Evaluation of Insecticides against Onion Thrips and Crop Phenology Based Population Fluctuates

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Abstract

*Onion (**Allium cepa** L.) is one of the most important vegetable crops commercially grown in Ethiopia. However, its productivity in Ethiopia is far below the world average. Among constraints of onion productivity in Ethiopia, high infestations of thrips are the most important ones. This field experiment was conducted to evaluate the efficacy of insecticides in controlling onion thrips and to analyze the population dynamics of thrips in relation to crop phenology in the Central Rift Valley of Ethiopia in 2022. The experiment evaluated four insecticides (lambda-cyhalothrin, profenofos, spinetoram and imidacloprid), which were laid out in a randomized complete block design with four replications. Two thrips species (Thrips tabaci and Frankliniella occidentalis) which belong to the Thripidae family were observed. Thrips tabaci accounted for 91.90%, while Frankliniella occidentalis accounted for 8.10% of the thrips collected with yellow water traps in the study area. The overall thrips population was higher at the vegetative growth stage, and the levels of the population decreased when the plants approached physiological maturity. Among the four evaluated insecticides against onion thrips, the yield increased by 48.88% and 43.78% for spinoteram and imidacloprid treatments, respectively, compared to the control. The lowest mean marketable bulb yield among the insecticide treatments was obtained from lambda-cyhalothrin, which suggests a loss in its efficacy and the development of resistance. Future studies ought to focus on the evaluation of different chemistries of insecticides, schemes of insecticide application, and integration of non-pesticide methods in to the current pesticide-dependent onion pest management method.*

Keywords; *Frankliniella occidentalis,* Resistance, *Thrips tabaci,* Yield loss

Introduction

Onion (*Allium cepa* L.) is one of the most important vegetable crops commercially grown in the world (Teshika *et al.*, 2019). In Ethiopia, it is an important vegetable produced across a wide range of latitudes, and like hot pepper; onion is an indispensable ingredient in traditional sauce or stew (Alemu *et al.*, 2004). Ethiopia has great potential to produce various vegetable crops including onion throughout the year for both local and export market. Onion has markets in fresh and processed forms (Ketema *et al.*, 2013), and increasing worldwide consumption due to its numerous health benefits (Kumar *et al.*, 2010).

The national average onion productivity in Ethiopia during the

2019 cropping season was (88,837 kg ha^{-1}) and it was very low as compared to the world average (189,068kg ha^{-1}) (FAOSTAT, 2020). Despite the onion being an economically important crop, its production in Ethiopia is low. According to Haile et al. (2016) and Negesse *et al.* (2020), the production of onions is limited by a poor cropping system, poor soil fertility, and a lack of input, diseases, and insect pests. Among the various insect pests', thrips are the most injurious and attack all Allium crops. Daniels and Fors (2015) also reported that thrips are a common pest to attack onions.

Thrips (Thysanoptera: Thripidae) are a well-known onion pest worldwide and the only insect pest that significantly reduces the yield of onion and warrants interventions in Ethiopia (Gill *et al.*, 2015). 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 onions in Melkassa, Meki, Minjar, and Werner, Ethiopia (Negash *et al.*, 2019). In the Ethiopian Central Rift Valley, thrips on onions are widely managed with insecticides and the group's carbamate, organophosphate, organochlorine, and pyrethroid are most frequently used (Mengistie *et al.*, 2017).

The use of insecticides in cropping systems is one of the crop protection methods that can mitigate the competitive interaction (Zhao *et al.*, 2017). The relative proportion of the thrips species in fields varied between sites and during the season, differences that might need to be considered when managing thrips on the onion crop (Mahaffey and Cranshaw, 2010). Negash *et al.* (2019) reported that the relative species composition varied significantly with locations. However, thrips are serious pests of crops, yet little is known about their species composition and population trends in Ethiopia.

The impact of insecticide use on thrips species composition and abundance has been assessed only in Melkassa, Meki, Minjar, and Werer, Ethiopia (Negash *et al.*, 2019). Practically no work has been done to establish the diversity of thrips species present in different growth stages of the onion crop. Abundance of onion thrips varied with growth stage of the plant (Zereabruk, 2017). Thrips populations fluctuate with crop phenology, environmental factors, and pesticide applications (Palomo *et al.*, 2015). Understanding these patterns and evaluating the efficacy of insecticides can help in developing more effective management strategies. Additionally, producers could make management choices without having precise information about thrips populations. Therefore, to implement timely control measures, it is crucial to understand the species composition of thrips and their peak activity.

Mayer *et al.* (1987) reported that chemical control of thrips depends upon the choice of effective insecticides and adequate spray coverage on plant parts where thrips inhabit. Assessment of pesticide susceptibility to pest populations is a proactive approach to detect any shift in insecticide performance and provide an early warning to modify chemical control strategies (Miller *et al.*, 2010). Early detection of insecticides provides a basis for the management of resistant pest populations (Osorio *et al.*, 2008). Hence, this research was conducted to evaluate the efficacy of insecticides in controlling onion thrips and to analyze the population dynamics of thrips in relation to crop phenology in the Central Rift Valley of Ethiopia.

Materials and Methods

Description of study area

The experiment was conducted in the Central Rift Valley of Ethiopia (Adami Tullu Jido Kombolcha and Bishan Guracha) from January to May 2022. Adami Tullu Jido Kombolcha is located at latitude and longitude 7˚56'N 38˚43'E and has an elevation of 1643 m.a.s.l. The annual average rainfall is 760.9 mm. The temperature ranges from 18-28^{0}C.

Bishan Guracha is located at latitude and longitude 7˚05'N 38˚49'E and has an elevation of 1708m.a.s.l. The annual average rainfall in Bishan Guracha is 1100 mm. The temperature ranges from 18-28^{0}C. The first rainy season locally known as Belg extends from the end of February to May and the second rainy season Kiremt extends from June to September. Both locations are characterized by dry sub-humid climates and major onion-growing regions (Begna, 2019).

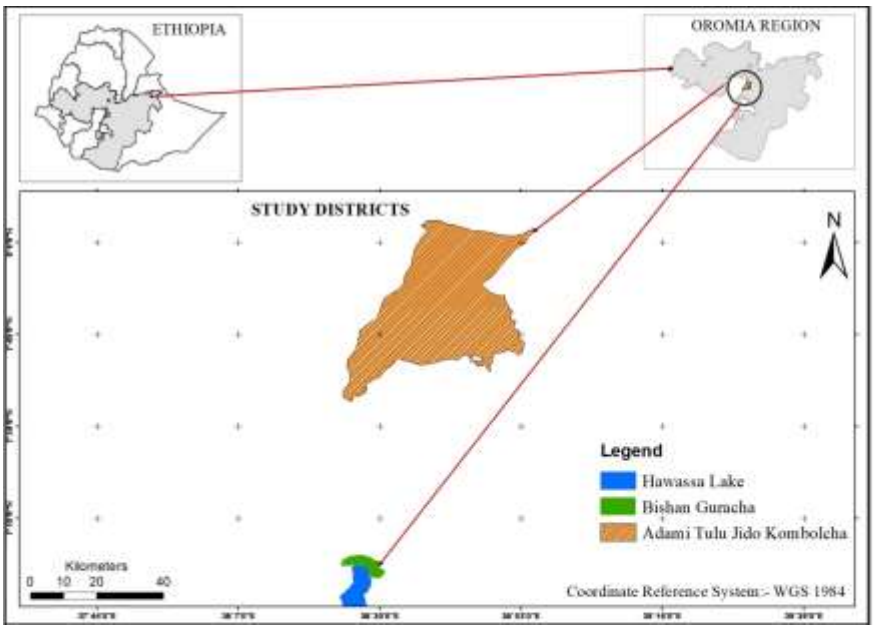

Figure 1. Geographical location of the study area

Experimental materials, treatment and design

The onion “Bombay Red” cultivar was used as a test crop in this experiment. The cultivar is popular in the CRV of Ethiopia (Ayana *et al.*, 2014). Four synthetic insecticides namely lambda-cyhalothrin (Pyrethroid), profenofos (Organophosphate), spinetoram (Spinosyns), and imidacloprid (Neonicotinoid) insecticides were evaluated in comparison with the untreated check at Bishan Guracha and Adami Tullu Jido Kombolcha, Ethiopia (Table 1). The experiment was laid out in randomized complete block design (RCBD) with five treatments and four replications and each gross plot size was 3 m x 2.4 m = 7.2 m^2 consisting of five rows, which accommodated 48 seedlings per row. Furrow, row and plants have all been spaced at 40, 20, and 10 cm, respectively. The spacing between plots and adjacent replications was 1 m. The total experimental field measured 19 m x 12.6 m, or 239.4 m^2, while the net plot area was 4.32 m^2.

After the land was conventionally prepared six weeks old onion seedlings were transplanted in February 07, 2022. The application of insecticides started when the pest population reached an economic threshold level. The economic threshold level of onion thrips reported that five to ten thrips per plant. In this experiment, insecticides application was started one month after transplanting. Insecticides were sprayed five times within seven days interval. Except for the pesticides chemical all the recommended agronomic practices were applied (EARO, 2004).

Table 1. List of insecticides applied for an experiment against onion thrips

Common name	Product and formulation	Manufacturer	Dose (ml ha^{-1})	Water (litre ha^{-1})	Recommended rate
lambda cyhalothrin	Karate5% EC	Syngenta	300	300	1.00
profenofos	Ajanta72% EC	Coromandel International Ltd.	700	300	2.33
spinetoram	Radiant120 SC	Dow Agro sciences	150	575	0.26
Imidacloprid	Confidor 35% EC	Crop safe pesticide India Pvt. Ltd.	400	200	0.50

Data collection

Abundance of thrips species: from each plot ten onion plants were sampled randomly from the two adjacent rows of the border rows. Samplings were done at the vegetative and physiological maturity growth stages of the crop. Onion plants were cut with a scissor from the ground level and placed in polythene bags and taken to the laboratory for species identification. Coarse vegetation was separated by sieving and the suspension allowed settling. Suspension is a mixture of sampled plant part and pests within liquid water in a petri dish. The species *Thrips tabaci* and *Frankliniella occidentalis* were identified at Hawassa University crop protection laboratory using a combination of taxonomic keys (Hodges *et al.,* 2009; Mehle and Trdan, 2012; Palmer, 1990). The numbers of thrips in each species were counted under a dissecting microscope.

Number of thrips per yellow water trap; yellow water traps was constructed from plastic containers 19 cm outer and 13.5 cm inner diameter. To collect onion thrips, five traps were put randomly in the experimental areas that were 2m apart and the same traps were put outside the experimental area. This experiment was performed weekly from February, 28 – May 01, 2022. The trapping began three weeks after the transplant of the onion and continued for nine consecutive weeks until the onion reaches maturity. The water trap was filled three-fourths with an aqueous solution made from 20 ml of liquid detergent and formalin, in a ratio of 1:3 in 4 liters of water. The liquid detergent was added to reduce surface tension and formalin to act as a preservative (Adesiyun, 1977). The contents of the traps were emptied into a sieve made of a fine clean cloth weekly and the collected thrips were counted.

Thrips population before and after insecticides spray; thrips were counted using hand lens from ten randomly selected plants per plot before and three days after spraying the insecticide treatments and the check sprayed with water.

Thrips damage incidence; incidence of thrips damage was determined by counting the number of damaged plants over the total number of plants per plot.

Thrips damage severity; was determined by randomly sampling ten plants from the inner rows of each plot. The percentage of leaf surface showing thrips damage was assessed based on a scale of 1 - 5 (Smith et al., 1993), where 1 = no damage, 2 = up to 25%, 3 = 26-50%, 4 = 51-75% and 5 = >75% damage.

Marketable and unmarketable bulb yield: at maturity, onion bulbs were harvested from the center of three double rows in each plot and then sorted out into marketable and unmarketable bulbs. The Marketable bulb yield (t ha−1) was identified after dumping of split bulbs, dense necked and unpleasant bulbs. The marketable bulb yield weight standard in Ethiopia is categorized as extra-large (above 160 g), large (100–160), medium (50–85), and smaller sized (21–50). Unmarketable bulb yields (t ha−1): were determined by classified as: under sized (160 g), contaminated, rotten, and disordered physiologically (thick-necked and divided bulbs) (Chala *et al.,* 2022).

Total bulb yield included both marketable and unmarketable bulb and the weight was converted into t ha-^{1}.

Yield gain (%) =

$$\frac{\text{Protected treatment} - \text{Untreated treatment}}{\text{Protected treatment}} x\ 100$$

Data analysis
Data were subjected to analysis of variance using PROC- GLM procedure of SAS software version 9.4 (SAS Institute, 2017). Mean separation was done based on LSD at a 5% level of significance.

Economic analysis
The relative economic returns of the treatments were calculated by subtracting the cost of insecticides and their application from the gross return. The price of onion bulbs was estimated based on the farm gate price per ton.

Results and Discussion

The effect of insecticides on population of thrips in different growth stages of onion crop
Thrips were present starting from the seedling stage, and their population increased through the vegetative growth stage of onion. The application of insecticides reduced the thrips population as compared to the untreated plot. Two thrips species (*T. tabaci* and *F. occidentalis*) were identified, and both of them belong to the Thripidae family. The highest *Thrips tabaci* population (15.07 thrips/plant) was recorded in the untreated check, while, the application of spinoteram had the lowest population (8.14 thrips/plant) at the vegetative stage. Similarly, the lowest *Thrips tabaci* population (4.82 thrips/plant) was recorded in the application of spinoteram, whereas the untreated check had the highest population (9.18 thrips/plant) at the physiological maturity period (Fig. 2).

The lowest *F. occidentalis* population (0.23 thrips/plant) was recorded in the application of spinoteram, whereas the untreated check had the highest population (1.15 thrips/plant) at the vegetative stage. Similarly, the highest *F. occidentalis* population (1.93 thrips/plant) was recorded in the untreated check, while, the application of spinoteram had the lowest population (0.09 thrips/plant) at the physiological maturity stage (Fig. 2).

Monitoring to identify when thrips arrive and to determine population levels helps design an appropriate control strategy. During this experiment, two thrips species (*T.tabaci* and *F.occidentalis*) were collected from onion crops. The overall thrips population was higher in the vegetative growth stage. Similarly, Negash *et al.* (2019) showed that *F. occidentalis* and *T. tabaci* were present in the Ethiopian Rift Valley with *T. tabaci* accounting for a higher proportion.

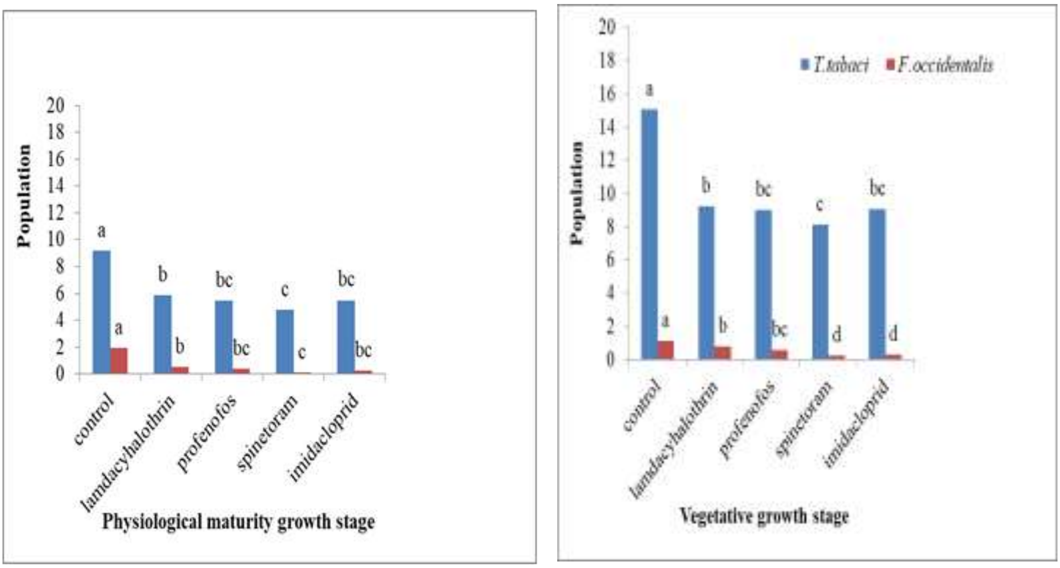

Figure 2. The effect of insecticides on population of thrips in different growth stages of onion

Thrips collected from yellow water traps

Adult onion thrips were trapped in yellow water traps from study area. The trapping began three weeks after the transplant of the onion and continued for nine consecutive weeks until the onion reaches maturity. The data were taken weekly from the mean of five yellow water traps. There is no thrips, traps that were put outside the experimental area .*Thrips tabaci* was the most abundant species (164.5 thrips) and a fewer number of *F. occidentalis* (14.5 thrips) were collected in nine weeks period. *T. tabaci* accounting 91.90%, while, *F.occidentalis* is 8.10% of thrips collected by yellow water traps in the study area. The distinct peaks of adult onion thrips activity on yellow water traps were observed during the eight week of sampling (Fig. 3). Studying onion thrips populations at different growth stages is important because it helps to understand how and when thrips populations fluctuate, and how to manage them. Large populations of thrips can develop, causing blemishes to the leaves, which reduce quality and may make the crop unmarketable (Rodríguez and Coy-Barrera, 2023). Therefore, this experiment results are important for the management of onion thrips by growers.

Onion thrips were more abundant at crop developmental stage of 7-14 leaves (Zereabruk, 2017). Neergude et al. (2014) reported that the population of thrips occurrence in onion crops was very low during the seedling stage and it gradually increased during the vegetative stage of the crop. Thrips were present in each crop cycle, and the levels of populations decreased when the plants were near senescence (Palomo *et al.*, 2015). The population of onion thrips declined towards the crop started to mature (Ullah *et al.*, 2010). According to Gitonga, (2006) finding, the vegetative growth stages were the most susceptible to thrips infestation and protection of onion crops at this growth stage resulted in the highest marginal returns. Therefore, to maximize onion production benefits, proper timing of thrips protection is necessary.

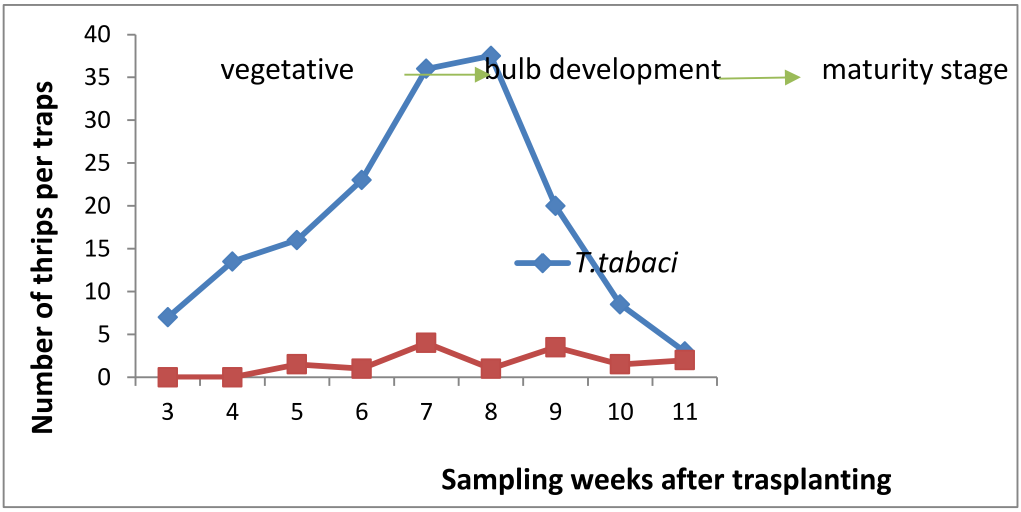

Figure 3. Numbers of adult thrips collected from yellow water traps in onion fields (February, 28 – May 01, 2022).

Effect of insecticides on population of thrips in onion fields

Insecticide application was done weekly and the data were recorded before spraying (pre spray 1), after three days of spraying (post spray 1), and after seven days of the first application (pre spray 2). After three applications, all of the treatments greatly reduced the thrips population in comparison to the untreated control (Table 2). Statistically, except the lambdacyhalothrin, all the tested insecticides are not significantly different in reducing the thrips. All treatments greatly reduced the thrips population after the second application (Table 2). Significantly higher reductions of the thrips and damage were observed on onions sprayed with spinoteram followed by imidacloprid. The lowest thrips population was recorded on onions, treated with spinoteram following the third application of treatments, with a value of 9.08 thrips per plant three days after spraying (Table 2).

Table 2. Effect of insecticides on the population of thrips on onion fields in the CRV of Ethiopia

Treatment	Spray count (Mean number of thrips per plant)					
	Pre sp 1	Post sp1	Pre sp 2	Post sp 2	Pre sp 3	Post sp 3
Control	8.25[ns]	11.0[a]	21.78[a]	24.86[a]	28.39[a]	29.75[a]
lambdacyhalothrin	8.35 [ns]	6.36[b]	14.74[b]	12.13[b]	12.41[b]	10.8[b]
Profenofos	8.63 [ns]	5.80[bc]	15.0[b]	12.08[b]	12.48[b]	9.81[bc]
Spinetoram	8.54 [ns]	4.90[d]	12.0[b]	10.33[b]	10.56[c]	9.08[c]
Imidacloprid	8.60 [ns]	5.71[c]	13.88[b]	11.49[b]	10.94[bc]	9.65[bc]
CV (%)	6.32	9.09	20.37	13.85	11.01	8.79
LSD (5%)	0.55	0.63	3.24	2.02	1.69	1.25

Means with the same letter are not significantly different ns = not significant, s = significant (column).

Level of thrips damage (incidence and severity) on onion treated by different insecticides

Silvery patches characteristically caused by thrips on onion leaves were used to assess thrips damage weekly from the fifth week after transplanting till the crop reaches maturity. Statistically, there is no significant difference in reducing thrips damage incidence after 10 weeks of onion transplanting (Table 3). This indicates that incidence of thrips infestation on onion crop or the presence of thrips per plant without considering the lowest or highest population number. Onion thrips caused damage to onion by feeding leaves that may cause green onions (scallions) to be unmarketable and dry bulb onion size to be reduced (Gill, 2015). Shiberu and Mahammed, (2014) reported that accelerated plant maturity and senescence due to thrips injury may truncate the bulb growth period. Thrips tabaci feeding damage results in leaf tissue silvering and photosynthesis reduction, leading to bulb size reduction and yield loss (Larentzaki *et al.,* 2008).

Statistically, there is significant difference except compared with untreated check in reducing the severity of onion thrips damage. Spinoteram and imidacloprid had the lowest severity score among the insecticides treatment 10 weeks after transplanting with a value of 1.25 and 1.34 respectively (Table 4). The control plot had the highest severity score with a value of 3.55 among the insecticides treatment 10 weeks after transplanting. This indicated that the thrips population caused 26 to 50% of the damage to the onion crop (Table 4). The sequential application of spinetoram and imidacloprid with less effective λ-cyhalothrin and profenofos by mixing with an adjuvant is recommended for thrips control as an integral component of thrips management in the CRV of Ethiopia (Negash et al., 2020).

Table 3. Thrips damage incidence on onion treated with insecticides in six weeks period in the CRV of Ethiopia

Treatment	Weeks after transplanting (W)					
	W5	W6	W7	W8	W9	W10
Control	71.40[ns]	81.2[ns]	92.19[a]	96.41[a]	98.01[a]	100.0[ns]
lambdacyhalothrin	72.14[ns]	81.54[ns]	88.59[b]	93.28[b]	97.92[a]	99.69[ns]
Profenofos	71.15[ns]	81.46[ns]	88.29[b]	93.19[b]	97.66[ab]	99.85[ns]
Spinetoram	72.49[ns]	81.65[ns]	88.11[b]	93.29[b]	96.46 [b]	99.59[ns]
Imidacloprid	69.75[ns]	81.18[ns]	88.13[b]	93.08[b]	97.61[ab]	99.69[ns]
CV (%)	2.90	3.27	4.86	7.87	7.57	9.32
LSD (5%)	3.04	3.51	1.94	2.0	1.46	0.35

Means with the same letter are not significantly different. ns = not significant, s = significant

Table 4. Severity of thrips damage (Scale 1 to 5) on onion under different insecticides in the CRV of Ethiopia

Treatment	Weeks after transplanting (W)					
	W5	W6	W7	W8	W9	W10
Control	2.91[a]	2.95[ns]	2.93[a]	3.26[a]	3.48[a]	3.55[a]
lambdacyhalothrin	2.86[ab]	2.91[ns]	2.75[b]	2.54[b]	2.15[b]	1.53[b]
Profenofos	2.78[b]	2.83[ns]	2.69[bc]	2.51[b]	2.11[b]	1.40[bc]
Spinetoram	2.85[ab]	2.81[ns]	2.55[d]	2.48[b]	2.00[b]	1.25[c]
Imidacloprid	2.91[a]	2.80[ns]	2.59[dc]	2.50[b]	2.05[b]	1.34[c]
CV (%)	4.66	5.24	4.84	6.29	6.95	9.33
LSD (5%)	0.14	0.15	0.13	0.17	0.17	0.17

Means with the same letter are not significantly different. ns = not significant, s = significant

Effect of insecticide application on onion bulb yield

Marketable bulb yield tons per hectare varied significantly across the treatments (Table 5). Plots treated with spinetoram had the highest mean marketable bulb yields (18.07 t/ha) and yield increased by 48.88% over the control followed by imidacloprid with 16.42 tons of marketable bulb and 43.78% yield increase ver the control. The control treatment which was not protected with insecticide had the lowest mean marketable bulb yield (9.14 t/ha). Profenofos and lambdacyhalothrin were intermediate in their performance and gave yield increases of 38.9% and 27.91% (Table 5).

In this study, the damage by thrips caused 27.91 to 48.88% bulb yield loss in CRV of Ethiopia. Similarly, Gitonga (2006) reported yield losses of between 29 and 59% due to thrips infestation. In another study in Ethiopia, onion thrips cause 26% to 57% yield loss in onions (Ayalew *et al.,* 2009). Beside this, at higher infestation, thrips caused up to 50-75% yield loss in onion (Zereabruk, 2017).

Mahmoud et al. (2009) tested spinetoram toxicity against onion thrips in the laboratory and greenhouse and reported a decrease in thrips infestations. Similarly, Diaz-Montano et al. (2012) reported that spinetoram is highly effective against larvae and adult thrips with residual activity of more than seven days. According to Jean-Simon and Victor (2005) reported, pyrethroids insecticide lambda-cyhalothrin can be recommended in rotation with other classes of insecticides for the control of onion thrips. However, straight lambda-cyhalothrin is not recommended because of the quick resistance build-up to synthetic pyrethroids (Jensen, 1995). *T. tabaci* infestations were managed effectively when spinetoram was applied after a three larvae per leaf threshold, but not when using lambda-cyhalothrin (Nault and Shelton, 2010).

Onion thrips can routinely lower bulb yields if they are not controlled. The most crucial methods for thrips control, in addition to IPM, are selective insecticides used in rotation; nevertheless, there are only a few branded insecticides approved in Ethiopia that offer reliable and effective thrips control (Gitonga, 2006).

Similarly, Ayalew *et al.* (2021) suggested insecticide Fighter (imidacloprid) followed by Radiant (spinetoram) performed better in reducing thrips number and minimizing yield loss. The performance of the organophosphate and Pyrethroid insecticides was poor and on par with the untreated check. Treatments with rotational application from different classes performed better than sole application. Periodic evaluation of insecticides registered for the control of the pest from different insecticide classes and development of insecticide application plans need to be made to delay the onset of insecticide resistance. Therefore, it is important to monitor resistant control methods for onion thrips through the rotation of insecticides. Onion growers should be informed of the resistant development of pests due to the repeated application of a single insecticide.

Table 5. Effect of different insecticides application against thrips on onion bulb yield in the CRV of Ethiopia

Treatment	Yield (tons/ ha)			
	Total bulb	Marketable	Unmarketable	Yield increment (%)
Control	9.35^{d}	9.14^{d}	0.21^{ns}	-
lambdacyhalothrin	12.97^{c}	12.73^{c}	0.24^{ns}	27.91
Profenofos	15.30^{b}	15.08^{b}	0.22^{ns}	38.89
Spinetoram	18.29^{a}	18.07^{a}	0.22^{ns}	48.88
Imidacloprid	16.63^{b}	16.42^{b}	0.21^{ns}	43.78
CV (%)	10.86	10.96	13.34	
LSD (5%)	1.62	1.61	0.03	

Means with the same letter are not significantly different. ns = not significant, s = significant

Economic returns

The maximum net return was obtained from spinoteram treatment (US$15,533.65) followed by imidacloprid and profenofos applications, while the lowest net return was from lambda-cyhalothrin (US$10,995.19) (Table 6).

Table 6. Marketable onion bulb yield and partial economic analysis of onion treated with selected insecticides in the CRV of Ethiopia

Treatment	Marketable yield (tons/ha)	Partial economics analysis			
		Gross return (US$/ha)	Cost of insecticides	Cost of insecticide spray	Net return (US$/ha)
Control	9.14	7,909.62	0.0	0.0	7,909.62
lambdacyhalothrin	12.73	11,016.35	13.46	7.69	10,995.19
Profenofos	15.08	13,050.00	11.54	7.69	13,030.77
Spinetoram	18.07	15,637.50	96.15	7.69	15,533.65
Imidacloprid	16.42	14,209.62	19.23	7.69	14,182.69

Conclusion

Two thrips species (*T. tabaci* and *F. occidentalis*) were identified, and both of them belong to the Thripidae family. *T. tabaci* was the most abundant in the study area. The thrips population was higher in the bulb development stage and decreased when the onion was near maturity. Among the four insecticides tested against onion thrips, spinoteram and imidacloprid effectively reduced the population density of the thrips in the field. Those insecticides were the most effective, reducing thrips population. In comparison to the untreated control, profenofos and lambda-cyhalothrin performed better bulb yield. Among the insecticides, the lowest marketable bulb yield was obtained from lambda-cyhalothrin suggesting losses in effectiveness to reduce onion thrips population.

Further studies over a season, location, and other insecticides are required for confirmation and to design thrips resistance management program. Moreover, studies ought to focus on the evaluation of different chemistries of insecticides, schemes of insecticide application, and integration of non-pesticide methods to the current pesticide-dependent onion pest management method.

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Conflict of interest statement

The authors declare that the research was conducted in the absence of any conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Adesiyun, A.A. 1977. Effects of the oat crop environment on colonization by Oscinella

frit L. (Diptera: Chloropidae) (Doctoral dissertation, University of London), 225.
Alemu, D., Dessalegne, L., Anchala, C. and Deressa, A. 2004. Domestic vegetable seed production and marketing. Ethiopian Institute of Agricultural Research (EIAR).
Ayalew, G., Mulatu, B., Negeri, M., Merene, Y., Sitotaw, L., Ibrahim, A. and Tefera, T. 2009. Review of research on insect and mite pests of vegetable crops in Ethiopia. Proceeding of Plant Protection Society of Ethiopia (PPSE): Increasing Crop Production through Improved Plant Protection, 2: 47–67.
Ayalew, G., Sisay, B. and Fekadu, A. 2021. Evaluation and rotational use of registered insecticides towards managing resistance in thrips (Thysanoptera: Thripidae) affecting onion. Results of Plant Protection Research, 228.
Begna, F. 2019. Evaluation of different insecticides for onion thrips management in East Shewa, Ethiopia. Advances in Plants and Agriculture Research, 9(2): 364–367.
Chala Kitila, Abdisa Abraham & Soressa Shuma. 2022. Growth and bulb yield of some onion (Allium cepa L.) varieties as influenced by NPS fertilizer at Dambi Dollo University research site, Western Ethiopia. Cogent Food & Agriculture, 8:1: 2097606.
Daniels, H. and Fors, S. 2015. Supply and value chain analysis of onions in Ethiopia. SLU, Swedish University of Agricultural Sciences.
Diaz-Montano, J., Fail, J., Deutschlander, M., Nault, B.A. and Shelton, A.M. 2012. Characterization of resistance, evaluation of the attractiveness of plant odors, and effect of leaf color on different onion cultivars to onion thrips (Thysanoptera: Thripidae). Journal of Economic Entomology, 105(2): 632–641.
Ethiopian Agricultural Research Organization (EARO). 2004. Directory of released crop varieties and their management. Addis Ababa, Ethiopia.
FAO. 2020. Crop production data: http://www.faostat.fao.org, Accessed October 26, 2021.
Gill, H.K., Garg, H., Gill, A.K., Gillett-Kaufman, J.L. and Nault, B.A. 2015. Onion thrips (Thysanoptera: Thripidae) biology, ecology, and management in onion production systems. Journal of Integrated Pest Management, 6(1): 1–9.
Gitonga, L.M., Waiganjo, M.M. and Mueke, J.M. 2006. Susceptible onion growth stages for selective and economic protection from onion thrips infestation. In XXVII International Horticultural Congress-IHC2006: International Symposium on Sustainability through Integrated and Organic, 767: 193–200.
Haile, B., Babege, T. and Hailu, A. 2016. Constraints in production of onion (Allium cepa L.) in Masha District, Southwest Ethiopia. Global Journal of Agriculture and Agricultural Sciences, 4(2): 314–321.
Hodges, A., Ludwig, S., Osborne, L. and Edwards, G.B. 2009. Pest thrips of the United States: field identification guide. USDA-CSREES Integrated Pest Management Centers in cooperation with the National Plant Diagnostic Network, APHIS, the National Plant Board, and the Land Grant Universities, 143.
Jean-Simon, L. and Victor, J.R. 2005. Integrated management of onion thrips (Thrips tabaci) in onion (Allium cepa L.). Proceedings of the 118th Annual Meeting of the Florida State Horticultural Society, 118: 125–126.
Jensen, L. 1995. Strategies for controlling onion thrips (Thrips tabaci) in sweet Spanish onions. Annual Report of Malheur County Crop Research, Oregon State University, 26: 26–33.
Ketema, S., Dessalegn, L. and Tesfaye, B. 2013. Effect of planting methods on maturity and yield of onion (Allium cepa var. cepa) in the Central Rift Valley of Ethiopia. Ethiopian Journal of Agricultural Sciences, 24(1): 45–55.
Kumar, K.S., Bhowmik, D., Chiranjib, B. and Tiwari, P. 2010. Allium cepa: A traditional medicinal herb and its health benefits. Journal of Chemical and Pharmaceutical Research, 2(1): 283–291.
Larentzaki, E., Shelton, A.M. and Plate, J. 2008. Effect of kaolin particle film on

Thrips tabaci (Thysanoptera: Thripidae), oviposition, feeding and development on onions: A lab and field case study. Crop Protection, 27(3–5): 727–734.

Mahaffey, L.A. and Cranshaw, W.S. 2010. Thrips species associated with onion in Colorado. Southwestern Entomologist, 35(1): 45–50.

Mahmoud, M.F., Osman, M.A.M., Bahgat, I.M. and El-Kady, G.A. 2009. Efficiency of Spinetoram as a biopesticide to onion thrips (Thrips tabaci Lindeman) and green peach aphid (Myzus persicae Sulzer) under laboratory and field conditions. Journal of Biopesticides, 2(2): 223–227.

Mayer, D.F., Lunden, J.D. and Rathbone, L. 1987. Evaluation of insecticides for Thrips tabaci (Thysanoptera: Thripidae) and effects of thrips on bulb onions. Journal of Economic Entomology, 80(4): 930–932.

Mehle, N. and Trdan, S. 2012. Traditional and modern methods for the identification of thrips (Thysanoptera) species. Journal of Pest Science, 85(2): 179–190.

Mengistie, B.T., Mol, A.P.J. and Oosterveer, P. 2017. Pesticide use practices among smallholder vegetable farmers in Ethiopian Central Rift Valley. Environment, Development and Sustainability, 19(1): 301–324.

Miller, A.L.E., Tindall, K. and Leonard, B.R. 2010. Bioassays for monitoring insecticide resistance. Journal of Visualized Experiments, (46): 3–7.

Nault, B.A. and Shelton, A.M. 2010. Impact of insecticide efficacy on developing action thresholds for pest management: a case study of onion thrips (Thysanoptera: Thripidae) on onion. Journal of Economic Entomology, 103(4): 1315–1326.

Neergude, M., Biradar, A.P., Veerendra, A.C. and Ravulapenta, S. 2014. Seasonal abundance of onion thrips, Thrips tabaci Lindeman and their natural enemies under dry land conditions. International Journal of Advances in Pharmacy, Biology and Chemistry, 3: 33–36.

Negash, B., Azerefegn, F. and Ayalew, G. 2019. Farmers insecticide use practices and species composition and abundance of thrips species (Thysanoptera: Thripidae) on onion in the Rift Valley of Ethiopia. African Journal of Agricultural Research, 14(32): 1537–1543.

Negash, B., Azerefegn, F. and Ayalew, G. 2020. Insecticide resistance management against thrips (Thysanoptera: Thripidae) on onion in the central Rift Valley of Ethiopia. International Journal of Tropical Insect Science, 40(4): 759–767.

Negesse, A., Gizachew, S., Esmael, A. and Bati, B. 2020. Crop production system and their constraints in East Shewa Zone, Oromia National Regional State, Ethiopia. International Journal of Energy and Environmental Science, 5(2): 30.

Osorio, A., Martínez, A.M., Schneider, M.I., Díaz, O., Corrales, J.L., Avilés, M.C., Smagghe, G. and Pineda, S. 2008. Monitoring of beet armyworm resistance to spinosad and methoxyfenozide in Mexico. Pest Management Science: formerly Pesticide Science, 64(10): 1001–1007.

Palmer, J.M. 1990. Identification of the common thrips of tropical Africa (Thysanoptera: Insecta). International Journal of Pest Management, 36(1): 27–49.

Palomo, L.A.T., Martinez, N.B., Johansen-Naime, R., Napoles, J.R., Leon, O.S., Arroyo, H.S. and Graziano, J.V. 2015. Population fluctuations of thrips (Thysanoptera) and their relationship to the phenology of vegetable crops in the central region of Mexico. Florida Entomologist, 98: 430–438.

Pathak, M.K., Pandey, M.K., Pandey, S., Gupta, R.C. and Gupta, P.K. 2021. Effect of silica-based surfactant on the efficacy of different insecticides against onion thrips. Journal of Entomological Research, 45(suppl): 967–970.

Rodríguez, D. and Coy-Barrera, E. 2023. Overview of updated control tactics for western flower thrips. Insects, 14(7): 649.

SAS Institute. 2017. Base SAS 9.4 procedures guide: Statistical procedures. SAS Institute.

Shiberu, T. and Mahammed, A. 2014. The importance and management option of onion thrips, Thrips tabaci (L.) (Thysanoptera: Thripidae) in Ethiopia: A review. Journal of Horticulture, 1(2): 1–6.

Smith, C.M., Khan, Z.R. and Pathak, M.D. 1993. Techniques for evaluating insect resistance in crop plants. CRC Press, 320.

Stuart, R.R., Gao, Y., Lin, and Lei, Z. 2011. Thrips: Pests of concern to China and the United States. Agricultural Sciences in China, 10(6): 867–892.

Tekeste, N., Dechassa, N., Woldetsadik, K., Dessalegne, L. and Takele, A. 2018. Influence of nitrogen and phosphorus application on bulb yield and yield components of onion (Allium cepa L.). The Open Agriculture Journal, 12(1).

Teshika, J.D., Zakariyyah, A.M., Zaynab, T., Zengin, G., Rengasamy, K.R., Pandian, S.K. and Fawzi, M.M. 2019. Traditional and modern uses of onion bulb (Allium cepa L.): A systematic review. Critical Reviews in Food Science and Nutrition, 59(sup1): S39–S70.

Ullah, F., Maraj-ul-Mulk, Farid, A., Saeed, M.Q. and Sattar, S. 2010. Population dynamics and chemical control of onion thrips (Thrips tabaci, Lindemann). Pakistan Journal of Zoology, 42(4): 401–406.

Zereabruk, G. 2017. Seasonal distribution and abundance of thrips (Thysanoptera: Thripidae) on onion production in central zone of Tigray, Ethiopia. International Journal of Life Sciences, 5(3): 323–331.

Zhao, X., Reitz, S.R., Yuan, H., Lei, Z., Paini, D.R. and Gao, Y. 2017. Pesticide-mediated interspecific competition between local and invasive thrips pests. Scientific Reports, 7: 1–7.