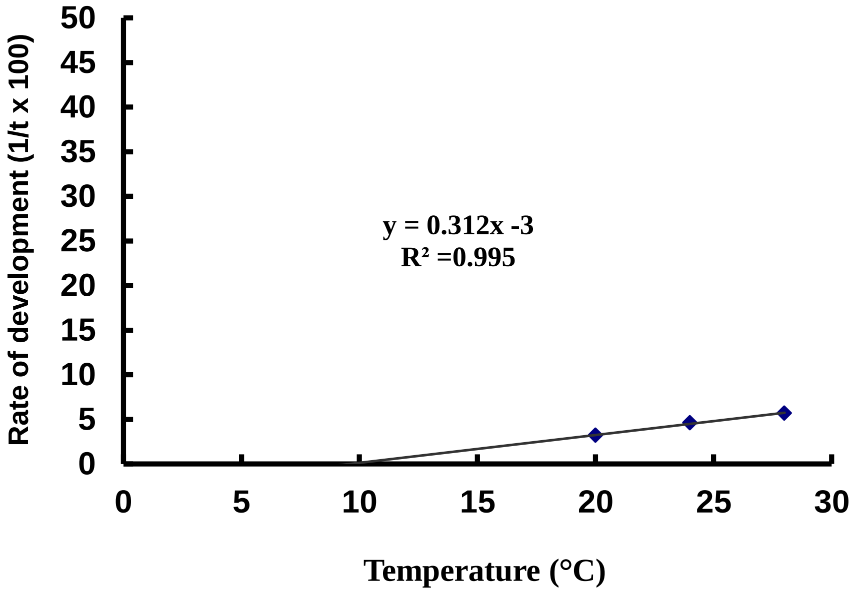


Fig. (7): Effect of three constant temperature on mean durations of *Tuta absoluta* larval stage.

1.2.3. Rate of development and thermal constant units for larval stage

Results in Table (7) summarized the effect of the three constant temperatures on the rate of development and thermal constant units of larval duration of *Tuta absoluta*.

These results revealed that both rate of development and thermal constant units for larval stage were obviously affected by prevailing temperatures. Rate of development larva was increased gradually as the temperature increased from 20 to 28°C. The lowest rate was occurred at 20°C (3.2) followed by 24°C (4.6); while the highest rate was occurred at 28°C (5.7). Also, results revealed that thermal constant units required for development of larval stage of *T. absoluta* were greatly affected by changes of prevailing temperature. The highest needed thermal unit was occurred at

28°C being 316.8 DD's ; while the lowest thermal units needed was occurred at 24°C being 306.6 DD's. From these results it could be stated that 28˚C seemed to be the most favorable for rearing larval stage. This result was disagree with **Barrientos *et al.*, (1998)**who found the thermal constant for the larval stage of *Tuta absoluta* was 238.5 DD.

1.2.4. Percentage of mortality of larval stage

Data in Table8& Fig. 8 showed the effect of the three tested temperatures on percentage of mortalities in the larval stage with results of statistical analysis.

These results revealed that temperature had highly significant effect on the percentage of mortalities of larval stage. ("F" value = 770.7 sig. at 0.001). The highest percentage of mortality was occurred at 32˚C.being 100%,followed by those at 24 & 28˚C being 74 %. While the lowest percentage of mortality was occurred at 20˚C being 52 %.

It's clear that 32˚C is a fetal high degree temperature to larval stage of *T. absoluta* especially for first instars whereas, all 1^{st} instars dead. **Cuthbertson *et al.*, (2013)** in UK, recorded at 19°C survival of *T. absoluta* from egg to adult was 52%. **Miranda *et al.*, (1998)** who found that the mortality of the larval stage of *T. absoluta* was 79.8%.

From these results it could be stated that 20˚C seemed to be the most favorable temperature for survival % where the lowest percentage of mortality (52%) was occurred at 20˚C.

Table (8): Effect of four constant temperatures on survival and mortality percentage of larval stage of *Tuta absoluta.*

Temp. (°C)	Mortality of larval stage %	Survival %
20	52 c	48 a
24	74 b	36b
28	74 b	36 b
32	100 a	0.0 c
F. value	770.7***	
L.S.D.	2.3	

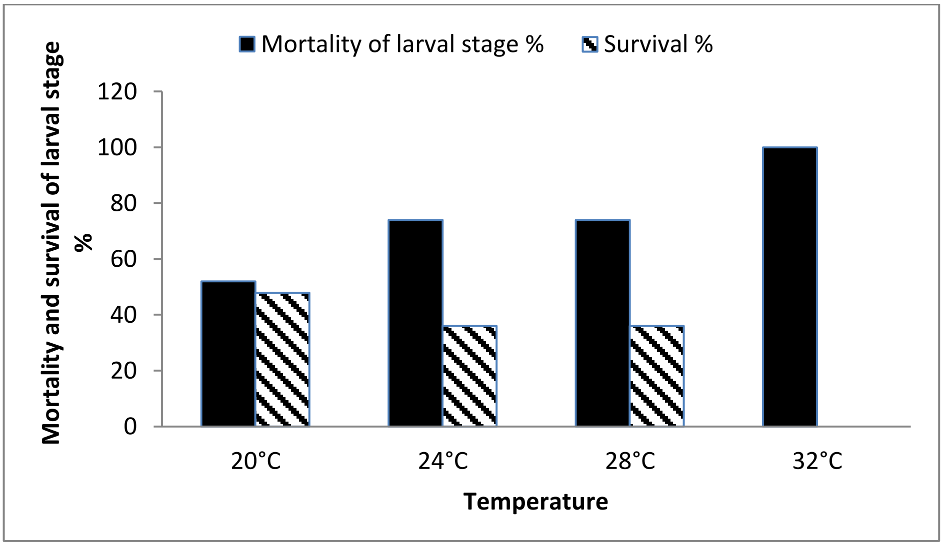


Fig. (8): Effect of four constant temperatures on survival and mortality percentage of larval stage of *Tuta absoluta.*

1.3. Pupal stage

1.3.1. Duration of pupal stage

Table (9) show that the pupal periods decreased as temperatures increased from 20 to 28 ºC. The average durations were 15.8, 9.5 and 8.1 days at 20, 24 and 28 ºC., respectively. When the analysis of variance was worked out, it yielded significant differences "F" value=179.9 sig. at 0.001 and L.S.D.=0.9 days. **Pires and Marques (2002)** recorded that the pupal period of *Tuta absoluta* was 6.5±0.33 days at 24.5 -31.2ºC & 45-100 R.H. %, and **Erdogan and Babaroglu (2014)** found that the period of pupae of *T. absoluta* development was 9.53 days on 25ºC

Table (9): Mean duration of *Tuta absoluta* pupae under three constant temperatures and 60-70 % R.H.

Stage / Temp.(º C)	Pupae		
	Pupal duration(days) (mean ±s.e.) &Range	Rate of development (1/t×100)	Thermal units DD's
20	15.8±0.3 a (15.0-17.0)	6.3	138.6
24	9.5±0.1 b (9.2-9.8)	10.5	121.5
28	8.1±0.4 c (7.7-9)	12.3	136.6
F value	179.9***		
L.S.D.(day)	0.9		

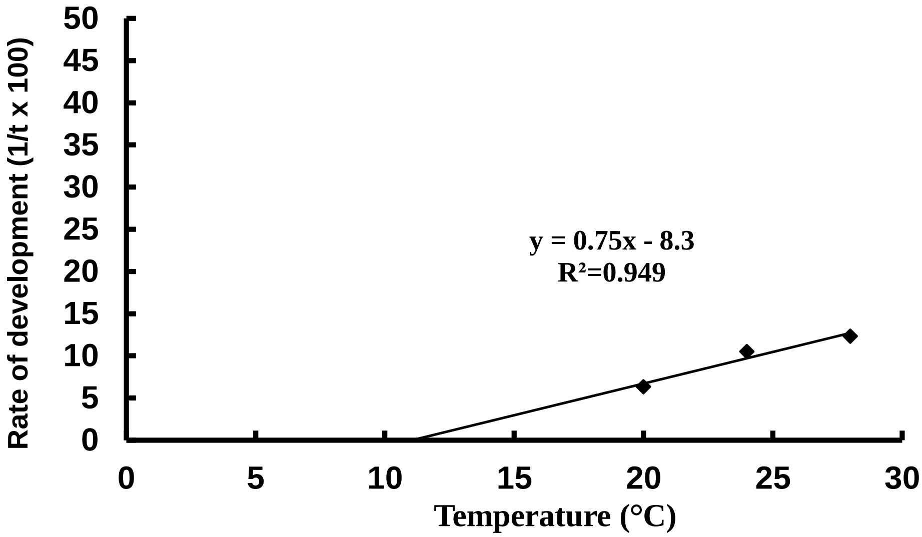


Fig. (9): Effect of three constant temperature on mean durations of pupal stage.

1.3.2. Zero of development of pupal stage

Data obtained for mean duration of the pupal stage at three constant temperatures was used to estimate zero of development for pupal stage. Results obtained are graphically illustrated in Fig.9. The development zero for pupal stage was 11.2°C.**Barrientos*et al.*, (1998)**found that the lower threshold temperature of *Tuta absoluta* pupae was 9.2ºC.

1.3.3. Rate of development and thermal constant units for pupal stage

Data in Table 9 summarized the effect of the three constant temperatures on the rate of development and thermal units of pupal durations of *T. absoluta*.

These results revealed that both rate of development and thermal constant units for pupal stage were obviously affected by prevailing temperatures. Rate of development was increased gradually as the temperature increased from 20 to 28°C. The lowest rate was occurred at 20°C (6.3) followed by 24°C (10.5); while the highest rate was occurred at 28°C (12.3). Also, results revealed that thermal constant units required for development of larval stage of *Tuta absoluta* were greatly affected by changes of prevailing temperature. The highest needed thermal unit was occurred at 20°C being 138.6 DD's ; followed by 28°C being 136.6DD's ; while the lowest thermal units needed was occurred at 24°C being 121.5 DD's. **Barrientos *et al.*, (1998)** found that the thermal constant for the pupal stage of *T. absoluta* was 117.3 DD.

1.3.4. Percentage of mortality of pupal stage:

Data in Table (10) & Fig. 10 showed the effect of the three tested temperatures on percentage of mortalities on the pupal stage with results of statistical analysis.

These results revealed that temperature had highly significant effect on the percentage of mortalities of larval stage. ("F" value =91.5). The highest percentage of mortality was occurred at 20˚C being 10.0%,followed by those at 24˚C being 5.0 %. While the lowest percentage of mortality was occurred at 28˚C being 1.0 %.

From these results it could be stated that 28˚C seemed to be the most favorable temperature where the lowest percentage of mortality was occurred throughout the larval stage and this result was disagree with **Miranda *et al.*, (1998)** who found that the mortality of the pupal stage of *T. absoluta* was 0.6%.

Table (10): Effect of three constant temperatures on mortality and survival percentage of pupal stage of *Tuta absoluta*

Temp. (°C)	Mortality of pupal% stage	Survival %
20	10.0 a	90 a
24	5.0 b	95 b
28	1.0 c	99 c
F. value	91.5***	
L.S.D.	1.6	

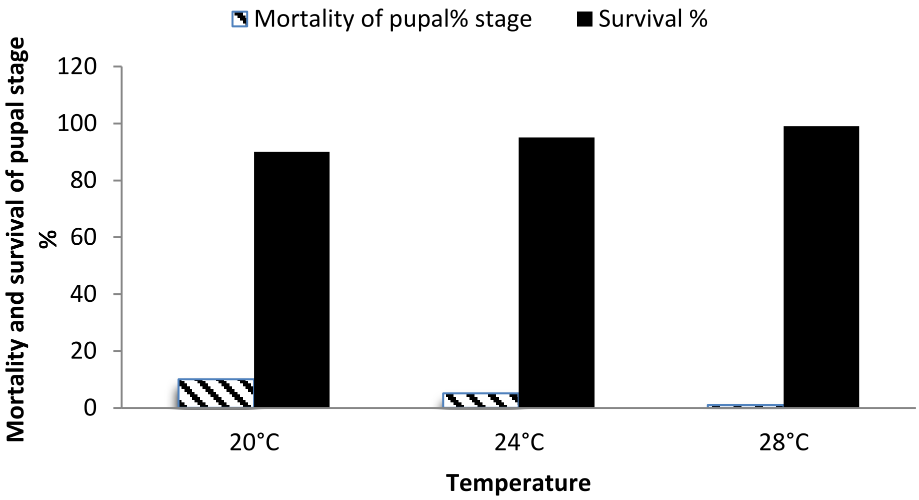


Fig. (10): Effect of three constant temperatures on mortality and survival percentage of pupal stage of *Tuta absoluta*

1.4. Adult stage

1.4.1. Pre-oviposition period

Table (11) showed that, the pre-oviposition periods for the tomato leaf miner, *Tuta absoluta* under different constant temperatures. The time required for maturation of the ovaries and starting egg laying, decreased as the temperature increased, theses duration were recorded 2.6, 2.2 and 1.0days at 20, 24 and 28ºC., respectively. When data analysis statistically, there were significant differences between the value of pre-oviposition period at 20, 24 and 28ºC. "F" value 6.9 sig. at 0.001 & L.S.D.=0.97 days.

The threshold of development was indicated from the data in the same Table, that illustrated graphically by extrapolation Fig. (11), this value was 15ºC, It's noticed that the rising of temperature hurling the rate of development of the female's ovaries of the pest insect. The average thermal units required for development of ovaries at 20, 24 and 28ºC.were 13.0, 19.8 and 13.0 DD's as determined by thermal summation equation k=y (T- 15). **Erdogan and Babaroglu (2014)** found that pre-oviposition period of *T. absoluta* was 1.28 daysat 25±1ºC, relative humidity 65±5% and under long daylight (16L:8D). **Krechemerand Foerster (2015)** in Brazil, mentioned that the pre-oviposition period of *T. absoluta* was longer at 10°C.

Table (11): Mean duration, rate of development and thermal units required for Pre-oviposition period for *Tuta absoluta* at three constant temperatures and 60-70 % R.H.

Stage / Temp.	Pre-ovipositionperiod		
	Pre-oviposition duration(days) (mean ±s.e.)&Range	Rate of development (1/t×100)	Thermal units DD's
20	2.6±0.5 a (1.0-3.0)	38.4	13.0
24	2.2±0.2 a (2.0-3.0)	45.4	19.8
28	1.0±0.0 b (1.0-1.0)	100	13.0
F value **L.S.D.**	6.9*** 0.97		

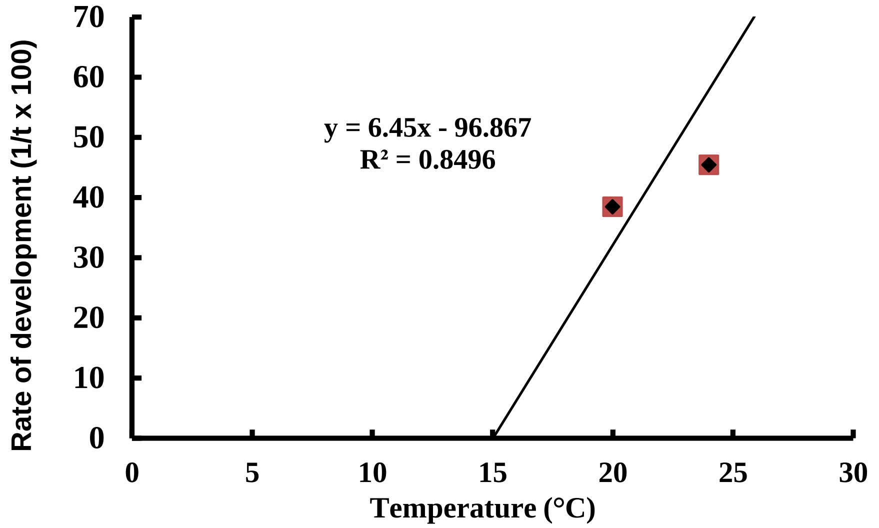


Fig. (11): The regression line of the pre-oviposition period of *Tuta absoluta* at different constant temperatures.

1.4.2. Oviposition period

Oviposition period found to be the longest period followed by pre-oviposition period, while post-oviposition period was the shortest period. Results of statistical analysis in Table (12) showed that temperatures had highly significant effect on oviposition period of *Tuta absoluta* ("F"= 39.0 sig. at 0.001&L.S.D.=0.94). Mean duration of oviposition period was decreased when temperature increased from 20 to 28°C. The longest mean duration was occurred at 20°C being 9.2 days, followed by those reared at 24°C being 6.0 days. While, the shortest mean was 5.8 days occurred at 28°C.The threshold of development was 6ºC as shown in Fig. 12. The average thermal units required for development of ovaries at 20, 24 and 28ºC.were 128.8, 108.0 and 127.6 DD's. Results are closely related to **Erdogan and Babaroglu (2014)** who found that oviposition period of *T. absoluta* was 7.88 daysat 25±1ºC,relative humidity 65±5% and under long daylight (16L:8D), while **Krechemerand Foerster (2015)** in Brazil, mentioned that the oviposition period of *T. absoluta* was similar at all the temperatures tested.

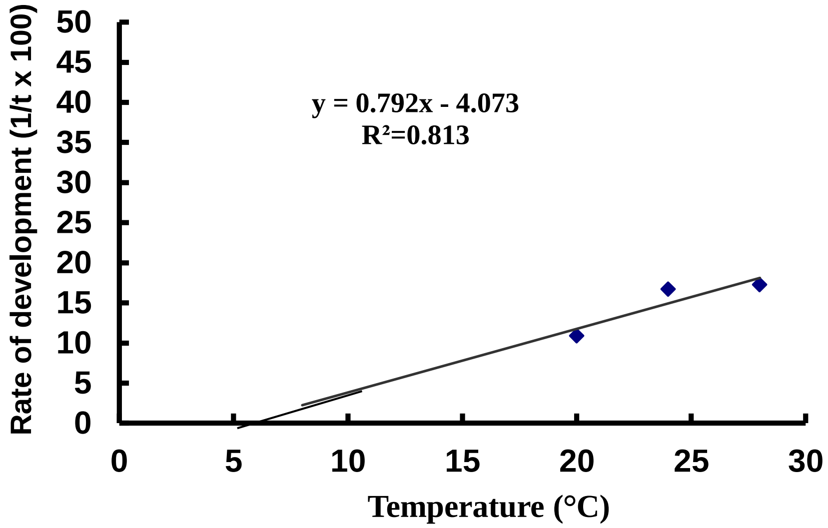


Fig. (12): Effect of three constant temperature on mean durations of *T.absoluta* oviposition period.

1.4.3. Post-oviposition period

Results of statistical analysis in Table (12) showed that temperature had highly significant effect on mean duration of post- oviposition period of *Tuta absoluta* ("F" = 10.8 sig. at 1%)). Mean durations of this period were decreased as temperature increased from 20 to 28°C. The longest mean duration was occurred at 20°C being 3.4 days, followed by those reared at 24°C being 2.6 days. While, the shortest mean was 1.4 days occurred for females reared at 28°C.The threshold of development was 15.2ºC (Fig.13). The average thermal units required for development of ovaries at 20, 24 and 28ºC.were 16.3, 22.9 and 17.9 DD's.

This result disagreed with **Erdogan and Babaroglu (2014)**who found that post-oviposition period of *T. absoluta* was 5.52daysat 25±1ºC,relative humidity 65±5% and under long daylight (16L:8D).

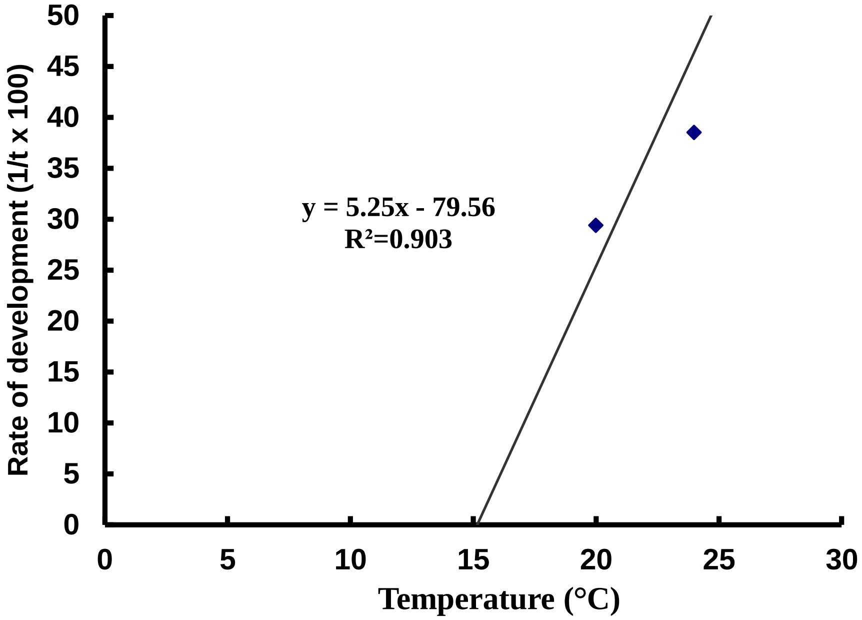


Fig. (13): Effect of three constant temperature on mean durations of post-oviposition period.

Table (12): Mean duration of Oviposition and Post-oviposition periods, Rate of development and Thermal units DD's for *Tuta absoluta* which reared at three constant temperatures and 60-70 % R.H.

Temp. (°C)	Oviposition Period			Post-oviposition		
	Duration(days)(mean ±s.e.)&Range	Rate of development (1/t×100)	Thermal units DD's	Duration(days) (mean ±s.e.)&Range	Rate of development (1/t×100)	Thermal units DD's
20	9.2±0.35 (8.0-10.0) a	10.9	128.8	3.4±0.23 (3.0-4.0) a	29.4	16.3
24	6.0±0.0 (6.0-6.0) b	16.7	108	2.6±0.38 (1.0-3.0) a	38.5	22.9
28	5.8±0.35 (5.0-7.0) b	17.24	127.6	1.4±0.23 (1.0-2.0) b	71.4	17.9
Mean	7			2.5		
F. value	39.0***			10.8**		
L.S.D.(day)	0.94			0.94		

1.5. Longevity

Longevity of male and female are represented by time elapsed between adults emergence from pupae until death. Data obtained about the effect of the three constant temperatures on longevity of both males and females of *Tuta absoluta* are given in Tables (13&14). Results of statistical analysis showed that the three constant temperatures had highly significant effects on means longevity of both sexes ("F" values 64.4 and 52.2 for male and female, respectively).

1.5.1. Female longevity

The female longevity was longer than means longevity of male at the three tested temperatures. These results showed that female means longevity was decreased as temperature increased. Means longevity were 15.6, 11.8 and 8.2 days at 20, 24 and 28°C., respectively.

The threshold of development was indicated by extrapolation Fig.(14) this value was 11.2 ºC.

The average of thermal unit required for adult female were 137.3, 151 and 137.8 degree-days at 20, 24 and 28ºC, which given by the equation: K= y(T- 11.2). This result similar to **Estay (2000)** who found that adult lifespan ranges of *T. absoluta* between 10 and 15 days for females, **Torrest *et al.*, (2001)** which found that female longevity of *T. absoluta* was from 10 and 22 days, but **Krechemer and Foerster (2015)** in Brazil, mentioned that there is no differences in the longevity of females and males of *T. absoluta*. **Mohamed *et al.*,(2015)**in Egypt, mentioned that longevity of either males or females of *T. absoluta* decreased as temperature increased. Adult survival rates were declined gradually to reach0% after 11 days post emergence at 30ºC, 17 days at 25ºC, 23 days at 20ºC, and 34 days at 15ºC.

Table (13): Mean of female longevity of *Tuta absoluta* at three constant temperatures and 60-70 % R.H.

Stage / Temp.	Female longevity		
	Female longevity (mean±s.e.)& Range	**Rate of development (1/t*100)**	**Thermal units DD's**
20	15.6±0.5 (14.0-17.0) a	6.4	137.3
24	11.8±0.4 (9.0-12.0) b	8.5	151
28	8.2±0.4 (7.0-9.0) c	12.2	137.8
F. value **L.S.D.(day)**	52.16*** 1.5		

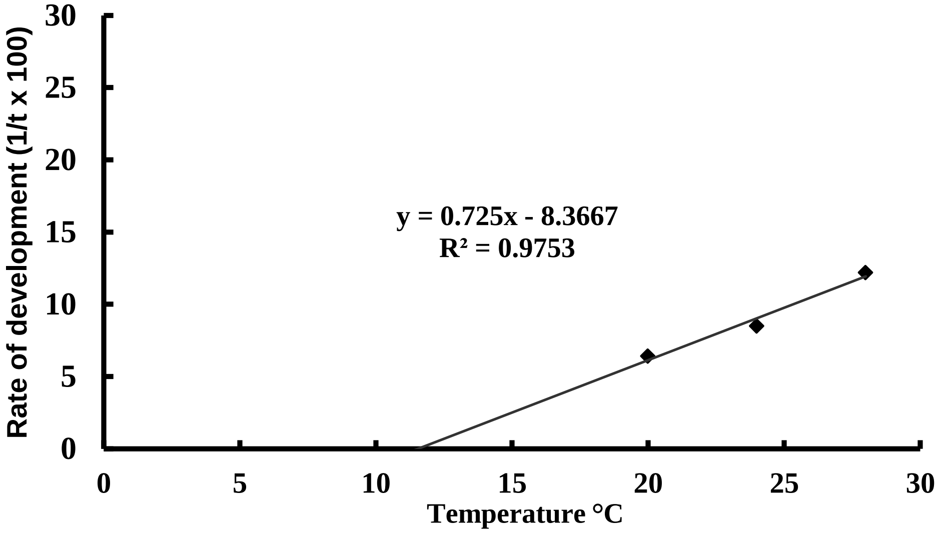


Fig.(14): The regression line of female longevity of *Tuta absoluta* at three constant temperatures.

1.5.2. Male longevity

These results showed that male means longevity was decreased as temperature increased. Means longevity were 12.8, 10.2 and 7.4 days, at 20, 24 and 28°C, respectively.

The threshold of development was indicated by extrapolation figure (15) this value was 9.8ºC. The average of thermal unit needed for adult male were 130.6 , 144.8 and 134.7 degree-days at 20, 24 and 28ºC. **Estay (2000)** mentioned that adult lifespan of *Tuta absoluta* ranges 6–7 days for males.

Table (14): Mean of male longevity of *Tuta absoluta* at three constant temperatures and 60-70 % R.H.

Stage / Temp.	Male longevity		
	Male longevity (mean±s.e.)&Range	Rate of development (1/t*100)	Thermal units DD's
20	12.8±0.4 (12.0-16.0) a	7.8	130.6
24	10.2±0.4 (12.0-14.0) b	9.8	144.8
28	7.4±0.3 (7.0-11.0) c	13.5	134.7
F.value L.S.D.(day)	64.4*** 1.04		

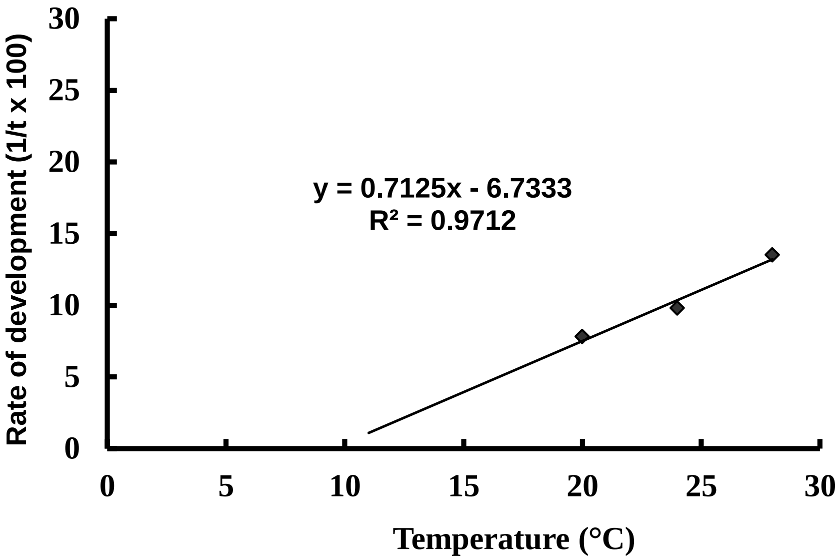


Fig. (15): The regression line of male longevity of *T.absoluta* at three constant temperatures.

Table (15): Zero of development for different stages of *Tuta absoluta* which reared under three constant temperatures.

Stage	Zero of development
Egg	7.0
Larvae	10
Pupae	11.2
Male	9.8
Female	11.2
Generation	10.5

1.6. Fecundity

The reproductive potentiality is expressed as total numbers of deposited eggs per female during its longevity. Ten females from each tested temperature were observed to detect their fecundity. Data obtained of female fecundity of *Tuta absoluta* which reared at the three constant temperatures are given in Table (16)& Fig.(16).

Results of statistical analysis revealed that temperature had highly significant effects on female fecundity ("F"= 83.03 sig. at 0.001& L.S.D.=17.3eggs). The highest mean fecundity was occurred at 28°C being 145.3 eggs/ female, followed by those reared at 24°C being 79.3 eggs / female, while the lowest mean was occurred for those reared at 20°C being 57.8 eggs / female.

From the results it could be stated that temperature 28°C seemed to be the most favorable conditions for rearing *T. absoluta* under laboratory conditions.**Torrest *et al.*, (2001)** reported that female fecundity of *T. absoluta* ranged from 60 to 120 eggs, **Erdogan and Babaroglu (2014)**found that fecundity of *T. absoluta* was found 141.16eggs/female in a climate chamber at 25±1ºC,relative humidity 65±5% and under long daylight (16L:8D) and **Krechemer and Foerster (2015)** in Brazil, mentioned that fecundity of *T. absoluta* was highest at 20 and 25°C, with averages of 134.8 and 149.1 eggs / female, respectively.**Mohamed *et al.*,(2015)**in Egypt, recorded that the daily average fecundity of females was 15.78, 18.19, 34.65 and28.26 eggs at 15, 20, 25 and 30ºC, respectively. The mean total lifetime fecundity of *T. absoluta* females was 13.92, 211,244.17 and 177.83 eggs at 15, 20, 25 and 30°C, respectively. On the contrary, **Uchoˆa-Fernandes *et al.*, (1995)** found that the most prolific oviposition period of *T. absoluta* is 7 days after first mating, and females lay 76% of their eggs at that time, with a maximum lifetime fecundity of 260 eggs/ female.

Table (16): Fecundity and fertility female of *Tuta absoluta* which reared on three constant temperatures

Temp. (°C)	Female fecundity (eggs/female +s.e.)	%Egg hatchability	%Mortality
20	57.8±5.8 c	72.0±0.39 c	28.0
24	79.3±5.8 b	97.0±0.39 a	3.0
28	145.3±2.9 a	89.0±0.38 b	11.0
F.value	83.2***	42.5***	
L.S.D.(egg&%)	17.3	1.2	

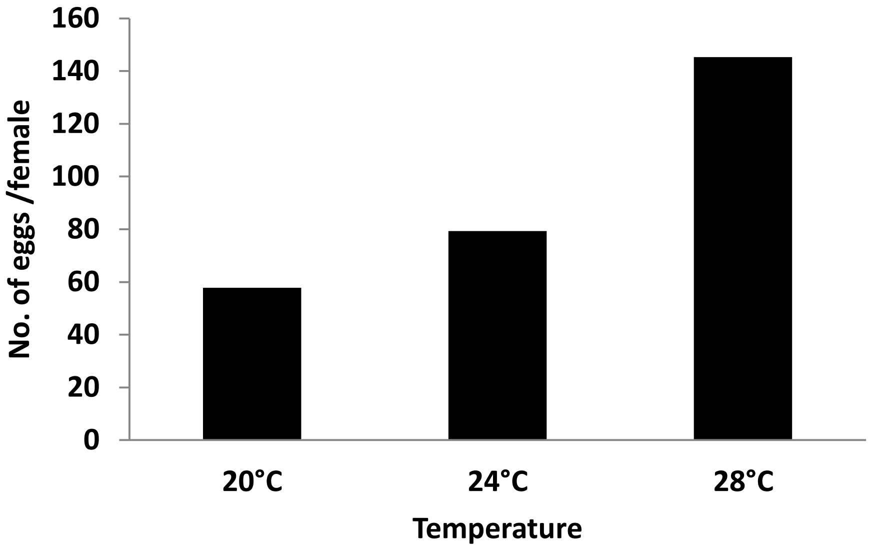


Fig. (16): Average number of eggs laid/female of *Tuta absoluta* at three different constant temperatures.

1.7. Egg fertility

Egg fertility is represented by percentage of egg hatchability of deposited eggs. Data in Table (16)& Fig.(17) showed percentages of hatchability of *Tuta absoluta* when reared under the three constant temperatures. Results of statistical analysis showed that temperatures had highly significant effects on percentage of egg fertility ("F" = 42.5). The highest mean of egg hatchability 97% was occurred at 24°C followed by 89% at 28°C, while the lowest was occurred at 20°C being 72%. So, 28°C.considered as the optimum degree for laying eggs.

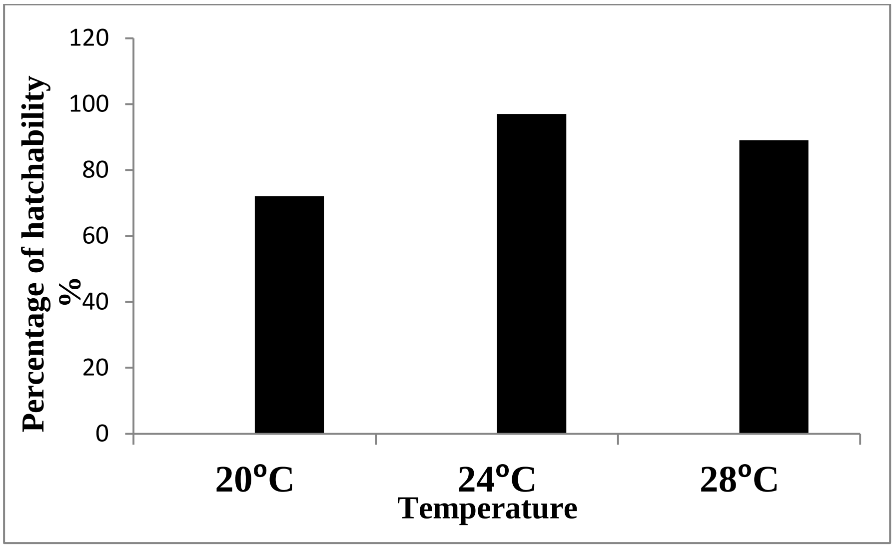


Fig. (17): Effect of three constant temperatures on the hatchability of *Tuta absoluta* eggs

1.8. Total generation duration

Data tabulated in Table 17 indicated duration of generation of *T. absoluta* under three constant temperatures had highly significant of means generations duration (F=392.8 sig. at 0.001& L.S.D.=2.3 days) whereas the shortest duration of generation were achieved at 28°C being 30.7day; followed by 38.6 days at 24°C., while the lowest was occurred at 20°C.being 56.1 days.

Table (17): Effect of three constant temperatures on durations of generation of *Tuta absoluta*

Temp. (°C)	Mean incubation period/days &Range	Mean duration of larvae/days &Range	Mean duration of pupae /days &Range	Mean duration of pre-oviposition/ days &Range	Mean duration of generation
20	6.8±0.18 (7.4-6.4)	30.9± 0.9 (28.3-34.3)	15.8±0.3 (15.0-17.0)	2.6±0.5 (1.0-3.0)	56.1
24	5.0±0.0 (5.0-5.0)	21.9±0.3 (21.0-22.6)	9.5±0.1 (9.2-9.8)	2.2±0.2 (2.0-3.0)	38.6
30	4.0±0.0 (4.0-4.0)	17.6±0.7 (15.7-19.7)	8.1±0.4 (7.7-9)	1.0±0.0 (1.0-1.0)	30.7
Average	5.3	23.5	11.1	1.9	41.8

One the other hand, the threshold of development was indicated by Fig.18&Table 17 this value was 10.5 ºC. The thermal constant which required for completing the development of generations were 533.0, 521.1 and 537.3 DD's at 20, 24 and 28°C., respectively in average about 530.4 DD's (Table18).

These results are closely to **Barrientos *et al.*, (1998)**who reported that the biological cycle of *T. absoluta* is completed in 76.3 days at 14ºC, 39.8 days at 19.7ºC and 23.8 days at 27.1ºC.,while the thermal constant from oviposition to adult emergence was 459.5 DD's. **Pires and Marques (2002)** found that the period from egg to adult emergence of *T. absoluta* was 22.2±0.35 days. **Abolmaaty *et al.*, (2010)** in Egypt found that the first generation of *Tuta absoluta* takes about 66 days.**Cuthbertson *et al.*,(2013)** in UK**,** mentioned that population development of *T. absoluta* ceases between 7 and 10°C.under laboratory conditions the total lifespan of the moth was longest (72 days) at 13°C and shortest (35 days) at both 23 and 25°C. Development from egg to adult took 58 days at 13°C, 37 days at 19°C and 23 days at 25°C.**Mohamed *et al.*,(2015)**in Egypt, mentioned that *T. absoluta* failed to survive due to the high mortality in cohort reared at 35ºC. Total developmental time was negatively correlated to the increase of temperature; being longest (67.67 days) at 15°C.**Özgökce *et al.*, (2016)** in Turkey, recorded that developmental threshold and thermal constant for total development of *T. absoluta* were estimated as 8.94°C and 419.46 degree-days respectively. Lower, optimum and upper temperature requests were estimated with different models and results obtained were in the range 8.9-12.5, 31.00-31.07 and 35.9- 38.5°C, respectively.

Table (18): Mean of generation, rate of development and constant temperature of *Tuta absoluta* at three constant temperatures and 60-70 % R.H.

Stage / Temp.	Generation		
	Generation Period& Range	Rate of development (1/t*100)	Thermal units DD's
20	56.1±1.6 (52.2-59.3)a	1.8	533
24	38.6±0.3 (37.7-39.7)b	2.6	521.1
28	30.7±0.4 (29.6-32.0)c	3.3	537.3
F.value L.S.D.(day)	392.8*** 2.3		

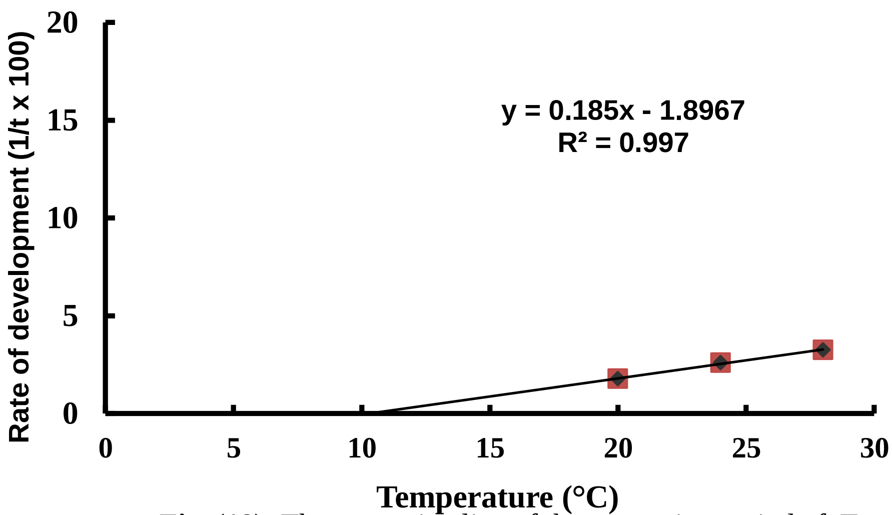


Fig. (18): The regression line of the generation period of *T. absoluta* at constant temperatures.

2. Life Table parameters of *Tuta absoluta*

Life Table analysis was carried out to investigate durations, survival ship and reproductive rate for different development stages of insect population (biotic potentiality). Also, was used to investigate the role of constant temperatures on insect population.

2.1. Percentages of apparent and real mortality

2.1.1. Percentage of apparent and real mortalities under constant temperature

In this experiment, fixed numbers of *T. absoluta* eggs were incubated on three constant temperatures (20, 24 and 28°C) throughout one complete generation (100 eggs for each temperature). The life expectancy and actual population size, after excluding number of dead individuals from different developmental stage, were recorded throughout this generation. Percentages of apparent and real mortality were calculated. Results obtained are given in Table (19).

These results revealed that both apparent and real mortalities differed from stage to another according the prevailing conditions. At the beginning of each experiment, 100 eggs were started for each tested temperature. At 20°C, 10 adult were obtained at the end of generation. While at 24°C, 18 adults were obtained. At 28°C, 14 adults were obtained i.e. the total population mortality of *T. absoluta* equal in average 86% and only 14% in average survival until adult stage. The same results obtained by **Miranda *et al.*, (1998)** who recorded that the total population mortality of tomato leaf miner was 92.3%.

Regarding the percentage of eggs mortalities (both apparent & real) at three tested temperatures, the highest percentage of mortalities were occurred on 20°C being 28.0 %, followed 11.0 % at 28°C, while the lowest percentage was occurred at 24°C being 3.0 %.It seemed that 24°C seemed to be the most favorable temperature of incubation of egg stage Table (18). From these results the apparent & real mortalities at egg stage in average equal 14%. **Miranda *et al*., (1998)** recorded that during the egg stage of *Tuta absoluta*, the mortality was 58.7%.

Regarding to the percentages of apparent mortalities and real mortalities of larval stage under the three tested temperatures were 72.2%&52% at 20˚C, 76.3%&74% at 24˚C, and 83.1%&74%at 28˚C, respectively Table (19).

From these results it could be stated larval stage was considered to be the critical stage. It showed the highest apparent and real mortalities (77.2%& 66.7% in averaged), the same results obtained by **Miranda *et al*., (1998)** who mentioned that larval stage of *T. absoluta* had the highest apparent mortality (79.8%).

The apparent and real mortalities of the pupal stage under three tested temperatures were 50%&10% at 20˚C, 21.7%&5.0% at 24˚C, and 6.7%&1.0%at 28˚C, respectively Table (19).

In average, apparent & real mortalities equal 26.1% and 3%, respectively. **Miranda *et al*., (1998)** found that the mortality at the pupal stage was low (0.6%) and was due to malformation.

From these results it could be stated 24˚C seemed to be the optimum temperature for rearing *T. absoluta* at this temperature the highest percentage of egg hatchability and the lowest percentages of mortalities of most different stages were occurred at this degree Table 16&19.

Table (19): Some life Table parameters of *Tuta absoluta* from egg stage to adult stage reared on three constant temperatures.

Temp. °C	Stages	Number of individuals dead (dx)	% Apparent mortality	% Real mortality
20°C	Egg	28	28	28.00
	Larvae	52	72.2	52.0
	Pupae	10	50	10.0
	Total	90		
	Adults(♀ + ♂)	**10**	----	----
24°C	Egg	3	3	3.0
	Larvae	74	76.3	74.0
	Pupae	5	21.7	5.0
	Total	82		
	Adults (♀ + ♂)	**18**	----	----
28°C	Egg	11	11	11.0
	Larvae	74	83.1	74.0
	Pupae	1	6.7	1.0
	Total	86		
	Adults (♀ + ♂)	**14**	----	----

2.1.2. Percentage of apparent and real mortalities under laboratory conditions

This experiment carried out under laboratory conditions whereas, mean temperature was (24-28°C) and mean relative humidity was (50-60%) during period from April to May 2016 throughout one complete generation (300 eggs). The life expectancy and actual population size, after excluding number of dead individuals from different developmental stage, were recorded throughout this generation. Percentages of apparent and real mortalities were calculated. Results obtained are given in Table (20).

These results revealed that both apparent and real mortalities differed from stage to another according the prevailing conditions. At the beginning of each experiment, 300 eggs were started under laboratory conditions, 22 adults were obtained at the end of generation about 7.3% from the total of population of *Tuta absoluta*.

Regarding the percentage of mortalities (both apparent & real) being (33.33&33.33) for egg stage, (86.5 & 57.7) for larval stage and (18.5 & 1.7) for pupal stage, respectively.

Table (20): Some life Table parameters of *Tuta absoluta* from egg stage to adult stage reared on tomato under Laboratory condition (24-28°C) and R.H.(50-60%).

Temp. °C	Stages	Number of individuals dead (d_x)	% Apparent mortality	% Real mortality
Lab. Condition (24-28°C)	Egg	100	33.3	33.3
	Larvae	173	86.5	57.7
	Pupae	5	18.5	1.7
	Total	278		
	Adults (♀ + ♂)	**22**	7.3	7.33

2.2. Survival and fecundity of adults:

Data obtain from biological studies of *T. absoluta* were used to calculate survival of adult female, fecundity and life Table parameters, age specific survival rate (l_x) and age specific fecundity (m_x) at three constant temperature (20, 25 and 28°C) are given in Tables (20&21&22&23). The obtained results are summarized in Table (25).

2.3. Net reproduction rate ($R_○$)

Results in Table 25for net reproduction rate indicated that *T. absoluta* female can give the highest birth average being 10.03 at 28°C, followed by 6.29 at 24°C.and 2.85 at 20°C while, the lowest birth average was being 3.15 and 2.85under laboratory conditions and 20°C.

2.4. Mean generation time (Gt)

Results in Table 25for generation time showed that the generation time of *Tuta absoluta* varied at the three tested temperatures and laboratory conditions. The shortest generation time was obtained at 28°C and laboratory conditions being 33.92 and 33.97days, respectively, followed by those at 24°C being 41.37 days while the highest was being 59.58 days at 20°C.

2.5. Intrinsic rate of increase (r_m)

The intrinsic rate of increase refers to the rate of daily population growth and is considered an important index of potential population performance. The calculated values of intrinsic rate of increase showed that these rates for *T. absoluta* adult were affected by the tested temperatures. The highest intrinsic rates individual / day were obtained at 28 °C being 0.13individual/day, followed by those at 24°C and under laboratory conditions being (0.07&0.04 individual/day, respectively), while the lowest was being 0.02 individual/day at 20˚C.

2.6.Finite rate of increase (λ)

The Finite rate of increase (λ) or (e^{rm}) considered the discrete version of (r_m). The calculated values of finite rate of increase of *T. absoluta* followed the same trend which occurred for the intrinsic rate of increase. The highest values were 1.14female/day at 28°C, followed by those at 24°C and under laboratory conditions being (1.07&1.04 female/day, respectively).While the lowest value was (1.02female/day) at 20°C.

2.7. Population double time (Dt)

Results in Table (25) showed that the population of *Tuta absoluta* reared at 20°C had longest double generation value (43.43days), followed by those at laboratory conditions being (21.71days); followed by those at 24°C being (12.41 days).While, the shortest double generation value was (6.68 days) which occurred at 28˚C.

From these results it could be concluded that 28˚C seemed to be the optimum degree for rearing *T. absoluta* on tomato. At this degree both female fecundity and net reproductive rate; intrinsic rate of increase and finite rate of increased recorded their maximum valuesand population doubling time recorded its minimum value.

Pereyra and Sanchez (2006) found that net reproductive rate (R_o), intrinsic rate of increase (r_m) and generation time (T_o) of *T. absoluta* were: R_o=48.92; T_o =27.98, r_m=0.14.**Erdogan and Babaroglu (2014)** in Turkey, found that, the intrinsic rate of increase (r_m), finite population increase (λ), net reproductive rate (R_o) andmean generation time (Dt) of *T. absoluta* were 0.13 day -1, 1.14day $^{-1}$, 42.01 and 28.25 days respectively. The life expectancy of a new born egg was 42.60 days at 25±1ºC,relative humidity 65±5% and under long daylight (16L:8D).**Mohamed *et al.*,(2015)** in Egypt, recorded that life Table analysis of the population of *T. absoluta* reared at 30°C had the highest intrinsic rate of increase (0.75), net reproductive rate (28.28), shortest population doubling time (0.93 days) and mean generation time (4.49 days), comparing to populations reared at 15, 20 and 25°C. Therefore, the optimum temperature for population growth of *T. absoluta* ranged between 20 to 30°C.

Table (21): Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female at constant temperature 20°C.

Stages	Age/days (x)	No. observation.	Survivors (l_x)	Fecundity (m_x)	l_x*m_x	l_x*m_x*x
Eggs	6.8	100	1.00			
Larvae	30.9	72	0.72			
Pupae	15.8	20	0.2			
Females	54.5	6	0.06	0.00	0.00	0.00
	55.5	6	0.06	0.00	0.00	0.00
	56.5	6	0.06	0.00	0.00	0.00
	57.5	5	0.05	20.00	1.00	57.50
	58.5	5	0.05	3.00	0.15	8.78
	59.5	5	0.05	16.40	0.82	48.79
	60.5	5	0.05	4.00	0.20	12.10
	61.5	4	0.04	4.00	0.16	9.84
	62.5	4	0.04	8.60	0.34	21.25
	63.5	4	0.04	2.80	0.11	6.99
	64.5	4	0.04	1.00	0.04	2.58
	65.5	3	0.03	1.00	0.03	1.97
	66.5	3	0.03	0.00	0.00	0.00
	67.5	2	0.02	0.00	0.00	0.00
	68.5	2	0.02	0.00	0.00	0.00
	69.5	1	0.01	0.00	0.00	0.00
	Total				2.85	169.8

The net reproductive ($R_{\circ}$) = 2.85
The generation time (Gt) = 59.58
The intrinsic rate of increase (r_m) = 0.02
The finite rate of increase (λ) = 1.02
The doubling time (Dt) = 43.43

Table (22): Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female at constant temperature 24°C.

Stages	Age/days (x)	No. observation	Survivors (l_x)	Fecundity (m_x)	l_x*m_x	l_x*m_x*x
Eggs	5	100	1.00			
Larvae	21.9	97	0.97			
Pupae	9.5	23	0.23			
Females	37.4	10	0.10	0.00	0.00	0.00
	38.4	10	0.10	0.00	0.00	0.00
	39.4	10	0.10	10.25	1.03	40.58
	40.4	9	0.09	19.25	1.73	69.89
	41.4	9	0.09	13.00	1.17	48.44
	42.4	8	0.08	17.50	1.40	59.36
	43.4	7	0.07	9.50	0.67	29.08
	44.4	5	0.05	5.75	0.29	12.88
	45.4	4	0.04	0.00	0.00	0.00
	46.4	3	0.03	0.00	0.00	0.00
	47.4	1	0.01	0.00	0.00	0.00
	Total				6.29	260.23

The net reproductive ($R_◦$) = 6.92
The generation time (Gt) = 41.37
The intrinsic rate of increase (r_m) = 0.07
The finite rate of increase (λ) = 1.07
The doubling time (Dt) = 12.41

Table (23): Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female at constant temperature 28°C.

Stages	Age/days (x)	No. observation.	Survivors (lx)	Fecundity (mx)	lx*mx	lx*mx*x
Eggs	4	100	1.00			
Larvae	17.6	89	0.80			
Pupae	8.1	15	0.15			
Females	30.7	8	0.08	0.00	0.00	0.00
	31.7	8	0.08	19.75	1.58	50.09
	32.7	8	0.08	37.75	3.02	98.75
	33.7	8	0.08	16.75	1.34	45.16
	34.7	7	0.07	20.75	1.45	50.32
	35.7	7	0.07	17.00	1.19	42.48
	36.7	5	0.05	24.25	1.21	44.41
	37.7	3	0.03	8.00	0.24	9.05
	38.7	1	0.01	0.00	0.00	0.00
	39.7	0	0.00	0.00	0.00	0.00
	Total				10.03	340.26

The net reproductive (R◦) = 10.03

The generation time (Gt) = 33.92

The intrinsic rate of increase (rm) = 0.13

The finite rate of increase (λ) = 1.14

The doubling time (Dt) = 6.68

Table (24): Age specific of *Tuta absoluta* survivors (l_x) and fecundity rates (m_x) for adult female under laboratory conditions.

Stages	Age/days (x)	No. observation.	Survivors (lx)	Fecundity (mx)	lx*mx	lx*mx*x
Eggs	6	300	1.000			
Larvae	14	200	0.667			
Pupae	9	27	0.09			
Females	30	15	0.05	0.00	0.00	0.00
	31	15	0.05	0.00	0.00	0.00
	32	14	0.05	10.25	0.51	16.32
	33	14	0.05	20.00	1.00	33.00
	34	13	0.04	13.00	0.52	17.68
	35	13	0.04	15.00	0.60	21.00
	36	10	0.03	9.50	0.29	10.44
	37	8	0.03	6.00	0.18	6.66
	38	6	0.02	2.00	0.04	1.52
	39	3	0.01	1.00	0.01	0.39
	40	1	0.003	0.00	0.00	0.00
	Total				3.15	107.01

The net reproductive ($R_\circ$) = 3.15

The generation time (Gt) = 33.97

The intrinsic rate of increase (r_m) = 0.04

The finite rate of increase (λ) = 1.04

The doubling time (Dt)=21.71

Table (25): Summary of life Table parameters for *Tuta absoluta* reared under three constant temperatures (20, 24 & 28) and under laboratory conditions.

Temp. (°C)	Net reproductive rate ($R_{\circ}$)	Generation time/day ($Gt_{;}$ days)	Intrinsic rate of increase (r_m; day^{-1})	Finite rate of increase (λ; day^{-1})	Population double time (Dt)
20	2.85	59.58	0.02	1.02	43.43
24	6.29	41.37	0.07	1.07	12.41
28	10.03	33.92	0.13	1.14	6.68
Lab. conditions	3.15	33.97	0.04	1.04	21.71

Ecological studies

3. Susceptibility of certain tomato genotypes to the infestation degree by *Tuta absoluta*

3.1. Field experiment

The average mean of mines were estimated for 10leaflets in each cultivars.

At the first, general weekly mean number of *T. absoluta* leaf mines were higher during 2013 (239.5/80leaflets) than 2012 (201.3/80leaflets). Infestation rate by *T. absoluta* increased during 2013 with 17.6 in compare with 2012 Table 26 & Fig.19.

Table (26): Average mean number of *Tuta absoluta* mines/10 leaflets on eight tomato cultivars during two successive seasons 2012&2013

Cultivars	Average mean of *T. absoluta* mines		Level	
	2012	2013	2012	2013
Red sun	36.7	46.6	a	a
Hybrid super strain B	32.6	37.0	a	b
Castle rock	23.1	35.0	b	b
Riogrande	25.4	25.3	b	c
Baladi	21.1	27.0	c	c
Nemaguard	21.0	24.5	c	c
Super set	21.4	23.7	c	cd
Hybrid bito86	20.0	20.4	d	d
Total	201.3	239.5		

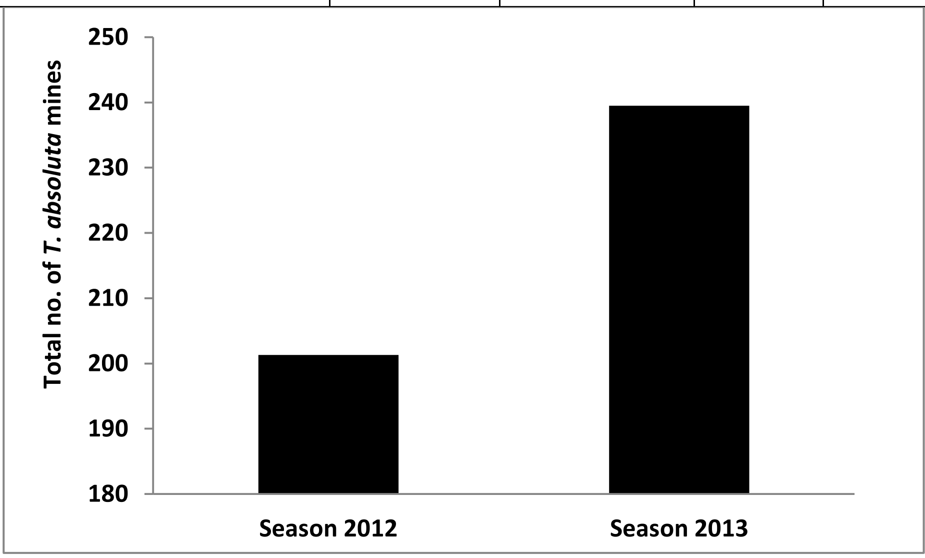


Fig. (19): Total number of *Tuta absoluta* mines/80leaflets on tomato cultivars (irrespective of cultivars) during two successive seasons 2012&2013

Data obtained and recorded in Table 27&28 and illustrated in Fig.20&21show the infestation rates by *Tuta absoluta* to eight tomato genotypes throughout 2012&2013 seasons.

During first season 2012, eight tomato cultivars significantly could be divided into four groups (Fvalue=10.5 sig. at 0.001 and L.S.D. = 1.0 mine). First group more susceptible contains Red sun and Hybrid super strain B cultivars (36.7 & 32.6 mines/10leaflets, respectively). Second group (susceptible) include Riogrande and Castle rock cultivars (25.4 & 23.1mines/10leaflets, respectively). While Super set and Baladi formed third group (resistance) whereas number of mines were 21.4&21.1 respectively. The fourth group (more resistant) includes Nemaguard and Hybrid bito86 (21.0&20.0 mines/10leaflets, respectively).

Second seasons, 2013 eight tomato cultivars, also significantly could be divided into four groups (F. value=39.9 sig. at 0.001 and L.S.D. = 0.8 mine) as follows: first group (more susceptible) contains Red sun cultivar only (46.6 mines/10leaflets); followed by 2nd group(susceptible) include Hybrid super strain B and Castle rock with mean of mine 37.0&35.0 mines/10leaflets, respectively. According to 3rd group (resistant) contains on Baladi, Riogrande and Nemaguard cultivars with mean mines 27.0 25.3 & 24.5 &mines/10leaflets, respectively. The more resistance 4th group include Super set and Hybrid bito86 (23.7&20.4mines/10leaflets, respectively).

The results above are in agreement with those obtained by **Ecole *et al.*, (2000), Giustolin *et al.*,(2000), Oliveira *et al.*, (2008), Antônio *et al.*, (2011) and Cherif*et al.*, (2013)**who reported that there are significant differences of *T. absoluta* population density on different tomato cultivars and recommended the selection of resistant tomato cultivars as a very important control element in depressing tomato leaf miner populations in any IPM program.

Table (27): Weekly average mean of *Tuta absoluta* mines on 10leaflets per each cultivar during the first season (2012) at Shoubra Elkheima, Qaliubya Governorate.

	Number/ 10 leaflets							
cultivars / Inspection dates	**Red sun**	**Hybrid super strain**	**Castle rock**	**Riogrande**	**Baladi**	**Nema guard**	**Super set**	**Hybrid Bito 86**
23/4/2012	0	0	0	0	0	0	0	0
30/4/2012	0	0	0	0	0	0	0	0
07/5/2012	9.7	12.0	3.7	4.3	5.3	3.7	8.7	5.0
14/5/2012	10.7	9.3	10.7	11.7	8.0	7.3	4	5.0
21/5/2012	12.0	8.0	5.7	6.7	4.1	6.3	3.7	5.0
28/5/2012	4.3	3.3	3.0	2.7	3.7	3.7	5	5.0
Total	36.7	32.6	23.1	25.4	21.1	21.0	21.4	20
Mean	9.2 a	8.2 a	5.8 b	6.4 b	5.3 c	5.3 c	5.4 c	5.0 d
F value	10.5*** sig. at 0.001							
L.S.D.	1.0 mine							

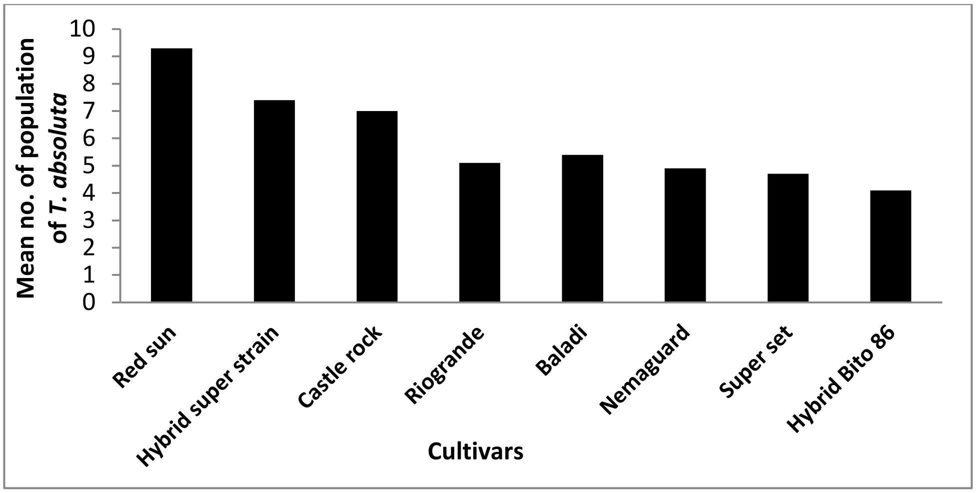


Fig (20): Weekly average mean of *Tuta absoluta* mines on 10 leaflets per each cultivar during the second season (2012) at Shoubra Elkheima, Qaliubya Governorate.

Table (28): Weekly average mean of *Tuta absoluta* mines on eight cultivars during the second season (2013) at Shoubra Elkheima, Qaliubya Governorate.

	Number/ 10 leaflets							
cultivars Inspection dates	**Red sun**	**Hybrid super strain**	**Castle rock**	**RIogrande**	**Baladi**	**Nemaguard**	**Super set**	**Hybrid Bito 86**
23/4/2013	0	0	0	0	0	0	0	0
30/4/2013	3.0	5.0	2.7	4.7	3.0	3.0	6.7	3.7
07/5/2013	6.0	12.7	6.7	5.3	11.0	8.0	4.0	5.7
14/5/2013	4.3	11.3	4.0	3.3	3.3	5.7	3.7	3.0
21/5/2013	20.0	3.7	12.3	6.3	4.0	3.0	5.0	2.7
28/5/2013	13.3	4.3	9.3	5.7	5.7	5.0	4.3	5.3
Total	46.6	37.0	35.0	25.3	27.0	24.5	23.7	20.4
Mean	9.3 a	7.4 b	7.0 b	5.1 c	5.4 c	4.9 c	4.7 cd	4.1 d
F value	39.9*** sig. at 0.001							
L.S.D.	0.8 mine							

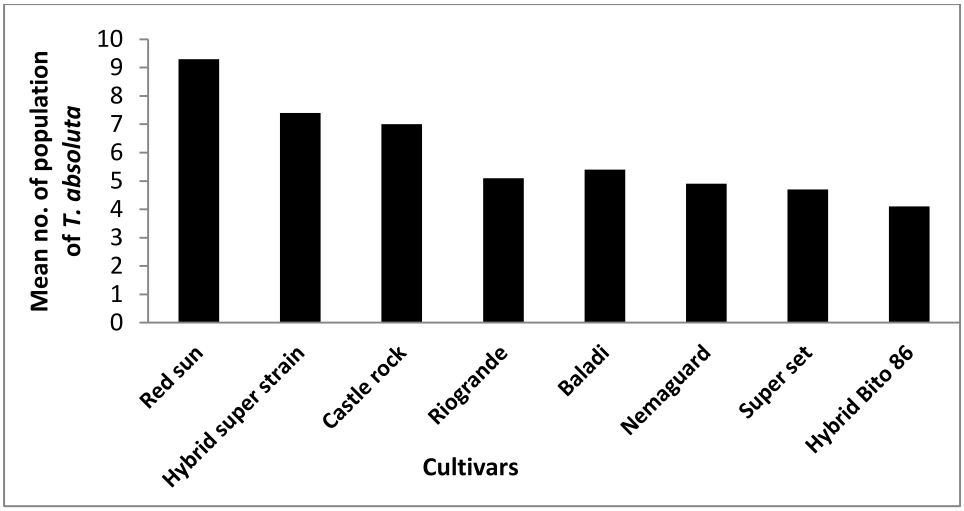


Fig. (21): Weekly average mean of *Tuta absoluta* mines on 10leaflets per each cultivar during the second season (2013) at Shoubra Elkheima, Qaliubya Governorate.

3.2. Effect of different leaf chemical components on rate infestation by *Tuta absoluta*

3.2.1. N. P. K.

Data obtained in Table (29) showed that mean *T. absoluta* leaf mines and the contents of N.P.K. component in leaves of eight tomato cultivars, in addition the correlation coefficient value between rate of infestation and the content of N.P.K. of eight tomato cultivars. The studied cultivars varied significantly in their content of N.P.K. whereas "F"value=43.1, 532.7 and 29.2, respectively. The highest of *T. absoluta* mines occurred on the leaflets of Red sun cultivar (9.3mines/10leaflets) was corresponding to the high level of N.P.K. (10.9mg/gm dry weight, 1956.7mg/gm dry weight and 550.0 uEq/gm dry weights, respectively). On the other hand Hybrid bito86 cultivar contained on lowest infestation was (4.1mine/10leaflets) corresponding to least value of N.P.K. (6.8mg/gm dry weight, 696.0mg/gm dry weight and 403.3uEq/gm dry weights, respectively)). The other cultivars come intermediate between them.

Statistical analysis revealed that, there is significant positive between the mean of leaf mines of *Tuta absoluta* and the content of P.K. with "r value" of 0.74 & 0.81, respectively. While between N and infestation rate of *T. absoluta* was 0.57 (insignificant positive).

These results are in accordance with **Leite *et al.*, (1998)** who found that an increase in N and K fertilization increased the *T. absoluta* oviposition rate on *Lycopersicon hirsutum*. Also, **Leite*et al.*, (2004)** reported that leaf potassium affected *Liriomyza* spp. attacks.**Han *et al.*,(2014)** found that an excess of N had no effect on both leaf N content and leaf C/N ratio. Sub-optimal nitrogen supplies, water treatments and their interactions significantly reduced the leaf miner survival rate and slowed down its development.

Table (29): Relationships between the content of N.P.K. phytochemical components in leaflets of eight tomato cultivars and mean number of *Tuta absoluta* leaf mines/ 10 leaflets during season, 2013.

Cultivars	Mean no. of *T. absoluta* leaf mines	Phytochemical components mg/g dry wt.		
		Nitrogen (mg⁄gm dry weight)	Phosphore (mg⁄gm dry weight)	Kalium(uEq⁄gm dry weight)
Red sun	9.3[a]	10.9[ab]	1956.7[a]	550[a]
Hybrid super strain B	7.4 [b]	7.0[d]	781.00 [e]	433.0[bc]
Castle rock	7.0[b]	11.5[a]	1317 [b]	436[b]
Riogrande	5.1[c]	7.3 [d]	746 [ef]	382.3 [d]
Baladi	5.4 [c]	10.1[bc]	1144.3[d]	389.3 [d]
Nemaguard	4.9[cd]	9.2[c]	1254.7[c]	394.7 [d]
Super set	4.7 [cd]	6.3[d]	668[g]	448.7 [b]
Hybrid bito86	4.1[d]	6.8[d]	696[gf]	403.3 [cd]
F. value	39.9***	43.1***	532.7***	29.2***
L.S.D.	0.8	0.93	57.6	30.2
Simple correlation (r)		+0.57ns	+0.74*	+0.81*
Regression coefficient (b)			+0.002	+0.026

3.2.2. Amino acid and Total protein

As shown in Table(30)the highest mean of *T. absoluta* mines occurred on Red sun cultivar (9.3mines/10leaflets) was associated with the highest amount of total free amino acids and total proteins(16.6ugalanine⁄gm dry weight&679.0mg/gm dry weight), respectively. On the contrary, Hybrid bito86 contained on lowest infestation 4.1 mines/10leaflets had the lowest content from total free amino acids and total proteins (4.2ugalanine⁄gm dry weight&41.6mg/gm dry weight, respectively). The rest of cultivars come intermediate between them.

Statistical analysis revealed that, there is insignificant positive correlation between infestation and free amino acid & total protein whereas r=+0.57 & +0.61, respectively. **Marwa Abd-Allah(2016)** recorded that the highest mean seasonal abundance of Aphids & *Tetranychus urtica* occurred on leaves of Bahi (cucumber cultivar) were associated with high levels of total protein, carbohydrate, lipid, reducing suger& total amino acids and associated with low levels of total phenols.

Table (30): Relationships between the content of free amino acid and total protein components in leaflets of eight tomato cultivars and mean number of *Tuta absoluta* mines/10 leaflets during season, 2013.

Cultivars	Mean no. of *T. absoluta* leaf mines	Phytochemical components mg/g dry wt.	
		Free amino acid (ugalanine⁄gm dry weight)	Total protein (mg⁄gm dry weight)
Red sun	9.3[a]	16.6 a	67.9 a
Hybrid super strain B	7.4[b]	4.6 e	45.4 de
Castle rock	7.0 [b]	5.8 d	69.8 a
Riogrande	5.1[c]	5.0 de	46.9 d
Baladi	5.4 [c]	13.4 b	61.8 b
Nemaguard	4.9[cd]	7.7 c	57.2 c
Super set	4.7[cd]	4.9 de	39.2 f
Hybrid bito86	4.1[d]	4.2 e	41.6 ef
F. value	39.9***	149.3***	72.9***
L.S.D.	0.8	1.1	4.2
Simple correlation (r)		+0.57ns	+0.61ns

3.2.3. Total phenol

The studied cultivars varied significantly in their content of total phenol (Table 31). The highest *Tuta absoluta* leaf mines occurred on Red sun cultivar (9.3leaf mine/10leaflets) with corresponding to low level of total phenol 4626.3 ugGA⁄gm dry weights. While the highest content of phenol 6228.0 ugGA⁄gm dry weight was found in Hybrid bito86 cultivar which infested with 4.1 leaf mines/10leaflets.

Statistical analysis indicated that, there is a significant negative correlation between infestation and amount of total phenol whereas r=-0.77 & b=-0.002mine at 5%.

These results are in accordance with **MarwaAbd-Allah(2016)** recorded that the highest mean seasonal abundance of Aphids &*Tetranychus urtica* occurred on leaves of Bahi (cucumber cultivar) were associated with high levels of total protein, carbohydrate, lipid, reducing suger& total amino acids and associated with low levels of total phenols. **Helmi and Mohamed (2016)** who found that total phenol content was significantly accumulated in the leaves of all tomato cultivars and the highest amount of phenol was found in the resistant. **Perveen *et al.*, (2001)** reported that resistant and semi-resistant varieties of cotton attacked by insects possessed significantly greater phenolic content than susceptible varieties.

Table (31): Effect of total phenol component in leaflets of eight tomato cultivars and mean number of *Tuta absoluta* leaf mines/10 leaflets during season, 2013.

Cultivars	Mean no. of *T. absoluta* leaf mines	Total phenol (ugGA/gm dry weight)
Red sun	9.3 [a]	4626.3 g
Hybrid super strain B	7.4[b]	5613.0 c
Castle rock	7.0[b]	4833.7 f
Riogrande	5.1 [c]	5136.0 e
Baladi	5.4[c]	5650.0 c
Nemaguard	4.9 [cd]	5330.3 d
Super set	4.7[cd]	5845.3 b
Hybrid bito86	4.1[d]	6228.0 a
F. value	39.9***	98.4***
L.S.D.	0.8	160.9
Simple correlation (r)		-0.77*
Regression coefficient (b)		-0.002

3.2.4. Total carbohydrate

As shown in Table 32, the lowest content of total carbohydrate101.3mg/gm dry weights was occurred in Hybrid bito86 cultivar which contained on least infestation by *T. absoluta* (4.1 leaf mines/10leaflets). On the contrary Red sun cultivar contains on 125.3mg/gm dry weight and infested with 9.3 leaf mines/ 10leaflets. In general the correlation coefficient was insignificantly negative -0.02.

Salama *et al.*, (2015) in Egypt, mentioned that the larvae with its taste receptors are able to discriminate between host plants and other chemicals. It showed great sensitivity to various sugars in varying degrees.

Table (32): Effect of total carbohydratecomponent in leaflets of eight tomato cultivars and mean numbers of *Tuta absoluta* leaf mines/10 leaflets during season, 2013.

Cultivars	Mean no. of *T. absoluta* leaf mines	Total carbohydrate (mg⁄gm dry weight)
Red sun	9.3[a]	125.3[c]
Hybrid super strain B	7.4[b]	107.0 [ef]
Castle rock	7.0[b]	124.0 [c]
Riogrande	5.1[c]	136.0[b]
Baladi	5.4[c]	113.0[ed]
Nemaguard	4.9[cd]	149.0 [a]
Super set	4.7[cd]	120.3 [cd]
Hybrid bito86	4.1[d]	101.3 [f]
F. value	39.9***	30.6***
L.S.D.	0.8	8.4
Simple correlation (r)		-0.02ns

3.2.5. α and β-esterases

The obtained results in Table33 revealed that there are insignificant differences between the content α and β-esterases enzymes in tomato cultivars. The correlation coefficients were insignificant positive 0.11 and 0.24 for α and β-esterases enzymes, respectively.

3.2.6. Peroxidase

Data obtained in Table33 revealed that there are significant differences between amounts of peroxidase enzyme in eight tomato cultivars. Red sun cultivar infested with the highest number of mines (9.3 leaf mines/10leaflets) contained on the highest amount of peroxidase enzyme 61.5ΔO.D.405⁄min⁄gm dry weight. On the contrary, Hybrid bito86 cultivar infested with (4.1leaf mines/10leaflets) contained on the least amount of peroxidase enzyme 13.9ΔO.D.405⁄min⁄gm dry weight.

The simple correlation was insignificant positive at 5% (+0.68). **War*et al.*, (2012)**recorded that the three groundnut lines tested ICGV86699 (resistant for *Spodoptera litura*) showed greater elevation in peroxidase (POD) and polyphenol oxidase (PPO) activities and in phenolic and hydrogen peroxidase H2O2 contents at different time intervals as compared to TMV2 (susceptible line).

Table (33): Relationships between the content of Alpha, Beta esterases& peroxidase enzymes in leaflets of eight tomato cultivars and mean number of *Tuta absoluta* mines/10 leaflets during season, 2013.

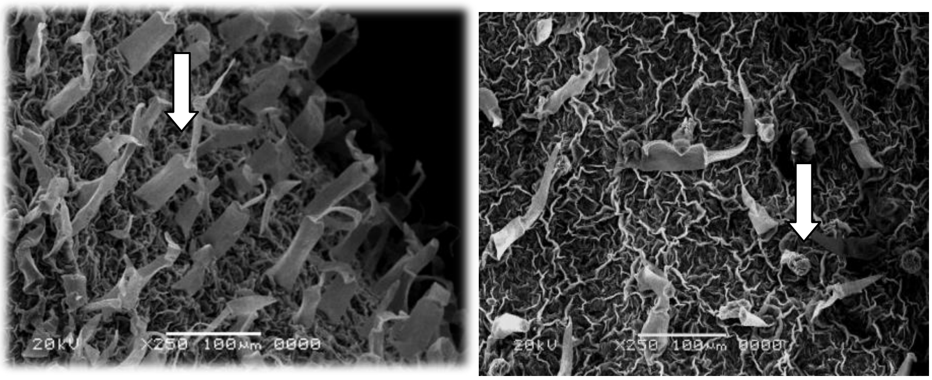
Cultivars	Mean no. of *T. absoluta* leaf mines	Antioxidant Enzymes mg/g dry wt.		
		Alpha esterase (ug α-naphthol⁄min⁄gm α -dry weight)	Beta esterase (ug β-naphthol⁄min⁄gm β-dry weight)	Peroxidase (ΔO.D.405⁄min⁄gm dry weight)
Red sun	9.3^{a}	260.7 ^{c}	241.3^{c}	61.5 ^{a}
Hybrid super strain B	7.4 ^{b}	227.0 ^{d}	192.0 ^{d}	18.3 ^{e}
Castle rock	7.0^{b}	423.7^{a}	323.3^{a}	32.4 ^{c}
Riogrande	5.1^{c}	209.7^{d}	195.7 ^{d}	22.7^{d}
Baladi	5.4^{c}	405.7^{a}	283^{b}	54.5 ^{b}
Nemaguard	4.9^{cd}	322.3^{b}	289^{b}	17.9^{e}
Super set	4.7^{cd}	316 ^{b}	194.7 ^{d}	16.2^{ef}
Hybrid bito86	4.1^{d}	214.3^{d}	182^{d}	13.9^{f}
F. value	39.9***	109.7***	25.3***	277.2***
L.S.D.	0.8	24.1	32.5	3.3
Simple correlation(r)		+0.2ns	+0.24ns	+0.68ns

Generally, it can be conducted that the most susceptible cultivars which presented with high number of *Tuta absoluta* leaf mines were correlated with high content of protein, carbohydrate, free amino acid and low level of phenol, while the most tolerant one were contained mid or low amount of theses component and high level of phenol.

3.3. Effect of physical features of tomato leaflet surface

Tomato plants are the most damaged by *T. absoluta*. The type, numbers and length of hairs on the leaflet may be considered as one the most important factors for host selection with the pest for egg deposition and developmental of the subsequent progeny. The present study was conducted in order to determine the influence trichomes of the population of *T. absoluta*.

Two trichomes types were found in all tested tomato cultivars in both leaflet surfaces; the dominant types I was non-glandular while the second type II was a glandular one (Fig.22). These results are similar to **Leite *et al.*, (1998).**



Type I **Type II**

Fig. (22): Non-glandular(typeI) on the left and Glandular tricomes (typeII) on the right

Statistical analysis of the correlation between different tomato cultivars' leaflet physical features and the population density of *Tuta absoluta* (Table 34)indicated that there are positive significant at 1% between *T. absoluta* mines and density of non-glandular trichomes/cm^2 in the upper surface, whereas the simple correlation "r" was +0.84 sig. at 0.01 and linear regression "b" was +0.4mine**,** while there is insignificant correlation between *T. absoluta* mines and length/µm of non-glandular trichomes in the upper surface. There is no correlation between the population density of *T. absoluta* and density& length of non-glandular trichomes in the down surface.

Table (34): Effect of different leaflet surface physical features of non glandular trichomes 250X of different tomato cultivars on *T. absoluta* infestation

Cultivars	Mean no. of *T. absoluta* leaf mines	Non glandular trichomes 250X			
		Upper		Down	
		Density cm^2	Length µm	Density cm^2	Length µm
Red sun	9.3^{a}	29	170.5	67	183.2
Hybrid super strain B	7.4^{b}	20	109.2	65	145.5
Castle rock	7.0^{b}	20	111.9	50	180
Riogrande	5.1^{c}	20	95.5	42	210.7
Baladi	5.4^{c}	20	110.4	45	158.5
Nemaguard	4.9^{cd}	20	91.9	77	135.6
Super set	4.7^{cd}	19	98.7	67	129.8
Hybrid bito86	4.1^{d}	15	144.5	38	168.9
F. value	39.9***				
L.S.D.	0.8mine				
Simple correlation(r)		+0.85**	+0.55ns	+0.33ns	+0.24ns
Regression coefficient (b)		+0.4 tricome			

The density of glandular trichomes showed insignificant correlation between the population density of *Tuta absoluta* and density, length and width of glandular trichomes in the upper and down surface Table (35).

Leite *et al.*, (1999) found that the glandular trichome density in *L. hirsutum* increased with plant age leading to an increase in the levels of tridecan-2-one, which slows larval development. **Leite *et al*., (2004)** mentioned that no significant effect of the trichomes densities of leaves was noted on *T. absoluta* populations. **Glas *et al.*, (2012)** in Spain, recorded that trichome density and physiology to facilitate customization of essential oil production or to tune biocide activity to enhance crop protection. They will provide an overview of the metabolic diversity found within plant glandular trichomes, with the emphasis on those of the Solanaceae, and of the tools available to manipulate theiractivities for enhancing the plant's resistance to pest. **Helmi and Mohamed (2016) in Egypt,** evaluated effects of tomato leaflet surface physical features on the susceptibility of five tomato cultivars. The density and length of leaflet non-glandular trichomes had negatively effect on the population density of *A. gossypii*, while this was not the case with glandular trichomes. From these results, the susceptibility of tomato cultivars on the basis of these results in the integrated pest management programs.

Table (35): Effect of different leaflet surface physical features of glandular tricomes 250X of different tomato cultivars on *Tuta absoluta* infestation

Cultivars	Mean no. of *T. absoluta* leaf mines	Glandular trichomes 250X					
		Upper			Down		
		Density cm^2	Length µm	Width µm	Density cm^2	Length µm	Width µm
Red sun	9.3 [a]	1	86	51	0	0	0
Hybrid super strain B	7.4 [b]	0	0	0	2	65	45
Castle rock	7.0[b]	2	56.2	46.2	1	95	68
Riogrande	5.1[c]	2	94	47	2	91.5	72
Baladi	5.4 [c]	0	0	0	0	0	0
Nemaguard	4.9 [cd]	4	85	60	0	0	0
Super set	4.7 [cd]	4	105	68	2	106	78
Hybrid bito86	4.1 [d]	5	91	65	0	0	0
F. value	39.9***						
L.S.D.	0.8 mine						
Simple correlation(r)		-0.65ns	-0.27ns	-0.30ns	-0.04ns	-0.05ns	-0.07ns

3.4. Effect of the interaction between physical factors and tomato cultivars on infestation rate by *Tuta absoluta*

This study involved the seasonal fluctuation of the investigated pest (*T. absoluta*) in relation to certain weekly main of the weather factors maximum, minimum temperature and mean relative humidity (R.H.%) obtained from the Central Laboratory for Agriculture Climate (CLAC), Agriculture Research Center, Dokki, Giza Governorate at the investigated seasons.

Effect the main whether factor was tested to clarify their simultaneous effects on the population dynamics of *T. absoluta* infesting tomato cultivars during two successive seasons 2012&2013. Weekly counts of total numbers of *T. absoluta* mines were used as dependent factor "Y". While the corresponding means of the selected factors were used as independent factors "X" i.e. maximum mean temperature x_1; minimum mean temperature x_2 and mean percentage of relative humidity x_3.The effect of each factor separately was obtained by applying simple correlation formula (r) and (b). The combined effects of these factors were obtained by applying C. multipliers formula and expressed as percentage of explained variance (E.V.).

At the first, it appears that mean temperature increase during season 2013 than season 2012, whereas the mean during 2012 equal 20.5° C increased to 24.1° C during 2013 i.e. about 17.6% increasing rate. This increasing rate of temperature during 2013 caused increasing in rate of infestation by *Tuta absoluta* which formed two peaks during experimental period in most cultivars instead of one peak during 2012. One the contrary, relative humidity during 2012 was 63.0% decreased to 48.0% in 2013season i.e. about 23.9% (decreasing rate) Table 36& Fig.23.

Table (36): Weakly mean temperature and relative humidity during experimental period in 2012 & 2013 seasons.

Seasons	**2012**		**2013**	
Inspection dates	**Mean temperature (° C)**	**Mean R.H.%**	**Mean temperature (° C)**	**Mean R.H.%**
23/4/2013	18.9	61.3	19.5	55.3
30/4/2013	19.6	64.1	21.4	49.7
07/5/2013	20.9	64.9	24.9	47.9
14/5/2013	21.3	61.7	25.7	49.2
21/5/2013	20.2	64.3	25.9	49.5
28/5/2013	22.3	61.6	27.2	45.4
Total	123.2	377.9	144.6	297.0
Mean	20.5	62.98	24.1	49.5

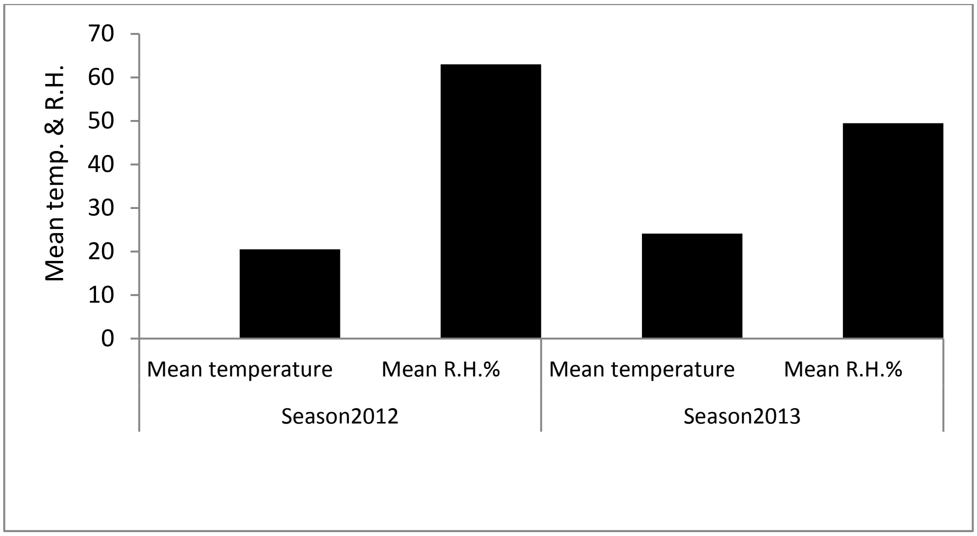


Fig. (23): Mean temperature and relative humidity during 2012&2013 seasons

Statistical analysis for the effect of the three selected abiotic factors on the population of *Tuta absoluta* during two successive seasons at Qaliubya Governorate are shown in Tables 37&39.

3.4.1. Red sun cultivar

During the first season 2012, the population abundance of *T. absoluta* infesting Red sun cultivar of tomato plants showed one peak on the 21th of May (Table 37 and Figure 24). The corresponding recorded number was 12 leaf mines/10 leaflets. During the second season 2013, also one peak was recorded on May, 21th. The total recorded number of peak was 20.0leaf mines/10 leaflets (Table 37 and Figure 24).

Statistical analysis of the effects of three selected physical factors on the population dynamics of *T. absoluta* during both seasons at Qalyiubya Governorate are shown in Tables (38&40**)**. These results showed insignificant positive effects to minimum, maximum temperature and relative humidity on the seasonal fluctuations of *Tuta absoluta* in the first season, whereas "r" values were 0.58, 0.39 and 0.34, respectively. In the second season, the results revealed insignificant effects to the same three factors on the seasonal fluctuations of *T. absoluta* whereas, "r" values were 0.79, 0.66 and -0.53, respectively. The percentages of explained variance (E.V.) for the tested factors during both seasons were 83.8% and 91.1% effects on the rate of infestation of *T. absoluta*.

3.4.2. Hybrid Super strain B cultivar

Hybrid Super strain cultivar was liable to infestation with *T. absoluta* (Table 37 and Figure 25).

In the first season, the first appearance of *T. absoluta* was occurred at the beginning of season and the population fluctuated up to down. Only one peak was recorded at 7th of May having 12.0leaf mines/10 leaflets. The second season 2013 two peaks were recorded on 7th of May and 28th being 12.7 and 4.3leaf mines/10 leaflets, respectively (Table 39 and Figure 25).

Statistical analysis of the effects of three selected physical factors on the population dynamics of *T. absoluta* during both seasons at Qaliubya Governorate are shown in Tables (38&40**)**. These results showed insignificant positive effects to minimum temperature and maximum on the seasonal fluctuations of *T. absoluta* in both seasons, whereas "r" values were 0.59 and 0.47, respectively during 2012 0.33 and 0.60, respectively during 2013. While there are insignificant effects to relative humidity whereas, "r" values were 0.42 and -0.51, during 2012 and 2013, respectively. The percentages of explained variance (E.V.) for the tested factors during both seasons were 85.5% and 87.1% effects on the rate of infestation of *Tuta absoluta*.

3.4.3. Castle rock cultivar

During season 2012, data in Table 37 and Figure 26, showed one peak of tomato leaf miner population on 14th of May on Castle rock cultivar. The recorded numbers was 6.7 leaf mines/10 leaflets. During the second season 2013, there are two peaks of tomato leaf miner numbers are recorded on 7th and 21th of May. The numbers of insect were 6.7 and 12.3 leaf mines/10 leaflets, respectively (Table 39 and Figure 26).

Statistical analysis of the effects of three selected physical factors on the population dynamics of *T. absoluta* during both seasons at Qaliubya Governorate are shown in Tables (38&40). These results showed insignificant effects to minimum, maximum temperature and relative humidity on the seasonal fluctuations of *T. absoluta* in the first season, whereas "r" values were 0.56, 0.48 and -0.1, respectively. In the second season, there is a significant positive effect to minimum temperature whereas "r" value was 0.84, while the results revealed insignificant effects to maximum temperature and relative humidity whereas "r" values were 0.79 and -0.67, respectively. The combined effect (E.V.) for the tested factors during 2012&2013 seasons were 87.8% and 90.7% effects on the rate of infestation of *T. absoluta*.

3.4.4. Riogrande cultivar

Data in Table 37 and Figure 27showed the same results as the above mentioned three studied cultivars. Only one peak of *T. absoluta* population was present in the first season 2012 on 14th of May being 11.7leaf mines/10 leaflets. During the following second season (2013), also two peaks of *Tuta* *absoluta* occurred on 7th and 14th of May with number of 5.3 and 6.3leaf mines/10 leaflets, respectively(Table 39 and Figure 27).

Statistical analysis of the effects of three selected physical factors on the population dynamics of *Tuta absoluta* during both seasons at Qaliubya Governorate are shown in Tables (38&40)**.** These results showed insignificant positive effects to minimum and maximum temperature on the seasonal fluctuations of *T. absoluta* in the first season, whereas "r" values were 0.53 and 0.43, respectively, while there are insignificant positive effects in the second season whereas, "r" values were 0.69 and 0.77, respectively. The results revealed insignificant negative effects to relative humidity on the seasonal fluctuations of *T. absoluta* during 2012 whereas "r" value was -0.05, while there is a significant negative effect during 2013whereas "r" value was -0.85. The percentages of explained variance (E.V.) for the tested factors during two successive seasons were 83.4% and 88.5% effects on the rate of infestation of *T. absoluta*.

3.4.5. Baladi cultivar

During season 2012, data in Table 37 and Figure 28, showed one peak of tomato leaf miner population on 14th of May on Baladi cultivar. The recorded numbers was 8.0leaf mines/10 leaflets. During the second season 2013, also two peaks of tomato leaf miner numbers were recorded on 7th and 28th of May. The two peaks were 11.0 and 5.7 leaf mines/10 leaflets, respectively (Table 39 and Figure 28).

Statistical analysis of the effects of three selected physical factors on the population dynamics of *T. absoluta* during both seasons are shown in Tables (38&40)**.** These results showed insignificant positive effects to minimum and maximum temperature on the seasonal fluctuations of *Tuta* *absoluta* in the first season, whereas "r" values were 0.73 and 0.69, respectively, while there are insignificant positive effects in the second season whereas "r" values were 0.39 and 0.67, respectively. The results revealed insignificant negative effects to relative humidity on the seasonal fluctuations of *Tuta absoluta* in both seasons whereas "r" values were 0.006 and -0.69 during 2012 and 2013, respectively. The percentages of explained variance (E.V.) for the tested factors showed that those factors were responsible as a group for 85.7% and 90.5% effects on the rate of infestation of *T. absoluta* throughout both seasons, respectively.

3.4.6. Nemaguard cultivar

The activity of this insect on Nemaguard had the same trend in the two studied seasons (2012 and 2013). In the first season, one peak occurred in May, 14th and recording 7.3 leaf mines/10 leaflets (Table 37 and Figure29). Again in the second season 2013, also two peaks were recorded. The highest peak of population was 8.0leaf mines/10 leaflets (7th of May), while the other peak was recorded at 28th of May (5.0leaf mines/10 leaflets) (Table 39 and Figure 29).

Statistical analysis of the effects of three selected physical factors on the population densities of *T. absoluta* during both seasons are shown in Tables (38&40**).** These results showed insignificant positive effects to minimum and maximum temperature on the seasonal fluctuations of *T. absoluta* in the first season, whereas "r" values were 0.67and 0.52, respectively, while there are insignificant positive effects in the second season whereas "r" values were 0.54 and 0.79, respectively. The results revealed insignificant negative effects to relative humidity on the seasonal fluctuations of *T. absoluta* in both seasons whereas "r" values were 0.04 and -0.77 during 2012 and 2013, respectively. The combined effect (E.V.) for these factors were responsible as a group for 84.9% and 95.8% effects on the population densities of *Tuta absoluta* throughout both seasons, respectively.

3.4.7. Super set cultivar

Data in Table 37 and Figure 30showed the total numbers of *T. absoluta* / 10 leaves during the two seasons.

In the first season 2012, the population fluctuated up and down. Two peaks in the population abundance were detected on 7th and 28th of May. The corresponding recorded number of populations of that peaks were 8.7 and 5.0leaf mines/10 leaflets, respectively. In the second season 2013, also two peaks were recorded on 30th of April and 21th of May (6.7 and 5.0leaf mines/10 leaflets)(Table 39 and Figure 30).

Statistical analysis of the effects of three selected physical factors on the population dynamics of *T. absoluta* during both seasons are shown in Tables (38&40)**.** These results showed insignificant positive effects to minimum and maximum temperature on the seasonal fluctuations of *T. absoluta* in the first season, whereas "r" values were 0.75 and 0.72, respectively, while there are insignificant positive effects to minimum and maximum temperature in the second season whereas, "r" value was 0.33 and 0.44,respectively. The results revealed insignificant effects to relative humidity on the seasonal fluctuations of *T. absoluta* in both seasons whereas "r" values were 0.36 and -0.66 during 2012 and 2013, respectively. The combined effect (E.V.) for the previous mentioned ecological factors showed that these factors were responsible as a group for 88.9% and 91.9% effects on the population densities of *T. absoluta* throughout both seasons, respectively.

3.4.8. Hybrid Bito86 cultivar

At the first season 2012, in Table 37 and Figure 31, the population density on Hybrid Bito86 cultivar expressed by one peak (7^{th} of May) being 5.0leaf mines/10 leaflets. Again at the second season, 2013 only two peak were recorded being 5.7 and 5.3 leaf mines/10 leaflets on May, 7^{th} and 28^{th} (Table39 and Figure 31).

Statistical analysis of the effects of three selected physical factors on the population dynamics of *Tuta absoluta* during both seasons are shown in Tables (38&40)**.** These results showed significant positive effects to minimum temperature in the first season, whereas "r" value was0.86, while there is insignificant positive effect to maximum temperature and relative humidity on the seasonal fluctuations of *T. absoluta* whereas "r" values were 0.75and 0.14, respectively. In the second season, there are insignificant positive effects to minimum and maximum temperature on the seasonal fluctuations of *T. absoluta* whereas "r" values were 0.52 and 0.74, respectively, while there is significant negative effect to relative humidity on the seasonal fluctuations of *T. absoluta* whereas "r" values were -0.92. The combined effect (E.V.) for these factors were responsible as a group for 92.7% and 90.3% effects on the population densities of *T. absoluta* throughout both seasons, respectively.

Table (37): Weekly mean number of *Tuta absoluta* leaf mines/10leaflets and the main three weather factors (Max., Min.temp. and Mean R.H.%) at Qaliubya Governorate during seasons, 2012

cultivars	Number of leaf mines/10leaf lets								Physical factors		
Inspection dates	Red sun	**Hybrid super strainB**	**Castle rock**	**Riogrande**	**Baladi**	**Nemaguard**	**Super set**	**Hybrid Bito86**	**Max. Tem.(x_1)**	**Min. Tem.(x2)**	**Mean R.H.%(x_3)**
23/4/2012	0	0	0	0	0	0	0	0	27.1	9.8	61.3
30/4/2012	0	0	0	0	0	0	0	0	27.3	11.4	64.1
07/5/2012	9.7	12.0	3.7	4.3	5.3	3.7	8.7	5.0	29.1	12.9	64.9
14/5/2012	10.7	9.3	10.7	11.7	8.0	7.3	4.0	5.0	29.3	13	61.7
21/5/2012	12.0	8.0	5.7	6.7	4.1	6.3	3.7	5.0	27.6	12.2	64.3
28/5/2012	4.3	3.3	3.0	2.7	3.7	3.7	5.0	5.0	30.2	13.9	61.6
Total	36.7	32.6	23.1	25.4	21.1	21.0	21.4	20	170.6	73.2	377.9
Mean	9.2 a	8.2 a	5.8 b	6.4 b	5.3 c	5.3 c	5.4 c	5.0 d	38.4	12.2	62.98
F value	10.5***										
L.S.D.	1.0 mine										

Table (38): Simple correlation and multiple regression values of the three main weather factors on *Tuta absoluta* mines and corresponding percentage of explained variance on eight tomato cultivars at Shoubra Elkheima, Qaliubya Governorate during season 2012

Studied cultivars	Tested factors															% E.V.
	Minimum Temp.					Maximum Temp.					Mean R.H.					
	Simple correlation		Multipleregression			Simple correlation		Multiple regression			Simple correlation		Multipleregression			
	r	P	b	S.E.	P	r	P	b	S.E.	P	r	P	b	S.E.	P	
Red sun	0.58	0.2	3.9	6.6	0.6	0.39	0.4	-2.3	7.7	0.7	0.34	0.5	0.38	2.6	0.8	83.8
Hybrid super strainB	0.59	0.2	-0.4	5.7	0.9	0.47	0.3	2.8	6.7	0.7	0.42	0.4	1.8	2.3	0.5	85.5
Castle rock	0.56	0.2	3.8	5.1	0.5	0.48	0.3	-2.7	5.9	0.6	-0.1	0.8	-1.1	2.03	0.6	87.8
Riogrande	0.53	0.2	4.3	5.9	0.5	0.43	0.3	-3.2	6.9	0.6	-0.05	0.2	-1.1	2.4	0.6	83.4
Baladi	0.73	0.09	1.4	3.5	0.7	0.69	0.1	0.2	4.1	0.9	0.006	0.9	-0.06	1.4	0.9	85.7
Nemaguard	0.67	0.1	3.6	3.4	0.4	0.52	0.2	-2.6	3.9	0.5	0.04	0.9	-0.7	1.4	0.6	84.9
Super set	0.75	0.08	-1.8	2.01	0.2	0.72	0.1	4.2	2.3	0.2	0.36	0.4	1.6	0.8	0.1	88.9
Hybrid Bito86	0.86	0.02	1.6	2.2	0.5	0.75	0.08	-0.12	2.5	0.9	0.14	0.7	0.06	0.8	0.9	92.7

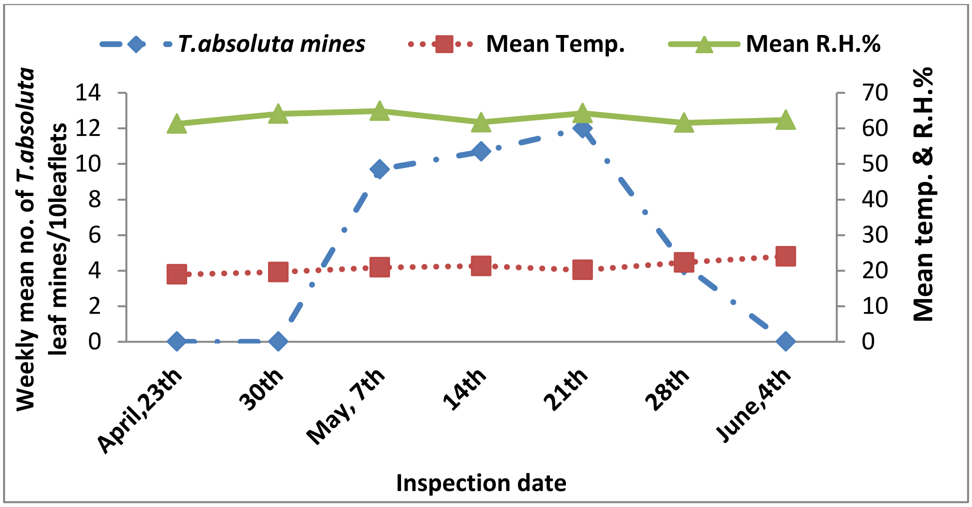
Table (39): Weekly mean number of *Tuta absoluta* leaf mines/10leaflets and the main three weather factors (Max., Min. temp. and Mean R.H.%) at Qaliubya Governorate during seasons, 2013

cultivars	Number of leaf mines/10leaf lets								Physical factors		
Inspection dates	**Red sun**	**Hybrid super strainB**	**Castle rock**	**Riogrande**	**Baladi**	**Nemaguard**	**Super set**	**Hybrid Bito86**	**Max. Tem.(x_1)**	**Min. Tem.(x2)**	**Mean R.H.%(x_3)**
23/4/2013	0	0	0	0	0	0	0	0	25.9	14.28	55.33
30/4/2013	3.0	5	2.7	4.7	3.0	3.0	6.7	3.7	28.7	15.14	49.66
07/5/2013	6.0	12.7	6.7	5.3	11.0	8.0	4.0	5.7	33.5	17.6	47.86
14/5/2013	4.3	11.3	4	3.3	3.3	5.7	3.7	3	33.6	19.26	49.2
21/5/2013	20.0	3.7	12.3	6.3	4.0	3.0	5.0	2.7	33.3	19.9	49.5
28/5/2013	13.3	4.3	9.3	5.7	5.7	5.0	4.3	5.3	34.7	20.46	45.4
Total	46.6	37	35	25.3	27.0	24.5	23.7	20.4	189.7	106.64	296.95
Mean	9.3 a	7.4 b	7.0 b	5.1 c	5.4 c	4.9 c	4.7 cd	4.1 d	31.62	17.77	49.49
F. value	39.9***										
L.S.D.	0.8mine										

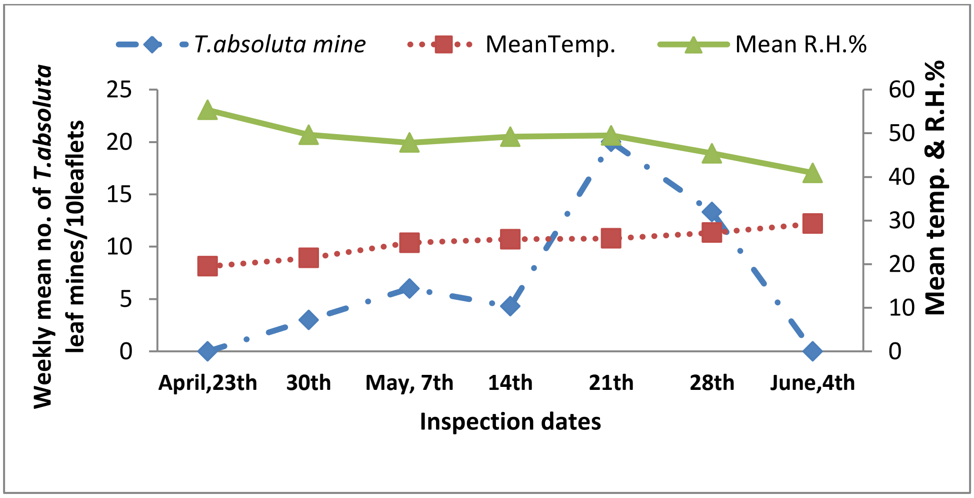
Table (40): Simple correlation and multiple regression values of the three main weather factors on *Tuta absoluta* mines and corresponding percentage of explained variance on eight tomato cultivars at Shoubra Elkheima, Qaliubya Governorate during season 2013

Studied cultivars	Tested factors															
	Minimum Temp.					Maximum Temp.					Mean R.H.					
	Simple correlation		Multipleregression			Simple correlation		Multipleregression			Simple correlation		Multipleregression			% E.V.
	r	P	b	S.E.	P	r	P	b	S.E.	P	r	P	b	S.E.	P	
Red sun	0.79	0.06	4.4	3.6	0.3	0.66	0.1	-2.1	3.6	0.6	-0.53	0.2	-0.49	2.02	0.8	91.1
Hybrid super strainB	0.33	0.5	-4.2	1.3	0.07	0.60	0.2	4.6	1.3	0.06	-0.51	0.2	1.03	0.72	0.2	87.1
Castle rock	0.84	0.03	1.6	2.1	0.5	0.79	0.06	-0.31	2.1	0.8	-0.67	0.1	-0.24	1.2	0.8	90.7
Riogrande	0.69	0.1	0.09	1.02	0.9	0.77	0.07	-0.01	1.02	0.9	-0.85	0.03	-0.55	0.58	0.4	88.5
Baladi	0.39	0.4	-2.7	1.2	0.1	0.67	0.1	2.6	1.2	0.1	-0.69	0.1	0.05	0.66	0.9	90.5
Nemaguard	0.54	0.2	-1.9	0.3	0.02	0.79	0.05	2.1	0.3	0.01	-0.77	0.07	0.14	0.16	0.4	95.8
Super set	0.33	0.5	-0.07	1.3	0.9	0.44	0.3	-0.3	1.3	0.8	-0.66	0.1	-0.79	0.74	0.3	91.9
Hybrid Bito86	0.52	0.2	-0.82	0.2	0.06	0.74	0.08	0.54	0.21	0.1	-0.92	0.008	-0.57	0.12	0.04	90.3

RESULT AND DISCUSSION

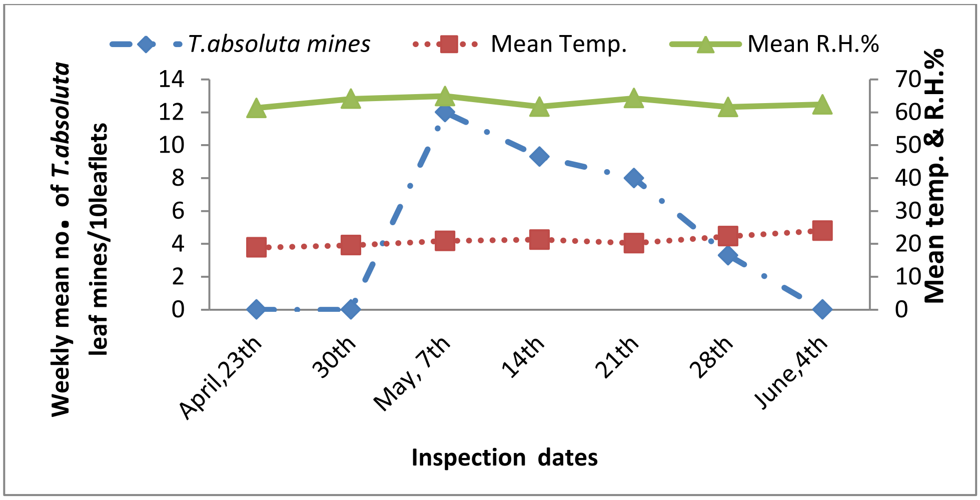


2012

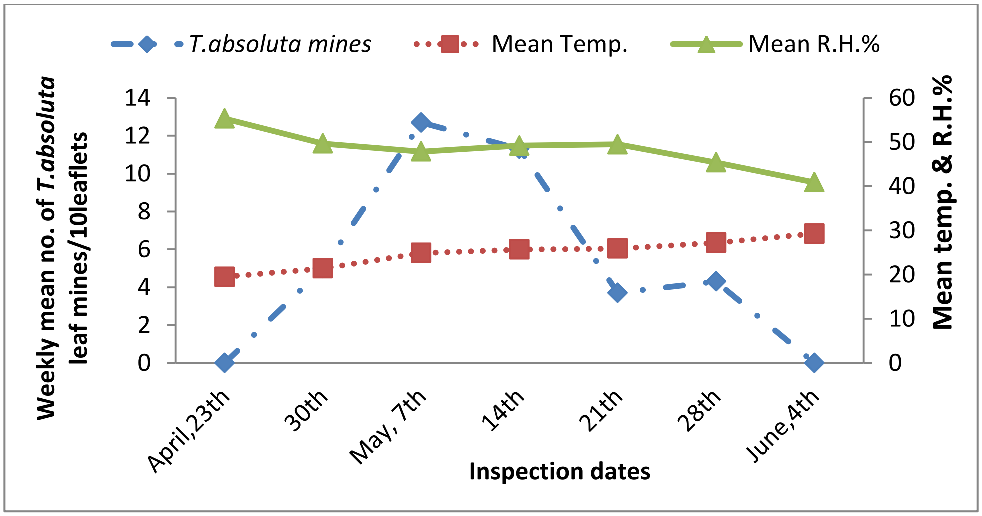


2013

Fig.(24): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Red sun during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.

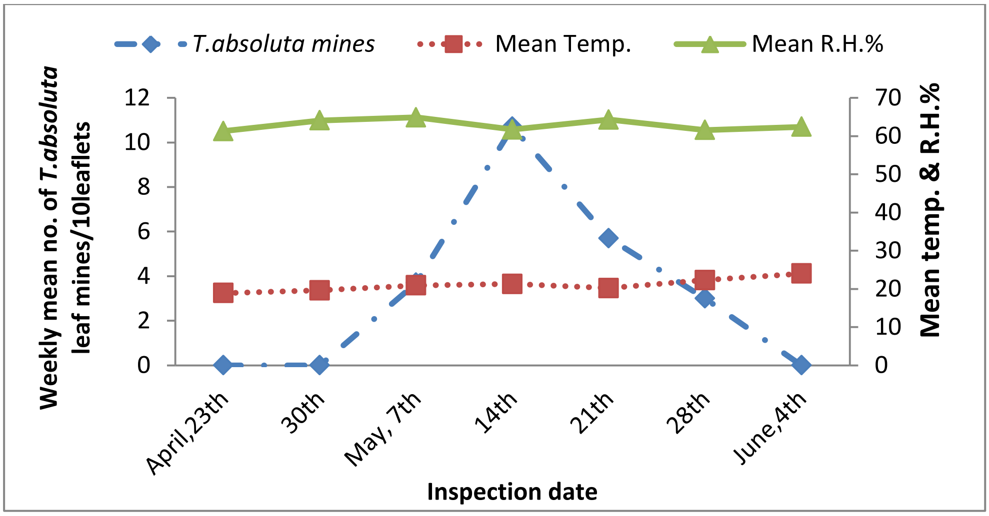


2012

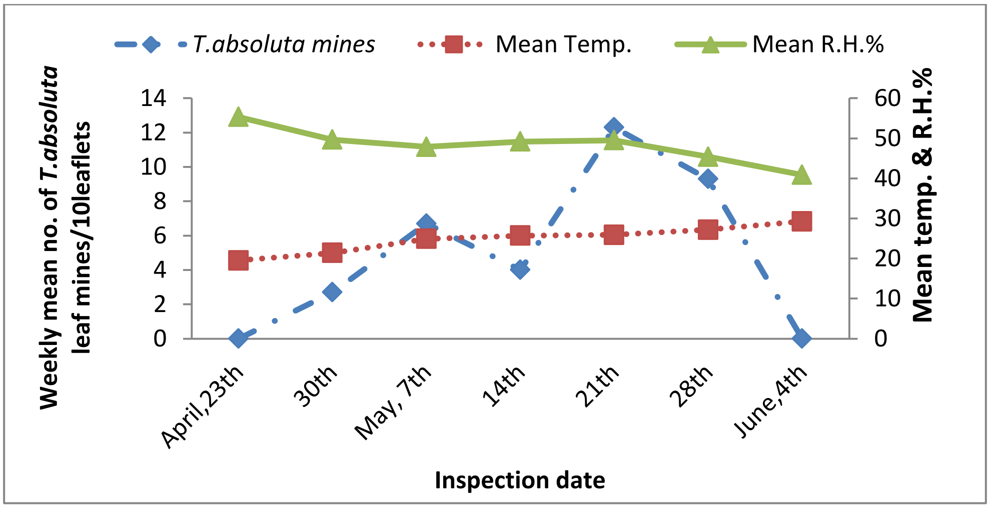


2013

Fig.(25): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Hybrid super strain B during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.

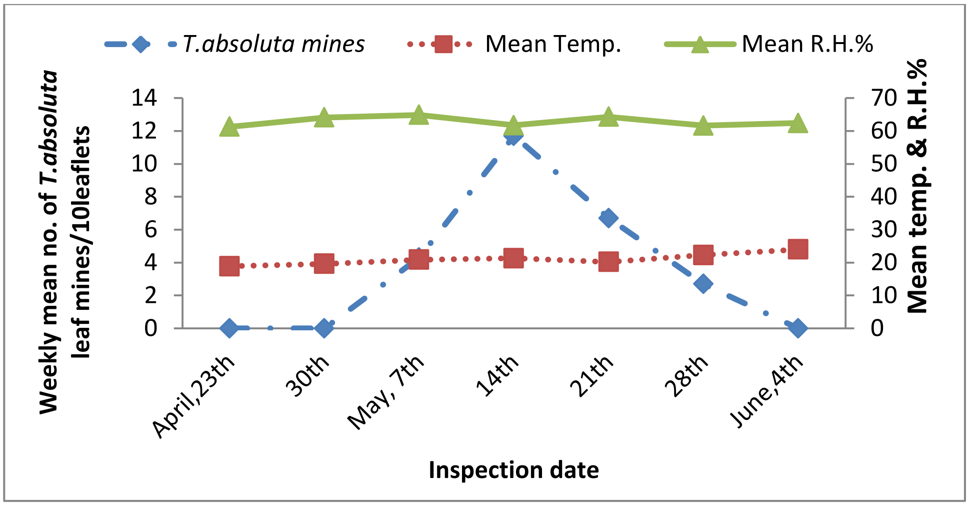


2012

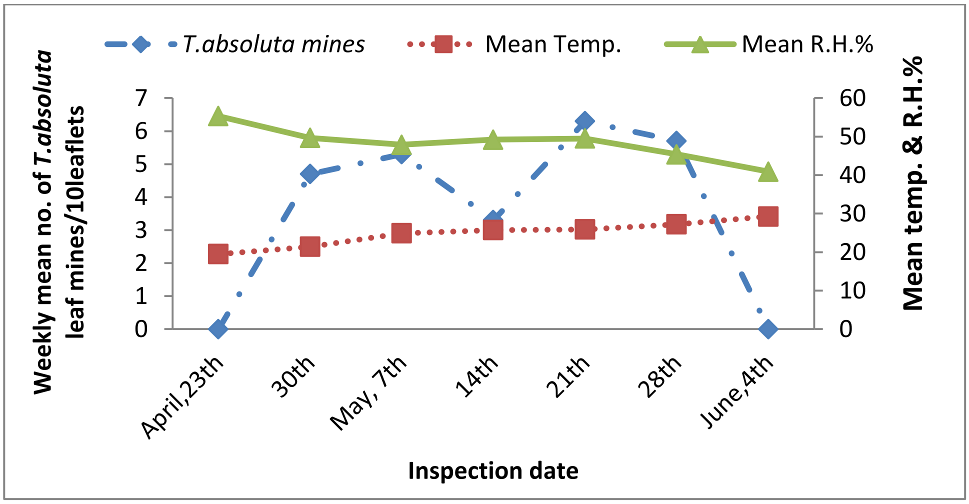


2013

Fig.(26): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Castle rock during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.

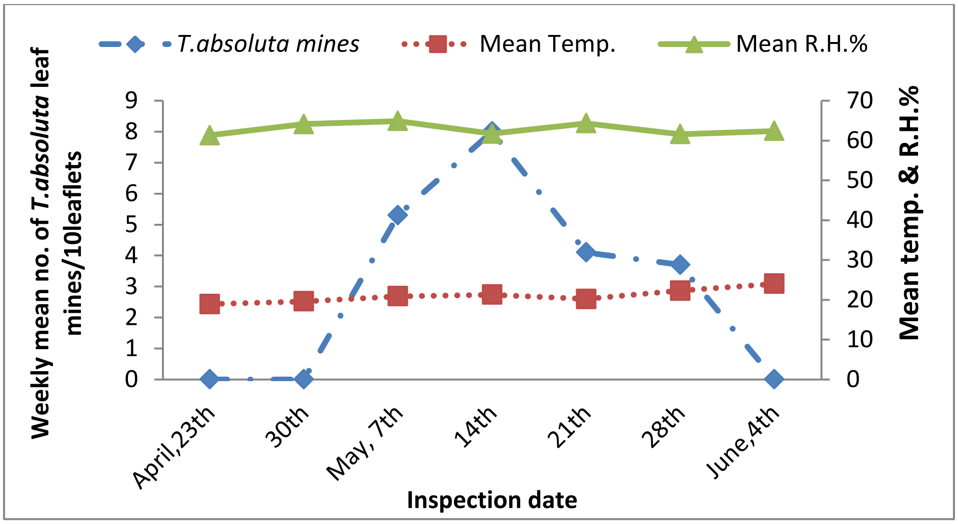


2012

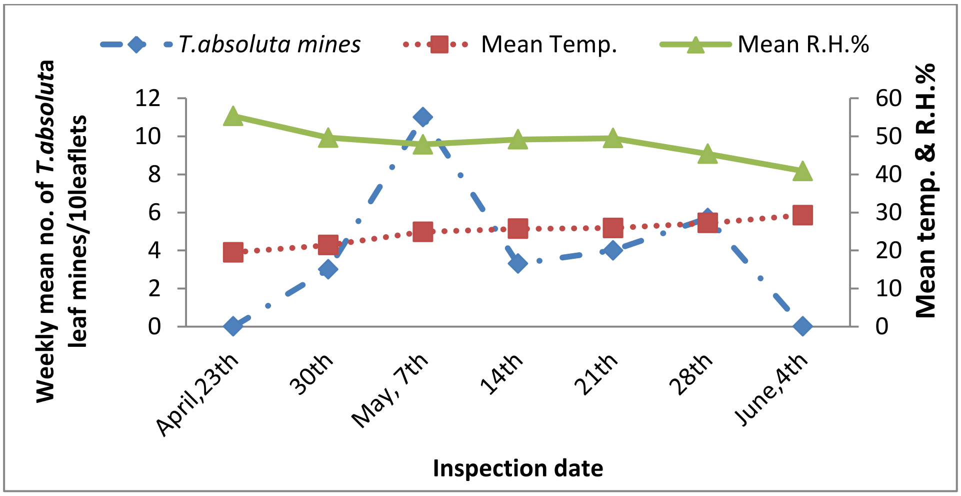


2013

Fig.(27): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Riogrande during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.

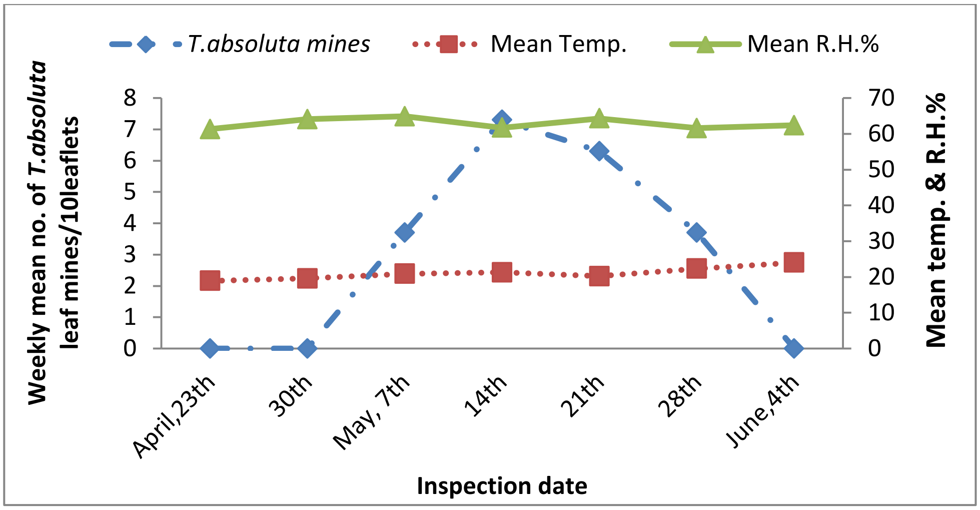


2012

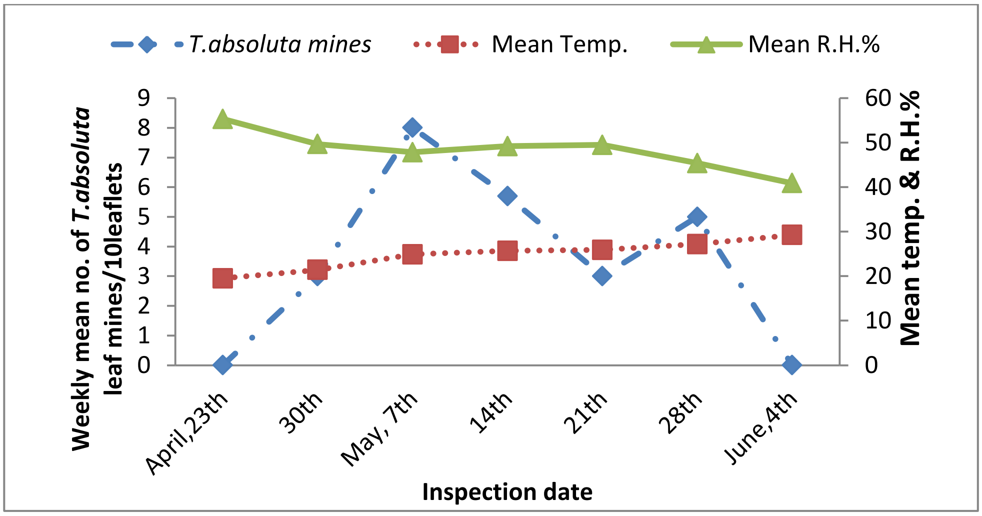


2013

Fig.(28): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Baladi during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.



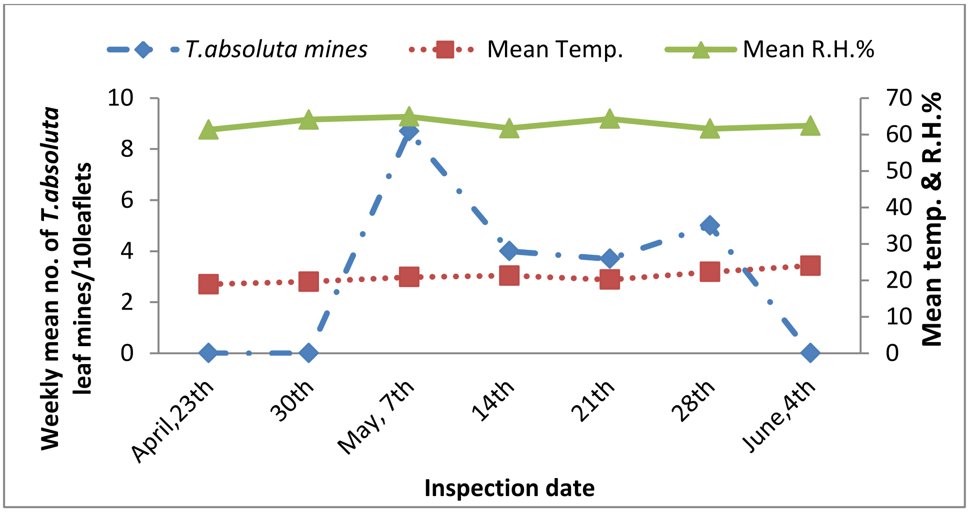
2012



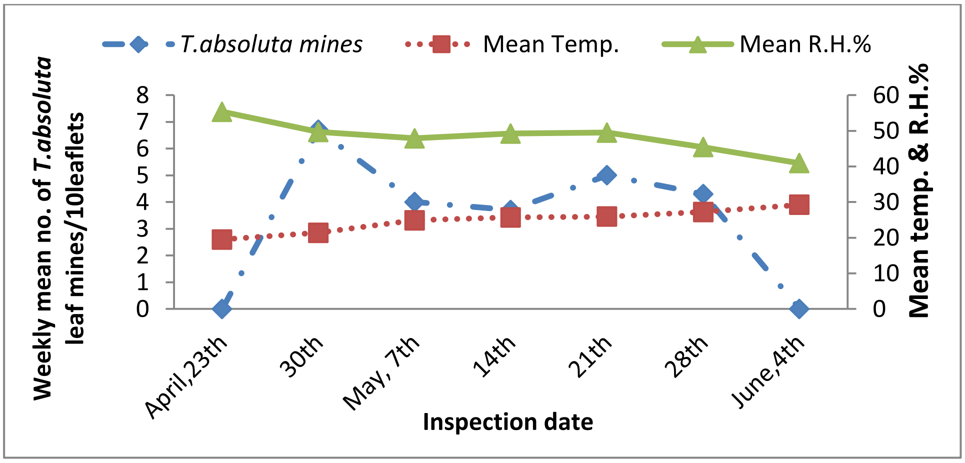
2013

Fig.(29): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Nemaguard during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.

RESULT AND DISCUSSION



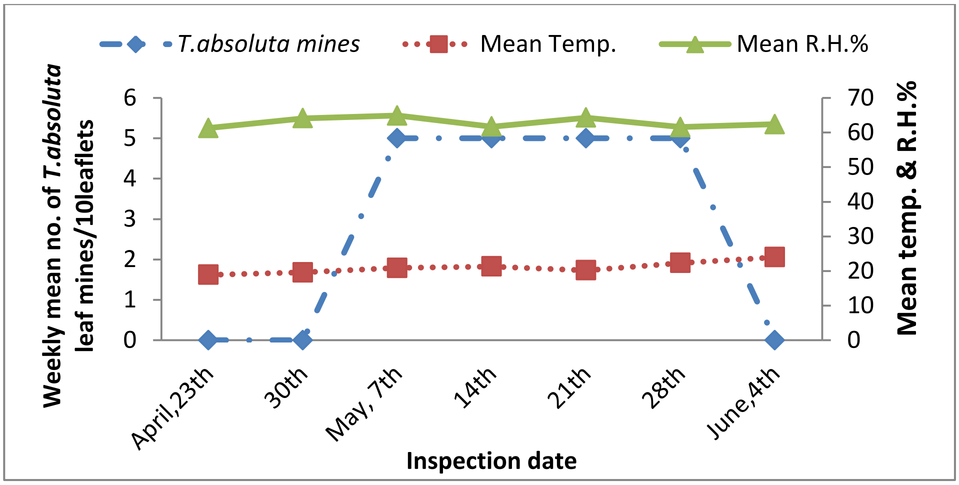
2012



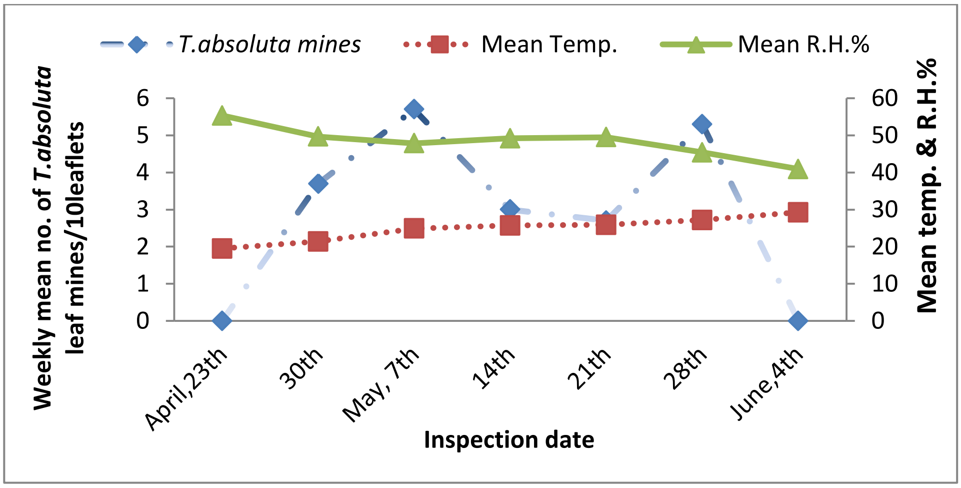
2013

Fig.(30): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Super set during two summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.

RESULT AND DISCUSSION



2012



2013

Fig.(31): Population fluctuations of *Tuta absoluta* leaf mines/10 leaflets occurred on tomato plants Hybrid Bito 86duringtwo summer seasons 2012 and 2013, at Shalakan, Qualiobya Governorate.

3.5. The effect of three plant growth regulator on induced resistance to *Tuta absoluta* in certain tomato cultivars

To evaluate effect of plant growth regulators namely; Benzyle adenin, Kinetin and Salicylic acid (main treatment) on induced resistance to *T. absoluta* in three tomato cultivars namely; Hybrid Super strain B, Baladi and Castle rock (susceptible cultivars) (sub treatment) during three weeks (sub.sub. treatment). Factorial experiment (split-split plot design) was carried out at Faculty Farm, Shoubra ElKheima, Qalyubia Governorate during growing season 2016.

Tables 41, 42& Fig. 32 indicated that there are highly difference between control and plant growth regulator, whereas F value=44 sigat 0.001 and L.S.D.=0.8 mine. These treatments (main treatment) significantly could be divided into three groups. 1st group contains Benzyle adenin and Kinetin with averages 2.8 & 3.5 mines/pot. 2nd group include Salcylic acid with 4.4mines/pot. 3rd one includes control treatment with 7.3mines/pot. The finding of the current study showed that the cultivars after applications of three plant growth regulators could be nominated as unsuitable hosts for tomato leaf miner.

Moreover, these results may develop the findings and screening process of relatively resistant cultivars to be used management of *T. absoluta.*

According to tomato cultivars (sub. treatment), data presented in Tables 41, 42& Fig. 33 showed that there are highly difference between tomato cultivars, whereas "F" value=13.6 sig. at 0.001 and L.S.D.=0.7mine. It clears that three tomato cultivars can be arranged follows; 1st group contains, Castle rock 3.4mines/pot and 2nd group include Baladi& Hybrid super strain B with 4.9 & 5.2 mine/pot.

According to date of inspection (sub. sub. treatment), there are a highly difference between three dates (Fig.34), whereas "F"value about 227.0 sig. at 0.001and L.S.D.= 0.7mine. Dates could be significantly divided into three groups; 1st one, third date 28th April with 1.5 mines/pot. 2nd group, second date 2th April with 5.3 mines /pot.3rd group, first date with 8.7mines/pot. These results are in line with those obtained by **Popova *et al.*, (1997**) in Bulgaria, who recorded that Salicylic acid as a natural inducer of thermogenesis and disease resistance in plants. Besides the physiological functions of Salicylic acid, the general properties, biosynthesis and metabolism of this plant growth regulator are discussed. **Sakhabutdinova *et al.*, (2003)** in Russia, found that the salicylic acid (SA) treatment reduced the damaging action of salinity and water deficit on seedling growth and accelerated a restoration of growth processes.**Javaheri *et al.*, (2012)** recorded that application of salicylic acid affected tomato yield and quality characters of tomato fruits so that tomato plants treated with salicylic acid 10 -6 M significantly had higher fruit yield (3059.5 g per bush) compared to non-treated plants (2220 g/bush) due to an increase in the number of bunch per bush.**Pacheco *et al.*, (2013)** in Brazil, mentioned that Salicylic acid exogenous application before the reproductive stage resulted in higher biomass production of marigold plants and added significant value to the raw material by increasing total flavonoids content in the inflorescences.

Table (41): Number of *Tuta absoluta* for three tomato cultivars treated with three plant growth regulators during three weeks at Shoubra Elkheima, Qaliubya Governorate during season 2016

Inspection dates	Rep.	Benzyleadenin				Kinetin				Salicylic acid				Control				Total	Mean
		Super strain B	Baladi	Castle rock	Total	Super strain B	Baladi	Castle rock	Total	Super strain B	Baladi	Castle rock	Total	Super strain B	Baladi	Castle rock	Total		
14-4-2016	A	5	6	5	16	9	4	7	20	9	14	6	29	22	13	6	41	106	
	B	6	5	3	14	12	11	9	32	6	6	7	19	18	14	9	41	106	
	C	8	6	5	19	8	6	5	19	7	12	8	27	18	11	10	39	104	
Total		19	17	13		29	21	21		22	32	21		51	38	25			
		49				71				75				121				316	8.7
21-4-2016	A	4	4	3	11	1	3	3	7	5	3	1	9	5	6	6	17	44	
	B	2	3	2	7	1	2	1	4	7	2	3	12	8	6	5	19	42	
	C	1	1	0	2	0	4	1	5	5	2	2	9	8	4	4	16	32	
Total		7	8	5		2	9	5		17	7	6		21	16	15			
		20				16				30				52				118	3.3
28-4-2016	A	0	1	1	2	1	3	0	4	2	1	3	6	3	5	1	9	21	
	B	0	3	1	4	0	1	0	1	1	1	2	4	1	5	2	8	17	
	C	0	1	0	1	0	3	0	3	1	2	2	5	2	3	1	6	15	
Total		0	5	2		1	7	0		4	4	7		6	13	4			
		7				8				15				23				53	1.5
Total of cultivars		26	30	20		32	37	26		43	43	34		85	67	44			
		76				95				120				196				487	
Mean of regulator		2.8				3.5				4.4				7.3					

Table (42): Analysis of variance for the effect of plant growth regulators on induced resistance to *Tuta absoluta* in certain tomato cultivars

Source of variance	d.f.	SS	MS	F value	L.S.D.
Plant growth regulator	3	308.3	102.8	44.7***	0.8
Cultivar	2	62.4	31.2	13.6***	0.7
Time	2	1042.6	521.3	227***	0.7
Plant growth regulator * Cultivar	6	49.9	8.3	3.6**	1.4
Plant growth regulator * Time	6	101.4	16.9	7.4***	1.4
Cultivar* Time	4	61.5	15.4	6.7***	1.2
Plant growth regulator *Cultivar*Time	12	127.6	10.6	4.6***	2.5
Error	72	165.3	2.3		
Total	107	1918.9			

Plant growth regulators	Benzyleadenin	Kinetin	Salcylic acid	Control
	2.8	3.5	4.4	7.3c
L.S.D.=0.8mine	a	a	b	c

cultivars	Hybrid super strain B	Baladi	Castle rock
L.S.D.=0.7mine	5.2c	4.9b	3.4a

Date	1st (14/4)	2nd (21/4)	3rd (28/4)
L.S.D.=0.7mine	8.7c	5.3b	1.5a

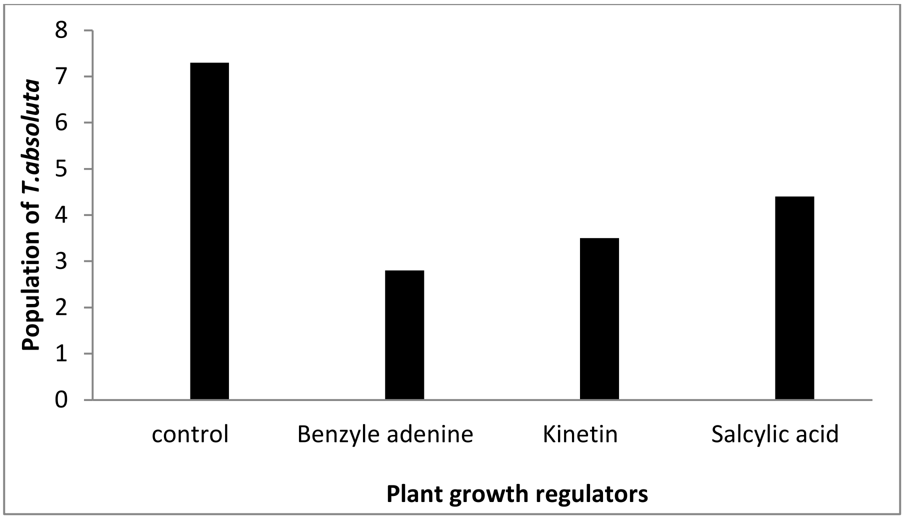


Fig. (32): Effect of three plant growth regulator (Benzyle adenin, Kinetin and Salicylic acid) on *Tuta absoluta* infestation contracting to contro*l*

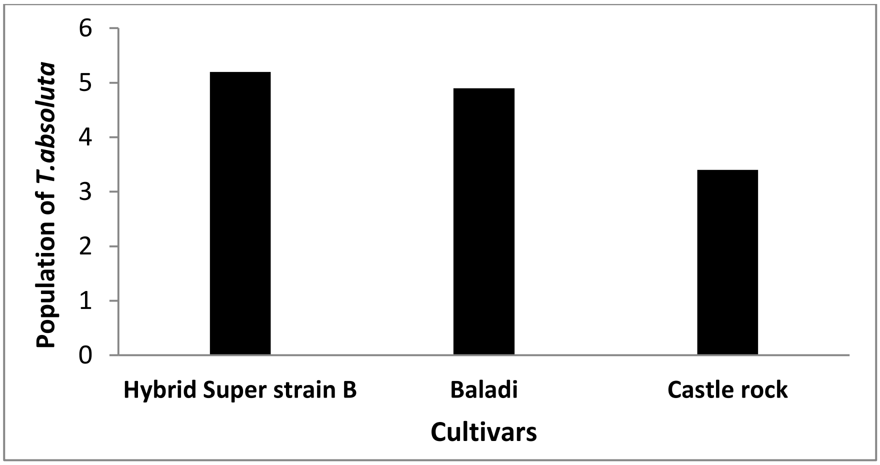


Fig. (33): Effect of sensitive cultivars (Hybrid super strain, Baladi and Castle rock) on *T. absoluta* infestation

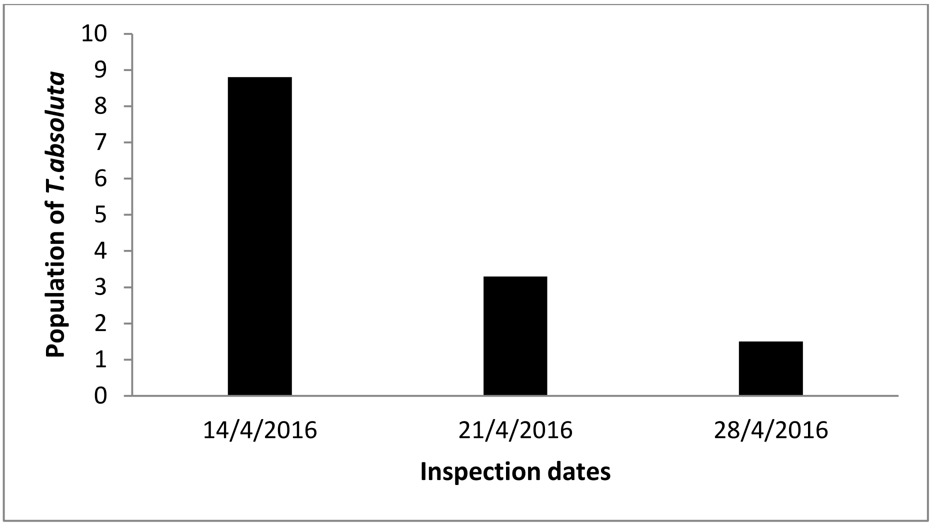


Fig. (34): Effect of inspection dates on *Tuta absoluta* infestation

4. Seasonal abundance and generations in relation to phermone trap catches

4.1. Monitoring the changes in *Tuta absoluta* population activity based on adult occurrence expressed as actual data figures

Monitoring the changes in the population dynamic of based on actual data figure of adults was carried out from May 2015 to May 2016. Moths were counted every week all over the year and the corresponding prevailing meteorological weather factors namely; Day maximum temperature(x_1), minimum temperature(x_2) and R.H.%(x_3) were recorded.

Data tabulated in Table43 indicated that the tomato leaf miner *T. absoluta* demonstrates 10 generations from May 2015 to May 2016. The appearance date of moths could be explained as follows:

The first generation (Table 43) occurred in tomato field during 2015 from the beginning of June 2015 to last week of same month lasted for 4 weeks. The maximum number of moths took place during 16th June (200moths/week). The second generation appeared from the second week of July to last July (4 weeks), the maximum number of moths occurred on 7th July (250moths/week).There are no recorded any fluctuations in the period from 28th July to 8th October. The third generation started from early October to the end of October, the peak of this generation recorded on 20th October (4weeks) (55moths/week). The fourth generation formed at the beginning of November to last week of same month, the peak of this generation recorded on 10th November (4weeks)(35moths/week). The fifth generation was recorded at the beginning of December and lasted three weeks, the maximum number of moths occurred on 8th December (4weeks) (27moths/week). The sixth generation began from last week of December till last week of January, the maximum number of moths took place during 19th January (5weeks) (35moths/week). Seventh generation took place from the beginning of February to the first week of March, the peak of this generation recorded on 16th February (5weeks) (50moths/week). Eighth generation began from the second week of March till the last of the same month, the peak of this generation recorded on 22th March (4weeks) (90moths/week). Ninth generation was appeared at the beginning of April and lasted three weeks, the maximum number of moths occurred on 19th April (3weeks) (250moths/week). The tenth generation formed at the first week of May to the mid of the same month, the maximum number of moths occurred on 10th May (3weeks) (300moths/week).

In general, there are four generations more dangerous namely generation of April (250 moths), generation of May (300 moths), generation of June (200 moths) and generation of July (250 moths/week) during spring and early summer seasons. The rest of six generations were not dangerous, whereas the number of moths during the peak of theses generations ranging from 27 to 90 moths/week. Also there are aestivation period from August to half of October, whereas the number of moths ranging from 1 to 15 moths per week during this period Table42& Fig. 35.

Table (43): Fluctuation of the population of *Tuta absoluta* moths all over the year and the corresponding average of main weather forecasting factors during 2015/2016.

Date	Mean no. of captured moths	Max. temp. (x_1)	Min. temp.(x_2)	Mean R.H.%(x_3)
26/05/2015	150	41	27	33
02/06/2015	300	31	21	52
09/06/2015	160	40	22	42
16/06/2015	200	39	24	58
23/06/2015	150	38	24	53
30/06/2015	200	33	22	54
07/07/2015	250	34	24	59
14/07/2015	200	36	23	63
21/07/2015	190	41	27	51
28/07/2015	100	37	27	57
04/08/2015	70	42	31	64
11/08/2015	15	38	29	34
18/08/2015	5	42	29	31
25/08/2015	4	36	26	62
01/09/2015	3	36	24	57
08/09/2015	2	37	27	56
15/09/2015	1	36	26	61
22/09/2015	1	39	27	36
29/09/2015	4	36	26	57

Date	Mean no. of captured moths	Max. temp. (x_1)	Min. temp.(x_2)	Mean R.H.%(x_3)
06/10/2015	6	32	24	62
13/10/2015	10	36	23	62
20/10/2015	55	36	25	68
27/10/2015	20	29	21	76
03/11/2015	25	29	19	66
10/11/2015	35	27	17	70
17/11/2015	20	25	18	79
24/11/2015	30	27	17	65
01/12/2015	20	25	16	54
08/12/2015	27	21	12	65
15/12/2015	10	30	13	71
22/12/2015	44	21	12	71
29/12/2015	33	21	12	53
05/01/2016	22	22	14	34
12/01/2016	21	22	13	73
19/01/2016	35	22	11	48
26/01/2016	5	18	9	73
02/02/2016	25	25	13	72
09/02/2016	15	24	12	54
16/02/2016	50	32	18	41
23/02/2016	35	29	16	56
01/03/2016	45	33	19	39
08/03/2016	60	32	18	50
15/03/2016	40	32	19	42
22/03/2016	90	32	22	49
29/03/2016	70	30	16	50
05/04/2016	25	41	27	45
12/04/2016	100	35	22	58
19/04/2016	250	36	22	59
26/04/2016	150	42	23	32
03/05/2016	200	37	23	41
10/05/2016	300	44	30	50
17/05/2016	250	44	29	50
24/05/2016	200	38	21	47

Statistical analysis for the effect of the three selected weather factors on the population dynamics of *Tuta absoluta* from May 2015 to May 2016 were given in Table 44 and Figures 35&36. These results revealed that minimum temperature had highly significant positive effects on population density of *T. absoluta* whereas r=0.34 significant at 0.01. On the contrary, maximum temperature had very highly significant negative effect whereas "r" value equal -0.45 significant at 0.0006. While the mean percentage of relative humidity had insignificant negative on population dynamics of *T. absoluta* r=-0.23.

Table (44): Simple correlation and multiple regression values of the three main weather factors on population density of *Tuta absoluta* and corresponding percentage of explained variance on tomato plants at Shalakan, Qalyubia Governorate during season 2015/2016

Tested factors															
Minimum Temp.					Maximum Temp.					Mean R.H.%					
Simple correlation		Multiple regression			Simple correlation		Multiple regression			Simple correlation		Multiple regression			%
r	P	b	S.E.	P	r	P	b	S.E.	P	r	P	b	S.E.	P	E.V.
0.34	0.01	-8.3	4.9	0.09	-0.46	0.0006	12.2	4.3	0.007	-0.23	0.09	0.22	1.0	0.8	22.3

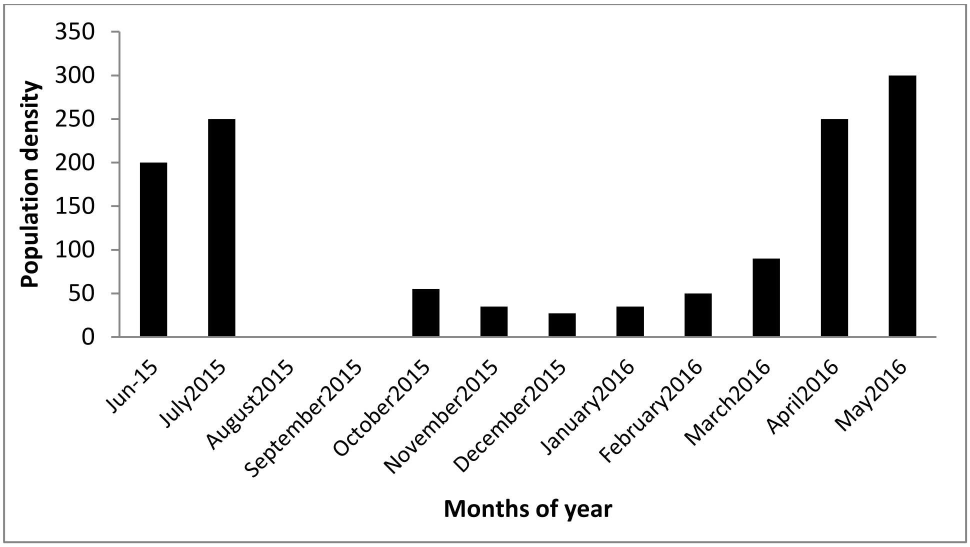


Fig. (35): Seasonal fluctuation of *Tuta absoluta* from May 2015 to May 2016 at Bahada village, Shalakan, Qualiubya Governorate.

Outhers are controversial in opinion concerning the activity of *T. absoluta* during all year round and development stops between 6 and 9^{o} C depending on the life stage. The biological cycle is completed in 29–38 days depending on environmental conditions. Results indicated that this species is not active all the year round, **Barrientos *et al.*, (1998)** recorded that *T. absoluta* overwinter as eggs, pupae or adults. **Ecole *et al.*,(2000)** in Brazil, recorded that fourteen peaks were identified for *T. absoluta* under green house. **EPPO, 2005** recorded that the number of generations per year can range from several up to 10-12. *T. absoluta* has been observed to have five generations per year in Argentina **(Korycinska and Moran 2009). Assaf *et al.*, (2013)** In Iraq, reported that a maximum number of males/ trap/ week were 56.66 recorded on 10/9/2012 in Kurdistan.

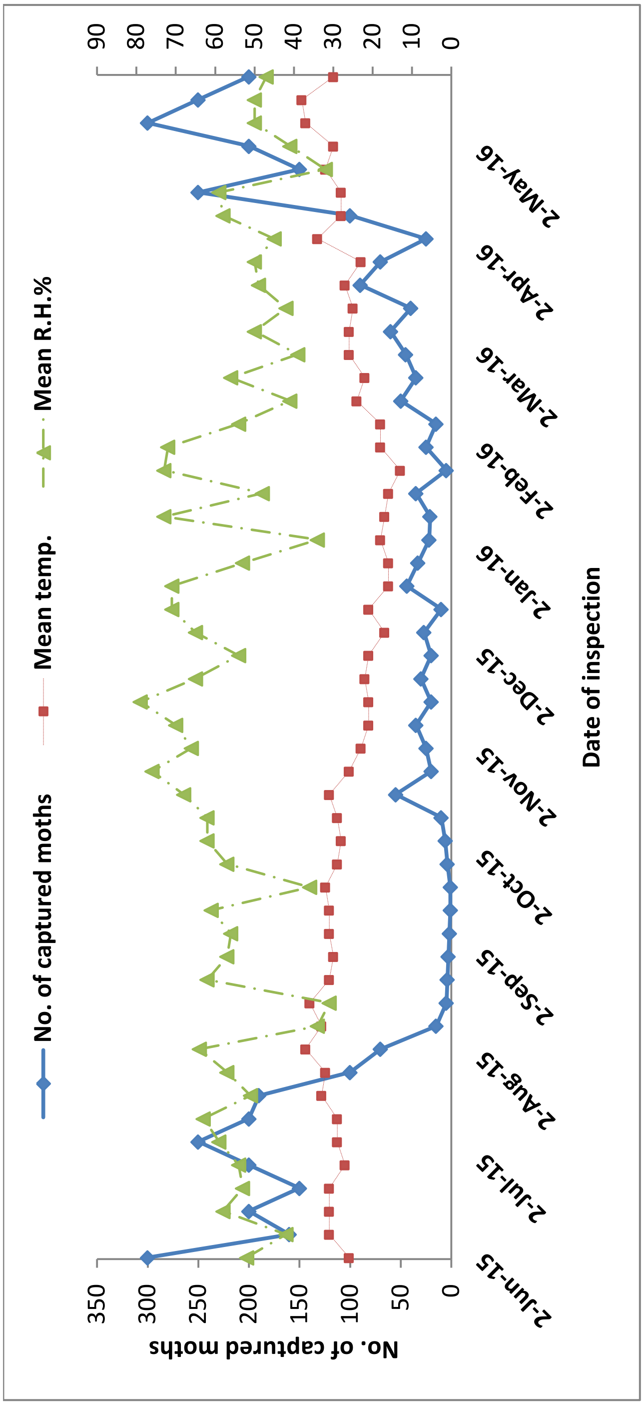


Fig. (36): Weekly mean number of *Tuta absoluta* moths and the main two weather factors (Mean temp. and Mean R.H.%) at Qaliubya Governorate during seasons, 2015/2016

4.2. Field generation of tomato leaf miner, *Tuta absoluta* depending on linear method:

The mean number of *T. absoluta* was counted and recorded from May 2015 to May 2016 to estimate the number and duration of pest generations. The method suggested by **Audemard and Milaire (1975)** and emended by **Jacob (1977)** was applied. Graphical representation of figures shows the number of generations for *T. absoluta* represented by regression lines.

Results in Table (46) showed the generations of the pest and its duration during 2015/2016 tomato season. Data in Table (44) and Fig.(37) revealed that *T. absoluta* had 10 generations. The first generation formed over only 5 weeks from the beginning of June to last week of same month. The second generation took place between the first weeks of July to the last of the same month. The third generation began from the beginning of October to last week of this month. There are no recorded any fluctuations in the period from 28th July to 8th October, the pest enter in aestivation stage. The fourth generation began at the beginning of November to the third week in the same month. The fifth generation was recorded at the beginning of December and lasted three weeks. The sixth generation began from last week of December till last week of January. Seventh generation took place from the beginning of February to the first week of March. Eighth generation began from the second week of March till the last of the same month. Ninth generation was appeared at the beginning of April and lasted three weeks. The tenth generation formed at the first week of May to the mid of the same month.

Table (45): Accumulated days of sampling and number of *Tuta absoluta* moths during 2015/2016 season (Shalakan /Qalyubia)

Date	Accumulated days	Actual number	Accumulated number	Accumulation number (%)
26th May	0	150	150	3.489995
2th June	7	300	450	10.469986
9th	14	160	610	14.192648
16th	21	200	810	18.845975
23th	28	150	960	22.335970
30th	35	200	1160	26.989207
7th July	42	250	1410	32.805956
14th	49	200	1610	37.459283
21th	56	190	1800	41.879944
28th	63	100	1900	44.206607
4th August	70	70	1970	45.835272
11th	77	15	1985	46.184272
18th	84	5	1990	46.006049
25th	91	4	1994	46.393671
1stSeptember	98	3	1997	46.463471
8th	105	2	1999	46.510005
15th	112	1	2000	46.533271
22th	119	1	2001	46.55638
29th	126	4	2005	46.649604
6th October	133	6	2011	46.789204
13th	140	10	2021	47.021871
20th	147	55	2076	48.301535
27th	154	20	2096	48.766868
3rd November	161	25	2115	49.208934
10th	168	35	2150	50.023267
17th	175	20	2170	50.488599

Date	Accumulated days	Actual number	Accumulated number	Accumulation number (%)
24th	182	30	2200	51.186598
1stDecember	189	20	2220	51.651931
8th	196	27	2247	52.280130
15th	203	10	2257	52.512797
22th	210	44	2277	52.978129
29th	217	33	2301	53.536529
5th January	224	22	2332	54.257794
12th	231	21	2353	54.746394
19th	238	35	2388	55.560726
26th	245	5	2393	55.677059
2nd February	252	25	2418	56.258725
9th	259	15	2433	56.607725
16th	266	50	2483	57.771056
23th	273	35	2518	58.694639
1st March	280	45	2563	59.632387
8th	287	60	2623	61.028385
15th	294	40	2663	61.959051
22th	301	90	2753	64.053048
29th	308	70	2823	65.681712
5th April	315	25	2848	66.402425
12th	322	100	2948	68.590042
19th	329	250	3198	74.406701
26th	336	150	3348	77.896696
3rd May	343	200	3548	82.550023
10th	350	300	3848	89.530014
17th	357	250	4098	95.34667
24th	364	200	4298	100

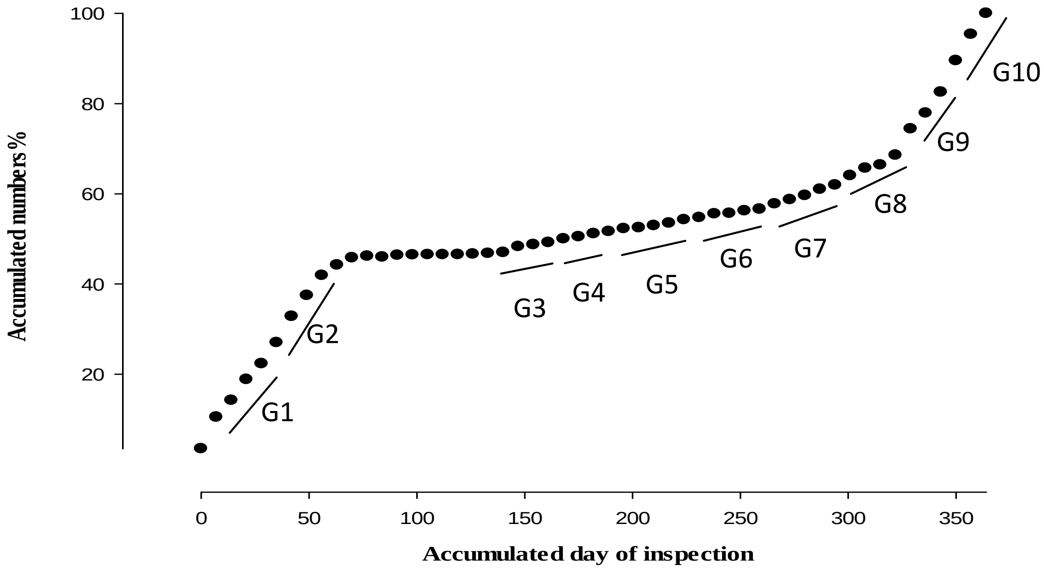


Fig. (37): The sequence of generations of *Tuta absoluta* on tomato plants at Shalakan, Qalyubia Governorate during 2015.

Table (46): Number and duration of generations of *Tuta absoluta* moths on tomato plants at Shalakan, Qalyubia Governorate during 2015 season (according linear method).

No. of generation	Approximate date of occurrence		Approximate duration
	From	To	
1st	2rd June	30th June	4weeks
2nd	7th July	28th July	4weeks
3rd	6th October	27th October	4weeks
4th	3rdNovember	24thNovember	4weeks
5th	1st December	22th December	4weeks
6th	29th December	26th January	5weeks
7th	2nd February	1st March	5weeks
8th	8th March	29th March	4weeks
9th	12th April	26th April	3weeks
10th	3rd May	17th May	3weeks

4.3. Predicted peak dates of *Tuta absoluta* according to accumulated thermal units (DD's)

This study aimed to estimate the occurrence dates of generations with the corresponding thermal units and estimating the duration and calculated degree-days for predicting peaks to determine the best control methods.

According to the laboratory study, the value of zero of developmental temperature threshold (t_0) was 10.5°C., while the average thermal units required for one generation of *T. absoluta* was 530.5 DD's.

Data in Table (47) and Fig.(38) demonstrated the observed and predicted peaks of the generations.

For 2015 tomato season, the first observed generation was occurred on 16th June and the predicted peak was on 15th June when the thermal accumulation reached 519DD's. The second observed generation was formed reiterated on 7th July and the predicted peak was on 5th July with thermal accumulation 537DD's. The third observed generation wasn't found and the predicted peak was on 26th July with thermal accumulation 525DD's.The fourth observed generation wasn't found and the predicted peak was at 18th August when the thermal accumulation reached 544DD's. The fifth observed generation wasn't formed and the predicted peak was on 7th September with thermal accumulation 548DD's. The sixth observed generation wasn't occurred and the predicted peak was on 27th September with thermal accumulation 530DD's. The seventh observed generation was occurred on 20th October and the predicted peak was on 19th October when the thermal accumulation reached 533DD's. The eighth observed generation was formed reiterated on 10th November and the predicted peak was on 11th November with thermal accumulation 523DD's. The ninth observed generation was occurred on 8th December and the predicted peak was on 10th December with thermal accumulation 537DD's. The tenth observed generation was occurred on 19th January and the predicted peak was on 18th January when the thermal accumulation reached 540DD's. The eleventh observed generation was formed reiterated on 16th February and the predicted peak was on 14th February with thermal accumulation 528DD's. The twelveth observed generation was occurred on 22th March and the predicted peak was on 19th March with thermal accumulation 537DD's.The thirteenth observed generation was occurred on 19th April and the predicted peak was on 18th

April when the thermal accumulation reached 546DD's. The fourteenth observed generation was formed reiterated on 10th May and the predicted peak was on 11th May with thermal accumulation 550DD's.

Number of predicted generation was agreement with **Abolmaaty *et al.*, (2010)**in Egypt, recorded that generation numbers of *Tuta absoluta* under climate change conditions increased especially in Qena governorates. However, the expected generation numbers of the pest at 2050 and 2100 are be 12-14 and 13-15 generations per year, respectively.

There is a difference between predicted peaks for *T. absoluta* which arrives to 14 generations and observed generation which equal 10 generations by the two previous methods. The period from end of July until half of October (72 days), there is no peak of *T. absoluta* was observed. The temperature arrive its peak all over the year during this period (Table 47). Also, data obtained from (Table6) it clear that all first instar larvae was dead at 32°C which is considered as the fatal high degree of temperature for this instars.

The data obtained are in harmony with those reported by **Mohamed *et al.*,(2015)**in Egypt, who recorded that the optimum temperature for population growth of *T. absoluta* ranged between 20 to 30°Cand *T. absoluta* failed to survive due to the high mortality in cohort reared at 35ºC.

So certainly, *T. absoluta* enter aestivation stage from 28th July to 8th October (about 72days). Therefore, the chemical control for this pest was not obligatory and the natural enemies are enough during this period.

Table(47): Predicted dates of peak generations of *Tuta absoluta* according to accumulated thermal units(DD's) and monitoring of moths by pheromone traps during 2015/2016 season (Shalakan, Qaliubya)

Generation	Date of peak dates			Units of predicted peak
	Observed	Predicted	Deviation(d)	
1st	16-Jun	15-Jun	-1	519
2nd	07-Jul	05-Jul	-2	537
3rd	No observed generation	26-Jul	-	525
4th		18-Aug	-	544
5th		07-Sep	-	548
6th		27-Sep	-	530
7th	20-Oct	19-Oct	-1	533
8th	10-Nov	11-Nov	+1	523
9th	08-Dec	10-Dec	+2	537
10th	19-Jan	18-Jan	-1	540
11th	16-Feb	14-Feb	-2	528
12th	22-Mar	19-Mar	-3	537
13th	19-Apr	18-Apr	-1	546
14th	10-May	11-May	+1	550

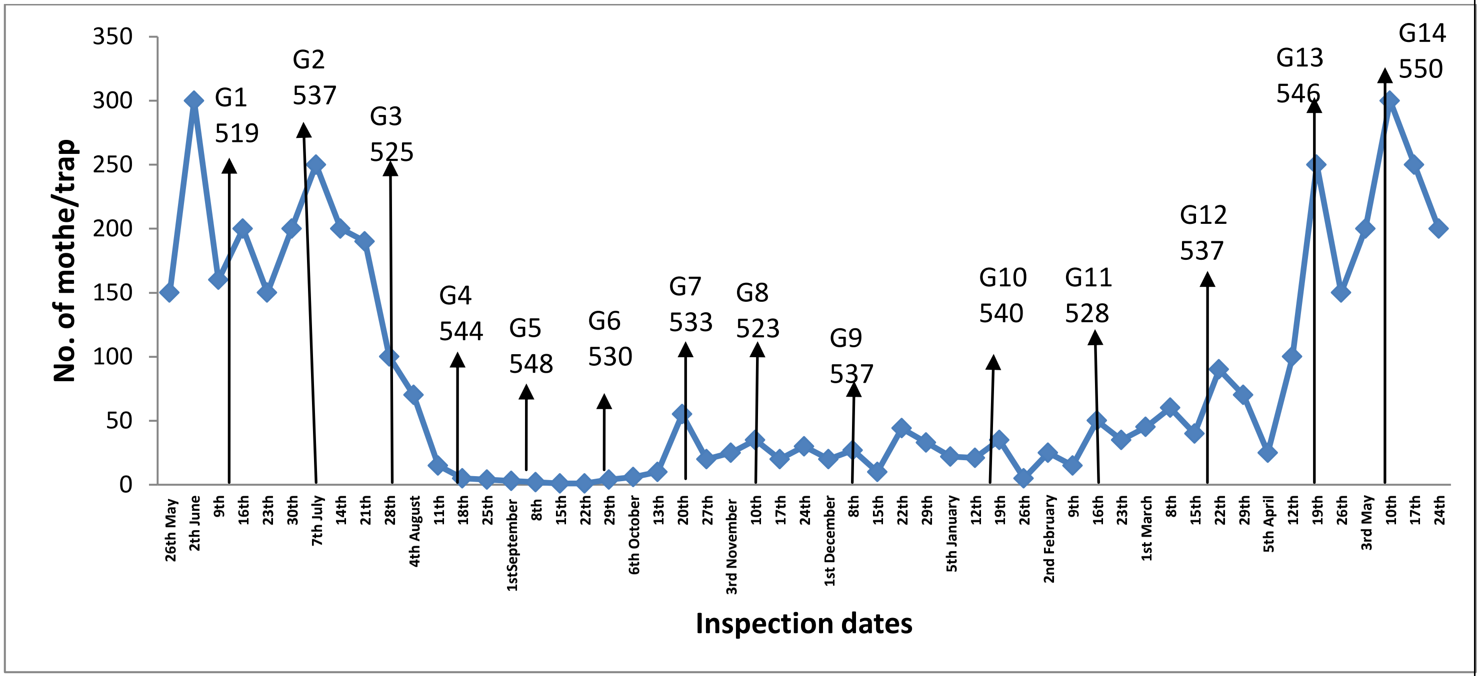


Fig. (38): Predicted dates of peak generations of *Tuta absoluta* according to degree-days and its relation to the number of moths captured by pheromone trap during 2015/2016 (Shalakan, Qalyubia)

5. Natural enemies associated with tomato leaf miner *Tuta absoluta* and Biological control

5.1. Parasitoids

Three different specimens of hymenopterous parasitoids were obtained from *T. absoluta* and identified to the genus level. Larval parasitoids of *T. absoluta* include *Diglyphus* sp.(Eulophidae) and *Elasmus* spp. (Elasmidae).The egg parasitoid is *Telenomus* sp. (Scelionidae). These parasitoids are the first record in Egypt.

5.1.1. *Diglyphus* sp.

Diglyphus sp. is a larval ectoparasitoid of *T. absoluta* (Fig.39). This result agrees with that of **Lopez *et al.*, (2011)** who reported that *D.isaea* is a larval ectoparasitoid of *T. absoluta* in Spain. **Mahdi *et al*., (2011)** recorded *Diglyphus* sp parasitizing *T. absoluta* in Algeria.**Giorgini *et al.*, (2012) and Zappala *et al.*, (2012)**found 16hymenopterous species including *D. crassinervis* belong to 13 genera and 6 families in Italy**. Gabarra *et al.*, (2013)** found 13 larval-pupal parasitoid species including *D. crassinervis* occasionally parasitize *T. absoluta* in Spain. **Perdikis *et al.*, (2016)** recorded *D. isaea* parasitizing *T. absoluta* in Greece. On the other hand, **Payer *et al.*, (2015)** observed that females of *D. isaea* are able to predate *T. absoluta* larvae, but they apparently do not parasitize this species in Spain.

Fig. (39): Adult of *Diglyphus* sp.

Description: Fore wing with sub margin al vein(SMV) with 3 or more setae dorsally.Postmarginal vein (PMV) present: at most 1.25 times longer than stigmal vein (STV), often equalor shorter. Scape usually slender,sometimes swollen and not exceeding apex of vertex. Funicle 2-segmented andclub 3-segmented both in male and female. Fronto-facial suture (ffs) adjacent anterior ocellus and one transverse groove (gr) between eye margin and scrobal cavity placed about halfway between ocellus and torulus.Malar sulcus present and straight. Propleura separated posteriorly and not covering prosternum. Notauli either incomplete, or complete and curving to meet axilla. Scutellum with 2 pair of setae and with 1 pair of longitudinal grooves. Propodeum with or without median carina and always with outplicae. Petiole notdistinct. Coloration entirely or prevalently metallic **(Reina and La Salle, 2003**).

5.1.2. *Elasmus* spp.

There are two unidentified species of *Elasmus* (Fig.40). *Elasmus* sp. is a larval-pupal parasitoid of *Tuta absoluta*.**Giorgini*et al.* (2012) and Zappala *et al.* (2012)** found 16 hymenopterous species including *Elasmus* sp. belong to 13 genera and 6 families in Italy.**Gabarra*et al.* (2013)** found 13 larval-pupal parasitoid species including *E. phthorimaeae* occasionally parasitize *T. absoluta* in Spain.

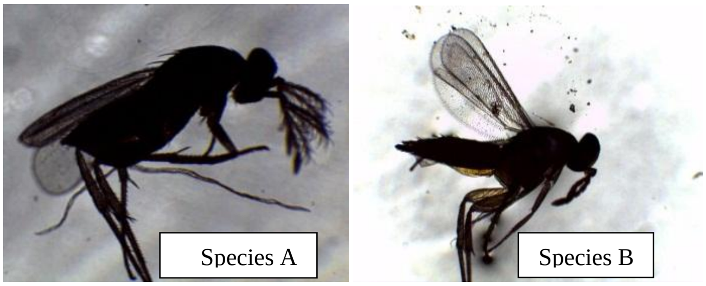


Fig. (40): Adult of *Elasmus* spp.

Description: Fore wing densely setose and wedge-shaped, with elongate marginal vein, short postmarginal, and slightly reduced stigmal vein. Female funicle 3-segmented with two anelli and 3-segmented clava; male funicle 4-segmented, F1-F3 with branches, clava 2-segmented with pronounced apical sensilum. Mesosoma densely setose, metasomasubsessile and gaster triangular in cross.Metanotum projecting as flat, triangular, often translucent plate over propodeum. Dorsal metanotal lamella projecting posterior over propodeum with partial and complete lateroventral keels. Scutellum with 2 pairs of long setae.Metacoxa greatly enlarged and flattened plate-like hind tibia with short bristles forming distinct diamond-shaped or undulating pattern (**Yefremova and Strakhova, 2010**).

5.1.3.*Telenomus* sp.

Telenomus sp. is an egg parasitoid of *Tuta absoluta* (Fig.41).**Al-Gerrawy *et al.* (2013)** also recorded *Telenomus* sp. parasitizing *T. absoluta* eggs in Iraq.

Fig. (41): Adult of *Telenomus* sp.

Description: Small wasp, almost always black or dark brown. Female antenna with 5-segmented club (when present), male antenna 12-segmented.Frons smooth **(Polaszek and Kimani, 1990).**

5.2. Predator

Nesidiocoris tenuis

N. tenuis was the only predator species that was found in the survey (Fig.42). It is an important predator of *T. absoluta* eggs. In this context, *N. tenuis* was recorded associating with *T. absoluta* on tomato by several authors in different countries **(Arno *et al.*, 2009** in Spain;**Cabello *et al.*, 2012** in Spain; **Molla *et al.*, 2009**in Spain; **Arno and Gabarra, 2011** in Spain**;Guenaoui and Bensaad, 2011** in France; **Mahdi *et al.*, 2011**in Algeria; **Molla *et al.*, 2011** in Spain; **El-Arnaouty and Kortam, 2012** in Egypt; **Biondi *et al.*, 2013** in France; **Sohrabi and Hosseini, 2015** in Iran**).**

Fig. (42): Adult of *Nesidiocoris tenuis*

Description: Body size 3–3.3 mm. Pale whitish green. Ocular index: 1.3–1.5. Left paramer very slender, strongly curved sickle shaped. Middle of the first segment, and base of the second segment of antenna-black.Adark ring at the apex of the 2nd antennal segment, 3rd and 4th segment - brown. At the rear edge of the corium there was a small dark brown spot and at the tip of the cuneus there was a small dark brown spot. Membrane – gray, veins – brown. Base of the tibia (knee) narrowly black **(Hosseini, 2013).**

5.3. Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*

Data tabulated in Table (48) and Figure (43) revealed that *T. absoluta* appeared one week earlier than *N. tenuis*. The population of *T. absoluta* had two peaks of 30.3 and 25.0 leaf mines/10 leaflets on 7^{th} and 28^{th} of May, 2013, respectively. *N. tenuis* similarly had two peaks of 58.8 and 73.3 nymphs and adults/plant on the same previous dates, respectively. This predator was significantly and positively correlated with *T. absoluta* (r = +0.87 and b= 0.26).

Table (48): Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*

Inspection date	Leaf mines of *T. absoluta*/10leaflets	*N. tenuis*(nymphs+ adults)/plant
April,23th	0	0
30th	10.8±0.2	0
May, 7th	30.3±0.3	58.8±0.6
14th	13±0.3	25.5±0.2
21th	24.3±0.6	48.8±0.5
28th	25±0.3	73.3±0.9
Total	103.3	206.4
Mean	17.2	34.4
Correlation coefficient(r)	+0.87*	
Regression coefficient (b)	+0.26	

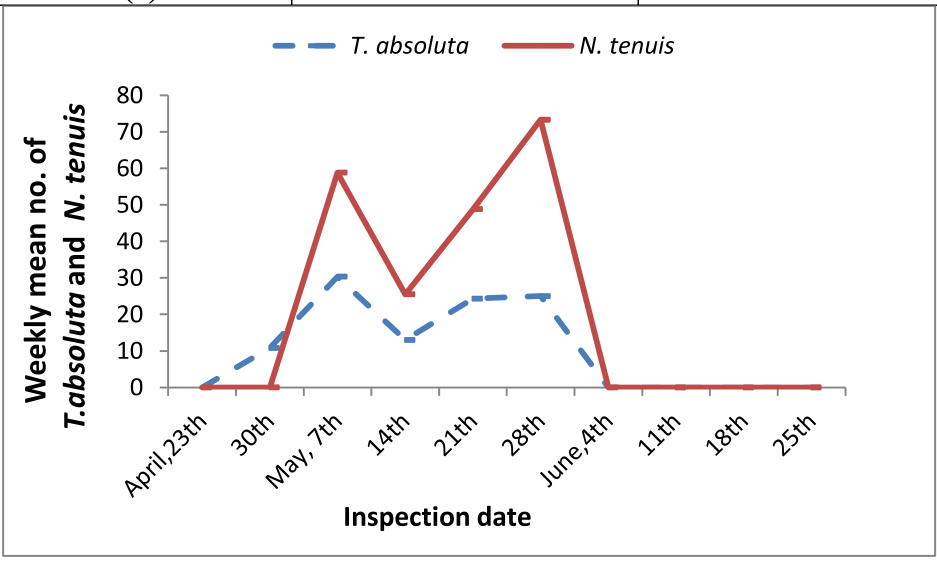


Fig. (43): Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*

5.4. Predatory efficiency of *Nesidiocoris tenuis* on *Tuta absoluta* eggs

Mean numbers of eggs consumed by nymph and adult stages of *N. tenuis* are shown in Table (49).The adult female consumed a higher number (125.3 eggs in 12.5 days) than the adult male (81.5 eggs in 7.5 days).The 4thnymphal instars devoured the highest number (30.6 eggs in 2.4 days), while the 1stnymphal instars ate the lowest (7.0 eggs in 2.1 days).

N. tenuis was highly effective in controlling *T. absoluta* eggs. Several authors reported that *N. tenuis* preyed actively on *T. absoluta* eggs and could regulate pest populations **(Arno, *et al*., 2009; Molla *et al*., 2009; Arno and Gabarra, 2010; Molla *et al.*, 2011; Biondi *et al*., 2013).**

Table (49): Predatory efficiency and durations of nymphal instars and adults of *Nesidiocoris tenuis* reared on *Tuta absoluta* eggs

Predator stages	Nymphal instar					Adult	
	1st	2nd	3rd	4th	5th	Male	Female
No. of prey eggs consumed (Mean ± s.e.)	7±0.2	20.5±0.5	26.6±0.4	30.6±0.6	28.6±0.5	81.5±1.2	125.3±0.3
Duration (Mean±s.e.)	2.1±0.03	2.2±0.04	2.2±0.04	2.4±0.06	3.3±0.05	7.5±0.65	12.3±0.4

IV-SUMMARY

In Egypt, Tomato (*Lycopersicon esculentum*) is the most export vegetable crop. The cultivated area about 599651 feedans at 2009 and the average production about 10.275521 tons according to Mukhtar ***et al.*** **(2009).** The tomato leaf miner became a serious pest to tomato in Egypt since 2009. The present study was conducting during 2012&2013 seasons to study some biological and ecological aspects of the tomato leaf miner *Tuta absoluta* under Egyptian conditions.

Results revealed that zero of developmental threshold, thermal units required for all stages of *T. absoluta* and life table parameters were calculated.

The study included also, the susceptibility of the tomato cultivars for the infestation by *T. absoluta*, the relationship between the mean density and length of tricomes on both surface of leave of the studied cultivars and tomato leaf miners. Numbers of generations in the field were recorded to *T. absoluta* by using thermal units, linear method and normal distribution curve. In addition, natural enemies associated with *T. absoluta* and biological control was estimated. Results may be summarized as follows:

The developmental parameters of tomato leaf miner pest *Tuta absoluta* as explained by thermal accumulated units:

Egg stage

Incubation period

The incubation period decreased as the temperature increased. The longest mean incubation period i.e. 6.8 days was occurred at 20°C, on the contrary, the shortest i.e. 3.0 day was occurred at 32°C, while the other incubation periods come intermediate them.

Percentage of hatchability

The percentage was calculate at four constant degrees, the percentage of hatchability were 72%,97%,89% and 95% under 20, 24, 28 and 32 ºC., respectively. It appears that favorable temperature for the egg hatching ranged from (24 to 32ºC).

Zero of development for egg stage

Data obtained for egg incubation period at the four constant temperatures 20, 24, 28 and 32°C were used to estimate zero of development for egg stage. Results showed that the value of zero development for egg stage was 7.0°C.

Rate of development and thermal units of egg stage

The results revealed that both of rates of development and thermal constant units for egg stage were obviously affected by the prevailing temperatures. Rate of development was increased gradually as the temperature increased from 20 to 32°C. The rates of development were 14.7, 20, 25 and 28.57 at 20, 24, 28 and 32˚C, respectively. Also, results revealed that thermal constant units required for development of egg stage of *Tuta absoluta* were greatly affected by prevailed temperature. The highest thermal units recorded was occurred at 20°C (88.4 DD's); while at 32°C (87.5DD's); at 24°C (85.0DD's) but the lowest thermal units recorded was occurred at 28°C being 84.0 DD's.

From these results it could be stated that 32°C seemed to be the optimum temperature for egg stage. At this degree, there are the highest percentage of hatchability and shortest incubation period.

Larval stage

Duration of larval stage

The longest time required for completing larval stage was recorded at 20ºC being to be 30.9 days while the shortest time required for this stage was recorded at 28ºC being to be 17.6 days. On the other hand, all larvae which reared under 32 ºC were dead.

Zero of development of larval stage

The duration of larval stage at the three constant temperatures were used to estimate zero of development for the larval stage whereas, this value was 10°C.

Rate of development and thermal constant units for larval stage

The results revealed that both rate of development and thermal constant units for larval stage were obviously affected by prevailing temperatures. Rate of development was increased gradually as the temperature increased from 20 to 28°C. The lowest rate was occurred at 20°C (3.2) followed by 24°C (4.6); while the highest rate was occurred at 28°C (5.7). Also, results revealed that thermal constant units required for development of larval stage of *Tuta absoluta* were greatly affected by changes of prevailing temperature. The highest needed thermal unit was occurred at 28°C being 316.8 DD's ; while the lowest thermal units needed was occurred at 24°C being 306.6 DD's. From these results it could be stated that 28˚C seemed to be the most favorable for rearing larval stage.

Percentage of mortality of larval stage

The highest percentage of mortality was occurred at 32˚C.being 100%, followed by those at 24 & 28˚C being 74 %. While the lowest percentage of mortality was occurred at 20˚C being 52 %.

It's clear that 32˚C is a fetal high degree of temperature to larval stage of *Tuta absoluta* especially for first instars whereas, all 1st instars dead. From these results it could be stated that 20˚C seemed to be the most favorable temperature for survival of larvae whereas the lowest percentage of mortality was occurred throughout the larval stage.

Pupal stage

Duration of pupal stage

The pupal periods decreased as temperatures increased from 20 to 28 ºC. The average durations were 15.8, 9.5 and 8.1 days at 20, 24 and 28 ºC., respectively.

Zero of development of pupal stage

Data obtained for mean duration of the pupal stage at three constant temperatures was used to estimate zero of development for pupal stage, whereas this value was 11.2°C.

Rate of development and thermal constant units for pupal stage

The results revealed that both rate of development and thermal constant units for pupal stage were obviously affected by prevailing temperatures. Rate of development was increased gradually as the temperature increased from 20 to 28°C. The lowest rate was occurred at 20°C (6.3) followed by 24°C (10.5); while the highest rate was occurred at 28°C

(12.3). Also, results revealed that thermal constant units required for development of larval stage of *Tuta absoluta* were greatly affected by changes of prevailing temperature. The highest needed thermal unit was occurred at 20°C being 138.6 DD's ; followed by 28°C being 136.6DD's ; while the lowest thermal units needed was occurred at 24°C being 121.5 DD's.

Percentage of mortality of pupal stage:

The results revealed that temperature had highly significant effect on the percentage of mortalities of larval stage. The highest percentage of mortality was occurred at 20˚C being 10.0%, followed by those at 24˚C being 5.0 %. While the lowest percentage of mortality was occurred at 28˚C being 1.0 %.

From these results it could be stated that 28˚C seemed to be the most favorable temperature for pupal stage whereas the lowest percentage of mortality was occurred throughout pupal stage**.**

Adult stage

Female duration

Pre-oviposition period

The time required for maturation of the ovaries and starting egg laying, decreased as the temperature increased, theses duration were recorded 2.6, 2.2 and 1.0 days at 20, 24 and 28ºC., respectively.

The threshold of development was 15.0ºC, It's noticed that the rising of temperature hurling the rate of development of the female's ovaries of this pest insect. The average thermal units required for development of ovaries at 20, 24 and 28ºC.were 13.0, 19.8 and 13.0 DD's.

Oviposition period

Oviposition period found to be the longest period followed by pre-oviposition period while post-oviposition period was the shortest period. Mean duration of oviposition period was decreased when temperature increased from 20 to 28°C. The longest mean duration was occurred at 20°C being 9.2 days, followed by those reared at 24°C being 6.0 days. While, the shortest mean was 5.8 days occurred at 28°C. The threshold of development was 6ºC. The average thermal units required for development of ovaries at 20, 24 and 28ºC.were 128.8, 108.0 and 127.6 DD's.

Post-oviposition period

Mean durations of this period were decreased as temperature increased from 20 to 28°C. The longest mean duration was occurred at 20°C being 3.4 days, followed by those reared at 24°C being 2.6 days. While, the shortest mean was 1.4 days occurred for females reared at 28°C. The threshold of development was 15.2ºC. The average thermal units required for development of ovaries at 20, 24 and 28ºC.were 16.3, 22.9 and 17.9 DD's.

Female longevity

The female longevity was longer than means longevity of male under the three tested temperatures. Means longevity were 15.6, 11.8 and 8.2 days, at 20, 24 and 28°C, respectively. The threshold of development was 11.2ºC. The average of thermal unit needed for adult female were 137.3 , 151.0 and 137.8 degree-days at 20, 24 and 28ºC.

Male longevity

The results showed that male means longevity was decreased as temperature increased. Means longevity were 12.8, 10.2 and 7.4 days, at 20, 24 and 28°C, respectively. The threshold of development was 9.8ºC. The average of thermal unit needed for adult male were 130.6 , 144.8 and 134.7 degree-days at 20, 24 and 28ºC.

Fecundity

The reproductive potentiality is expressed as total numbers of deposited eggs per female during its longevity. The highest mean fecundity was occurred at 28°C being 145.3 eggs/ female, followed by those reared at 24°C being 79.3 eggs / female, while the lowest mean was occurred for those reared at 20°C.being 57.8 eggs / female.

From the results it could be stated that temperature 28°C seemed to be the most favorable conditions for rearing *Tuta absoluta* under laboratory conditions.

Egg fertility

Egg fertility is represented by percentage of egg hatchability of deposited eggs. The highest mean of egg hatchability 97% was occurred at 24°C followed by 89% at 28°C, while the lowest was occurred at 20°C being 72%. So, 28°C.was considered as the optimum degree for laying eggs.

Total generation duration

The shortest duration of generation were achieved at 28°C being 30.7day; followed by 38.6 days at 24°C., while the lowest was occurred at

20°C.being 56.1 days. In the other words, this pest can formed about 12 generations per year at 28°C., 9-10 generations per year under 24°C. and 6-7 generations at 20°C.

One the other hand, the threshold of development was 10.5 ºC. The thermal constant which required for completing the development of generation were 533.0, 521.1 and 537.3 DD's at 20, 24 and 28°C., respectively in average about 530.4 DD's.

Life table parameters of *Tuta absoluta*

Percentage of apparent and real mortalities under constant temperature

The results revealed that both apparent and real mortalities differed from stage to another according the prevailing conditions. At the beginning of each experiment, 100 eggs were started for each tested temperature. At 20°C, 10 adult were obtained at the end of generation. While at 24°C, 18 adults were obtained. At 28°C, 14 adults were obtained i.e. the total population mortality of *Tuta absoluta* equal in average 86% and only 14% in average survival until adult stage at 28°C.

Regarding the percentage of eggs mortalities (both apparent & real) the three tested temperatures, the highest percentage of mortalities were occurred on 20°C being 28.0 %, followed 11.0 % at 28°C, while the lowest percentage was occurred at 24°C being 3.0 %. It seemed that 24°C seemed to be the most favorable temperature of incubation of egg stage. From these results the apparent & real mortalities at egg stage in average equal 14%.

Regarding to the percentages of apparent mortalities and real mortalities of larval stage under the three tested temperatures were

72.2%&52% at 20˚C, 76.3%&74% at 24˚C, and 83.1%&74% at 28˚C, respectively.

From these results it could be stated larval stage was considered to be the critical stage. It showed the highest apparent and real mortalities (77.2%& 66.7% in averaged).

The apparent and real mortalities of the pupal stage at three tested temperatures were 50%&10% at 20˚C, 21.7%&5.0% at 24˚C, and 6.7%&1.0% at 28˚C, respectively.

In average, apparent & real mortalities equal 26.1% and 3%, respectively.

From these results it could be stated 24˚C seemed to be the optimum temperature for rearing *Tuta absoluta* at this temperature the highest percentage of egg hatchability and the lowest percentages of mortalities of most different stages were occurred at this degree.

Percentage of apparent and real mortalities under laboratory conditions (24-28°C & 40-50 R.H.%)

The results revealed that both apparent and real mortalities differed from stage to another according the prevailing conditions. At the beginning of each experiment, 300 eggs were started under laboratory conditions, 22 adults were obtained at the end of generation about 7.3% from the total of population of *T. absoluta*.

Regarding the percentage of mortalities (both apparent & real) being (33.33&33.33) for egg stage, (86.5 & 57.7) for larval stage and (18.5 & 1.7) for pupal stage, respectively.

Survival and fecundity of adults

Data obtain from biological studies of *T. absoluta* were used to calculate survival of adult female, fecundity and life table parameters, age specific survival rate (l_x) and age specific fecundity (m_x) at three constant temperature (20, 24 and 28°C).

Net reproduction rate ($R_\circ$)

The highest average birth of *Tuta absoluta* female was 10.03 at 28°C., followed by 6.29 at 24°C.and 2.85 at 20°C., on the other hand, the lowest birth average was 3.15 under laboratory conditions.

Mean generation time (Gt)

The shortest generation time was obtained at 28°C and lab., conditions were 33.92 and 33.97 days, followed by those at 24°C was 41.37 days while the highest was 59.58 days at 20°C.

Intrinsic rate of increase (r_m)

The highest intrinsic rates individual / day were obtained at 28 °C being 0.13individual/day, followed by those at 24°C and under laboratory conditions being (0.07&0.04 individual/day, respectively), while the lowest was being 0.02 individual/day at 20˚C.

Finite rate of increase (λ)

The highest values were 1.14female/day at 28°C, followed by those at 24°C and under laboratory conditions being (1.07&1.04 female/day, respectively).While the lowest value was (1.02 female/day) at 20°C.

Population double time (Dt)

The longest double generation value (43.43 days), followed by those at laboratory conditions being (21.71days); followed by those at 24°C being (12.41 days).While, the shortest double generation value was (6.68 days) which occurred at 28˚C.

From these results it could be concluded that 28˚C seemed to be the optimum degree for rearing *Tuta absoluta* on tomato. At this degree both female fecundity and net reproductive rate; intrinsic rate of increase and finite rate of increased recorded their maximum values and population doubling time recorded its minimum value.

Ecological studies

Susceptibility of certain tomato genotypes to the infestation by *Tuta absoluta*

At the first, general weekly mean number of *T. absoluta* leaf mines were higher during 2013 (239.5/80leaflets) than 2012 (201.3/80leaflets). Infestation rate increased during 2013 with 17.6% in comparing with 2012.

According to susceptibility of eight cultivars to the infestation degree by *T. absoluta*, data obtained indicated that during 1st season 2012, eight tomato cultivars significantly could be divided into four groups (Fvalue=10.5 sig. at 1% and L.S.D.=0.1 mine). First group contains Red sun and Hybrid super strain B cultivars (36.7 & 32.6 mines/10leaflets, respectively). 2nd group include Riogrande and Castle rock cultivars (25.4 & 23.1 mines/10leaflets, respectively). While Super set and Baladi formed 3rd group whereas number of mines were 21.4&21.1 respectively. The 4th group (more resistant) includes Nemaguard and Hybrid bito 86 (21.0&20.0 mines/10leaflets, respectively).

2nd seasons, 2013 eight tomato cultivars, also significantly could be divided into four groups as follows: 1st group contains Red sun cultivar only (46.6 mines/10leaflets); followed by 2nd group include Hybrid super strain B and Castle rock with mean of mine 37.0&35.0 mines/10leaflets, respectively. According to 3rd group contains on Baladi, Riogrande and Nemaguard cultivars with mean mines 27.0 25.3 & 24.5 &mines/10leaflets, respectively. The more resistance 4th group include Super set and Hybrid Bito86 (23.7&20.4 mines/10leaflets, respectively).

Effect of different leaf chemical components

N. P. K.

The highest of *Tuta absoluta* mines occurred on the leaflets of Red sun cultivar was corresponding to the high level of N.P.K. (10.9mg/gm dry weight &1956.7mg/gm dry weight & 550.0 uEq/gm dry weights, respectively). On the other hand Hybrid bito86 cultivar contained on lowest infestation (4.1mine/10leaflets) with corresponding to least value of N (6.8mg/gm dry weight). Also, Super set cultivar showed 4.7 mines/10leaflets had least amount of P (668.0mg/gm dry weight), while Riogrande cultivar infested with 5.1mines/10leaflets with corresponding to least amount of K (382.3 uEq/gm dry weights).

Statistical analysis revealed that, there is significant positive between the mean of leaf mines of *T. absoluta* and the content of P.K. with "r value" of +0.74 & +0.81, respectively. While between N and infestation rate of *T.absoluta* was +0.57(insignificant).

Amino acid and Total protein

the highest mean of *T. absoluta* mines occurred on Red sun cultivar (9.3mines/10leaflets) was associated with the highest amount of total free amino acids and total proteins(16.6 ug alanine⁄gm dry weight&679.0mg/gm dry weight), respectively. On the contrary, Hybrid bito86 contained on lowest infestation 4.1 mines/10leaflets had the lowest content from total free amino acids and total proteins (4.2 ug alanine⁄gm dry weight &41.6mg/gm dry weight, respectively). The rest of cultivars come intermediate between them.

Statistical analysis revealed that, there is insignificant positive correlation between infestation and free amino acid & total protein whereas r=+0.57 & +0.61, respectively.

Total phenol

The highest *Tuta absoluta* mines occurred on Red sun cultivar (9.3leaf mine/10leaflets) with corresponding to low level of total phenol 4626.3 ugGA⁄gm dry weights. While the highest content of phenol 6228.0 ugGA⁄gm dry weight was found in Hybrid bito86 cultivar which infested with 4.1 leaf mines/10leaflets.

Statistical analysis indicated that, there is a significant negative correlation between infestation and amount of total phenol whereas r=-0.77 at 5% & b=-0.002 at 5%.

Total carbohydrate

The lowest content of total carbohydrate 101.3 mg⁄gm dry weights was occurred in Hybrid bito86 cultivar which contained on least infestation by *T. absoluta* (4.1 leaf mines/10leaflets). On the contrary Red sun cultivar contains on 125.3mg⁄gm dry weight and infested with 9.3 leaf mines/ 10leaflets. In general the correlation coefficient was insignificantly -0.02.

α and β-esterases enzymes

There are an insignificant differences between the content α and β-esterases enzymes in tomato cultivars. The correlation coefficients were insignificant positive 0.2 and 0.24 for α and β-esterases enzymes, respectively

Peroxidase enzyme

Red sun cultivar infested with the highest number of mines (9.3 leaf mines/10leaflets) contained on the highest amount of peroxidase enzyme 61.5ΔO.D.405⁄min⁄gm dry weight. On the contrary, Hybrid bito86 cultivar infested with (4.1leaf mines/10leaflets) contained on the least amount of peroxidase enzyme 13.9ΔO.D.405⁄min⁄gm dry weight.

The correlation coefficient was insignificant positive +0.68.

Generally, it can be conducted that the most susceptible cultivars which presented with high number of *Tuta absoluta* leaf mines were correlated with high content of protein, carbohydrate, free amino acid and low level of phenol, while the most tolerant one were contained mid or low amount of theses component and high level of phenol.

Effect of physical features of tomato leaflet surface

Two trichomes types were found in all tested tomato cultivars in both leaflet surfaces; the dominant types I was non-glandular while the second type II was a glandular one.

Statistical analysis of the correlation between different tomato cultivars' leaflet physical features and *T. absoluta* mines indicated that there are positive significant at 1% between *Tuta absoluta* mines and density of non-glandular trichomes/cm^2 in the upper surface (r=+0.85 & b=+0.4)**,** while there is insignificant correlation between *T. absoluta* mines and length/µm of non-glandular trichomes in the upper surface. Also, there is no correlation between *T. absoluta* mines and density& length of non-glandular trichomes in the down surface.

The density of glandular trichomes showed insignificant correlation between *T. absoluta* mines and all previous cases.

Effect of the interaction between physical factors and tomato cultivars on infestation rate by *Tuta absoluta*

Effect the main whether factor was tested to clarify their effects on the population dynamics of *T. absoluta* infesting tomato cultivars during two successive seasons 2012&2013. Weekly counts of total numbers of *T. absoluta* mines were used as dependent factor "Y". While the corresponding means of the main whether factors used as independent factors "X". The effect of each factor seperataly was obtained by applying C. multipliers formula and expressed as percentage of explained variance (E.V.).

Mean *T. absoluta* mines/10 leaflets for eight tomato cultivars were estimated during two successive seasons 2012&2013. Data obtained indicated that,

Red sun cultivar

During the first season 2012, the population abundance of *T. absoluta* infesting Red sun cultivar of tomato plants showed one peak on the 21^{th} of May. The corresponding recorded number was 12 leaf mines/10 leaflets. During the second season 2013, also one peak was recorded on May, 21^{th}. The total recorded number of peak was 20.0leaf mines/10 leaflets.

The results showed insignificant positive effects to minimum, maximum temperature and relative humidity on the seasonal fluctuations of *Tuta absoluta* in the first season, whereas "r" values were 0.58, 0.39 and 0.34, respectively. In the second season, the results revealed insignificant effects to the same three factors on the seasonal fluctuations of *T. absoluta* whereas, "r" values were 0.79, 0.66 and -0.53, respectively.

Hybrid Super strain cultivar

Hybrid Super strain cultivar was liable to infestation with *T. absoluta*.

In the first season, the first appearance of *T. absoluta* was occurred at the beginning of season and the population fluctuated up to down. Only one peak was recorded at 7^{th} of May having 12.0leaf mines/10 leaflets. Again at the second season 2013 two peak was recorded on 7^{th} of May and 28^{th} being 12.7 and 4.3leaf mines/10 leaflets, respectively.

The results showed insignificant positive effects to minimum temperature and maximum on the seasonal fluctuations of *T. absoluta* in both seasons, whereas "r" values were 0.59 and 0.47, respectively during 2012 & 0.33 and 0.60, respectively during 2013. While there are insignificant effects to relative humidity whereas, "r" values were 0.42 and -0.51, during 2012 and 2013, respectively.

Castle rock cultivar

During season 2012, data showed one peak of tomato leaf miner population on 14th of May on Castle rock cultivar. The recorded numbers was 6.7 leaf mines/10 leaflets. During the second season 2013, also two peaks of tomato leaf miner numbers were recorded on 7th and 21th of May. The numbers of insect were 6.7 and 12.3 leaf mines/10 leaflets, respectively.

The results showed insignificant positive effects for three physical factors on seasonal fluctuations of *Tuta absoluta*. In the second season, there is a significant positive effect to minimum temperature whereas "r" value was 0.84, while the results revealed insignificant effects to maximum temperature and relative humidity whereas "r" values were 0.79 and -0.67, respectively.

Riogrande cultivar

Data showed that only one peak of *T. absoluta* population was present in the first season 2012 on 14th of May being 11.7leaf mines/10 leaflets. During the following second season (2013), but two peaks of *T. absoluta* occurred on 7th and 14th of May with number of 5.3 and 6.3leaf mines/10 leaflets, respectively.

There are insignificant positive effects to minimum and maximum temperature on the seasonal fluctuations of *T. absoluta* in both seasons. The results revealed insignificant negative effects to relative humidity on the seasonal fluctuations of *T. absoluta* during 2012 whereas "r" value was -0.05, while there is a significant negative effect during 2013 whereas "r" value was -0.85.

Baladi cultivar

During season 2012, data showed one peak of tomato leaf miner population on 14th of May on Baladi cultivar. The recorded numbers was 8.0leaf mines/10 leaflets. During the second season 2013, also two peaks of tomato leaf miner numbers were recorded on 7th and 28th of May. The numbers of mines were 11.0 and 5.7 mines/10 leaflets, respectively.

There are insignificant positive effects to three factors on the seasonal fluctuations of *Tuta absoluta* in both seasons.

Nemaguard cultivar

The activity of this insect on Nemaguard had the same trend in the two studied seasons (2012 and 2013). In the first season, one peak occurred in May, 14th and recording 7.3 leaf mines/10 leaflets. In the second season 2013, also two peaks were recorded. The highest peak of population was 8.0leaf mines/10 leaflets (7th of May), while the other peak was recorded at 28th of May (5.0leaf mines/10 leaflets).

The results showed insignificant effects for the three factors tested on population density of *T. absoluta* during this period.

Super set cultivar

Data showed the total numbers of *T. absoluta* / 10 leaves during the two seasons.

In the first season 2012, the population fluctuated up and down. Two peaks in the population abundance were detected on 7th and 28th of May. The corresponding recorded number of populations of that peaks were 8.7 and

5.0leaf mines/10 leaflets, respectively. In the second season 2013, also two peaks were recorded on 30th of April and 21th of May (6.7 and 5.0leaf mines/10 leaflets).

The results showed insignificant effects for the three factors tested on population density of *Tuta absoluta* during this period.

Hybrid Bito86 cultivar

At the first season 2012, the population density on Hybrid Bito86 cultivar expressed by one peak (7th of May) being 5.0leaf mines/10 leaflets. In the second season, 2013 two peak were recorded being 5.7 and 5.3 leaf mines/10 leaflets on May, 7th and 28th.

The results showed significant positive effects to minimum temperature in the first season, whereas "r" value was 0.86, while there is insignificant positive effect to maximum temperature and relative humidity on the seasonal fluctuations of *T. absoluta* whereas "r" values were 0.75 and 0.14, respectively. In the second season, there are insignificant positive effects to minimum and maximum temperature on the seasonal fluctuations of *T. absoluta* whereas "r" values were 0.52 and 0.74, respectively, while there is significant negative effect to relative humidity on the seasonal fluctuations of *T. absoluta* whereas "r" values were -0.92.

The effect of three plant growth regulator on induced resistance to *Tuta absoluta* in certain tomato cultivars

There are highly difference between tomato in control (untreated) and tomato treated with plant growth regulators, whereas F value=44 sig. at 0.001 and L.S.D.=0.8 mine. These treatments (main treatment) significantly could be divided into three groups. 1st group contains Benzyle adenin and Kinetin with averages 2.8 & 3.5 mines/pot. 2nd group include Salicylic acid with 4.4mines/pot. 3rd one includes control treatment with 7.3mines/pot. The finding of the study showed that the cultivars after applications of three plant growth regulators should be nominated as an unsuitable host for *T. absoluta*. Moreover these results may develop the findings and secreening process of relatively resistance cultivars to be used management of *T. absoluta.*

According to tomato cultivars (sub. treatment), data presented in Tables 40, 41 & Fig. 26 showed that there are highly difference between tomato cultivars, whereas "F" value=13.6 sig. at 0.001 and L.S.D.=0.7mine. It clears that three tomato cultivars can be arranged follows; 1st group contains, Castle rock 3.4mines/pot and 2nd group include Baladi & Hybrid super strain B with 4.9 & 5.2 mine/pot.

According to date of inspection (sub. sub. treatment), there are a highly difference between three dates, whereas "F"value about 227.0 sig. at 0.001and L.S.D.=0.7mine. Dates could be significantly divided into three groups; 1st one, third date 28th April with 1.5 mines/pot. 2nd group, second date 21th April with 5.3 mines /pot. 3rd group, first date with 8.7 mines/pot.

Seasonal abundance and generations in relation to phermone trap catches

Monitoring the changes in *Tuta absoluta* population activity based on adult occurrence expressed as actual data figures

Monitoring the changes in the population dynamic of based on actual data figure of adults was carried out during the season 2015. Moths were counted every week and according monthly figures were completed. The corresponding prevailing meteorological weather factors namely; Day maximum temperature, minimum temperature, mean temperature and RH%.

The tomato leaf miner *T. absoluta* demonstrates 10 generations during tomato season 2015. The appearance date of moths could be explained as follows:

The first generation occurred in tomato field during 2015 from the beginning of June 2015 to last week of same month lasted for 5 weeks. The maximum number of moths took place during 16th June (200moths/week). The second generation appeared from the second week of July to last July (4 weeks), the maximum number of moths occurred on 7th July (250moths/week). There are no recorded any fluctuations in the period from 28th July to 8th October. The third generation started from early October to the end of October, the peak of this generation recorded on 20th October (4weeks) (55moths/week). The fourth generation formed at the beginning of November to last week of same month, the peak of this generation recorded on 10th November (4weeks)(35moths/week). The fifth generation was recorded at the beginning of December and lasted three weeks, the maximum number of moths occurred on 8th December (4weeks) (27moths/week). The sixth generation began from last week of December till last week of January, the maximum number of moths took place during 19th January (5weeks) (35moths/week). Seventh generation took place from the beginning of February to the first week of March, the peak of this generation recorded on 16th February (5weeks) (50moths/week). Eighth generation began from the second week of March till the last of the same month, the peak of this generation recorded on 22th March (4weeks) (90moths/week). Ninth generation was appeared at the beginning of April and lasted three weeks, the maximum number of moths occurred on 19th April (3weeks) (250moths/week). The tenth generation formed at the first week of May to the mid of the same month, the maximum number of moths occurred on 10th May (3weeks) (300 moths/week). These results are agreement with the generations expected when using thermal units and linear regression.

Field generation of tomato leaf miner, *Tuta absoluta* depending on linear method:

This way was adopted to calculate number and duration of generations. When used this method *T. absoluta* formed Ten generations during season 2015.

Predicted dates of peak generations of *Tuta absoluta* according to degree-days

This study aimed to estimate the occurrence dates of generations with the corresponding thermal units and estimating the duration and calculated degree-days for predicting peaks to determine the best control methods.

According to the laboratory study, the value of zero of developmental temperature threshold (t0) was 10.5°C., while the average thermal units required for one generation of *Tuta absoluta* was 530.5 DD's.

The observed generation was to 10 generations and predicted peaks of the generations were to be 14 generation. There are no recorded fluctuations in the date from 28th July to 29th September. There is a difference between predicted and observed peaks of *T. absoluta*. From biological studies in this. Thesis indicated that 32°C was the fetal high degree of temperature for larvae especially 1st larvae. On the other hand, during period from 28th July until

29th September the temperature arrive to its peaks. Therefore, certainly *T. absoluta* enter aestivation stage for (72 days).

Survey natural enemies associated with tomato leaf miner *Tuta absoluta*

Parasitoids

Three different specimens of hymenopterous parasitoids were obtained from *T. absoluta* and identified to genus level. Larval parasitoids of *T. absoluta* include *Diglyphus* sp. (Eulophidae) and *Elasmus* spp. (two species) (Elasmidae). The egg parasitoid includes *Telenomus* sp. (Scelionidae). These parasitoids are the first record in Egypt.

Predator

The predator bug, *Nesidiocoris tenuis* Reuter (Heteroptera: Miridae) was the only predator species that was recorded in Egypt.

Seasonal abundance of *Nesidiocoris tenuis* associated with *Tuta absoluta*

Data obtained revealed that *T. absoluta* appeared one week earlier than *N. tenuis*. The population of *T. absoluta* had two peaks of 30.3 and 25.0 leaf mines/10 leaflets on 7th and 28th of May, 2013, respectively. *N. tenuis* similarly had two peaks of 58.8 and 73.3 nymphs and adults/plant on the same previous dates, respectively. This predator was positive significantly correlated with *T. absoluta* (r = +0.87 sig. at 5% and b= 0.26) nymph or adult.

Predatory efficiency of *Nesidiocoris tenuis* on *Tuta absoluta* eggs

The adult female of *N. tenuis* consumed a higher number (125.3 eggs in 12.5 days) than the adult male (81.5 eggs in 7.5 days).The 4thnymphal

instars devoured the highest number (30.6 eggs in 2.4 days), while the 1st nymphal instars ate the lowest (7.0 eggs in 2.1 days). *N. tenuis* was highly effective in controlling *T. absoluta* eggs.

VI- REFRENCES

Abbes, K. and B.Chermiti (2012). Failure of the biological control of *Tuta absoluta* using the predator *Nesidiocoris tenuis* in a protected tomato crop: analysis off actors. **IOBC/WPRS Bull., 80:231-236.**

Abbes, K.; A.Harbi and B.Chermiti (2012). Comparative study of 2protectionstrategies against *Tuta absoluta* (Meyrick) in late open field tomato crops in Tunisia. **Bull. OEPP/EPPO Bull., 42(2):297-304.**

Abd-Allah, Marwa, A. (2016). Factors influencing certain cucumber cultivars to the infestation with pests and the occurrence of natural enemies. **Ph.D. Thesis, Fac. Agric. Ain Shams Univ., Egypt, PP. 180.**

Abdul Razzak, A.S.; I.I.Al-Yasiri and H.Q.Fadhil (2010). First record of tomato borer (tomato moth) *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on tomato crop in Iraq. **Arab and Near East Plant Prot. Newsletter.51: 31.**

Abolmaaty, S.M.; M.K.Hassanein; A.A.Khalil and A.F.Abou Hadid (2010). Impact of climatic changes in Egypt on degree-day's units and generation number for tomato leaf miner moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). **Nature and Sci., 8(11): 122-129.**

Al-Gerrawy, A.J.; H.K.Al-Zubaidy and N.N.Hama (2013). First record of important natural enemies on tomato Borer *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Greenhouses in Middle of Iraq. **Second Sci. Conf., Fac. Agric., Carbelaa Univ.: 953-960.**

Al-Jboory, I.J.; A.Katbeh-Bader and A.Z.Shakir (2012). First observation and identification of some natural enemies collected from heavily infested tomato by *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Jordan. **Middle East J. Sci. Res., 11(6):787-790.**

REFERENCES

Altmani, W. (2010). Tomato leaf miner, *Tuta absoluta* invades East Mediterranean countries. **Arab and Near East Plant Prot. Newsletter 50: 29.**

Amin, T.R. and N.A.El-Halafawy (2002). Sodium and potassium ions content of haemolymph in the normal and starved cotton leaf worm, *Spodoptera littoralis* (boisd.). **Bull. ent. Soc. Egypt, Econ. Ser., 28:49-57.**

Antônio, A.d.C.; D.J.H.d. Silva; M.C.Picanço; N.T.Santos; and M.E.d.S.Fernandes (2011). Tomato plant inherbitance of antixenotic resistance to tomato leaf miner. **Pesq. agropec. bras. Brasília, 46(1):74-80.**

Arno, J.; and R.Gabarra (2011). Side effects of selected insecticides on the *Tuta absoluta* (Lepidoptera: Gelechiidae) predators *Macrolophus pygmaeus* and *Nesidiocoris tenuis* (Hemiptera: Miridae). **J. Pest Sci., 84(4):513-520.**

Arno, J.; R.Sorribas; M.Prat; M.Matas; C.Pozo; D.Rodriguez; A.Garreta; A.Gomez and R.Gabarra (2009). *Tuta absoluta*, anew pest in IPM tomatoes in the northeast of Spain. IOBC/**WPRS Bull., 49:203-208.**

Assaf, L.H.; F.R.Hassan; H.R.Ismael and S.A.Saeed (2013). Population density of tomato leaf miner *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) under plastic houses conditions (b). **IOSR J. Agric. and Vete. Sci. (IOSR-JAVS), 5(4): 7-10.**

Audemard, H. and H.G.Milaire (1975). Le piegeage du Carpocapsa (Laspeyresia) pomonella L. avec uni pheromone sexuelle de synthese: premiers resultata utilizable pour 1. Estimation des populations et la conduit de la lulte. **Ann. Zoll. Ecol. Anim. 7:61-80.**

Bakr, E.M., (2005). A new software for measuring leaf area, and area damaged by *Tetranychus urticae* Koch. **J. Appl. Entomol., 129 (3): 173-175.**

Banamieri, V. and A.Cheraghian (2011). First report of *Tuta absoluta* inIran and initial control strategies. **EPPO/IOBC/FAO/NEPPO Joint Inter. Symp. on management of *Tuta absoluta* (Tomato borer), Agadir, Morocco, November 16–18, 2011.**

Barrientos, Z.R.; H.J.Apablaza; S.A.Norero and P.P. Estay (1998). Threshold temperature and thermal constant for development of the South american tomato moth, *Tuta absoluta*(Lepidoptera: Gelechiidae). **Cienciae Invest. Agraria. 25(3) :133-137.**

Bavaresco, A.; A.N.L.Torres and G.Pilati (2005). Use of synthetic sexual pheromone for monitoring the seasonal fluctuation of *Tuta absoluta* in Planal to Norte of Santa Catarina State. **Agropecuaria Catarinense. 18(2): 83-86.**

Bean, J.L., (1961). Predicting emergence of second instars spruce bud worm larvae from hibernation under field conditions in Minnesota. **Ann. Ent. Soc. Amer., 54:175-177.**

Benvenga, S.R.; O.A.Fernandes and S.Gravena (2007). Decision making for integrated pest management of the South American tomato pinworm based on sexual pheromone traps. **Hortic. Brasileira. 25 (2): 164-169.**

Biondi, A.; A.Chaillcux; J.Lambion; P.Han; L.Zappala and N.Desneux (2013). Indigenous natural enemies attacking *Tuta absoluta* (Lepidoptera: Gelechiidae) in Southern France**. Egypt. J. Bio. Pest Control, 23(1):117-121.**

Birch, L.C., (1984). The intrinsic rate of natural increase of an insect population. **J. Anim. Ecol., 17(1):15-26.**

Blunk, M., (1923). Die Entwicklung Von *Dytiscus marginalis* L. Vom. E.bis Zur Imago, 2 Teil. Die Metamorphase Zracht-Wiss. **Sool,121-171.**

Boualem, M.; H.Allaoui and R.Hamadi (2011). Biology of *Tuta absoluta* (Meyrick) and the natural predator *Nesidiocoris tenuis* (Reuter) in Mostaganem area (Algeria). **Les Cochenilles: ravageurprincipal ou**

secondaire. 9eme Conf. Inter. sur les Ravageurs en Agric., Sup Agro, Montpellier, France, 25-27octobre: 299-307.

Boualem, M.; A.Mokhbi; M.Medjahed; I.Boukhalfa; Z.Limam and A. Ghelamallah (2014). Test of integrated control of *Tuta absoluta* populations on greenhouse tomato. **AFPP – Dixième Conf. Inter. sur les Ravageurs en Agric. Montpellier, Algérie, 22 et 23 octobre.**

Bradford, M.M., (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing protein dye binding. **Anal. Biochem., 72:248-254.**

Buhl, O.; P.Falck; O.Karsholt; K.Larsen and F.Vilhelmsen (2010). Records of microlepidoptera from Denmark in 2009 (Lepidoptera). **Entomol. Meddelelser. 78: 101–116 (in Danish).**

Cabello, T.; J.R.Gallego; F.J.Fernandez; M.Gamez; E.Vila; M. Pino and E.delHernandez-Suarez (2012). Biological control strategies for the South American tomato moth (Lepidoptera: Gelechiidae) in greenhouse Tomatoes. **J. Eco. Entomol., 105(6): 2085-2096.**

Calvo, F.J.; M.J.Lorente; P.A.Stansly and J.E.Belda (2012). Pre-plant release of *Nesidiocoris tenuis* and supplementary tacticsfor control of *Tuta absoluta* and *Bemisa tabaci* in greenhouse tomato. **Entomol. Exp. et Appl., 143(2):111-119.**

Cherif, A.; R.Mansour and K.Grissa-Lebdi (2013). Biological aspects of tomato leaf miner *Tuta absoluta* (Lepidoptera: Gelechiidae) in conditions of Northeastern Tunisia: possible implications for pest management. **Environ. & Exp. Biol., 11: 179–184.**

Crompton, M. and L.M.Birt (1967). Changes in the amounts of carboyhdrates, phosphagen and related compounds during the metamorphosis of the blowfly, *Lucilia cuprina*. **J. Insect physiol.,13:1575-1595.**

Cuthbertson, A.G.S.; J.J.Mathers; L.F.Blackburn; A.Korycinska; W.Luo; R.J.Jacobson and P.Northing (2013). Population

Development of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) under Simulated UK Glasshouse Conditions. **Insects, 4:185-197**.

Davidson, J., (1944). On the relation between temperatures and rate of development of insects at constant temperatures. **J. Anim. Ecol., 13:26-38.**

Desneux, N.; E.Wajnberg; K.A.G.Wyckhuys; G.Burgio; S.Arpaia; C.A.Narva´ez-Vasquez; J.Gonza´lez-Cabrera; Diana,C. 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. **J. Pest Sci., 83:197–215.**

de Oliveira, A.C.R.; V.da R.S.de Veloso; R.G.Barros; P.M.Fernandes and E.R.B.Souza (2008). Capture of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) with light trap in tomato crop. **Pesquisa Agro. Trop. 38 (3):153-157.**

Dubois, M.; K.A.Gilles; J.K.Hamilton; P.A.Rebers and F.Smith (1956). Colorimetric method for determination of sugars and related substances**. Analyt. Chem., 28:350-356.**

Ecole, C.C.; M.Picanco; M.D.Moreira and S.T.V.Magalhaes (2000). Chemical components associated with resistance of *Lycopersicon hirsutum f.* typicum to *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). **Anais da Sociedade Entomol. do Brasil. 29(2): 327-337.**

El-Arnaouty, S.A. and M.N.Kortam (2012). First record of the mirid predatory species, *Nesidiocoris tenuis* Reuter (Heteroptera: Miridae) on the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Egypt. Egypt. **J. Biol. Pest Cont., 22(2):223-224.**

EPPO (2005). Data sheets on quarantine pests: *Tuta absoluta*. Bull., OEPP/EPPO Bull. 35: 434–435.

REFERENCES

EPPO (2008). EPPO Reporting Service n. 1, 9. **http://www.eppo.org/ Puplications/reporting/reporting_service.htm [accessed on 10February, 2012].**

EPPO (2009). EPPO Reporting Service n. 1, 2, 3, 6, 8, 9, 10, 11. **http://www.eppo.org/Puplications/reporting/reporting_service.htm[accessed on 10 February 2012].**

EPPO (2010). EPPO Reporting Service n. 1, 2, 3, 6, 8. **http://www.eppo.org/Puplications/reporting/reporting_service.htm [accessedon 10 February 2012].**

EPPO(2011). EPPO Reporting Service n. 4, 11**. http://www.eppo.org/ Puplications/reporting/reporting_service.htm [accessed on 10February 2012].**

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

Estay, P. (2000). Polilla del tomate *Tuta absoluta* (Meyrick). **Infermativo, la platina. Instit. Invest. Agropécuria, Cent. Région Invest. la Platina, 1 – 4.**

Ferrara, F.A.A.; E.F.Vilela; G.N.Jham; A.E.Eiras; M.C.Picanco; A.B.Attygalle; A.Svatos; R.T.S.Frighetto and J.Meinwald (2001). Evaluation of the synthetic major component of the sex pheromone of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). **J. Chem. Ecol., 27(5):907-917.**

FAOSTAT (2014). Food and Agriculture Organization of the United Nations Regional Office for the Near East and North Africa, Cairo, pp. 174.

FAOSTAT (2011). Production. Crops. http://faostat.fao. org/site/567/ default. aspx#ancor [accessed on 20 October 2011]

Gabarra ,R.; J.Arno´; L. Lara; M.J. Verdu´; A.Ribes ; F.Beitia; A.Urbaneja ; M.M.Te´llez ; O.Molla´ and J.Riudavets (2013). Native parasitoids associated with *Tuta absoluta* in the tomato production areas of the Spanish Mediterranean Coast. **BioControl, 59: 45–54.**

Gharekhani, G. H. and H. Salek-Ebrahimi (2014). Life table parameters of *Tuta absoluta* (Lepidoptera: Gelechiidae) on different varieties of tomato. J. Eco. Entomol., 107(5):1765-1770.

Giorgini, M.; U.Bernardo and P.A.Pedata (2012). The parasitoid complex of *Tuta absoluta* (Meyrick) in Italy. **Italiana Entomol. Anno LX, 77-84.**

Giustolin, T.A.; J.D.Vendramim and M.L.Haddad (2000). Development of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on two tomato genotypes in laboratory and greenhouse. **Ecossistema 25(2): 145-148.**

Glas, J.J.; B.C.J. Schimmel; J.M.Alba; R.Escobar-Bravo; R.C.Schuurink and M.R.Kant (2012). Plant Glandular Trichomes as Targets for Breeding or Engineering of Resistance to Herbivores. **Int. J. Mol. Sci., 13:17077-17103.**

Greene, G.L.; N.C.Leppla; W.A.Dickerson (1976). Velvet bean caterpillar: a rearing procedure and artificial diet**. J. Eco. Entomol., 69(4): 487-488.**

Guenaoui, Y., (2008). Nouveau ravageur de la tomate en Alge ´rie.Premie `re observation de *Tuta absoluta*, Mineuse de la tomate invasive, dans la re´gion de Mostaganem, au printemps 2008. **Phytoma, La De´fense des Ve´ge´taux. 617: 18–19.**

Guenaoui, Y. and R.Bensaad (2011). Behaviour of *Tuta absoluta*larvae attacking tomato fruit. **Les Cochenilles: ravageur principalou secondaire. 9eme Conference Internationale sur les Ravageursen Agriculture, SupAgro, Montpellier, France, 25-27 octobre2011, 318-323.**

Guenaoui, Y.; R.Bensaad; K.Ouezzani and R.Vercher (2011). Emerging opportunities to use native entomophagous against *Tuta absoluta* Meyrick (Lepidoptera: Gelechidae) infesting tomato in unheated greenhouse in Northwestern Algeria between benefits and risks. **Les Cochenilles: ravageur principal ou secondaire.9eme Conference Internationale sur les Ravageurs en**

Agriculture,SupAgro, Montpellier, France, 25-27 octobre 2011, 324-334.

Hafez, M.M., (1961). Seasonal fluctuations of population density of the cabbage aphid, *Brevicoryne brassicae* (L.) in the Netherlands and the role of its parasite *Aphidius* (Diaeretiella) *rapae* (Curtis). **Ph.D. Thesis, Holland, 168pp.**

Han, P.; A.Lavoir; J.L.Bot; E.Amiens-Desneux and N.Desneux (2014). Nitrogen and water availability to tomato plants triggers bottom up effects on the leaf miner *Tuta absoluta*. **Sci. Rep., 1-8.**

Helmi, A. and H.I.Mohamed (2016). Biochemical and ultrastructural changes of some tomato cultivars after infestation with *Aphis gossypii* Glover (Hemiptera: Aphididae) at Qalyubiyah, Egypt. **Gesunde Pflanzen, 68:41–50.**

Hosseini, R. (2013). On the tribe Dicyphini (Hemiptera: Heteroptera: Miridae: Bryocorinae) in Guilan province and adjacent area (Iran). **Entomofauna, 34 (11): 157–158.**

Hrncˇic´, S. and S.Radonjic´ (2011). *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), a new pest in Montenegro. **IOBC/WPRS Bull., 68: 71–74.**

Izhevsky, S.S.; A.K.Akhatov and S.Y.Sinyov (2011). *Tuta absoluta* has been detected in Russia. **Zashchita i Karantin Rastenii. 3: 40–44.**

Jacop, M. (1977). Un model matimatic pentra stabilirea limitelor economic de tolerenta a atacalui molilor fructilor in lupte integrata. **Anal. Instit. Cerc. Prot. Plant. 13:151-179.**

Javaheri, M.; K.Mashayekhi; A.Dadkhah and F.Z.Tavallaee (2012). Effects of salicylic acid on yield and quality characters of tomato fruit (*Lycopersicum esculentum*Mill.). **Inter. J. Agri. Crop Sci., 4 (16):1184-1187.**

KahkÖnen, M.P.; A.I.Hopia; H.J.Vuorela; J.P.Rauha; K.Pihlaja; T.S.Kujala and M.Heinonen (1999). Antioxidant activity of plant extracts containing phenolic compounds. **J. Agric. Food chem., 47:3954-3962.**

Kajanshikov, N.B., (1946). Kbonpocy oxnbhehhom tempnueckom ontnmyme 8-olabnlbhocntn npuoueccob pazbnata hacekomblx bothowehnn tempnuecknx bilnahnn **300- Lx4 prl.25, C.27-35.**

Keresi, T.; M.Ivanovic and D.Tolic (2010). Tomato moth (*Tuta absoluta* Povolny), new potential threat to tomato production in Serbia. **Biljni Lekar. 38: 474–484 (in Serbian).**

Korycinska, A. and H.Moran (2009). Plant Pest Notice: South American tomato moth, *Tuta absoluta*. **Food and Environ. Res. Agency 56: 1–4.**

Krechemer, F.d.S. and L.A.Foerster (2015). *Tuta absoluta* (lepidoptera: Gelechiidae): thermal requirements and effect of temperature on development, survival, reproduction and longevity. **Eur. J. Entomol., 112(4): 658–663.**

Kılıc¸ T. (2010). First record of *Tuta absoluta* in Turkey. **Phytoparasitica, 38: 243–244.**

Lee, Y.P. and T.Takabashi (1966). An improved colorimrtric determination of amino acids with the use of ninhydrin. **Anal. Biochem., 14: 71-77.**

Leite, G.L.D.; M.Picanco; A.A.Azevedo; Y.Zurita and F.Marquini (1998).Oviposition and mortality of *Tuta absoluta* on *Lycopersicon hirsutum*. **Manejo Integrado de Plagas. 49: 26-34.**

Leite, G.L.D.; M.Picanço; G.N.Jham; and F.Marquini (2004). Intensity of *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) and Liriomyza spp. (Diptera: Agromyzidae) attacks on *Lycopersicum esculentum* Mill. **Ciênc. agrotec., Lavras.28(1): 42-48.**

Lopez, J.A.; F.Amor; P.Bengochea; P.Medina; F.Budia and E.Viñuela (2011). Short communication Toxicity of emamectin benzoate to adults of *Nesidiocoris tenuis* Reuter, *Macrolophus pygmaeus* (Rambur) (Heteroptera: Miridae) and *Diglyphus isaea* Walker

(Hymenoptera: Eulophidae) on tomato plants Semi-field studies. **Spanish J. Agric. Res., 9(2): 617-622.**

Mahdi, K.; B.Doumandji-Mitiche; A.Ababsia and S.Doumandji (2011). Natural enemies of the tomato leaf miner *Tuta absoluta* (Meyrick, 1917) in Algeria: prospects for biological control. **4eme Conf. Inter. sur les Methodes Alternatives en Prot. des Cultures. Evolution des cadres reglementaires europeen et francais. Nouveaux moyens et strategies Innovantes, Nouveau Siecle, Lille, France, 8-10 mars 2011, 561-567.**

Mihsfeldt, L.H. and J.R.P.Parra (1999). Biology of *Tuta absoluta* (Meyrick, 1917) reared on an artificial diet. **Sci. Agricola. 56(4): 769-776.**

Millonig, G., (1961). Advantages of a phosphate buffer of O_sO_4 solution in fixation. J. **Appl. Phys., 32:1637.**

Miranda, M.M.M.; M.Picanco; J.C.Zanuncio and R.N.C.Guedes (1998). Ecological life table of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). **Biocontrol Sci. and Technol., 8 (4): 597-606.**

Mohamed, A.M.O.; N.S.Mandour; M.A.Abd El-Hady and A.A.Sarhan (2015). Influence of temperature on some biological attributes and life table analysis of the tomato leaf miner, *Tuta absoluta* (Lepidoptera; Gelechiidae). **Entomol. Appl. Sci. Lett., 2(2):7-15.**

Molla, O.; H.Monton; P.Vanaclocha; F.Beitia and A.Urbaneja (2009). Predation by the mirids *Nesidiocoris tenuis* and *Macrolophus pygmaeus* on the tomato borer *Tuta absoluta*. **IOBC/WPRS Bull., 49:209-214.**

Molla, O.; J.Gonzalez-Cabrera and A.Urbaneja (2011). The combined use of *Bacillus thuringensis* and *Nesidiocoris tenuis* against the tomato borer *Tuta absoluta*. **BioControl. 56(6):883-891.**

Moussa, S.; F.Baiomy; A.Sharma and F.Eid - eladl (2013). The status of tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera:

Gelechiidae) in Egypt and potential effective pesticides. **Academic J. Entomol., 6(3):110-115.**

Mukhtar, S.K.; A.Hashim; M.Peterschmitt and M.K.Abdrahman (2009). Field screening and molecular identification of tomato leaf curl virus Sudan source. Arab **J. Plant Prot., 27(1): 95–98.**

Nannini, M.; F.Atzori; G.Murgia; R.Pisci and F.Sanna (2012). Useof predatory mirids for control of the tomato borer *Tuta absoluta*(Meyrick) in Sardinian greenhouse tomatoes. **Bull., OEPP/EPPO Bull., 42(2):255-259.**

Ni, X.; S.S.Quisenberry; T.Heng-Moss; J.Markwell; G.Sarath; R.Klucas and F.Baxendale (2001). Oxidative responses of resistant and susceptible cereal leaves to symptomatic and nonsymoptomatic cereal aphid (Hemiptera: Aphididae) feeding. **J. Eco. Entomol., 94:743-751.**

Oliveira, F.A.; D.J.H.de Silva; G.L.D.Leite; G.N.Jham and M.Picanco (2008). Resistance of 57 greenhouse-grown accessions of *Lycopersicon esculentum* and three cultivars to *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). **Sci. Horticulturae. 119: 182–187.**

Ostraukas, H. and P.Ivinskis (2010). Records of the tomato pinworm (Tutaabsoluta (Meyrick, 1917)) – Lepidoptera: Gelechiidae in Lithuania. **Acta Zool. Lithuanica. 20: 151–155.**

Özgökce, M.S.; A.Bayindir and İ.Karaca (2016). Temperature- dependent development of the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on tomato plant *Lycopersicon esculentum* Mill. (Solanaceae)**. Türk. Entomol. Derg., 40 (1): 51-59.**

Oztemiz, S. (2013). Population of *Tuta absoluta* and natural enemies after releasing on tomato grown greenhouse in Turkey. **African J. Biotechnol., 12(15):1882-1887**.

Pacheco, A.C.; C.d.S.Cabral; É.S.d.S.Fermino and C.C.Aleman (2013). Salicylic acid-induced changes to growth, flowering and flavonoids production in marigold plants. **J. Med. Plants Res., 7(42): 3158-3163.**

Payer, R.; E.Figueiredo and A.Mexia (2015). Evaluation of parasitism and predation of *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) by *Diglyphus isaea* (Walker, 1838) (Hymenoptera: Eulophidae). **SHILAP Rev. lepid., 43 (170) : 173-179.**

Perdikis, D.C.; K.A.Arvanitia and D.M.Papadimitriou (2016). Effects of sticky traps on *Dacnusa sibirica*, *Diglyphus isaea* and *Nesidiocoris tenuis*. **Entomol. Hellenica,25 : XX-XX.**

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

Perveen, S.S.; T.M.Qaisrani; S.Amin; R.Perveen and S.H.M.Nagvi (2001). Biochemical basis of insect resistance in cotton. **Online J. Biol. Sci., 1:496–500.**

Pires, L.M. and I.M.R.Marques (2002). Biological data of the tomato pinworm and storage of its eggs and pupae at low temperature. **Rev. de Agric. (Piracicaba). 77 (3): 357-368.**

Polaszek, A. and S.W.Kimani (1990).*Telenomus* species (Hymenoptera: Scelionidae) attacking eggs of pyralid pests (Lepidoptera) in Africa. A review and guide to identification. **Bull. Ent. Res., 80: 57-71.**

Popova, L.; T.Pancheva and A.Uzunova (1997). Salicylic acid: properties, biosynthesis and physiological role. **BULG J. Plant Physiol., 23(1–2):85–93.**

Potting, R.; D. Janvan der Guag, A. Loomans, M. Van der Straten, H.Anderson, A. Macleod, L.M.G.Castrillon and G.V.Cambro (2009). *Tuta absoluta* leaf miner moth. **Ministry of Agriculture Nature and Food Quality(LVN) Plant Protection Service of the Netherlands. http:/www.minlnv. n/cd/pub/servelt/CD Servlet.**

Rani, P.U. and Y.Jyothsna (2010). Biochemical and enzymatic changes in rice as a mechanism of defense. **Acta Physiol. Plant, 32:695–701**.

Reina, P. and J.La Salle 2003. Key to the world genera of Eulophidae parasitoids (Hymenoptera) of leaf mining agromyzidae (Diptera). **http://www.ento.csiro.au/science/eulophids.html(CSIRO Entomol., GPO Box 1700, Canberra, ACT 2601, Australia - john.lasalle@csiro.au).**

Richmond, J.A.; H.A.Thomas and H.B.Hattachargypa (1983). Predicting spring flight of Nantucket pine tip moth (Lepidoptera: Olethreutidae) by heat unit accumulation. **J. Econ. Entomol., 76: 269-271.**

Rockstein, M. and P.W.Herron (1951). Colorimetric determination of inorganic phosphate in microgram quantities. **Analyte. Chem., 23:1500-1501.**

Roditakis, E.; D.Papachristos and N.E.Roditakis (2010). Current status of the tomato leaf miner, *Tuta absoluta* in Greece. **Bull., OEPP/EPPO Bull. 40: 163–166.**

Sadasivam, S. and A.Manickam (1991). Amino acids and proteins in biochemical methods for agricultural sciences **(Wiley eastern limited and Tamil Nadu agric. Univ., Coimbtore) pp., 33-95.**

Sakhabutdinova, A.R.; D.R.Fatkhutdinova; M.V.Bezrukova and F.M.Shakirova (2003). Salicylic acid prevents the damaging of stress factors on wheat plants. **Bulg. J. Plant Physiol., Special Issue, 314–319.**

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). **Ecol. Balkanica, (7):35-44.**

Salas, J., (2004). Capture of *Tuta absoluta* (Lepidoptera: Gelechiidae) in traps baited with its sex pheromone. **Rev. Colombiana de Entomol., 30(1): 75-78.**

Sanchez, N.E.; P.C.Pereyra and M.G.Luna (2009). Spatial patterns of parasitism of the solitary parasitoid *Pseudapanteles dingus* (Hymenoptera: Braconidae) on *Tuta absoluta* (Lepidoptera: Gelechiidae). **Environ. Entomol., 38(2) : 365-374.**

SAS instituite 1988: SAS/stat user's guide. 6.03 ed. **SAS institute Cary,Nc.**

Seplyarsky, V.; M.Weiss and A.Haberman (2010). *Tuta absoluta* Povolny (Lepidoptera: Gelechiidae), a new invasive species in Israel. **Phytoparasitica. 38: 445–446.**

Singleton,V.L. and J.A.Rossi (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotugstic acid reagents. **Am. J. Enol. Vitic., 16:144-158.**

Sohrabi, F. and R.Hosseini (2015). *Nesidiocoristenuis* (Reuter) (Heteroptera: Miridae), a predatory species of the tomato leafminer, *Tutaabsoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Iran. **J. Plant Prot. Res., 55(3), 322-323.**

Svatos, A.; A.B. Attygalle; G.N.Jham; R.T.S.Frighetto; E.F.Vilela; D.Saman and J.Meinwald (1996). Sex pheromone of tomato pests *Scrobipalpuloides absoluta* (Lepidoptera:Gelechiidae). **J. Chem. Ecol., 22(40):787-800.**

Taha, A.M.; T.E.Emara; A.R.I.Hanafy and G.M.Hassan (2014). Evaluation of pheromone lures for trapping the tomato borer moths, *Tuta absoluta* in tomato fields in Egypt. **Inter. J. Environ. Sci. &Engin. (IJESE)5: 99-109.**

Torrest, J.F.; CA; W.S.Evangeliste and D.Pratissoli (2001). Within-plant distribution of the leaf miner *Tuta absoluta* (Meyrick) immature inprocessing, with notes on plant phenology. **Inter. J. Pest Management, 47(3): 173-178.**

Traw, B.M. and T.E. Dawson (2002). Reduced performance of two specialist herbivores (Lepidoptera: Pieridae, Coleoptera: chrysomelidae) on new leaves of damaged black mustard plants. **Environ. Entomol., 31:714–722.**

Tropea Garzia, G.; G.Siscaro; A.Colombo and G.Campo (2009). *Tuta absoluta* recovered in Sicily. **L'Informatore Agrario 4: 71.**

Uchoˆa-Fernandes, M.A.; T.M.C.Della Lucia and E.F.Vilela (1995). Mating, oviposition and pupation of *Scrobipalpula absoluta* (Meyrick) (Lepidoptera: Gelechiidae). **Anais da Sociedade Entomol. Brasil., 24:159–164.**

Urbaneja, A.; H.Monton and O.Molla (2009). Suitability of the tomato borer *Tuta absoluta* as prey for *Macrolophus pygmaeus* and *Nesidiocoris tenuis*. **J. Appl. Entomol., 133 (4) 292-296.**

Urbaneja, A.; R.Vercher; V.Navarro; F.Garcı´aMarı´ and J.L.Porcuna (2007). La polilla del tomate, *T.absoluta*. **Phytoma Espan˜a, 194:16–23.**

Uric, Z. and S.Hrncic (2010). Tomato leaf miner, *Tuta absoluta* Meyrick in the Republic of Srpska. **Agro Znanje Agro knowledge J., 11: 17–23 (in Serbian).**

Van Asperen, K., (1962). A study of house fly esterase by means of sensitive colourimetric method. **J. Insect physiol., 8:401-416.**

Vanderlei Carus Guedes, J.; S.T.Bastos Dequech and A.L.De Paula Ribeiro (1996). Efficacy of traps in capturing the tomato leaf miner (*Scrobipalpuloides absoluta* (Meyrick, 1917)) using sex pheromone in a plastic greenhouse. **Ciencia Rural., 26(1): 143-145.**

Vetter, P. (1958). Quantitative determination of peroxidase in sweet corn. **Agric. & food chem., 6(1):39-41.**

Viggiani, G.; F.Filella; G.Delrio; W.Ramassini and C.Foxi (2009). *Tuta absoluta*, new moth reported also in Italy. **L'Informatore Agrario. 2:66-68. (in Italian).**

Virgala, M.B.R. and E.N.Botto (2010). Biological studies on Trichogrammatoidea *bactrae Nagaraja* (Hymenoptera: Trichogrammatidae), egg parasitoid of *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae). **Neotropic. Entomol., 39 (4) 612-617.**

War, A.R.; M. G. Paulraj, M. Y. War and S. Ignacimuthu (2012). Herbivore-induced resistance in different groundnut germplasm lines to Asian army worm, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae). **Physiol. Plant., 34: 343.**

Werker, E. (2000). Trichome diversity and development. **Adv. Bot. Res., 31:1–35.**

WPTC (2011). Report of world processing tomato council.10 p. **Available at: (http://www.wptc.to/releases-wptc).**

Yefremova Z.A. and I.S.Strakhova (2010). A review of the species of the genus *Elasmus* Westwood (Hymenoptera: Eulophidae) from Russia and neighboring countries. **Entomol. Rev., 90(7): 903-926.**

Zappalà,L.; U. Bernardo; A. Biondi; A. Cocco; S. Deliperi; G. Delrio; M. Giorgini; P. Pedata; C. Rapisarda; G. T. Garzia and G. Siscaro (2012). Recruitment of native parasitoids by the exotic pest *Tuta absoluta* in Southern Italy. **Bull. Insectol. 65 (1), 51-61.**

الملخص العربي

تعتبر الطماطم من المحاصيل التصديرية الهامة وأحد مصادر الحصول علي العملة الأجنبية حيث تعتبر مصر خامس دولة من حيث كمية الإنتاج علي مستوي العالم، وتزرع مصر سنويا مساحة 599.651 فدان من الطماطم تنتج حوالي 10.275521طن وتزرع الطماطم علي مدار العام. منذ عام 2009 هاجمت حافرة أوراق الطماطم مصر بسرعة وبكثافة عالية حيث أنها تتغذي علي الأوراق والسيقان والثمار حيث يؤدي ذلك إلي قلة الإنتاج وخفض مستوي جودة ثمار الطماطم الأمر الذي يتطلب إجراء بعض الدراسات البيولوجية والإيكولوجية وأيضا حصر للأعداء الحيوية المصاحبة لها للإستعانة بكل هذه المعلومات في عملية المكافحة المتكاملة لهذه الحشرة وتتلخص هذه الدراسة علي النقاط التالية:

أولا: الدراسات البيولوجية

1-حساب صفر النمو والوحدات الحرارية للأطوار المختلفة وللجيل الكامل

عن طريق تربية الحشرة علي بيئة صناعية علي أربع درجات حرارة 20 ،24 ، 28، 32°م ، ورطوبة نسبية 70-60 %.

أ- طور البيضة

1- فترة حضانة البيض

وجد أن فترة حضانة البيض تقل بإرتفاع درجة الحرارة حيث سجلت هذه الفترة 3.5 ,4.0 ,5.0 ,6.8 يوما علي درجات حرارة 20 24, 28, 32 , درجة علي التوالي.

2- النسبة المئوية لفقس البيض

تم حساب النسبة المئوية لفقس بيض صانعة أنفاق أوراق الطماطم علي الأربع درجات المذكورة ووجد أن درجة حرارة 24 درجة مئوية تمثل أعلي نسبة فقس حيث وصلت97% ، بينما عند 20, 28, 32 كانت نسبة الفقس 95% ,89% ,72% علي التوالي.

3- صفر النمو لطور البيضة

كما تم حساب صفر النمو لهذا الطور ووجد أنه يساوي 7.0 درجة مئوية.

4- معدل النمو والوحدات الحرارية للنمو الجنيني داخل البيضة

يزداد معدل النمو كلما زادت درجة الحرارة من 20-32°C، حيث أن معدل النمو يساوي 28.57 ,25 ,20 ,14.7 علي درجات حرارة 32 ,28 ,24 ,20 درجة مئوية علي التوالي. أيضا تم حساب الوحدات الحرارية لهذا الطور ووجد أن أعلي تسجيل لها علي درجة حرارة 20 درجة مئوية حيث بلغت 88.4 وحدة حرارية، بينما عند 32 درجة مئوية كانت 87.5 وعند24 درجة مئوية كانت 85.0 وحدة حرارية ولكن أقل وحدات حرارية سجلت عند 28درجة مئوية حيث بلغت حوالي 84.0 وحدة حرارية.

ب- طور اليرقة

1- فترة الطور اليرقي

وجد أن أطول فترة زمنية استغرقها هذا الطور كانت عند درجة الحرارة 20 درجة مئوية كانت 30.9 يوم ، بينما أقلهم تم تسجيلها عند درجة حرارة 28 درجة مئوية بلغت 17.6 يوم.

2- صفر النمو للطور اليرقي

ووجد أن صفر النمو لهذا الطور كان 10.0 درجة مئوية.

3- معدل النمو والوحدات الحرارية للطور اليرقي

يزداد معدل النمو كلما زادت درجة الحرارة من 20-28°C، حيث أن أقل معدل نمو عند 20 درجة مئوية يساوي 3.2 ، يتبعه عند درجات حرارة 24 درجة مئوية حيث بلغ 4.6 ، بينما كان أعلي معدل نمو عند 28 درجة مئوية حيث بلغ 5.7. أيضا تم حساب الوحدات الحرارية لهذا الطور ووجد أن أعلي تسجيل لها علي درجة حرارة 28 درجة مئوية حيث بلغت 316.8 وحدة حرارية، بينما عند20 درجة مئوية كانت 309.0 وحدة حرارية ولكن أقل وحدات حرارية سجلت عند 24 درجة مئوية حيث بلغت حوالي 306.6 وحدة حرارية.

4- النسبة المئوية لموت اليرقات

أعلي نسبة موت حدثت لليرقات عند درجة حرارة 32 درجة مئوية بلغت 100%،ويعتبر درجة 32 هي درجة الحرارة العليا المميتة للطور اليرقي وخصوصا العمر اليرقي الأول نظرا لتأثير الحرارة العالية في إحداث تغيرات كيميائية في تركيب البروتولازم ، يليها عند 28 ,24 درجة مئوية كانت نسبة الموت عند الدرجتان متساوية وبلغت 74%، بينما كانت أقل نسبة موت عند 20 درجة مئوية وبلغت 52%.

ت-طور العذراء

1- فترة طور العذراء

وجد أن فترة طور العذراء تقل بإرتفاع درجة الحرارة حيث سجلت هذه الفترة 15.8, 9.5, 8.1 يوما علي درجات حرارة , 20 28 ,24 درجة علي التوالي.

2- صفر النمو لطور العذراء

وجد أن صفر النمو لهذا الطور بلغ 11.2 درجة مئوية.

3- معدل النمو والوحدات الحرارية لطور العذراء

يزداد معدل النمو كلما زادت درجة الحرارة من 20 إلي 28 درجة مئوية ، حيث أن أقل معدل نمو عند 20 درجة مئوية يساوي 6.3 ، يتبعه عند درجات حرارة 24 درجة مئوية حيث بلغ 10.5 ، بينما كان أعلي معدل نمو عند 28 درجة مئوية حيث بلغ 12.3. أيضا تم حساب الوحدات الحرارية لهذا الطور ووجد أن أعلي تسجيل لها علي درجة حرارة 20 درجة مئوية حيث بلغت 138.6 وحدة حرارية، بينما عند28 درجة مئوية كانت 136.6 وحدة حرارية ولكن أقل وحدات حرارية سجلت عند 24 درجة مئوية حيث بلغت حوالي 121.5 وحدة حرارية بمتوسط قدره 132.2وحدة حرارية.

4- النسبة المئوية لموت العذاري

أعلي نسبة موت حدثت للعذاري عند درجة حرارة 20 درجة مئوية بلغت 10.0%، يليها عند 24 درجة مئوية كانت نسبة

الموت تساوية 5.0%، بينما كانت أقل نسبة موت عند 28 درجة مئوية وبلغت 1.0%.

ث-طور الحشرة الكاملة

أ- طور الأنثي

1- فترة ما قبل وضع البيض

الفترة اللازمة لنمو وتطور المبايض لعملية وضع البيض تقل بزيادة درجة الحرارة حيث سجلت 1.0 ,2.2 ,2.6 يوما علي درجات حرارة 28 ,24 ,20درجة مئوية علي التوالي. سجل صفر النمو لهذه المرحلة 15.0 درجة مئوية ، بينما متوسط الوحدات الحرارية اللازمة لنمو وتطور مبايض إناث هذه الحشرة يساوي 13.0 ,19.8 ,13.0وحدة حراريةٍ علي درجات حرارة 20, 24, 28درجة مئوية علي التوالي.

2- فترة وضع البيض

وجد أنه بإرتفاع الحرارة أدي ذلك إلي تقليل هذه الفترة ، حيث وصلت هذه الفترة 5.8 ,6 ,9.2 يوما عند درجات حرارة 28 ,24 ,20 درجة مئوية علي التوالي. تم حساب صفر النمو لهذه الفترة ووجد أنها تساوي 6.0 درجة مئوية ، بينما متوسط الوحدات الحرارية يساوي 127.6 ,108.0 ,128.8 وحدة حراريةٍ علي درجات حرارة 28 ,24 ,20 درجة مئوية علي التوالي.

3- فترة ما بعد وضع البيض

وصلت فترة ما بعد وض البيض إلي 1.4 ,2.6 ,3.4 يوما عند درجات حرارة 28 ,24 ,20 درجة مئوية علي التوالي. سجل صفر النمو لهذه المرحلة 15.2 درجة مئوية ، بينما متوسط الوحدات الحرارية يساوي 17.9 ,22.9 ,16.3 وحدة حراريةٍ علي درجات حرارة 28 ,24 ,20 درجة مئوية علي التوالي.

وعموما عمر الأنثي أطول من عمر الذكر حيث بلغ متوسط عمر الأنثي 8.2 ,11.8 ,15.6 يوما علي درجات حرارة 20, 28 ,24درجة مئوية علي التوالي وكان الحد الحرج للنمو لطور الأنثي هو 11.2°م ، وعلي الجانب الآخر كان متوسط الوحدات

الحرارية اللازمة لطور الأنثي 137.8 ,151.0 ,137.3 وحدة حراريةٍ علي درجات حرارة 28 ,24 ,20 درجة مئوية علي التوالي.

ب-الكفاءة التناسلية

تم حساب درجة الخصوبة عند الأنثي فكان أعلي متوسط لوضع بيض الأنثي 145.5 بيضة/أنثي علي درجة حرارة 28 درجة مئوية ، بينما سجل أقل عدد عند 20 درجة مئوية حيث وصل متوسط وضع البيض إلي 57.8 بيضة/أنثي.

من هذه النتائج يتضح أن درجة الحرارة 28 درجة مئوية هي الدرجة الملائمة لتربية الحشرة تحت ظروف المعمل.

ت-طور الذكر

وجد أن فترة عمر الذكر تقل بإرتفاع درجة الحرارة حيث سجلت هذه الفترة 7.4 ,10.2 ,12.8 يوما علي درجات حرارة , 20 24 ,28 درجة علي التوالي.

وجد أن صفر النمو لطور الذكر يساوي 9.8 درجة ، بينما متوسط الوحدات الحرارية يساوي 134.7 ,144.8 ,130.6 وحدة حراريةٍ علي درجات حرارة 28 ,24 ,20 درجة مئوية علي التوالي.

ج-الجيل الكامل

أقصر فترة للجيل الكامل تحققت عند درجة حرارة 28 درجة مئوية بلغت 30.7 يوما يتبهعا 38.6 عند 24 درجة مئوية ، بينما أطول مدة كانت عند 20 درجة مئوية وصلت إلي 56.1 يوما. سجل صفر النمو للجيل الكامل 10.5 درجة مئوية ، بينما بلغت الوحدات الحرارية اللازمة لنمو وتطور الجيل الكامل 537.3 ,521.0 ,533.0 وحدة حراريةٍ علي درجات حرارة 28 ,24 ,20 درجة مئوية علي التوالي ، بمتوسط قدره 530.5 وحدة حرارية.

2- جداول الحياة للحشرة

تم دراسة جداول الحياة لحساب فترات البقاء ومعدل التكاثر للأطوار المختلفة (الإقتدار الحيوي) وكذلك إيضاح دور درجات الحرارة في التأثير علي تعداد الحشرة.

أ-نسب الموت الظاهري والحقيقي

سجلت أعلي نسبة مئوية للموت الظاهري والحقيقي لطور البيضة علي درجة حرارة 20°م (28.0%) ، يتبعها درجة حرارة 28°م (11.0%) ، يتبعها 24°م (3.0%).

سجلت أعلي نسبة مئوية للموت الظاهري لطور اليرقة علي درجة حرارة 28°م (83.1%) ، يتبعها درجة حرارة 24°م (76.3%) ، يتبعها درجة حرارة 20°م (72.2%). كذلك النسب المئوية للموت الحقيقي لطور اليرقة أخذ نفس الإتجاه حيث كانت هذه النسب 52% ,74 ,74 علي درجات حرارة 20 ,24 ,28°م علي التوالي.

سجلت النسبة المئوية للموت الظاهري لطور العذراء 6.7% ,21.7 ,50 علي درجات حرارة 28 ,24 ,20°م علي الترتيب. كذلك النسب المئوية للموت الحقيقي لطور العذراء أخذ نفس الإتجاه حيث كانت هذه النسب 1.0% ,5.0 ,10.0 علي درجات حرارة 28 ,24 ,20°م علي التوالي.

سجلت نسب الموت الحقيقي والظاهري لطور البيضة اليرقة والعذراء علي درجة حرارة المعمل (33.33&33.33) & (57.7 & 86.5) & (1.7 & 18.5) علي التوالي.

ب-خصوبة وفترة بقاء الحشرات الكاملة

سجلت أطول فترة حياة اليرقات والعذاري والإناث الكاملة(16.0 ,15.8 ,30.9) يوماعلي التوالي علي درجة حرارة 20°م ، وسجلت هذه الفترات(9.5, 21.9, 11.0) يوما علي التوالي علي درجة حرارة 24°م ، بينما سجلت اقصر فترة (10.0 ,8.1 ,17.6) يوما علي التوالي علي درجة حرارة 28°م.

ت-معدل التوالد التكاثري R_0

أوضحت النتائج أن أعلي معدل للتوالد التكاثري كان 10.03 فردا/جيل عند التربية علي درجة حرارة 28°م ، يتبعها 6.29 فردا/جيل عند التربية علي درجة حرارة 24°م ، بينما كان أقل معدل للتوالد التكاثري 2.85 , 3.15 فردا/جيل عند التربية علي 20°م ودرجة حرارة المعمل علي التوالي.

ث- مدة الجيل Gt

أظهرت النتائج أن مدة الجيل كانت أقصر عند التربية علي درجة حرارة 28°م ودرجة حرارة المعمل (33.92 ، 33.97) يوما علي التوالي ، بينما سجلت أطول مدة علي درجة حرارة 20°م (59.58 يوم) ، بينما كانت علي درجة حرارة 24°م (41.37 يوم).

ج-معدل الزيادة التي تضاف للمجموع الحشري في وحدة الومن r_m

أظهرت النتائج أن نسبة الزيادة في عدد الأفراد عند التربية علي درجة حرارة 28°م كانت أعلاها(0.13 فردا/يوم) ، بينما كانت عند 24°م (0.07فردا/يوم) ودرجة حرارة المعمل (0.04 فردا/يوم) ،أما أقلها كان عند التربية علي درجة حرارة 20°م (0.02 فردا/يوم).

ح-معدل زيادة الخصوبة في وحدة الومن λ

سجل أعلي معدل لزيادة الخصوبة (1.14 فردا/يوم) عند التربية علي درجة حرارة 28°م ، و(1.07فردا/يوم) عند التربية علي درجة حرارة 24°م و(1.04فردا/يوم) عند التربية علي درجة حرارة المعمل ، بينما سجل أقل معدل (1.02فردا/يوم) عند التربية علي درجة حرارة 20°م.

خ-زمن تضاعف العشيرة Dt

وجد أن أعلي جيل مضاعف (43.43 يوم) عند التربية علي درجة حرارة 20°م، يتبعه(21.71 يوم) عند التربية علي درجة حرارة المعمل، يتبعه

(12.41يوم) عند التربية علي درجة حرارة 24°م ، بينما كان أقل جيل مضاعف(6.68يوم) عند التربية علي درجة حرارة 20°م.

تشير النتائج السابقة إلي أن درجة حرارة 28 م تبدو المثلي لتربية حشرة صانعة أنفاق أوراق الطماطم ، عند هذه الدرجة تزداد كل من خصوبة الإناث ومعدل التوالد التكاثري ومعدل الزيادة التي تضاف للمجموع الحشري في وحدة الزمن ومعدل زيادة الخصوبة في وحدة الزمن مسجلة أعلي قيم لها، بينما الزمن اللازم لتضاعف العشيرة فقد سجل أقل قيمة.

ثانيا: الدراسات البيئية

1-دراسة حساسية بعض أصناف محصول الطماطم للإصابة بحشرة حافرة أنفاق أوراق الطماطم

من النتائج تبين أن صنف الردصن والسوبر استرين ب وكاسل روك هم أكثر الأصناف حساسية ، يليهم أصناف الريوجراند والبلدي والنيماجارد فهم متوسطي الحساسية، بينما صنفي سوبرست والبيتو86 هما أكثر الأصناف مقاومة.

في الموسم الأول 2012 يمكن تقسيم الثمانية أصناف طماطم حسب حساسيتهم للإصابة بحشرة صانعة أنفاق أوراق الطماطم إلي إلي أربع مجموعات تحتوي المجموعة الأولي علي صنفي الردصن والسوبر استرين ب بمتوسط تعداد 32.6 & 36.7 نفق/10وريقات علي التوالي، بينما تضم المجموعة الثانية صنفي الريوجراند وكاسل روك بمتوسط تعداد 23.1 & 25.4 نفق/10وريقات علي التوالي، أما صنفي السوبر ست والبلدي يكونان المجموعة الثالثة بمتوسط تعداد 21.1 & 21.4 نفق/10وريقات علي التوالي. المجموعة الرابعة هي الأكثر مقاومة وتضم صنفي النيماجارد والبيتو86 بمتوسط تعداد 20.0&21.0 نفق/10وريقات علي التوالي.

في الموسم الثاني2013 أيضا تم تقسيم الثمانية أصناف طماطم حسب حساسيتهم للإصابة بحشرة صانعة أنفاق أوراق الطماطم إلي إلي أربع مجموعات تحتوي المجموعة الأولي علي صنف الردصن فقط بمتوسط تعداد 46.6 نفق/10وريقات ، بينما تضم المجموعة الثانية صنفي السوبر استرين ب وكاسل

روك بمتوسط تعداد 35.0 & 37.0 نفق/10وريقات علي التوالي، أما أصناف البلدي والريوجراند والنيماجارد يكونان المجموعة الثالثة بمتوسط تعداد & 27.0 24.5 & 25.3 نفق/10وريقات علي التوالي. المجموعة الرابعة هي الأكثر مقاومة وتضم صنفي السوبرست والبيتو86 بمتوسط تعداد 20.4 & 23.7 نفق/10وريقات علي التوالي.

وعموما فإن متوسط عدد الأنفاق الأسبوعي لصانعة أنفاق أوراق الطماطم خلال عام 2013(80/239.5 نفق) أعلي من عام 2012 (80/201.3 نفق) ، حيث أن النسبة المئوية للزيادة حوالي 17.6% في عام 2013 مقارنة بعام 2012.

أ- دراسة تأثيربعض المكونات الكيميائية لأوراق بعض أصناف محصول الطماطم وعلاقتها بدرجات الإصابة

1- N.P.K.

وجد أن أعلي عدد أنفاق تواجد في صنف الردصن حيث أعلي مستوي من العناصر الثلاثة .N.P.K 10.9mg/gm dry weight &1956.7mg/gm dry weight & 550.0 uEq/gm dry weights علي الترتيب. من ناحية أخري فإن صنف البيتو86 هو الصنف الأقل إصابة حيث يحتوي علي أقل مستوي من النيتروجين.

ووجد أيضا أن الإرتباط بين متوسط أنفاق الحشرة وتركيز النيتروجين في الورقة هو إرتباط غير معنوي موجب(0.57)، بينما في حالة الفوسفور فالإرتباط معنوي موجب(0.74) ، وفي حالة البوتاسيوم فإن الإرتباط معنوي موجب أيضا(0.81).

2- مجموع الأحماض الأمينية الكلي والبروتين الكلي

وجد أن أعلي عدد أنفاق تواجد في صنف الردصن حيث أعلي مستوي من الأحماض الأمينية الحرة والبروتين (16.6 ug alanine/gm dry weight & 679.0mg/gm dry weight) علي الترتيب. علي النقيض فإن صنف البيتو86 هو الصنف الأقل إصابة وعنده أقل مستوي من الأحماض الأمينية الحرة والبروتين (4.2 ug alanine/gm dry weight & 41.6mg/gm dry weight)

ووجد أيضا أن الإرتباط بين متوسط أنفاق الحشرة مستوي الأحماض الأمينية والبروتين في الورقة هو إرتباط غير معنوي موجب(0.57 & 0.61) علي التوالي.

3-الفينول الكلي

وجد أن أعلي عدد أنفاق تواجد في صنف الردصن حيث أقل مستوي من الفينول 4626.3 ugGA/gm dry weights ، علي النقيض فإن صنف البيتو86 هو الصنف الأقل إصابة وعنده أعلي مستوي من الفينول 6228.0 ugGA/gm dry weight.

ووجد أيضا أن الإرتباط بين متوسط أنفاق الحشرة ومستوي الفينول في الورقة هو إرتباط غير معنوي سالب(0.77-).

4-الكربوهيدرات الكلي

وجد أن أقل مستوي من الكربوهيدرات 101.3 mg/gm dry weights في صنف البيتو86 الذي هو أقل إصابة ، وعلي العكس فإن صنف الردصن الحساس عنده أعلي مستوي من الكربوهيدرات 125.3mg/gm dry weight.

ووجد أيضا أن الإرتباط بين متوسط أنفاق الحشرة ومستوي الكربوهيدرات في الورقة هو إرتباط غير معنوي سالب(0.02-).

5-انزيمات ألفا وبيتا استيريزس

وجد أن الإرتباط بين متوسط أنفاق الحشرة ومستوي انزيمي ألفا وبيتا استيريز في الورقة هو إرتباط غير معنوي موجب(0.11 & 0.24) علي التوالي.

6-إنزيم البيروكسيديز

وجد أن أعلي مستوي من انزيم البيروكسيديز 61.5ΔO.D.405/min/gm dry weight في صنف الردصن الذي هو

أعلي إصابة ، وعلي العكس فإن صنف البيتو86 المقاوم عنده أقل مستوي من البيروكسيديز13.9ΔO.D.405/ min/ gm dry weight.

ووجد أيضا أن الإرتباط بين متوسط أنفاق الحشرة ومستوي إنزيم البيروكسيديز في الورقة هو إرتباط غير معنوي موجب(0.68).

ب- دراسة تأثير الصفات المورفولوجية لاوراق بعض أصناف محصول الطماطم على درجة الإصابة

تم تصوير أوراق النباتات كل صنف علي حده بالميكروسكوب الإلكتروني الماسح .S.E.M لمعرفة أنواع الشعيرات وعددها وطولها وتأثيرها على الإصابة بالآفة فلوحظ أنه يوجد إرتباط معنوى موجب (0.85) بين كثافة الشعيرات الغير غدية على السطح العلوى للورقة وبين تعداد أنفاق الآفة بينما يوجد أرتباط معنوى سالب (0.6) بين كثافة الشعيرات الغير غدية علي السطح العلوي للورقة وبين تعداد نفق الآفة.

ت-ايجاد علاقة بين الإصابة بالحشرة و درجات الحرارة والرطوبة

عند تحليل النتائج إحصائيا لوحظ أنه يوجد ارتباط معنوى موجب بين درجات الحرارة الصغرى Hybrid Bito 86 وبين نسبة الإصابة فى الموسم الأول 2012 ، بينما يوجد إرتباط معنوى موجب بين الحرارة الصغرى للصنف Castle rockوبين نسبة الإصابة فى الموسم الثانى 2013 ، كذلك يوجد إرتباط معنوى سالب بين الرطوبة النسبية للصنف Riogrande وبين نسبة الإصابة في الموسم الثاني 2013.

ث- دراسة تأثير بعض منظمات النمو النباتية علي بعض الأصناف الحساسة للطماطم وعلاقتها بالإصابة بالآفة

يوجد فروق معنوية بين المعاملات والأصناف وتاريخ الفحص وكذلك التداخل فيما بينهم فكانت معاملة منظم النمو النباتى Benzyle adenine أفضل معاملة حيث أنه يعطى أقل إصابة (2.8 نفق10 /وريقات) مقارنة بالكنترول(7.3نفق10/وريقات)، والصنف الأكثر مقاومة للإصابة بالآفة هو Castle rock حيث يعطي أقل إصابة (3.4 نفق10/وريقات) بينما كان ميعاد الفحص الثالث الأكثر معنوية وأقل إصابة من المعاملة حيث يوجد عنده أقل إصابة (1.5 نفق10 /وريقات) ، ويمكن إستخدام هذه التقنية في مجال المكافحة المتكاملة لهذه الحشرة.

2-رصد النشاط الموسمي للحشرة بإستخدام المصائد الفرمونية

من خلال تسجيل النشاط الموسمي لفراشات صانعة أنفاق أوراق الطماطم بإستخدام المصائد الفرمونية (الجاذبات الجنسية) وجد أن لها 10 أجيال متداخلة علي مدار السنة

أ- وعند تسجيل العوامل الجوية المقابلة للتعداد الأسبوعي للآفة (المنحني الناقوسي) وإيجاد العلاقة بين تعداد الآفة والعوامل الجوية (الحرارة العظمي والصغري والرطوبة النسبية) وجد أن للحشرة 10 أجيال متداخلة علي مدار العام وأخطر هذه الأجيال هم جيل إبريل (250 فراشة/أسبوع) ، جيل مايو (300 فراشة/أسبوع) ، جيل يونيو (200 فراشة/أسبوع) وأخيرا جيل يوليو(250 فراشة/أسبوع) وخلال هذه الفترة لابد من تكثيف عمليلت المكافحة المتكاملة للحد من هذه الأعداد أما بقية الأجيال الستة الأخري فيجب إيقاف عمليات المكافحة الكيماوية والإستمرار في عمليات المكافحة الأخري حتي يحد من عمليات التلوث – ومن إهدار العملة الصعبة – تنشيط الأعداء الحيوية.

ب-كذلك أيضا تم حساب عدد الأجيال بطريقة Jacop (الطريقة الخطية) وكان أيضا عدد الأجيال عشرة أجيال وكانت متطابقة مع المنحني الناقوسي.

بإجراء التحليل الإحصائي بإستخدام الإرتباط المتعدد لإيجاد العلاقة بين تعداد الحشرة ودرجات الحرارة العظمي والصغري والرطوبة النسبية وجد أن هناك علاقة موجبة علي مستوي 5% بين تعداد الفراشات ودرجة الحرارة الصغري وعلي النقيض كان العلاقة سالبة ومعنوية علي مستوي 0.0006 بين درجة الحرارة العظمي وتعداد الفراشات. أما بالنسبة للرطوبة النسبية فكانت العلاقة غير معنوية وهذا يؤكد أن

الحشرة تتعارض أحتياجاتها الحرارية مع الحرارة المرتفعة وخصوصا في شهور يوليو وأغسطس حيث تصل الحرارة إلي أقصي معدل لها.

ت-علي الجانب الآخر تم حساب عدد الأجيال بإستخدام الوحدات الحرارية اللازمة لإتمام الجيل الواحد وعليه تم التنبؤ بعدد الأجيال علي مدار السنة وكان عددها 14جيل.

لكن نلاحظ أن الحشرة لم يكن لها تواجد يذكر من خلال مصائد الفرمونات في الفترة من آخر يوليو وحتي أوائل أكتوبر حيث ترتفع الحرارة خلال هذه الفترة إلي أعلي معدل لها ويفسر ذلك بأن الحشرة تدخل فترة بيات صيفي ويؤكد ذلك أن الحرارة المرتفعة 32°م أدت إلي موت اليرقات عمر أول وهذا يفسر التناقض بين عدد الأجيال(10أجيال بواسطة المصائد و14 جيل حسابيا علي أساس درجات الحرارة المتراكمة). وعليه يمكن عدم إجراء المكافحة الكيماوية خلال فترة البيات الصيفي والإكتفاء بالأعداء الحيوية فهي كفيلة بالقضاء علي الأعداء الضئيلة للحشرة.

3-حصر الطفيليات والمفترسات الحشرية المصاحبة للحشرة في الحقل

سجلت ثلاث أجناس وأربع أنواع من طفيليات رتبة الحشرات غشائية الأجنحة: نوع من *Diglyphus* sp. (فصيلة إيولوفيدى) ، نوعين من *Elasmus* spp. (فصيلة إلاسميدى) ، نوع من *Telenomus* sp. (فصيلة إسكليونيدى) تمثل التسجيل الأول فى مصر. تم أيضا تسجيل المفترس *Nesidiocoris tenuis* (رتبة الحشرات غير متجانسة الأجنحة : فصيلة ميريدي) .

دراسة النشاط الموسمي للحشرة مع المفترس *Nesidiocoris tenuisi*

أظهرت حافرة أوراق الطماطم قمتين خلال فترة التجربة(إبريل-يونيو) 30.3 ، 25.0 نفق 10/وريقات فى يومى 7 ، 28 مايوعام 2013 على التوالى. سجلت أيضا البقة المفترسة قمتين 58.8 ، 73.3 حورية وحشرة كاملة / نبات في نفس التاريخين السابقين علي التوالي.

وكذلك يوجد إرتباط معنوى موجب على مستوى معنوية 5% (0.89) بين تعداد نفق الآفة وبين تعداد المفترس *Nesidiocoris tenuis* وكان معامل الإنحدار 0.26 حورية أو حشرة كاملة للمفترس.

تربية وإكثار أحد المفترسات في المعمل وتقدير الكفاءة الإفتراسية له

تم تربية البقة المفترسة *N. tenuis* بأعداد كبيرة لتقييم الكفاءة الإفتراسية للحورية والحشرة الكاملة (الذكر والأنثى) على بيض حافرة أوراق الطماطم. إستهلكت الحورية والذكر والأنثى 113.3 ، 81.5 ، 125.3 بيضة من الآفة على التوالى. إلتهمت حورية العمر الرابع أعلى عدد(30.6 بيضة) بينما إستهلكت حورية العمر الأول أقل عدد (7.0 بيضات) ، ويعتبر بقة مفترس *N. tenuis* ناجح فى مجال المكافحة الحيوية ويمكن الإعتماد عليها مع بقية أنواع الطفيليات الأخرى وخصوصا فى الأجيال الستة السابق ذكرها فى الفترة من أكتوبر وحتى مارس من العام الذى يليه حيث تكون قليلة إلى متوسطة ويمكن التحكم فيها بدون الرجوع إلى المركبات الكيميائية للحصول علي بيئة نظيفة وللحد من أزمة الدولار وللحفاظ علي صحة الإنسان.

إتجاهات بيئية وبيولوجية لصانعة أنفاق أوراق الطماطم علي نباتات الطماطم

رسالة مقدمة من

إيمان محمد محمد عبدالمقصود

بكالوريوس علوم زراعية (حشرات)، جامعة عين شمس، 2010

للحصول على

درجـــــة الماجستير في العلـــــوم الزراعيـــــة

(حشرات إقتصادية)

قسم وقاية النبات

كلية الزراعة

جامعة عين شمس

2016

صفحة الموافقة على الرسالة

إتجاهات بيئية وبيولوجية لصانعة أنفاق أوراق الطماطم علي نباتات الطماطم

رسالة مقدمة من

إيمان محمد محمد عبدالمقصود

بكالوريوس علوم زراعية (حشرات)، جامعة عين شمس، 2010

للحصول على

درجـــــة الماجستير في العلـــــوم الزراعيـــــة

(حشرات إقتصادية)

وقد تمت مناقشة الرسالة والموافقة عليها

اللجـــــــــــــــنة:

د. محمد عبدالغفار محمود ....

أستاذ الحشرات الإقتصادية المتفرغ، كلية الزراعة ، جامعة الأزهر

د. أحمد أحمد عبدالرحمن سالم ....

أستاذ الحشرات الإقتصاديةالمتفرغ ، كلية الزراعة ، جامعة عين شمس

د. شكري أحمد السيد الرفاعي ....

أستاذ الحشرات الإقتصادية المتفرغ ، كلية الزراعة ، جامعة عين شمس

تاريخ المناقشة: 7 / 9 /2016

جامعة عين شمس

كلـــيـــة الزراعـــــة

رسالة ماجستير

اســـم الطـــالبة: إيمان محمد محمد عبدالمقصود

عنوان الرسالة: إتجاهات بيئية وبيولوجية لصانعة أنفاق أوراق الطماطم علي نباتات الطماطم

اسم الدرجـــة: ماجستير في العلوم الزراعية (حشرات اقتصادية)

لجنة الإشراف:

د. شكري أحمد السيد الرفاعي

أستاذ الحشرات الإقتصادية المتفرغ ، قسم وقاية النبات ، كلية الزراعة ، جامعة عين شمس (المشرف الرئيسي)

د. أشرف حلمي فتحي

أستاذ الحشرات الإقتصادية المساعد، قسم وقاية النبات، كلية الزراعة، جامعة عين شمس

تاريخ التسجيل: 2011/10/17

الدراسات العلـــيـــــا

ختم الإجازة

أجيزت الرسالة بتاريخ

2016 / 9 / 7

موافقة مجلس الكلية

2016 / /

موافقة مجلس الجامعة

2016 / /