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Farmers' insecticide use practices and species composition and abundance of thrips species (Thysanoptera: Thripidae) on onion in the Rift Valley of Ethiopia

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A survey was conducted in 2016 in the major onion producing areas of the Ethiopian Central Rift Valley. A structured questionnaire was used to assess farmers' management practices with a focus on the use of insecticides. Plant samples were collected to assess species composition of thrips and their abundance. Results showed that insecticides were the only control methods for onion growers to control thrips infesting onion. The insecticides diazinon, dimethoate, profenofos, lambda-cyhalothrin and spinetoram were commonly used. Level of insecticide use was higher in Meki than Melkassa and Werer. The volume of insecticide for thrips control and thrips population was noted to be on the increase over the years. *Frankliniella occidentalis* and *Thrips tabaci* were present in all surveyed areas with *T. tabaci* accounting for a higher proportion. The relative species composition varied significantly with location. The highest proportion of *T. tabaci* was recorded at Werer, where insecticide use was relatively minimal. On the other hand, *F. occidentalis* was highest at Meki where insecticide use was also higher. The study suggests that thrips infesting onion have developed resistance to the commonly used insecticides. Further studies are required to confirm and develop a thrips resistance management program in the area.

Key words: *Frankliniella occidentalis*, *Thrips tabaci*, onion, species composition.

INTRODUCTION

Ethiopia has great potential to produce various vegetable crops including onion (*Allium cepa* L.) throughout the year for both local consumption and export. Onion has become popular among producers because of its high yield potential, availability of desirable cultivars and ease of propagation. Additionally, high domestic and export

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markets in fresh and processed forms (Selamawit et al., 2013) and increasing world-wide consumption due to their numerous health benefits (Wang et al., 2006). Despite being an economically important crop, its production and productivity is low, with average production in Ethiopia reaching 7.73 t ha^{-1} (CSA, 2016). This low productivity in Ethiopia is speculated to be caused by a high infestation of thrips, as thrips are a common pest of onion (Daniels and Fors, 2015).

Thrips (Thysanoptera: Thripidae) are a well-known onion pest worldwide (Gill et al., 2015) and the only insect pest that significantly reduces yield of onion and warrants interventions in Ethiopia (FAO, 2010). Two thrips species onion thrips, *Thrips tabaci* (Lindeman) and western flower thrips, *Frankliniella occidentalis* (Pergande) are highly invasive and damaging throughout the world (Stuart et al., 2011). These two species are also present on onion in Ethiopia. When the species co-occur, one species tends to eventually predominate over the other. The use of insecticides in cropping systems is one possible factor that can mitigate the competitive interaction (Zhao et al., 2017). All species of thrips are not equally susceptible to a given insecticide and western flower thrips, *F. occidentalis* is known to be resistant or to develop resistance rapidly to many standard insecticides used for thrips control (Zhao et al., 2017). Variable susceptibility to insecticides may increase the likelihood of one species being replaced by another, thus driving changes in population demographics (Gao et al., 2012).

Insecticides are commonly used to control thrips on onion. The most commonly applied insecticide classes include: carbamate, organophosphate, organochlorine, and pyrethroids, often applied repeatedly and indiscriminately in the central rift valley of Ethiopia (Belay et al., 2017). However, the impact insecticide use on thrips species composition and abundance has not been assessed in onion producing areas of Ethiopia. This lack of information is cause for concern because growers may make management decisions without accurate knowledge of their thrips populations. Hence, this research was designed to assess the species composition and abundance of thrips under different management approaches on onion in the rift valley of Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted from February to March 2016 in the major onion growing areas (Melkassa, Meki, and Werer) in the central rift valley region of Ethiopia (Figure 1). The study districts were purposely selected because of their intensive vegetable production, access to irrigation water and proximity to lucrative local markets. Farmers can produce vegetables in three cycles within the same year, but two-cycle production is the most common (Tebkew and Getachew, 2015). The survey areas were varied in elevations, pest control measures and type and frequency of insecticide application. Other vegetable crops like tomatoes and cabbage were also cultivated along with onion.

Assessment of farmers insecticide use

The survey was carried out to assess farmers' insecticides use practices to control thrips on onion. A total of 80 onion farmers, 25 from Werer, 25 from Melkassa and 30 from Meki districts were systematically selected along the irrigated areas of each district. The selected farmers' fields had similar growth stage and were free from insecticides for at least three days in each district. Data were collected using local the language in a face-to-face interview, often conducted in the farmers' field using a structured questionnaire. The questionnaires focused on insecticide practices, types of insecticides and frequency of insecticide application for thrips control on onion.

Assessment of thrips species composition and their abundance

A thrips sample was taken from ten randomly selected plants within each farmers' field. The selected plant was covered with a plastic bag and then gently shaken to dislodge the thrips into the bag. Thrips were transferred vials containing 70% ethyl alcohol and taken to the laboratory for identification. Adult thrips were mounted and identified using a compound microscope in the laboratory at the Melkassa Agricultural Research Center. Thrips were identified using taxonomic keys, digital images and descriptions (Reed et al., 2003; Sparks and Liu, 1914). Mature onion thrips, *T. tabaci* is slightly smaller than western flower thrips, *F. occidentalis*. *T. tabaci* has ocellar pigment which is usually grey, has 7-segmented antennae and wings fringed with at least one rows of incomplete setae. Mature *F. occidentalis* have fringed wings with two complete rows of setae, pronotal anteromarginal setae are equal in length to anteroangular setae, ocellar pigment usually red and the antennae have 8-segments. Well-developed hairs or setae are present on the anterior part of the thorax for all Frankliniella species and absent in Thrips species, including onion thrips (Reed et al., 2003; Sparks and Liu, 1914). In addition, thrips abundance was assessed visually by counting thrips on ten randomly selected plants from within each field. The coordinates of the study areas were recorded by GPS then using Arc view version 32 (GIS) software the study sites were mapped.

Data analysis

Survey data were summarized and analyzed using (SPSS software version 16.0). Descriptive statistics were used to analyze the collected data. Associations of species composition with different region and insecticide application interval were examined using chi-square ($\chi 2$) test. Correlation between mean numbers of thrips per plant, thrips counts for each farmers and insecticide application interval was analyzed.

RESULTS

Insecticide type and frequency of application

All onion growers surveyed controlled thrips using synthetic insecticides. A total of seven insecticides were used in the surveyed onion farming areas. Most frequently used classes were organophosphates and pyrethroids. Profenofos with different trade names (Girgit-Plus, Profit and Selecron) and dimethoate were frequently used. Lambda cyhalothrin, spinetoram and diazinon were

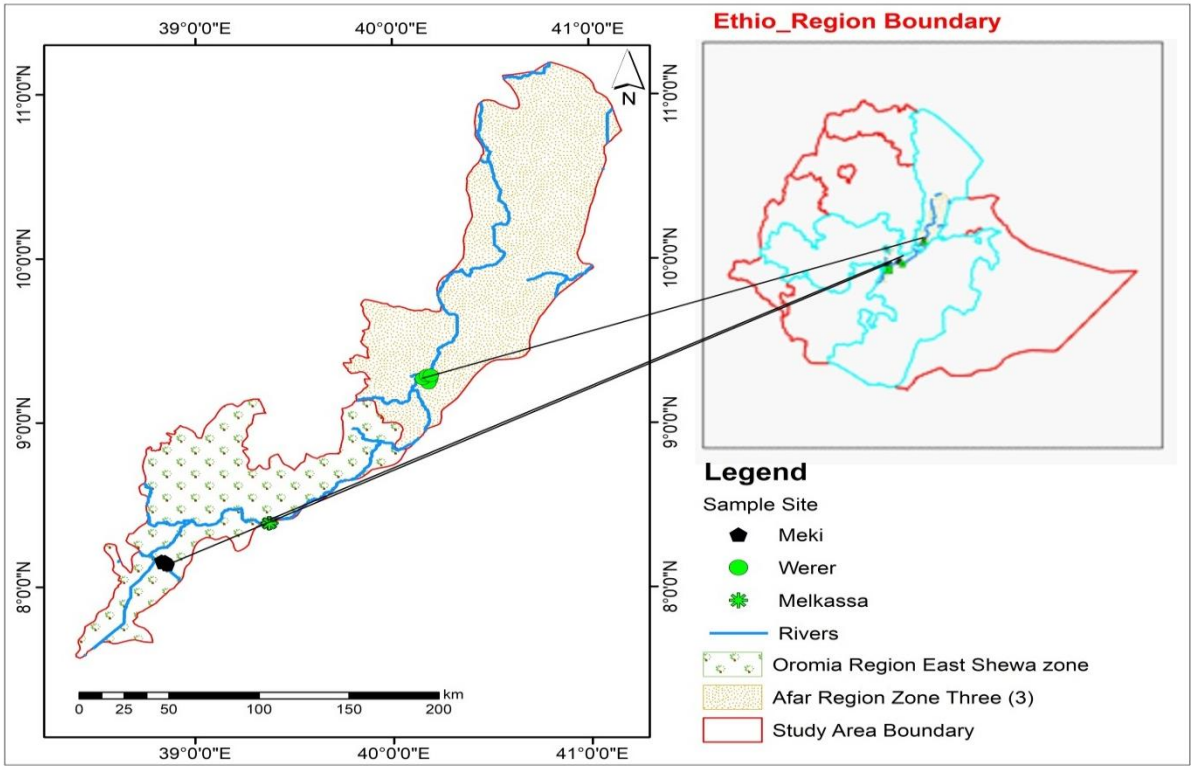

Figure 1. Map of the surveyed onion growing areas, 2016.

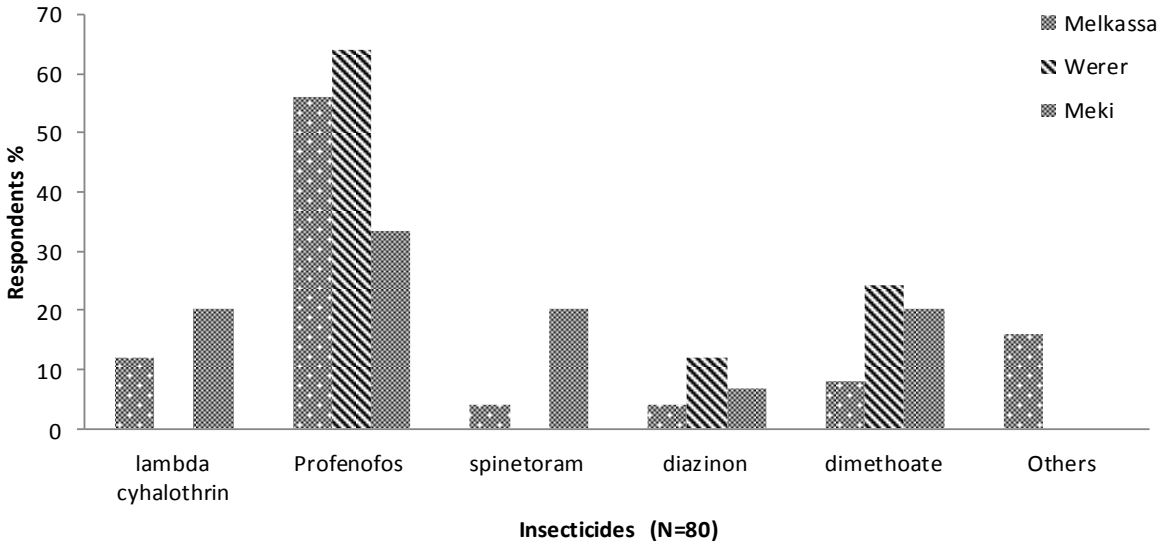

Figure 2. Types of insecticides used by farmers in Melkassa, Werer and Meki, districts, Ethiopia, 2016.

used less frequently (< 20% of farmers) (Figure 2).

Onion farmers sprayed insecticides in less than seven day interval. On the average, about 50% of the respondents sprayed insecticides in less than seven day interval, 43% of them at the seven day interval and the remaining 8% sprayed as necessary (Table 1). A significant difference was found between regions with respect to the insecticide spraying interval ($\chi 2 = 19.56$, $P = 0.001$). The total number of applications per season ranged from 3 to15 times. The numbers of sprays per crop season varied significantly between locations ($\chi 2 = 56.46$, $P = 0.001$). Regarding the practice of insecticide

Table 1. Percentage of survey respondents, with in each location, reporting their frequency of insecticide use to control thrips on onion.

S/N	Variable	Locations and percent of respondents (N=80)			
		Melkassa (%)	Werer (%)	Meki (%)	Total (%)
1	Management methods				
	Chemicals	100	100	100	100
2	Spraying interval				
	< 7 days	56	24	66.6	50
	7 days	44	52	33.4	42.5
	As necessary	0	24	0	7.5
3	Spraying frequency per cropping season				
	<5 times	12	44	0	17.5
	7 times	56	56	13.3	40
	8 times	24	0	16.7	13.8
	> 10 times	8	0	70	28.8
4	Quantity of yearly insecticides use				
	Increase	80	100	100	93.75
	Decrease	0	0	0	0
	No change	20	0	0	6.25

Table 2. Percentage of survey respondents describing their perception of insecticide use in onion production in Ethiopia.

S/N	Variable	Locations and percent of respondents (N=80)			
		Melkassa (%)	Werer (%)	Meki (%)	Total (%)
1	Effect of insecticides on onion production				
	Increase	88	88	100	92.5
	No change	6	6	0	3.75
	I don't know	6	6	0	3.75
2	Effectiveness of insecticides				
	Effective	92	100	100	97.5
	Not effective	0	0	0	0
	No change	8	0	0	2.5
3	Yearly change in intensity of thrips				
	Increase	52	88	100	81.2
	Decrease	24	0	0	7.5
	No change	24	12	0	11.2

use, about 93.8% of the respondent observed that it has increased year to year; only 6.2% of farmers were of the opinion that there was not much change (Table 1).

Farmers' perceptions of insecticides use in onion production

The majority of farmers (97.5%) were of the opinion that thrips on onion can be effectively controlled with the use of insecticides, while only a few of them (2.5%) perceived that insecticides did not solve their thrips problem. Additionally, about 92.5% of respondents attributed the increase in productivity of onion to the use of insecticides. Although farmers believed that the insecticides were effective against thrips, about 81.2% of the respondents stated that the abundance of onion thrips increased year to year, while the remaining respondents indicated that the abundance of thrips decreased or did not change much (Table 2).

Species composition and abundance of thrips on onion

Two thrips: species onion, *T. tabaci* and western flower

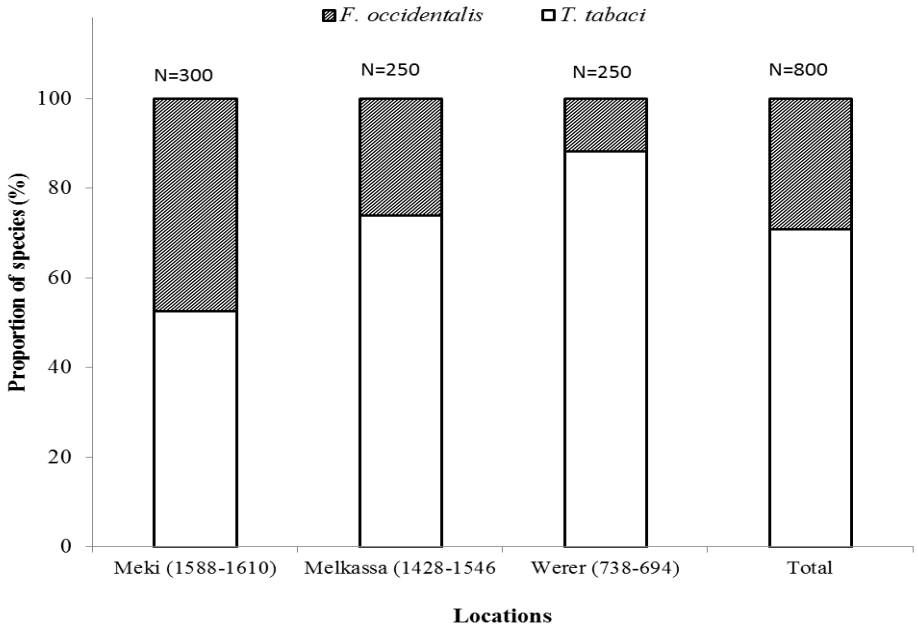

Figure 3. Species composition of thrips (within brackets indicate the altitude in m.a.s.l).

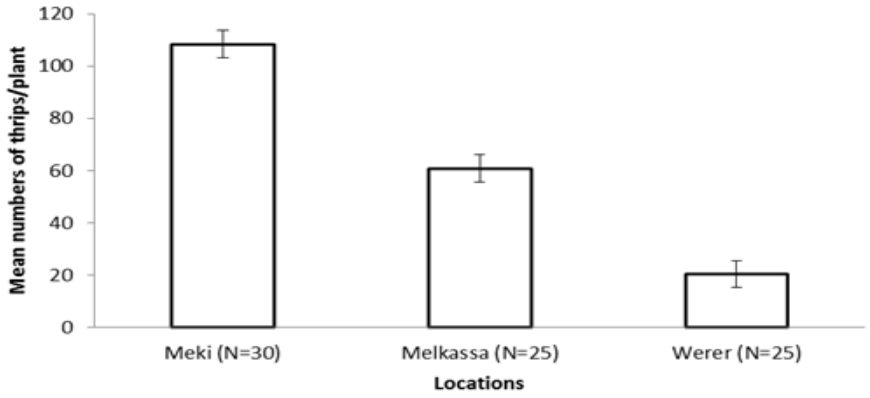

Figure 4. Mean number of thrips/plant from the total of 80 onion grower farms fields visited at Meki, Melkassa and Werer, 2016. Error bars show SEs.

Thrips composition was statistically different between locations ($\chi 2 = 69.45$, $P = 0.001$). *T. tabaci* was the dominant species in Melkassa (74%) and in Werer (88.2%), while the two thrips species were present in equal proportion at Meki (Figure 3). Composition of thrips species was significantly affected by the insecticide application interval ($\chi 2 = 151$; $P = 0.001$) and number of insecticide sprays per one crop periods ($\chi 2 = 18.39$, $P = 0.001$). The abundance of thrips varied between locations. A higher number of thrips was recorded at Meki and Melkassa (Figure 4), where insecticide use was relatively higher. At the field level, the mean number of thrips per plant was not significantly correlated with insecticide application interval (Pearsons 2-tailed, $r = -0.072$).

DISCUSSION

Onion farmers routinely applied older chemistries (organophosphates and pyrethroids) at varying spray intervals and sprays frequencies per crop season to control thrips on onion. Only a few farmers were used newer insecticides chemistries (spinetoram) and applied when necessary. Similar studies by Belay et al. (2017) reported that vegetable grower used different types of commercial pesticides with different chemical composition and applied indiscriminately and often in violation of the recommendations. Tebkew and Getachew (2015) reported that all small-scale vegetable growers in East Shewa Zone, Ethiopia, rely solely on pesticides and spray pesticides frequently to control pest. However, such

intensive application of insecticides is conducive to increasing insecticide resistance. Adilakshmi et al. (2008) has reported that frequent insecticide use contributes to the reduction of beneficial and natural enemies and increases the development of insecticide resistance. Another researcher indicated that the frequent use of synthetic chemical insecticides leads to resistance development in *T. tabaci* (Khaliq and Tahir, 2015).

Most of farmers believed that increment of insecticide use solved their thrips problems and increased onion yield. This misperception about insecticides use lead to increase the volume of insecticide use every year, in parallel the intensity of onion thrips was increased every year. This miss use and misperception of insecticides use is aggravating the problem of thrips in onion production, because large quantity and frequently applied of pesticide have posed to increased incidence of pest resurgence and appearance of pest species that are resistant to pesticides (Kaur and Garg, 2014). Bommarco et al. (2011) also found that lower abundances of natural enemies and lower parasitism rates were observed on insecticide treated fields.

The species composition of thrips varied across the study area. *T. tabaci* was the most abundant species, especially at Werer. The highest proportion of *F. occidentalis* was recorded where the frequency and amount of insecticide use was high. This clearly shows that farmers' insecticide use affects the species composition of thrips in onion fields. When two species co-occur, one species dominated over the other due to the use of insecticides in cropping systems, because *F. occidentalis* was known significantly more tolerant to insecticides than *T. tabaci* (Zhao et al., 2017). In another study by Bielza (2008) *F. occidentalis* was reported less susceptible to many insecticides and to develop resistance quickly. However, altitude is an important factor that may also contribute to species composition. A survey conducted in East Africa indicated that *F. occidentalis* was more abundant in the high altitude zones as compared to the low altitude zones (ICIPE, 2009). Mound and Azidah (2009) also found *F. occidentalis* to be abundant in highland areas. Farmers' insecticide use also affected thrips abundance, where by the highest thrips counts occurred in frequently sprayed locations as compared with less frequently sprayed locations. However, Ssemwogerere et al. (2013) found that the highest thrips occurrence was recorded where farmers that applied one pesticide spray per week ascompared to those using two sprays a week.

Conclusion

The trend of insecticides use for control of thrips on onion is increasing year to year. The survey has shown that the frequency of insecticide spray per crop season ranged from 3 to 15 times. However, it is known that extensive use of insecticides has adverse effects on thrips population that lead to develop resistance to insecticides. This indiscriminate use of insecticides could be the reason for the increased volume of insecticides used every year. These farmers insecticide use affected the species composition and abundance of thrips on onion. From these results concerning the insecticides used to control thrips in onion, onion farmers should reduce their on reliance insecticides. Finally, understanding the compositions of thrips species in farmers' fields is needed to control thrips effectively using IPM.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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