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Tadele Shiberu
Department of Zoological Sciences, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Emana Getu
Department of Zoological Sciences, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Correspondence
Tadele Shiberu
Department of Zoological Sciences, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Estimate of yield losses due to *T. absoluta* Meyrick (Lepidoptera: Gelechiidae) on tomato crops under glasshouse and field conditions in Western Shewa of Central Ethiopia

Tadele Shiberu and Emana Getu

Abstract
Tomato leaf miner, *Tuta absoluta* (Meyrick) became one of the most devastating insect pests for tomato in the greenhouse, glasshouse and field productions. The larvae damages to the above ground parts of the plant especially leaf and fruits from seedling stage to maturity. The studies were conducted in the glasshouse and farmers fields in three different districts in Western Shawa of Central Ethiopia under irrigation conditions. The yield loss due to *T. absoluta* was found 87.50-100% was observed under glasshouse condition from November 2015 to June 2016 in two consecutive seasons. Crop loss assessment at different locations revealed that there was significant reduction in yield when compared with untreated control. The yield loss due to *T. absoluta* was in the range of 60.08% to 82.31% in West Shewa of Central Ethiopia under farmer's field conditions. However, several times application of Chlorantraniliprole (Coragen 200 SC) controlled the *T. absoluta* and contributed to increased marketable yield on protected farmer's fields.

Keywords: Tomato, *Tuta absoluta*, glasshouse, farmer's filed, marketable yield and yield loss

1. Introduction
Tomato, *Lycopersicon esculentum* (Mill) is a vegetable crop of large importance throughout the world [1, 11, 10]. It is an important source of nutrients such as vitamins A, C, E and constitutes an important part of the house hold diet and national economy [3, 10].
The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is the most important constraint to tomato production in Ethiopia and quickly became one of the key insect pests of tomato since 2012 [9]. This crop plays a vital role in farming production in the greenhouse, glasshouse and open fields. Small-scale farmers have grown tomato for a long time for their livelihood needs since the start of its commercialization. Yet, average yield of tomato in Ethiopia is low, ranging from 6.5-24.0 Mg ha-compared with average yields of 51, 41, 36 and 34 Mg ha^{-1} in America, Europe, Asia and the entire world, respectively [7]. Among of these challenges tomato plants can be attacked at any developmental stage, from seedlings to mature stage by *T. absoluta*.
The rapid spread throughout the country, mainly related to the marketing of tomato berries and nursery plants, which allowed the insect to colonize all the areas involved in the production of the tomato crop. It causes significant economic loss to tomato cropping in many countries in South America [17]. This pest has become one of the most severe pests of Solanaceae with estimated, crop losses of up to 100% in South America [8, 14]. The yield loss study due to *T. absoluta* on tomato production in Ethiopia yet not studied. Therefore, the studies were carried out to explain the yield losses due to *T. absoluta* in tomato production under West Shawa of central Ethiopia.

2. Materials and methods
2.1 Under glasshouse
The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. In glasshouse sixteen pots were prepared and filled with compost, loam soil and sand soil in the ratio of 1:1:2, respectively. A Pot having a height of 25cm and a diameter of 20cm was used. Eight pots were protected from any insect infestation put in four different cages and eight pots were open for insect infestation (unprotected) treatment. Purposefully the

Door and windows of the glasshouse was kept open for 24 hours for the entrance of moths. Unprotected treatment was kept for *T. absoluta* infestation.

2.2 On field Conditions

Tomato fruit yield loss assessment study due to tomato leaf miner, *T. absoluta* was carried out on farmers field for the year 2015 to 2017 during the dry seasons in three location at Western Shawa of Central Ethiopia. *T. absoluta* control was done using fortnightly foliar application of a recommended insecticide using a knapsack sprayer. The plots were separated by a 3m buffer zone of bare ground. Whenever insects were observed to make the plot free of insect infestation as much as possible. Treated tomato plants were sprayed with insecticides every five days with Chlorantraniliprole (Coragen 200 SC) at 200ml/hectare. Since it is not possible to completely protect and obtain insect free check plots in the experiment, percent yield losses were calculated based on the estimated yield for insect free.

2.3 *Yield Assessment*

Yield data in treated and untreated plots in the tomato harvest seasons (2015 to 2017), under glasshouse and field conditions represented by weight in ton per hectare was estimated. Yield loss was estimated according to the following formula:

$$Yield\ loss\ (\%) = \frac{Potential\ yield - Actual\ yield}{Potential\ yield} \times 100$$

Potential yield is protected treatment was considered the standard for comparison with the other ones unprotected from *T. absoluta* (Actual yield).

2.4 Data recorded

Number of leaf infested, marketable and non-marketable fruits, bored/tunneled fruits were recorded during maturity stage before harvesting and finally yield data were weighed.

2.5 Data analysis

The data were analysed using SAS software version 9.1 [16] analysis of variance (ANOVA) table to compare treatment effect.

3. Results

3.1 Under glasshouse conditions

Results on (Table 1) showed that highly significant (P<0.01) different was observed between protected and unprotected treatments. The infestation number on protected leaves (2.25/plant) was very low as compared with unprotected leaves (43.75/plant) during November, 2015 to February 2016. Similarly, fruit bored per plant under protected treatment completely free while on unprotected treatment it was recorded (11.5/plant). Highly significant (P < 0.01) difference was observed between protected and unprotected treatments concerning to marketable yield per plant. It was recorded 86.95 and 108.5 gm/plant in unprotected and protected treatments, respectively. Weight of single fruit of unprotected treatment due to *T. absoluta* was considerably less as compared to the protected treatment. The result has also shown that the number of infested leaves is lowest in the treatment sprayed with Coragen 200 SC. The protected treatment sprayed with Coragen 200 SC has the highest fruit marketable weight (867.95gm/plant) as shown in the table below.

Table 1: Impact of tomato leafminer, *T. absoluta* on yield and yield components of tomato during November 2015 to Feburary 2016 under glasshouse condition.

Treatments	No. of Infested leaf/plant	No. of tunneled fruit/plant	Average single fruit weight in gm	Marketable fruit wt/plant in gm	Total fruit yield/plant in gm
Protected	2.25[b]	0.00[b]	57.32[a]	867.95[a]	1003.58[a]
Unprotected	43.75[a]	11.50[a]	41.00[b]	108.5[b]	382.50[b]
LSD at 0.01	10.80	5.59	6.78	225.22	477.40
MSE±	2.61	1.35	1.64	54.53	115.61
CV (%)	11.37	23.55	3.34	11.17	16.68

Note: Means with the same letter(s) in rows are not significantly different for each other.

All treatment effects were highly significant at p<0.01 (DMRT)

Fig 1: Infested tomato plant by *T. absoluta* during November 2015 to February 2016 under glasshouse condition.

In the second season (March to June 2016) the infestation level of *T. absoluta* was very high and completly damaged the leaves of tomato under glasshouse condition. A significant (P<0.01) difference was also noted on the marketable fruit yield during this season. Hence, due to all leaves dried rate of photosynthesis reduced and finally flowering and fruit setting were stopped and finally dead. The unprotected control had 100% yield loss recorded.

Fig 2: Infested tomato plant by *T. absoluta* during March to June 2016 under glasshouse Conditions.

Fig 3: Protected tomato plant from any pest infestation in cages during March to June 2016 under glasshouse conditions.

Table 2: Impact of tomato leafminer, *T. absoluta* on tomato leaf during March to June 2016 under glasshouse condition.

Treatments	No. of Infested leaf/plant
Treated	2.25[b]
Untreated	170.25[a]
LSD at 0.01	38.08
MSE±	9.22
CV (%)	10.69

Note: Means with the same letter(s) in rows are not significantly different for each other.

All treatment effects were highly significant at p<0.01 (DMRT)

3.2 Under Field Conditions

The first year experiments were conducted during November 2015 to March 2016. In other season the second year experiments were conducted to November 2016 to March 2017 at three locations of West Shewa of central Ethiopia. Also, the results on yield loss assessment showed that highly significant (P < 0.01) difference was recorded between treated and untreated treatments presented in (Figure 4 and 5). The treated was imposed irrespective of *T. absoluta* occurrence from 10 days after transplanting till harvesting. The results revealed that significantly lower infestation level and higher marketable yield were recorded in all locations as compared to the untreated control (Figure 4, 5 and 6).

Chlorantraniliprole (Coragen 200 SC) spray was quite effective in reducing population density of *T. absoluta*. Leaf infested and fruit tunneled were least in all three locations, that is twelve times sprays of Chlorantraniliprole (Coragen 200 SC) at 200 ml per hectare and the *T. absoluta* was completely minimized with treated treatments. Maximum marketable yield (30.8, 28.18 and 27.48 t/ha) was obtained with treated treatments in Dandi, Ambo and Toke kutaye districts, respectively. While minimum marketable yields in two years were recorded at Dandi (5.45 t/ha) followed by Toke kutaye (7.95 t/ha) and Ambo (11.25 t/ha) Districts.

Two years mean data presented in Table 3 showed that the minimum total yield loss was recorded 43.83% and marketable yield was 60.08% in Ambo district whereas, the maximum total yield and marketable yield losses were observed in Dandi district 62.89%, and 82.31%, respectively. These results indicated that *T. absoluta* can cause 60.08% to 82.31% marketable tomato fruit yield loss under field condition at Western Shawa of central Ethiopia.

Table 3: Impact of tomato leafminer, *T. absoluta* on yield and yield components of tomato during 2015- 2017 on open farmers field in West Shawa of central Ethiopia

Treatments	No. of Infested leaf/plant	No. of tunneled fruit/plant	Marketable yield in ton/ha	Total yield in ton/ha	Percent yield losses
Ambo district					
Protected	3.75[b]	0.25[b]	28.18[a]	35.43[a]	
Unprotected	24.25[a]	13.5[a]	11.25[b]	19.9[b]	43.83-60.08
LSD at 0.01	5.06	5.0	7.82	11.85	
CV (%)	8.75	17.57	9.60	10.38	
SE±	1.22	1.21	1.89	2.87	
Dandi district					
Protected	1.0[b]	0.5[b]	30.8[a]	35.38[a]	
Unprotected	35.75[b]	15.75[b]	5.45[b]	13.13[b]	62.89-82.31
LSD at 0.01	9.65	6.48	7.96	9.04	
CV (%)	12.71	19.30	10.63	9.02	
SE±	2.34	1.57	1.93	2.19	
Toke kutaye district					
Protected	3.5[b]	0.5[b]	27.48[a]	34.2[a]	
Unprotected	33.5[a]	18.0[a]	7.95[b]	16.2[b]	52.63-71.67
LSD at 0.01	6.31	5.0b	10.63	16.68	
CV (%)	8.26	13.24	14.53	16.02	
SE±	1.53	1.24	1.57	4.04	

Note: Means with the same letter(s) in rows are not significantly different for each other.

All treatment effects were highly significant at p<0.01 (DMRT)

T. absoluta larval feeding not only reduces the marketability of plants, but it also reduces the photosynthetic capacity of plants, which reduces plant vigor, growth and yield [2]. In this study *T. absoluta* feeding on plants result in reduced rate of photosynthesis, facilitate for pathogen, and an increase in leaf transpiration. Maximum leaf and fruit damages were recorded in untreated control treatment whereas, minimum infestation of leaves and fruit damage were recorded on treated treatment. High marketable yield was obtained from the treated treatment. The results of the present investigations can be corroborated with the findings of earlier researchers [13] and [4]. These findings are confirmed with the previous work of Mohamed and Khalid [12] in Sudan, they are reported that *T. absoluta* is recorded as a serious problem to tomato and potato crops after the official report in the country in 2011 with infestation levels from 50% and up to 80%.

Our findings are in accordance with Öztemiz [14], he was reported that *T. absoluta* larvae reduce tomato yield and fruit quality losses range from 80 to 100% by attacking leaves, flowers, burrowing stalks, apical buds, green and ripe fruits. Tomato plant in the world suffered about 100% yield loss due to *T. absoluta* [5]. The larvae can destroy up to 100% of the leaf surface and damage 50-100% of fruits in severely attacked on fields [6]. Garzia *et al*. [8] and Öztemiz [14] reported 100 percent yield loss due to *T. absoluta* infestation. Similarly, Ramirez *et al.* [15] have reported 100% yield loss in unprotected tomato crops by *T. absoluta.* These were in concord with the present study. The present study was indicated that the yield loss depends on the level of leaf infestation and fruit bored. Therefore, appropriate timely spray schedule is an important component which is quite effective in mitigating the losses caused by the *T. absoluta*. This suggests the need for avoiding timely yield losses due *T. absoluta* in tomato.

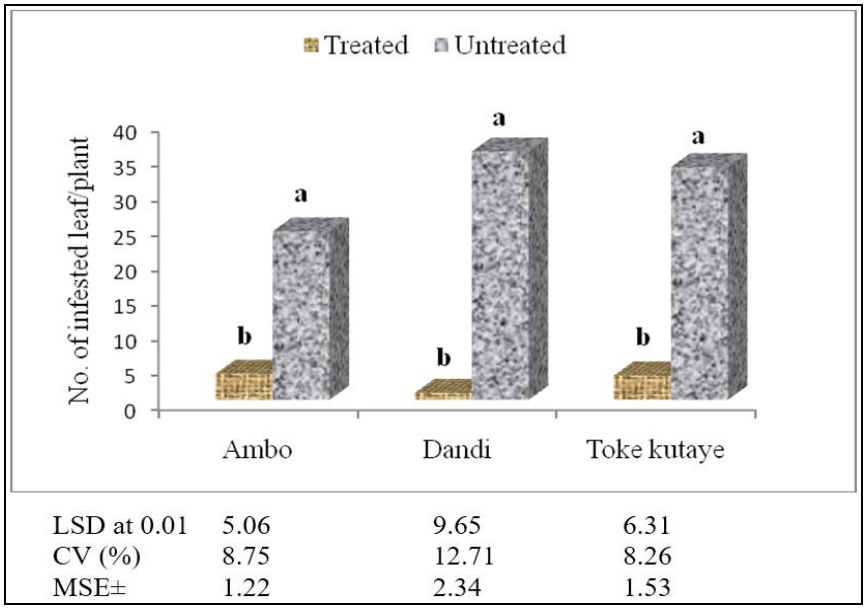

Fig 4: Effect of *T. absoluta* on leaf of tomato at different districts of Western Shawa Central Ethiopia during November 2015 to March 2016.

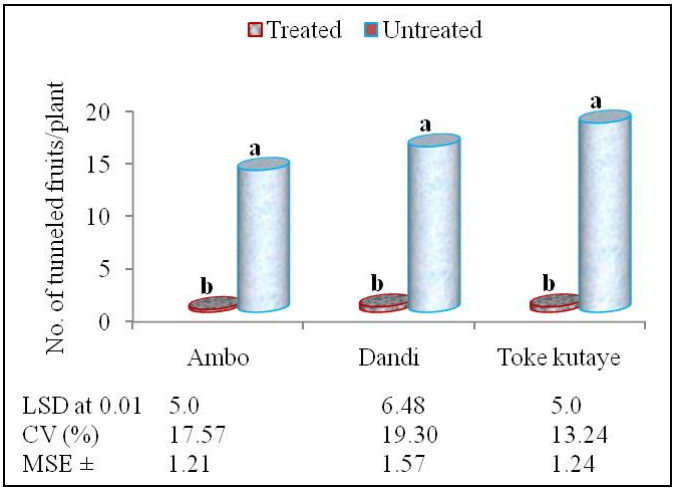

Fig 5: Effect of *T. absoluta* on tomato fruits at different districts of Western Shawa Central Ethiopia during November 2016 to March 2017.

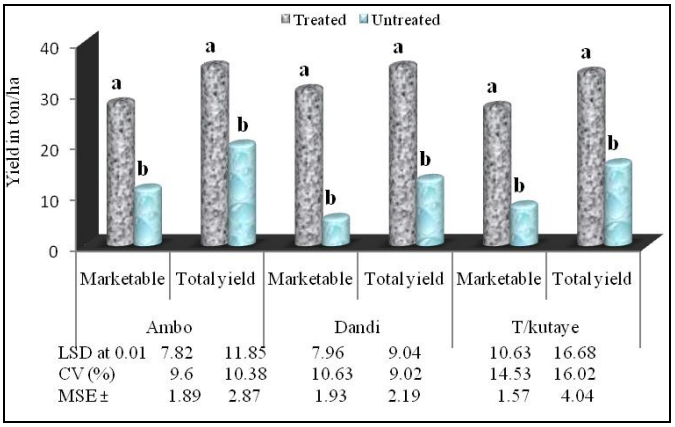

Fig 6: Effect of *T. absoluta* on mean yield of tomato at different districts of Western Shawa Central Ethiopia during 2015 to 2017.

4. Conclusion and recommendation

The larvae of tomato leafminer, *T. absoluta* is a serious pest of tomato in West Shawa of central Ethiopia and causes extensive feeding on the leaves due to which leaves dry up, become defoliated and even ceased flower and fruit setting and finally yield of fruits are significantly reduced. Under glasshouse and field conditions high estimation of yield losses recorded during March to June 2016 and low during November, 2015 to February, 2016. This indicated that during March to June the population of *T. absoluta* was increased and infestation level also increased. Therefore, tomato planting is more prefer from November to February rather than from March to June to escape from highly devastating of *T. absoluta.* Management strategies of *T. absoluta* based on different tactics and environmental friendly is an important component of an integrated pest management strategy.

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