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Reseasrch Article

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Population Dynamics Study of *T. absoluta* in Western Shewa of Central Ethiopia

Tadele Shiberu* **and Emana Getu**

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

***Corresponding author:** Tadele Shiberu, Department of Zoological Sciences, Addis Ababa University, College of Natural and Computational Sciences, Ethiopia, Tel: +251920839476; E-mail: tshiberu@yahoo.com

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Abstract

Tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is an important pest infesting Solanaceous plants all over the world. It became a problem on tomato crop since 2012 in Ethiopia. For enhancing the IPM control of this pest, very few studies have been conducted for assessing seasonal abundance and spatial distribution in Ethiopia. This study aims to monitor the population fluctuation and infestation rate of *T. absoluta* on tomato crop under glasshouse and open field conditions. Different stages of *T. absoluta* were investigated in glasshouse during three plantation periods in 2015-2016 and four plantation periods for open-field study in 2015-2017. Different stages of *T. absoluta* were investigated in glasshouse and open fields during 2015 to 2017 for six and four plantation periods, respectively. At August 2016 the highest populations of *T. absoluta* per plant were recorded under glasshouse whereas under open fields the highest populations of *T. absoluta* per plant were recorded at December and March during 2015-2016. Low number of *T. absoluta* was recorded in the first cropping cycle at December 2015 and 2016. The field study showed that *T. absoluta* population progress is increasing during tomato phenologic cycle, the period of peak activities of *T. absoluta* compromise at vegetative time with flowering and early fruit setting stages of the crop.

Keywords: *Lycopersicum esculentum*; *Tuta absoluta*; Monitoring; Phenology; Glasshouse; Open field

Introduction

Tomato, *Lycopersicum esculentum* (L.) is one of the economically important vegetable crops and widely cultivated in the world with a total area and production of 5,227,883 ha and 129,649,883 tons in 2008. Tomato produced by small and medium scale farmers for consumption and as a source of income [1,2].

The tomato leaf miner, *Tuta absoluta*, originated from South America is a significant pest of tomato, as well as other solanaceous crops like potatoes, egg plants, peppers, beans and datura [1-3]. It attacks all aerial parts of the host plant (leaves, stems and fruits) and feeds within the tissues [1]. The unintentional introduction of exotic insects has resulted in a high number of established species with considerable negative economic impact like tomato leaf miner *T. absoluta* to the new biotic community of the world has brought several problems in different places of the world. Recently, the production of tomato has been declined due to various factors including insect pest and diseases [4,5]. There are several insect species feeds on tomato including tomato leaf miner, whose potential geographic distribution and relative abundance are mostly poorly understood, even after costly and long-standing management programs [6,7].

This invasive pest, *T. absoluta* is considered a serious threat to tomato production worldwide [5]. Thousands of tomato farmers are suffering from serious production losses due to devastating pest that destroying their valuable crop [4,5]. This pest can cause losses of 80 to 100% in tomato farms in glasshouse or in open fields if control measures are not properly implemented [8].

The pest was reported for the first time in Eastern Shewa of Oromia Regional State, Ethiopia since 2012 and then invaded different parts of the country [9,10]. It might have introduced to Ethiopia likely from border countries like Egypt and Sudan as these were first affected countries prior to Ethiopia [11-13].

The pest started infesting tomato farms in the eastern Shewa of the country to regions like Oroma, Tigiray, Amhara, and Gambela. Lack of strong quarantine regulations or poor enforcement of available regulations and lack of screening at the boarders are the factors behind the spread of the pest in Ethiopia and in other African countries [14]. *T. absoluta* can devastate an entire tomato farm, if effective control measures are not employed.

Since it was introduced to Ethiopia in 2012, there was no any control mechanisms and action plan being implemented by the government, research institutions, horticultural agency and other stakeholders to control and mitigate the progress of the spread of *T. absoluta* to new regions of the country. Consequently, the ongoing invasion of *T. absoluta* has prompted applied research to undertake studies on many aspects of its biology, ecology and population dynamics. With the infestation of the entire Ethiopian tomato growing regions by *T. absoluta* now an important threat, there is an urgent need to understand the management options of the pest in its invaded range and develop environmentally sustainable, economically sound and effective integrated pest management (IPM) strategies for this pest. Hence, the objective of this study was to investigate the population dynamics and evaluate the infestation level of *T. absoluta* under glasshouse and open field conditions.

Materials and Methods

The study on the population fluctuation of *T. absoluta* was conducted during 2015-2016 (for greenhouse) and 2016-2017 (for open-field study) on tomato plants. The open-field experiment was carried out under West Shewa ecological conditions at Toke Kutaye, Ambo and Dandi Districts under field conditions. Tomato cultivar \`Koshoro\` was planted on 1st October 2015 and 1st February 2016 for all locations and similar trends were repeated started from 1st October 2016 on second year (2016/17). In addition to field studies one glasshouse experiment was conducted at Ambo University main Campus. In glasshouse, every four-month planting was conducted started from October 1st 2015 to September 30th 2017 for 24 months.

Leaves sampling for recording eggs, larvae and pupae

To calculate the eggs, larvae, pupae and mines number of *T. absoluta*, on fields were divided to four sub area approximately 12 m^2/ each. Each sub area with a similar number of plants to ensure that all the area was represented in the samplings. Every 10 days sampling was carried out from October to January, February to May and June to September in greenhouse and open fields. Ten plants were tagged and at each plant five leaves were collected and individually packed in labeled plastic cans then transported to the laboratory. At the laboratory, with aid of Binocular microscope, each leaf was examined and the number of eggs, mines and larvae per leaf was recorded [15]. The minimum and maximum temperature and relative humidity data were recorded during study period.

Data analysis

The data was subjected to analysis of variance (ANOVA) and the means were compared by Least Significant Different (LSD) test at 0.05 levels, using SAS program version 9.1 (SAS, 2009).

Results

Glasshouse experiment

Egg, larval and pupal-population versus months: Population dynamics study was conducted in three different cropping cycles under glasshouse conditions during 2015-2016, the results showed that significant (P<0.01) differences were observed among the months. The first cropping cycle (October to January) *T. absoluta* eggs and larvae had already occurred. Its egg laid numbers, larvae and pupae were gradually increased by the end of January. The graph for population dynamics (Figure 1), for the second cropping cycle (February to May), showed that the population of all stages (eggs, larvae and pupae)/plant were increased in the beginning of May to September even the flying adults also highly populated in the glasshouse (Table 1 and Figure 1).

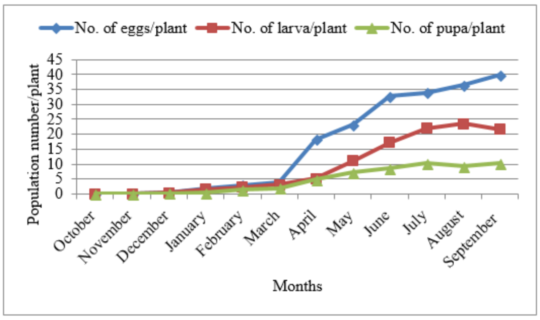

Figure 1: Monthly average population dynamics of *T. absoluta* on different stages per plant under glasshouse conditions during 2015-2016.

Leaf and fruit damage versus months: Leaf damaged and fruit tunneled of tomato plants are caused by larval instars occurs throughout December-September (Table 1). Leaf damaged and fruit tunneled of tomato plants are caused by larval instars occurs throughout the year. The results presented on Table 1 showed that highly significant (P<0.01) differences were recorded among the months. According to our results, damage on tomatoes was much larger in the third cropping cycle followed by second, apart from damage on tomatoes in the first cropping cycle, with tomatoes plants from the second cropping cycle, gradual increasing of damages on the leaves. In this cycle, the largest and most evident were damages on the leaves due to the high larval population occurred and also the mean temperature of the glasshouse 20.5-32.5°C during this cropping cycle.

	Mean different stages of population			Infestation	
Months	No. of egg/plant	No. of larva/plant	No. of pupa/plant	Mean no. of Leaf	Mean no. of Fruit
October	0.00^{d}	0.00^{e}	0.00^{e}	0.00^{f}	0
November	0.00^{d}	0.00^{e}	0.00^{e}	0.00^{f}	0
December	0.57^{d}	0.37^{e}	0.27^{e}	4.63^{f}	0
January	1.70^{d}	1.57^{de}	0.33^{e}	5.56^{f}	0.3
February	2.87^{d}	2.33^{de}	1.37^{e}	8.92^{f}	0.8
March	3.83^{d}	3.17^{de}	2.0^{d}	11.37^{f}	2.15
April	18.27^{c}	5.17^{d}	4.83^{c}	36.17^{e}	7.67
May	23.2^{c}	11.13^{c}	7.13^{b}	65.07^{d}	***
June	32.80^{b}	17.17^{b}	8.60^{ab}	84.17^{c}	***

July	33.93b	22.03a	10.31a	107.73b	***
August	36.47ab	23.60a	9.20a	133.27a	***
September	39.83a	21.60a	10.30a	145.33a	***
LSD at 0.01	5.69	3.63	1.93	14.85	
SE ±	3.34	2.13	1.14	8.72	
CV (%)	20.72	23.66	25.09	17.52	

Table 1: Mean population and number of *T. absoluta* damaged on tomato under glasshouse conditions during 2015-2016.

Note: Means with the same letter(s) in columns are not significantly different for each other. All treatment effects were highly significant at p<0.01 (DMRT). *** Due to highest damaged of *T. absoluta* the leaf became dried and no fruit setting (100% yield losses).

It is important to emphasize that with tomatoes from the first cropping cycle there were damages on the leaf, flower and fruits. *T. absoluta* larvae were damaged tomatoes in the second cycle, damages on all entire part of the plant were visible (Figure 2). However, the greatest damages were found on the leaves of the plants during the third cropping cycle, because of this damaged no flowering and fruit setting of tomato during the end of second and third cropping cycle (Table 1 and Figure 3). As indicated in Table 2 the highest infestation of *T. absoluta* on tomato plants were detected during the 3rd cropping cycle at temperature between 20-27.5 (84.17-145.33 leaves/plant).

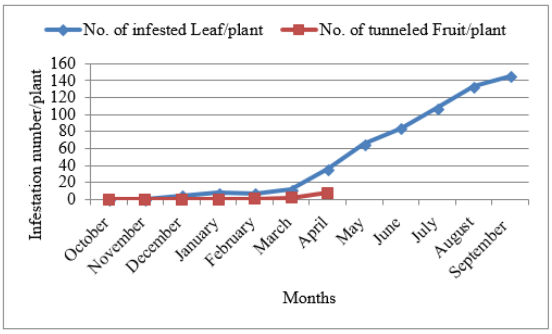

Figure 2: Damaged of *T. absoluta* on tomato plant under glasshouse conditions during 2015-2016.

	Temperature (°C)			Relative humidity (%)		
Months	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
October	24	30	27	57	68	62.5
November	21	28	24.5	52	55	53.5
December	25	33	29	44	52	48
January	27	35	31	39	46	42.5
February	26	39	32.5	37	44	40.5
March	24	37	30.5	42	47	44.5
April	23	35	29	41	46	43.5
May	25	37	31	40	49	44.5
June	22	33	27.5	47	52	49.5
July	20	28	24	60	66	63
August	16	25	20.5	55	60	57.5
September	18	27	22.5	56	62	59

Table 2: Mean temperature and relative humidity during 2015-2016 under glasshouse conditions.

Population density and damages are presented in Figure 3 for each month of observation. Egg, Larval and pupal density of *T. absoluta* and months of observations were a strong positive correlation and linear relationship between those two variables. Damaged leaf and tunneled fruit revealed significant (p<0.05) positive correlation in both the years i.e., 2015 to 2016. The linear regression co-efficient 'b' value during the same year was significant with higher r^2 value showing more pronounced effect of *T. absoluta* eggs, larvae and pupae on leaves. The highest value of r^2 (0.966) indicated 96.6% variation in yield due to *T. absoluta* larvae damaged of leaves (Figures 3 and 4). The regression equations derived were below:

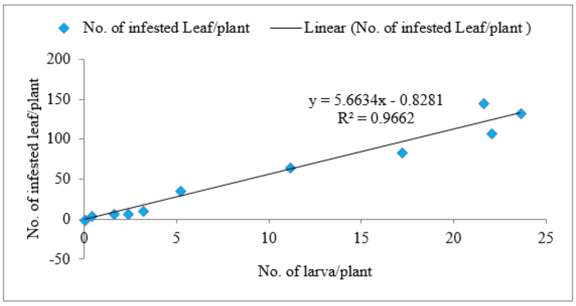

Figure 3: Correlation Coefficient between larval population of *T. absoluta* and damaged leaf during 2015 to 2016 under glasshouse.

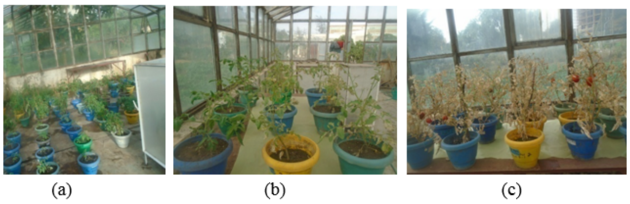

Figure 4: Effect of tomato leaf miner, *T. absoluta* on tomato crop during 2015-2016 under glasshouse conditions: (a) Damaged tomato leaf at different phonological stages, (b) Tunneled tomato fruit, (c) Desiccated leaf.

During second year (2016-2017) study period the population number of all stages of *T. absoluta* were increased during months of June to August 2017 under glasshouse conditions. The infestation level of *T. absoluta* larvae was very high during months of July and August 2017. Due to highly damaged leaves the plant becomes dead at flowering stage and no fruit setting was observed (Figures 5 and 6). As compared with first year (2015-2016) the infestation level and population number of the pests somehow similar.

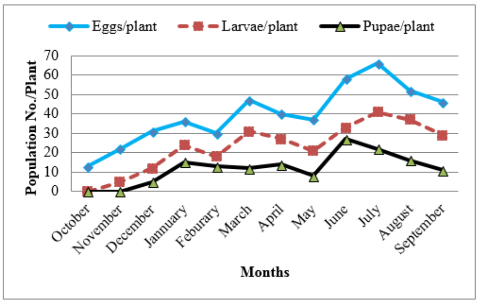

Figure 5: Damaged of *T. absoluta* on tomato plant under glasshouse conditions during 2016-2017.

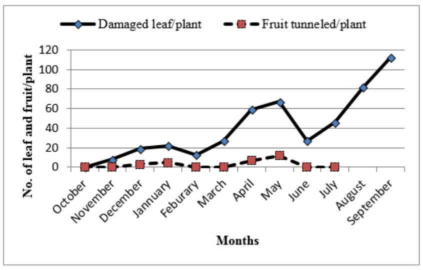

Figure 6: Damaged of *T. absoluta* on tomato plant under glasshouse conditions during 2016-2017.

Field Experiment

Egg larval and pupal-population versus months

The present study, statistical analysis showed that significant (P<0.05) differences were observed among the treatments. *Tuta absoluta* was observed in two main cropping cycles at Ambo, Dandi and Toke kutaye districts, although the maximum density was found in all study areas. The results of the three study areas in first year (2015/16) in both cropping cycles are presented in Figures 7a-9d. At Ambo district first cropping cycle *T. absoluta* population revealed steady progressive (after crop transplanted) to the field and maximum population recorded in the late of December (5.4 eggs/plant and 2.36 larvae/plant) and declined thereafter. In the second cropping cycle peaked in the late March (24.62 eggs and 11.74 larvae/plant) were recorded in the same district.

During 2015/16, at Ambo district first cropping cycle eggs were first recorded at the beginning of December (Figure 7a) whereas at Dandi district, eggs were first observed at beginning of November (Figure 8a). On the other hand, at Toke kutaye eggs were first found at the mid December (Figure 9a). The first peak was observed at the vegetative to initiation of flowering of the crop at all study areas. The second period of *T. absoluta* activity occurred at the beginning of February at all locations. Similarly, the peak of *T. absoluta* eggs and larvae at Toke kutaye in the first and second cropping cycles were recorded at mid-December (14.26 eggs/plant and 9.06 larvae/plant) and the population remained high up to the end of April (Figures 9a and 9b), respectively.

The insect infestation appeared in the early November at Dandi compared with Ambo and Toke kutaye (Figure 8a). The early appearance of *T. absoluta* at Dandi in this particular cropping cycle was associated with early planting of the crop in the surrounding farmer's fields. It was recorded highest population number at mid-December (10.48 eggs/plant). In the second cropping cycle the population of egg, larva and pupa of *T. absoluta* were high at the end of April (22.62 eggs/plant, 16.30 larvae/plant and 9.36 pupae/plant) compared with Ambo and Toke kutaye in all cropping cycles (Figure 9b).

The overall impacts of *T. absoluta* at Ambo and Toke kutaye districts, the populations were very low in the second year in both cropping cycles as compared to the previous year. *T. absoluta* had two peaks per year, the first peak December months at all study areas, whereas the second peak recorded at the end of March and the beginning of April (Figures 7a, 8d and 9d). The different stages of *T. absoluta* (egg, larva, and pupa) begun to increase at vegetative stage of the crop before fruit setting and peak numbers attained at flowering stage. During vegetative and flowering stage, most of the product of photosynthesis move upward to developing fruits, at vegetative period the adult *T. absoluta* concentrated to laid eggs on the upper young leaves and developing fruit as it was observed in all occasions.

In all study areas, the maximum eggs laid were found at vegetative stages followed by flowering stages. In the first year (2015/16), second cropping cycle the population of *T. absoluta* in all stages (egg to pupa) found at seedling stages and the maximum populations were recorded at March (14.26-24.62 eggs/plant) and the minimum eggs were recorded at the mid of May at maturity stages. On Similar manner, at Dandi district the maximum eggs were found started mid-March to at the end of April (16.14-22.62 eggs/plant). In general, the period of peak activities of the *T. absoluta* compromise with vegetative time with flowering and early fruit setting stages of the crop. As a result, large populations, consisting larvae damage the crop leaves at vegetative and then passed to fruit. In 2015/16, patterns of abundances were similar to those of 2016/17. However, in 2016/17 at Ambo and Toke kutaye first and second cropping cycle the population of *T. absoluta* eggs, larvae and pupae were low as compared to Dandi district.

Citation: Shiberu T, Getu E (2018) Population Dynamics Study of *T. absoluta* in Western Shewa of Central Ethiopia. Adv Crop Sci Tech 6: 361. doi:10.4172/2329-8863.1000361

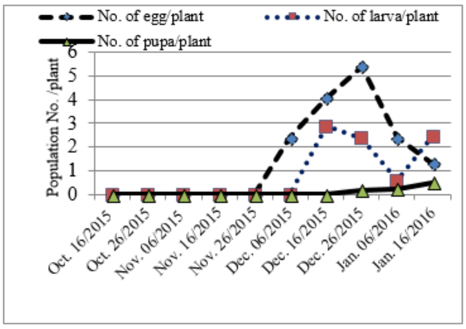

Figure 7a: Mean population number of *T. absoluta* on tomato at Ambo district during 2015/16 1st year 1st Cropping Cycle on open field.

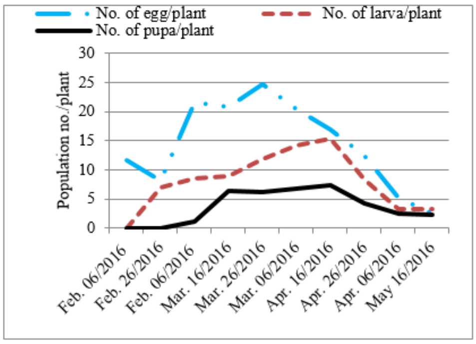

Figure 7b: Mean population number of *T. absoluta* on tomato at Ambo district during 2016 1st year 2nd Cropping Cycle on open field.

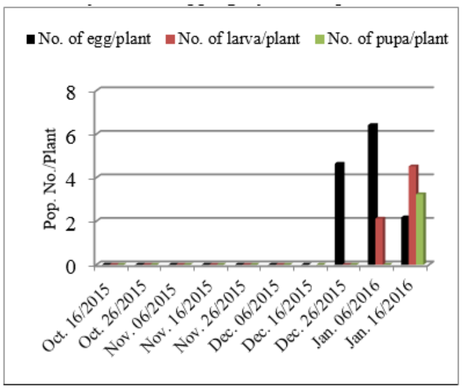

Figure 7c: Mean population number of *T. absoluta* on tomato at Ambo district during 2016/17 2nd year 1st Cropping Cycle on open field.

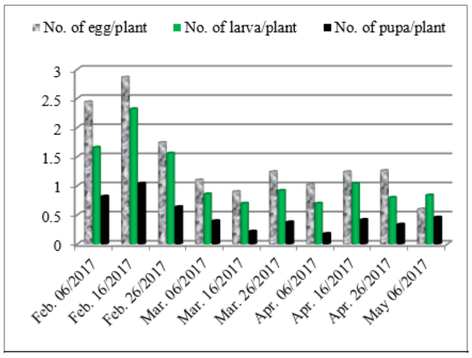

Figure 7d: Mean population number of *T. absoluta* on tomato at Ambo district during 2017 2nd year 2nd Cropping Cycle on open field.

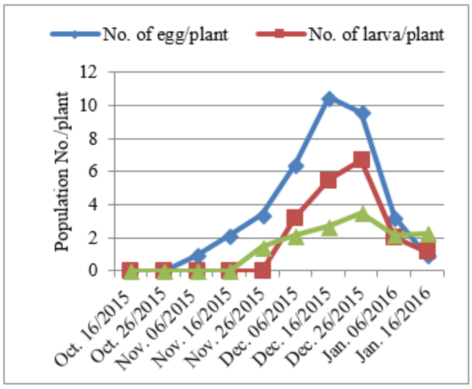

Figure 8a: Mean population number of *T. absoluta* on tomato at Dandi district during 2015/16 1st year 1st Cropping Cycle on open field.

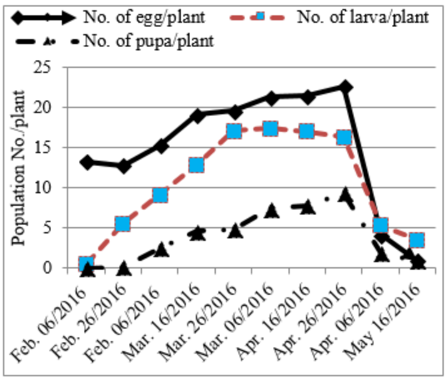

Figure 8b: Mean population number of *T. absoluta* on tomato at Dandi district during 2016 1st year 2nd Cropping Cycle on open field.

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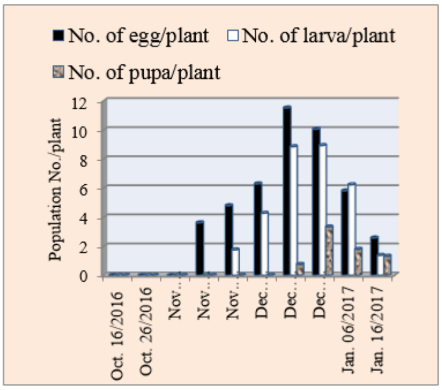

Figure 8c: Mean population number of *T. absoluta* on tomato at Dandi district during 2016/17 1st year 1st Cropping Cycle on open field.

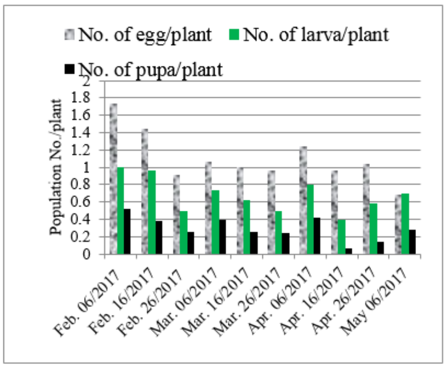

Figure 8d: Mean population number of *T. absoluta* on tomato at Dandi district during 2017 1st year 2nd Cropping Cycle on open field.

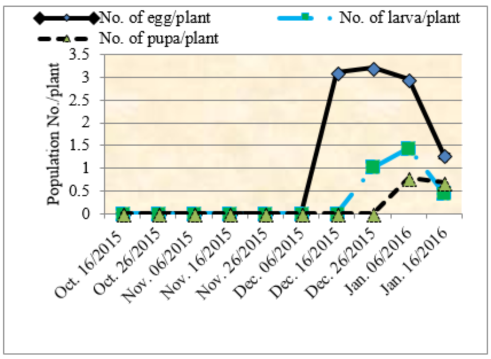

Figure 9a: Mean population number of T. absoluta on tomato at Toke kutaye district during 2015/16 (1st year 1st Cropping Cycle) on open field.

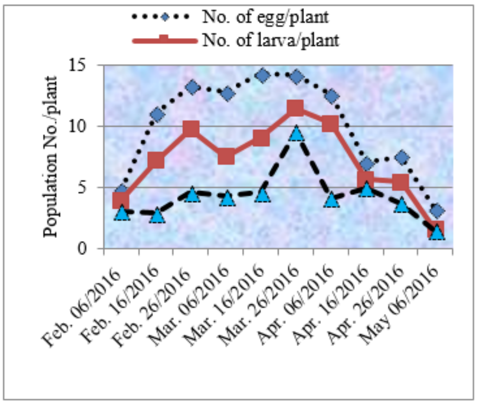

Figure 9b: Mean population number of *T. absoluta* on tomato at Toke kutaye district during 2016 (1st year 2nd Cropping Cycle) on open field.

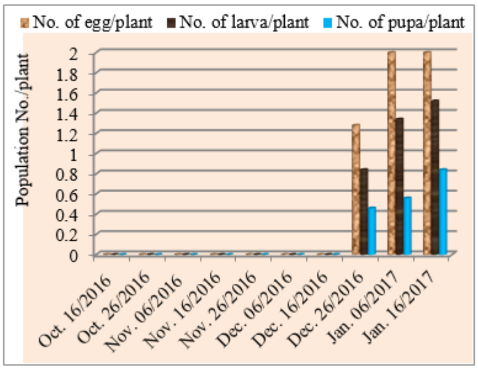

Figure 9c: Mean population number of *T. absoluta* on tomato at Toke kutaye district during 2016/17 (2nd year 1st Cropping Cycle) on open field.

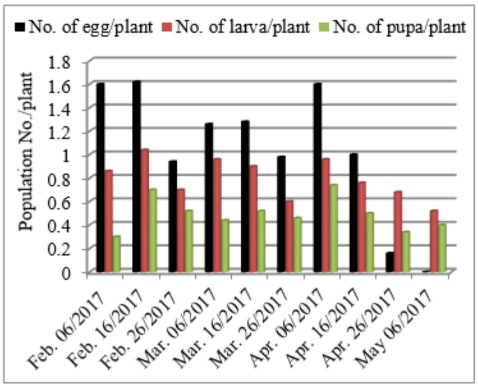

Figure 9d: Mean population number of *T. absoluta* on tomato at Toke kutaye district during 2017 (2nd year 2nd Cropping Cycle) on open field.

Discussion

T. absoluta is a key pest of tomato crops in West Shewa of Ethiopia causing high losses. The knowledge of its population dynamics under laboratory, glasshouse and open field conditions is considered as major step to plan effective management strategies. The present results showed that *T. absoluta* eggs and larval population number evolving at Ambo glasshouse was larger than that of all field studies. This number was influenced perhaps by abiotic factors like temperature, insecticide applications, distance between glasshouses and by biotic factors i.e., absence of natural enemies. Our results confirmed the previous studies of Miranda et al. they reported that during the first phonologic stages of the crop, tomato plants are free from attack of *Tuta absoluta* [16]. The average temperature recorded at this period was approximately 20-25°C. Their number became relatively high, as their attack became intense towards at vegetative stage of crop cycle. These results matched with those found by several authors [17]. These authors underlined the occurrence and increase in *T. absoluta* captures during the crop season.

Allache and Demnati mentioned that in Algeria, during the first phonologic stages of the crop, tomato plants are free from attack of *T. absoluta* [18]. Harizanova et al. pointed that the leaves were the most heavily damaged plant parts [19]. Leite et al. found that the attack of *T. absoluta* was severe at the end of growing season, these authors suggested removal of crop residues and rotating with crops that were not suitable host for this pest [20]. *T. absoluta* females deposited their eggs on all plant parts, they prefer laying eggs on leaves [21,22]. Thus, their numbers were high on the upper than lower leaf surface. In the present study, most of eggs deposited on upper leaves were taken into account. However, minimum egg laying in October and May was recorded. The nutritional quality of tomato leaves (terpenes) seemed to have a positive effect on the laying behaviour of *T. absoluta* [20]. The number of eggs increased in the three study areas in the first and second year, second cropping cycles (from mid-February to the end of the cropping cycle).

The tomato leaf miner, *T. absoluta* eggs number evolution in the glasshouse study was different from that of field studies. The number of eggs mentioned in this work was low compared with results of Pereyra and Sanchez [23]. After Miranda et al., natural enemies played an important role in controlling tomato pests and their preservation by farmers was necessary [24]. *T. absoluta* was attacked at its various stages by several natural enemies, however the rate of parasitism was variable according to species [22,25]. *T. absoluta* pupation was frequent in the leaves but the pupae might be found in the ground, mainstem and in fruit [21].

In Ethiopia, *T. absoluta* resistance to pesticides was not studied. To manage this problem, using integrated pest management (IPM) and other alternative approaches, reducing pesticides use and preserving natural enemies by growers might be a solution [24,26]. In summary, this study highlighted that the three field study areas and one glasshouse study lodged all *T. absoluta* developmental stages. Moreover, it was present during all tomato vegetative cycle and on all plant parts.

Conclusion and Recommendation

Damaged of tomatoes were high in the second cropping cycle, apart from damage on tomatoes in the first cropping cycle. With tomatoes from the first cropping cycle in both years, the maximum and most evident were damages on the leaves during vegetative stage. It is important to emphasize that with tomatoes from the first cropping cycle there were damages on the leaves and fruits of tomato. It was concluded that the infestation level of *T. absoluta* was exist throughout the year if host is available and mostly depends on phonological stages. From this study, damages of tomatoes from the second cropping cycle, damages on all parts of the plant were visible but specifically the leaf parts totally invaded before fruit setting particularly under the glasshouse conditions. Hence, to manage *T. absoluta* this information can be utilized to know when to begin monitoring and control measures to be implemented.

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