Full Length Research Paper

Determination of the economic threshold level of tomato leaf miner, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on tomato plant under glasshouse conditions

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Tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera:Gelechiidae) is an important pest of tomato crops native to South America. It is considered to be one of the major pests of tomato crop in Ethiopia since 2012. The aim of this study was to determine the economic threshold level of *T. absoluta* under glasshouse conditions. The damage potential and economic threshold level for *T. absoluta* larvae on tomato crop were studied during 2015 to 2016 under glasshouse conditions. Significant (P < 0.05) differences were observed among the treatments during the study period. The number of larvae per plant reduced the yield to the extent of 10.51 to 75.62% during 2015, and 11.87 to 80.22% during 2016 cropping season. The mean values of marketable yield gained to the cost of insecticide application at 0, 1 and 4 larvae per plant were 34,913, 31,006 and 16,574.5 kg/ha from 2015 to 2016, respectively. The lowest yield was observed at control/unsprayed treatment (7,751.5 kg/ha). The economic injury level (EIL) lies at the pest population density where Benefit-Cost ratio would be 1.08. From this study, the EIL of *T. absoluta* was determined as 3.0 larvae per plant based on the findings of glasshouse experiments conducted over the period of two years. The economic threshold level (ETL) was worked out at 2.25 larvae per plant during the same years under glasshouse conditions.

Key words: Economic, infestation, injury, larva, management, threshold, tomato, *Tuta absoluta*, yield.

INTRODUCTION

Tomatoes are produced by small and medium scale farmers for fresh consumption, and as a source of income (Bawin et al., 2014; Retta and Berhe, 2015). Tomato for consumption as fresh vegetable is produced under open fields and greenhouse conditions. It can be eaten either fresh or processed into different products. It is a vegetable crop of large importance throughout the world (Abdussamee et al., 2014; Mehraj et al., 2014; Kaur and Rishi, 2014). It is an important source of nutrients (vitamins A, B, C and E), and constitutes an important part of household diet and national economy (Baloch, 1994; Bhowmik et al., 2012; Kaur and Rishi,

2014). Tomato (*Lycopersicon esculentum* Miller) production is threatened by multiple insect pests. Among these pests, tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera:Gelechiidae) is a dangerous pest of tomato crops native to South America (Filho et al., 2000). *T. absoluta* has a wide geographical distribution throughout the world, attacking a wide range of host plants (Desneux et al., 2010). It is considered as the most severe pest against the tomato plant in Mediterranean Basin, and also in Africa, where it has become much more abundant over recent years particularly in Ethiopia (Gashawbeza and Abiy, 2013). Larvae of this pest feed mainly on leaves and fruits of tomato. Economic injury level and economic threshold level (ETL) of *T. absoluta* depend on the population size and infestation level. However, the decision making management action of this devastating insect pest is not known in Ethiopia until now.

There are two basic items of the management decision; the economic injury level and economic threshold level (Stern et al., 1959; Pedigo et al., 1986). Integrated Pest Management (IPM) poses some of other considerations for the estimation of economic injury level (EIL). It involves substitution of information for pesticide application, recognizing costs of pest control beyond the direct chemical and application costs, and consideration of management options to reduce the necessity for chemical treatment. The challenge is to incorporate more host and pest dynamics into the economic injury level, which can help to verify the pest management decisions and to recognize more efficient economic thresholds.

To manage *T. absoluta* larvae, pest management programmes employ intensive curative and/or preventive treatments that are economically unjustified. However, to control *T. absoluta* a number of chemical treatments are applied arbitrarily during the infestation of this insect pest with no regard to economic benefit. The applications of economic injury and economic threshold level analysis for the calculation of cost/benefit (C/B) ratios in order to control *T. absoluta*, demonstrate the definition of the EIL advanced by Pedigo and Higley (1992) to estimate the cost-benefit ratios.

This study was initiated to quantify the marketable yield loss from larval feeding of the tomato plants, and to estimate the EIL in order to determine economic threshold level per plant, when and how many times control measures against this devastating insect pest are justified economically. Hence, the objective of this study was to determine the economic threshold and economic injury level of *T. absoluta* under glasshouse conditions.

MATERIALS AND METHODS

The experiment was conducted at Ambo University experimental glasshouse in dry seasons during 2015 to 2016. The experiment was laid out in randomized complete block design (RCBD) with three replications. There were seven treatments consisting of six different larval densities, that is, 0, 1, 2, 3, 4, 5 and control per plant. Tomato seedlings were planted into plastic pots maintaining

80 cm row to row distance of plants. Eggs were introduced into each treatment to know the status of larval densities. The numbers of larvae established in each treatment are sprayed with standard chemical (Coragen, 200 SC) of 200 ml/ha according to larval densities of *T. absoluta*. The number of total damaged leaves and fruits was counted, and fruit yields were weighed for each treatment. Relationship between the larval densities and the number of leaf and fruit damaged was worked out by correlation co-efficient and regression equations. Yield losses, due to different treatments, were calculated by deducting the yield of the respective treatment from the yield of control (where no egg and larva protected treatment). The value of yield losses was determined according to the wholesale market price of tomato at current market situations. Benefit cost ratio (BCR) was considered as the ratio of the yield value saved to the cost of insecticidal application. Standard chemical was considered for calculating the cost of insecticidal application. The ETL was determined based on the benefit cost ratio, as suggested by Farrington (1977).

Data collection

The periodical counts of damaged leaves and fruits were taken from each pot, where the leaves and fruits have been checked for larvae. However, when the sprayable level was attained, the pots were sprayed one day later with the appropriate insecticides, according to the pest situation.

Data analysis

The obtained data were analyzed using the statistical software package (SAS, 2009) for analysis of variance of the experiment. The economic threshold level for leaf miner larvae was calculated by fitting regression equation $Y = a + bx$, between larval population levels and Benefit Cost Ratio. The larval density corresponding to unit benefit cost ratio was the economic injury level, and economic threshold levels were set at 75% of EIL (Pedigo, 1991). Benefit-cost ratio was calculated using the following formula**:**

$$BCR = \frac{\text{Value of yield loss saved}}{\text{Total Cost}} \times 100$$

Actuality, the EIL value can be complicated to calculate the exact number because of the dynamic nature of pest infestation level, damage system and crop value. However, the economic injury level (EIL) is often expressed mathematically by the following formula:

$$EIL = \frac{C \times N}{V \times I}$$

Where: "C" is the unit cost of controlling the pest (Birr/plant); "N" is the number of pests injuring the commodity unit (number of pest/plant); "V" is the unit value of the commodity (Birr/plant) and "I" is the percentage of the commodity unit injured (% loss)/plant

RESULTS AND DISCUSSION

Infestation of tomato plant

In 2015 and 2016, differences among the various treatments were found significant ($P < 0.05$) on effect of leaf infestation and fruit yield damaged. Total number of damaged leaves per plant ranged from 0 to 87.33 leaves, during 2015, and 0 to 94.0 leaves during 2016. The

Table 1. Infestation level of *T. absoluta* on tomato plants and marketable yield per plant in kg during 2015 to 2016 under glasshouse conditions.

Larval density	2015			2016		
	No. of infested leaves /plant	No. of tunneled fruit /plant	Marketable yield/plant in (kg)/plant	No. of infested leaves /plant	No. of tunneled fruit /plant	Marketable yield/plant (kg)/plant
T_1	0.0^e	0.0^d	0.92^a	0.0^f	0.0^e	0.93^a
T_2	11.0^d	2.67^c	0.82^a	9.67^e	2.0^{de}	0.83^a
T_3	23.0^c	3.33^c	0.43^b	19.0^d	3.0^{cd}	0.40^b
T_4	29.0^{ab}	4.0^c	0.44^b	26.0^{cd}	5.0^c	0.43^b
T_5	$31.0b^a$	7.33^b	0.40^{bc}	29.33^c	5.67^c	0.38^b
T_6	34.67^b	8.33^b	0.33^{bc}	40.33^b	10.0^b	0.30^{bc}
T_7	87.33^a	11.67^a	0.23^c	94.0^a	15.67^a	0.18^c
LSD	7.32	2.54	0.20	7.74	2.75	0.15
MSE ±	4.08	1.41	0.11	13.80	1.53	0.08
CV (%)	13.21	21.345	21.73	4.30	20.88	16.98

T_1: 0 larva density; T_2:1 larval densities; T_3: 2 larval densities; T_4: 3 larval densities; T_5: 4 larval densities; T_6: 5 larval densities; T_7: Control.

tunneled fruits due to larval damage of *T. absoluta* increased significantly with a rise in the larval density/plant during the two seasons, ranging from 0 to 11.67 during 2015, and 0 to 15.67 during 2016 (Table 1).

Yield and yield losses

Under the glasshouse conditions, the marketable fresh fruit yield/hectare varied between 8.571 and 34.787 kg, during 2015, and between 6.932 and 35.039 kg, during 2016 (Table 2), compared to the larval densities above 5 to 0 per plant, respectively. Result of the marketable fresh fruit yield indicated significant variations among the treatments (Tables 1 and 2).

'T_1' recorded maximum marketable fresh fruit yield/hectare (34.787 kg), followed by 'T_2' (31.132 kg), 'T_3' (25.912.84 kg), and 'T_4' (21.376.61 kg). The minimum fresh fruit yield (8.571 kg) was recorded by 'T_7' during 2015 study period. As obtained by the study during 2016, the maximum

fresh fruit yields were recorded by 'T_1' (35.039 kg), followed by "T_2" (30.880 kg)/ hectare, the minimum marketable fresh fruit yields was also recorded by 'T_7' (6.932 kg), followed by 'T_6' (11,218 kg) which may be attributed to the maximum net profit/hectare (Table 2).

A density of one larva/plant 10.51% marketable yield loss was recorded during 2015, which represents 3.655kg minimum yield loss/hectare and maximum yield loss 26.307 kg which represents 75.62% yield loss was recorded. In 2016, a density of one larva/plant indicated 11.87% marketable yield loss, that represents 4,159.0 kg minimum yield reduction/hectare, and maximum yield reduction was observed (28,107.0 kg/ha) which showed 80.22% yield losses.

The data on *T. absoluta* infestation at different larval densities and fruit yield loss showed significant (P < 0.05) positive correlation in both years. The linear regression co-efficient 'b' value during 2015 was highly significant with higher r^2 value (0.965) showing more pronounced effect of *T. absoluta* infestation on yield. The highest value

of $r^2 = 0.965$ indicated 96.5% variation in yield due to *T. absoluta* infestation. Similarly during 2016 also, the linear regression co-efficient 'b' value was highly significant with high value of r^2 (0.873) which explained 87.3% variation in total yield (Figures 1 and 2).

A positive correlation was found between number of leaf infestation and marketable yield loss (r^2 =0.720), and (r^2 =0.637) during 2015 and 2016, respectively. However, increase in the larval population/plant did show parallel increase in the marketable yield loses (Figure 1). The relationship between *T. absoluta* number of leaf infestation and marketable yield loss % was expressed by the regression equation Y= 0.854x + 15.12 and Y= 0.771x + 22.96 for years 2015 and 2016, respectively. A density of two larvae per plant caused about 6.33% leaf damage during 2015 which indicated 10.51% yield losses. In 2016, 5.83% leaf damage was observed which showed 11.87% yield losses (Table 2). The control (unsprayed) treatments caused 56.97% leaf damage during 2015, and 59.44% during 2016.

Table 2. Marketable yield in kg/hectare during 2015-2016 under glasshouse conditions.

Larval density	Year I (2015)				Year II (2016)			
	Marketable yield (kg)	Marketable yield loses			Marketable yield (kg)	Marketable yield losses		
		kg/ha	Percentage (%)	U.S ($/ha)		Kg/ha	Percentage (%)	U.S. ($/ha)
T_1	34.787[a]	-	-	-	35.039.00[a]	-	-	-
T_2	31.132[ab]	3.655.0	10.51	1.589.13	30.880.00[a]	4.159.0	11.87	1.808.26
T_3	25.912.84[b]	8.874.16	25.51	3472.50	26.902.94[b]	8.136.06	23.22	3183.67
T_4	21.376.61[bc]	13.410.39	38.55	5.247.54	22.260.28[b]	12.778.7	36.47	5.0 00.36
T_5	14.999[d]	19.788.0	56.88	8.603.48	14.243.00[c]	20.796.0	59.35	9.041.74
T_6	12.478[d]	22.309.0	64.13	9.699.57	11.218.00[c]	23.821.0	67.98	10.356.96
T_7	8.571[d]	26.307.0	75.62	11.437.83	6.932.00[cd]	28.107.0	80.22	12.220.44
LSD	8362.60	-	-	-	5663.70	-	-	-
MSE ±	5209.83	-	-	-	3151.56	-	-	-
CV (%)	25.63	-	-	-	16.98	-	-	-

T_1: 0 larva density, T_2:1 larval densities, T_3: 2 larval densities, T_4: 3 larval densities, T_5: 4 larval densities, T_6: 5 larval densities, T_7: Control.   Cost of insecticides 365.22 U.S.$/liter; Average price of tomato 0.35 U.S.$/kg; Labor charge 3.04 U.S.$/day; 1.00 U.S $=23.00 Eth. Birr.
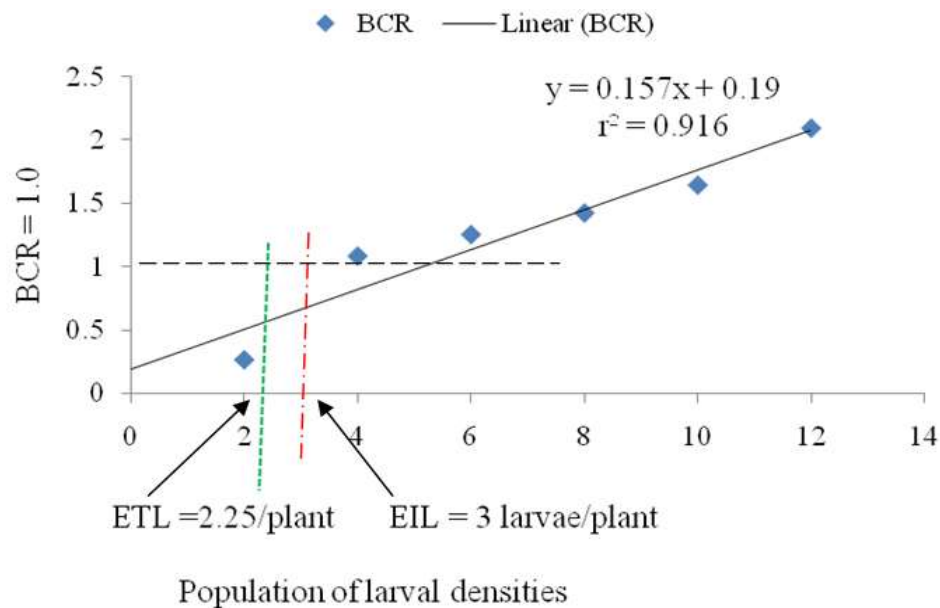

Figure 1. Relationship between larval densities and BCR during 2015-2016 under glasshouse conditions. X = Larval density per plant and y = BCR.
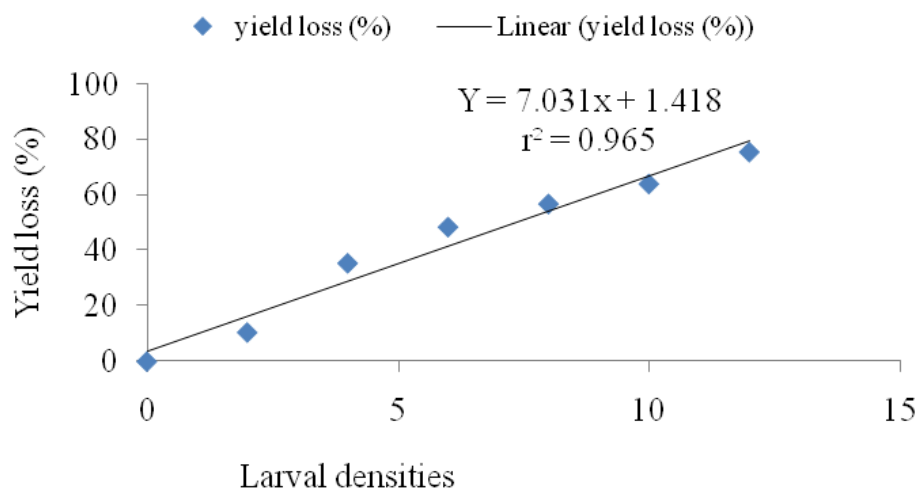
Figure 2. Relationship between larval densities of *T. absoluta*/plant and yield loss in percentcorrelation coefficient during 2015 under glasshouse conditions.

Table 3. Economic analysis of *T. absoluta* on management of tomato crop during 2015-2016 under glasshouse conditions.

Treatment	Mean yield loss				Cost of production (Birr/ha)						
	Marketable yield (kg/ha)	(kg/ha)	Percentage (%)	Value of Yield loss (U.S.$/ha)	Mean Cost of insecticide U.S.$/ha	Mean Labor charges U.S.$/ha	Other production cost (E.g. Fertilizer, cost of planting pot, cost of marketing and distribution) (U.S.$/ha)	Total cost U.S.$/ha	Total income U.S.$/ha	Net in come U.S.$/ha	CBR
T$_1$	34.913.0	-	-	-	1.552.17	2.482.83	3.166.96	7.201.96	13.661.61	6.459.65	-
T$_2$	31.006.0	3.907.0	11.19	1.698.670	1.004.35	2.482.83	3.166.96	6.654.13	12.132.78	5.478.65	1.82
T$_3$	18.843.0	8.505.03	24.37	3.328.09	821.74	2.482.83	3.166.96	6.471.52	7.373.35	901.83	1.14
T$_4$	17.141.5	13.094.55	37.51	5.123.95	547.83	2.482.83	2.881.74	5.912.40	5.962.26	49.86	1.00
T$_5$	14.621.0	20.292.0	58.12	8.822.61	547.83	2.482.83	2.881.74	5.912.40	5.721.26	-191.14	0.97
T$_6$	11.848.0	23.065.0	66.04	10.028.26	456.52	2.482.83	2.553.35	5.492.70	4.636.17	-856.53	0.84
T$_7$	7.751.5	27.161.5	77.80	11.809.35	0.0	2.482.83	1.814.35	4.297.18	3.033.20	-1263.98	0.71

Cost of insecticides 365.22 U.S.$/liter; Average price of tomato 0.35 U.S.$/kg; Labor charge 3.04 U.S.$/day; 1.00 U.S $=23.00 Eth. Birr.

The control treatments in both years revealed 75.62 and 80.22% yield losses during 2015 and 2016, respectively (Table 3).
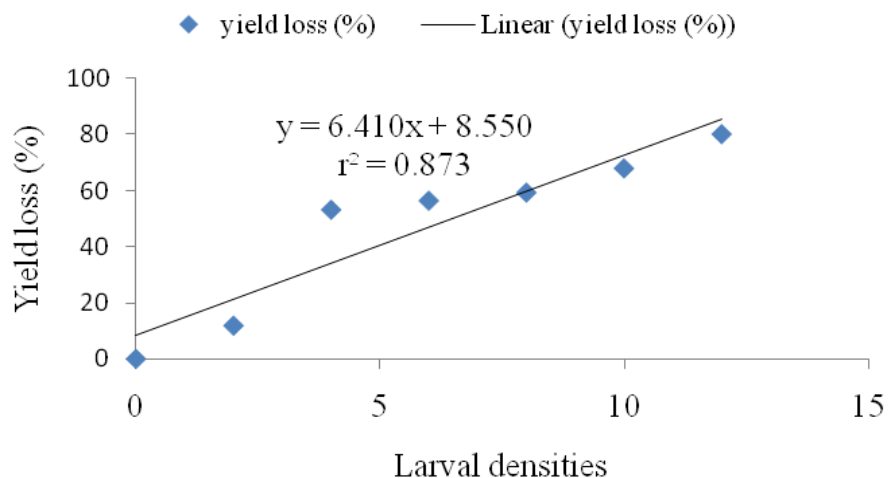
Figure 3. Relationship between larval densities of *T. absoluta*/plant and yield loss (%) correlation coefficient during 2016 under glasshouse condition.

Benefit-cost ratio, economic injury level and economic threshold

The cost of *T. absoluta* control (cost index in EIL formula) was estimated by adding the cost of insecticide per plant, number of pest/plant, total cost of plant production and yield loss percent/plant. The ratio of the value of yield saved to the cost of insecticide application at three larvae per plant was 1.08 during 2015 to 2016.

EIL lies at the pest population density where BCR would be 1.08. In order to calculate the exact larval density at which BCR would be 2.25 larvae, the correlation of larval density (X) with the BCR (Y) was calculated. There was a strong positive correlation and linear relationship between those two variables (Figure 1). The regression equations derived were y= 0.157x + 0.19 during 2015 to 2016.

The study results were consistent with those results of Pedigo and Higley (1992) who reported that to recapitulate the primary variables to define the EIL is not a discrete pest density, but its variable depends on the control costs, the value of the production protected, production losses per pest, and the efficacy of the control. It should be noted that the estimate of damage caused by pests rather than pest density is very important for tomato leaf miner, *T. absoluta*.

From the aforementioned equations, the EILs of *T. absoluta* larvae were determined as three larvae during 2015 to 2016 (Figure 1). On the basis of means of two years, the EIL value was 3 larvae per plant under glasshouse. Therefore, the economic threshold level was determined as 2.25 larvae per plant.

Yield loss-larval population relationship

Data of the larval density and yield loss % were summarized in Table 1, and illustrated in Figures 1, 2 and 3, for each year of the experiment. Each of the larval density and yield loss % was in a strong positive correlation, and linear relationship between those two variables was shown.

The regression equations derived were y=7.013x + 1.418 during 2015/16, and under glasshouse conditions during 2015 and y = 6.410x + 8.550 during 2016. The values of the parameters for calculation of yield loss and EIL over the two years of the experiment are presented in Figures 2 and 3. Number of larvae indicates that initiated control prevented pests from causing economic injury while number of larval population rate above the limit indicates that the economic threshold was inadequate to prevent an increasing infestation from causing economic damage.

The economic threshold is the population level where insect control should be initiated to avoid exceeding the economic injury level. The EIL is the most persistent and influential element in pest management. Indeed, EIL and ETL continue to function as the primary mechanisms for making pest management decision (Sarmahl et al., 2011). Many authors (Stern et al., 1959; Stone and Pedigo, 1972; Smith and Vanden Bosch, 1967; Ram and Patil, 1986) highlighted the importance of EIL and ETL in pest management for different crop plants.

Yield-leaf infestation relationship

The data of *T. absoluta* infestation at different exposure periods and marketable fruit yield losses showed significant positive correlation (p < 0.05) in both years. The linear regression co-efficient 'b' value during 2015 was significant with higher r^2 value showing more pronounced effect of *T. absoluta* infestation on the yield. The highest value of r^2 (0.720) indicated 72% variation in
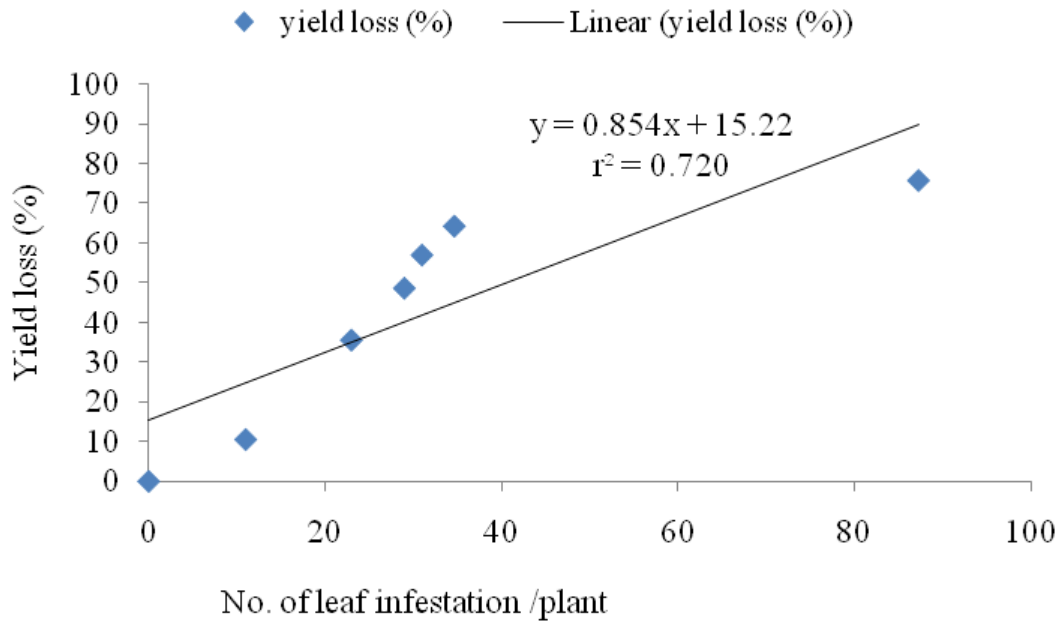
Figure 4. Relationship between the number of leaf infestation/plant and yield loss (%) correlation coefficient under the glasshouse conditions during 2015.
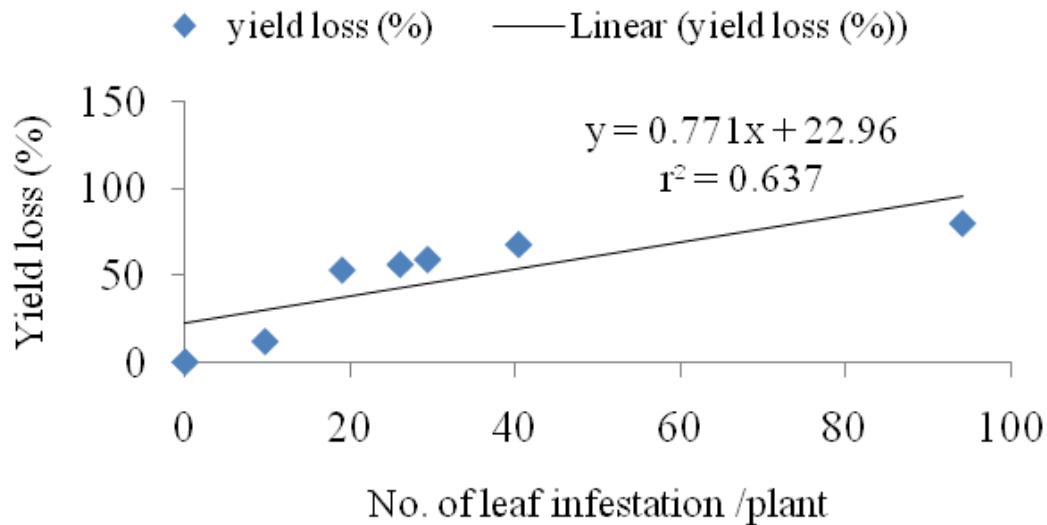

Figure 5. Relationship between no.of leaf infestation/plant and yield lss (%) correlation coefficient under the glasshouse conditions during 2016.

yield due to *T. absolut* infestation. Similarly during 2016, the linear regression co-efficient 'b' value was significant with high value of r^2 (0.637) which explained 63.7% variation in total yield (Figures 4 and 5). The relationship between *T. absoluta* infestation and marketable yield loss was expressed by the regression equation Y = 0.854x + 15.22, and Y= 0.771x + 22.96 for years 2015 and 2016, respectively.

Frequency of application

The frequency of application was made sixteen times within 5 day-intervals at the recommended application rates during 2015, and eighteen times within 5 day-intervals in 2016 for protected (insect free) treatment. On the other hand, the insecticide application times ranged from 4 to 12 times during both years in other treatments

Table 4. Frequency of insecticide application on management of *T. absoluta* on tomato crop under glasshouse during 2015-2016.

Larval density	Frequency of application	
	(2015)	(2016)
T_1	16	18
T_2	10	12
T_3	8**	10**
T_4	5*	7*
T_5	5	7
T_6	4	6
T_7	0	0

** indicate ETL, while * indicate EIL.

(Table 4). The management option of *T. absoluta* by insecticide was made when the economic threshold level was determined 8 to 10 times' application per season during 2015 to 2016.

CONCLUSION AND RECOMMENDATION

This study shows that the determination of economic injury level and economic threshold level tool for timely control of *T. absoluta* under glasshouse conditions in Ethiopia is better than the most common current practice of insecticide applications. For Tomato growers under favorable climatic conditions, *T. absoluta* infestations 2.25 larvae/plant do not affect tomato yield under glasshouse conditions. Results of the present study revealed that the control measures should be initiated when the *T. absoluta* larval population reaches 2.25 larvae per plant in glasshouse in order to prevent the population from reaching economic injury levels. The frequency of application time also depends on infestation level of *T. absoluta*. Finally, both entomologists and economists have the same working definitions for economic injury and economic threshold levels for insect pests. Further, both disciplines are struggling together to find ways to account for the costs and benefits ratio of *T. absoluta* management strategies under open fields.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Abdussamee H, Hussain M, Ali M, Siddique MS, Jato SU, Shahbaz K, Talib Sahi ST, Hannan A (2014). Genetic response of tomato germplasm against early blight and its management through fungicides, Appl. Sci. Rep. 2(3):119-127.

Baloch FA (1994). Vegetable crops. In: Horticulture National Book Foundation, Islamabad. P 508

Bawin T, De Backer L, Dujeu D (2014). Infestation level influences oviposition site selection in the tomato leafminer *Tuta absoluta* (Lepidoptera: Gelechiidae). Insects 5(4):877-884.

Bhowmik D, Sampath KP, Kumar KP, Paswan S, Srivastava S (2012). Tomato A Natural Medicine and Its Health Benefits. J. Pharmacogn. Phytochem. 1(1):33-43.

Desneux N, Wajnberg E, Kris A, Wyckhuys G, Burgio G, Arpaia S, Consuelo AN, Gonza´lez-Cabrera J, Ruescas DC, Tabone E, Frandon J, Pizzol J, Poncet C, Cabello T, Urbaneja A (2010). Biological invasion of European tomato crops by Tuta absoluta: ecology, geographic expansion and prospects for biological control. Pest Sci. 83:197-215.

Filho MM, Vailela EF, Attygalle AB, Meinwald J, Savatos A, Jham G (2000). Field trapping of tomato moth, *Tuta absoluta* with pheromone traps. J. Chem. Ecol. 26(4):875-881.

Gashawbeza A, Abiy F (2013). Occurrence of a new leaf mining and fruit boring moth of tomato, *Tuta absoluta* (Meyric) (Lepidoptera: Gelechiidae) in Ethiopia. Pest Manage. J. Ethiop. 16:57-61.

Farrington J (1977). Economic threshold of insect pest population in present agriculture: A question of applicability *Pest* Articles and News Summaries 23(2):143-148.

Kaur H, Rishi P (2014). Nematicidal effect of neem and Bt on *Meloidogyne incognita* Infesting tomato plant by seed dressing treatment. Discov. Agric. 2(6):28-40.

Mehraj H, Mutahera S, Roni MZK. Nahiyan ASM, Jamal Uddin AFM (2014). Performance Assessment of Twenty Tomato Cultivar for Summer Cultivation in Bangladesh. J. Sci. Technol. Environ. Inform. 1(1):45-53.

Pedigo LP, Higley LG (1992). The economic injury level concept and environmental quality a new perspective. Am. Entomol. 38(1):12-21.

Pedigo LP (1991). Entomology and Pest Management, Macmillan Publishing Company, New York. pp. 107 119.

Pedigo LP, Hutchins SH, Higley LG (1986). Economic Injury Levels in theory and practice. Ann. Rev. Entomol. 31:341-368.

Ram S, Patil BD (1986). Economic injury level of major defoliator insect pests of fodder cowpea, *Vigna unguiculata* (L) Walp. 1. Ent. Res.10(2):199-202.

Retta AN, Berhe DH (2015). Tomato leaf miner, *Tuta absoluta* (Meyrick), a devastating pest of tomatoes in the highlands of Northern Ethiopia: A call for attention and action. Res. J. Agric. Environ. Manag. 4(6):264-269.

Sarmahl M, Phukan AK, Rahman A, Borthakur M (2011). Yield loss-infestation relationship and determination of economic injury level of tea mosquito bug. Two and a Bud 58:62-64.

Statistical Analysis System (SAS) (2009). Statistical Analysis System Software. Ver. 9.1. SAS Institute Inc., Carry. NC.

Smith RF, Van den Bosch R (1967). Integrated control. *In* Pest Control, Biological, Physical and selected Methods. (Kilqore, w.w. and Doutt, R.L., eds.). Academic Press, New York. P. 477.

Stern V, NiL RF, Smith R, Vanden B, Hagen KS (1959). The integrated control concept. *Htlgarda* 29(2):81-101.

Stone JD, Pedigo LP (1972). Development and economic injury level of green clover worm on soyabean in Iowa. 1 2 3. J. Econ. Entomol. 65(1):197-202.