World Journal of Environmental Biosciences
Available Online at: **www.environmentaljournals.org**

Volume 12, Issue 1: 32-40

https://doi.org/10.51847/bbmj8P5dll

ISSN 2277- 8047

Integrated Management of Onion Thrips on Onion, Mecha District, Ethiopia

Etagegn Mulu[1], Abaynew Jemal Jenber[2*], Adane Tesfaye[2], Besfat Belay[2]

[1]*Department of Plant Sciences, Wollo University, Dessie, Ethiopia.*
[2]*Department of Plant Sciences, Bahir Dar University, Bahir Dar, Ethiopia.*

ABSTRACT

Insect pests like thrips attack onion crops and cause a yield loss of 30-90% in the Mecha district. Hence, field research was conducted in Mecha District, Ethiopia, under irrigation conditions in 2019/2020 to develop management options for onion thrips. The treatment combinations were: two onion varieties: Adama red and Bombay red; two botanicals, namely, Datura stramonium and Azadirachta indica leaf powder, and the two synthetic insecticides, dimethoate (40%) and karate (5%). The study was set up in a randomized full-block design and repeated three times. Data were recorded and an analysis of variance was performed 3 times. The highest mortality percentage (65%) with the lowest population of thrips per plant (1.66) was shown from the Adama red variety treated with Datura stramonium. The lowest mortality (24.43%) with a high population of thrips per plant (4.0) was shown on Bombay red treated with Karate 5% EC. Bombay treated with Karate 5% EC gave the highest mortality percentage (53.3%), plant height (13.2 cm), marketable yield in kg ha-1 (8600, and total yield ha-1 (9441), subsequently Adama red treated with Datura stramonium. Partial budget analysis revealed that the application of Karate 5% EC ha-1 on the Bombay red variety yielded the highest net benefit with the lowest production cost that can be recommended for the study area.

Keywords: *Botanicals, Insecticides, Onion varieties, Thrips infestation*

Corresponding author: Abaynew Jemal Jenber
e-mail ✉ abujemal900@gmail.com
Received: 20 November 2022
Accepted: 03 March 2023

INTRODUCTION

Onion (*Allium cepa* L.), is a vital bulb crop and is associated with the Alliaceae family. It is regarded as the second most crucial horticultural crop, after tomatoes, with annual world production in 2017 of around 97 million tonnes (FAOSTAT, 2019). The bulbs are the fleshy structure that serves as a storage organ and vary in size, shape, color, and pungency, though warmer climates generally produce onions with a milder, sweeter flavor as compared to other climates. Physical protection is given by the dry outer papery scales, which form a close-fitting coat around the bulb.

Onions are one of the most commonly grown and commercialized vegetables grown under irrigation in the Amhara region of Ethiopia. Currently, farmers in the most irrigable areas of the Amhara region produce large numbers of onion bulbs each year. In Mecha District (study site), during 2016–2017, onions covered 931 hectares of land, and 10,719,100 kg was produced, of which 8,039,300 kg was supplied to the market (ATA, 2018).

This may make green onions unmarketable and dry bulb onions less expensive. Onion thrips feeding can reduce bulb yields by 60% as well as transmit plant pathogens and exacerbate plant diseases (Leach *et al*., 2020). In Ethiopia, onion thrips are a major insect pest that destroys onion farms, especially during the dry season when rainfall is scarce. Yield loss in onion bulbs by onion thrips has been reported to range from 10-85% (Esheteu *et al*., 2015).

Despite the immense merits of onions, their production has been constrained by a myriad of biotic and abiotic factors, as well as institutional ones. Yield losses of 26-57% were reported due to onion thrips in Ethiopia. Eshetetu *et al*. (2015) also reported a yield loss of 10-85% in the Upper Awash Agro-Industry Enterprise. These low yield results indicated the presence of a huge gap in using improved onion varieties and appropriate insecticides because of the absence of improved cultivars and limited attention and awareness of the benefits of botanical and synthetic insecticides. Therefore, this research was carried out to evaluate selected onion varieties, botanicals, and synthetic insecticides as management options for onion thrips in the study area.

MATERIALS AND METHODS

Description of the study site

This literature was done in *Mecha* District, Northwestern Ethiopia, under irrigation conditions during 2019/2020. Mecha District is geographically located at 11°10′ N to 11°25′ N latitude & 37°02′ E to 37°17′ E longitude with an elevation of 1960 m. a. s. l (Meters above sea level). Annual rainfall is 1395.23 mm. The mean maximum and minimum temperatures are 27 °C and 12.8 °C, respectively. The major crops produced in the area are *Zea mays, Eleusinecoracana*, *Triticumaestivum,* and *Eragrostistef* on the course of the main cropping season, and *Triticum aestivum*, *Solanum tuberosum*, *Allium cepa*, and *Brassica oleracea* during the irrigation season. The soil type of the area is characterized by 93% red soil, 3% black soil, and the remaining 4% gray soil.

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Experimental materials and design

For each variety, seeds of the Bombay and Adama varieties were sown at the rate of 4 kg ha-1 (EIAR, 2007) on a 5 x 1 m well-prepared seedbed. The seedbeds were spaced 50 cm apart. After the seeds were sown, they were lightly covered with soil. All the necessary management practices were applied except for insecticides. Fifty days after sowing, the seedlings were transplanted into the experimental field. A Knapsack sprayer was used for spraying the insecticides. At the time of insecticide sprays, plastic sheets were used to prevent spray drift within plots.

There were ten treatment combinations of two onion varieties, i.e., Adama red and Bombay red, and four insecticides, i.e., two botanicals, jimson weed (*Datura stramonium*), neem (*Azadirachta indica*) leaf powder, and two synthetic insecticides, dimethoate (40%) and Karate (5%), applied to 10 experimental units. Experiments were designed with a factorial randomized complete block design (RCBD) with three replicates. Each plot is made up of ten rows two meters in length. The size of the gross plot was 2m x 2m (4 m^2), and the total area was 232 m^2. With spacing for improved onion production, 10 cm was spacing between plants, 20 cm between rows, and 40 cm was the size of the plant bed, including the irrigation water path used for irrigating the plants. The spaces between plots and replications were 1m and 1m wide, respectively. Diammonium phosphate (4.64 kg) and UREA (3.48 kg) fertilizers were applied and all agronomic practices were undertaken (EIAR, 2007).

Methods of botanicals collection and extraction

Neem (*Azadirachta indica*): The neem leaves were collected and dried in the laboratory for 3 days, and then ground using an electrical blender to make a coarse powder. 50 g of the powder was dissolved in one liter of water and extracted overnight. The next day, it was filtered with cheesecloth and diluted with one liter of neem leaf extract and nine liters of water. The solutions were ready to spray on onions infested with thrips. The application was made during evening watering. In Ethiopia, the economic threshold level for onion thrips was five to ten thrips per plant.

Jimson weed (*Datura stramonium*): Leaves were collected and dried in the laboratory for three days and ground using an electrical blender to make a coarse powder. The powder was mixed with water at a rate of 50 g/l and left overnight as described in (Keshav & Singh, 2013). The mixture was filtered the following day by the use of cheesecloth and then prepared for spraying when the threshold of five thrips per plant was exceeded (Alemnew, 2017).

Data collection

Vegetative data

The number of leaves per plant was obtained from 10 randomly selected plants. One week before harvest, measurements were taken on 10 randomly selected plants from each treatment plot in the central row.

Plant height (cm): was measured from the soil surface to the apex of the plant using a ruler at harvest.

Bulb yield and yield components

Biomass yield (kg): Biomass yields were recorded from ten randomly sampled plants after harvesting.

Marketable bulb yield (kg): determined after discarding unmarketable yields, which are damaged, small bulbs, splitters, thick-necked bulbs, doubles, rotten, off-color, and discolored bulbs. The weight of healthy bulbs and they are having locally acceptable marketable size were taken at harvest from each harvestable plot, excluding borders.

Unmarketable yield (kg): damaged, small bulbs, splitter, thick-necked, doubles, rotten, off-color, and discolor bulbs were taken at harvest from each harvestable plot, excluding border rows.

Total yield (kg): was calculated by adding marketable and unmarketable yield.

Number of thrips/plant

Data on thrips numbers were recorded at 15-day intervals, starting a week after transplanting and continuing until physiological maturity. The nymphs and adults were counted by inspecting the entire plant with a 10x hand lens. The thrips were counted during the wind-free time of the day, late afternoon.

The percent reduction in thrips/plants was calculated using the formula in Dutta *et al*. (2014) as in Eq. 1.

$$\text{Efficacy (\%)} = \frac{\text{Pre} - \text{spray count} - \text{Post– spray count}}{\text{Pre} - \text{spray count}} \times 100 \quad (1)$$

Onion thrips infestation

Infestation with thrips was determined by counting thrips from ten plants in each plot. Infestation started a week after transplanting and continued until the physiological maturity of the onion. The percentage of thrips was calculated as a ratio of infested to total sampled plants (Dutta *et al*., 2014), as in Eq. 2.

$$\%\ \text{infestation} = \frac{\text{No. of infested plants}}{\text{Total plants observed}} \times 100 \quad (2)$$

Thrips damage severity on onion per plant

The presence of silvery patches on onion leaves was used to determine the severity of thrip damage. About ten onion plants were randomly selected from each plot. Damage levels were rated a week after transplantation and continued until harvest. Leaves of each randomly tagged standing plant were examined based on (Smith *et al*., 1994) to assess severity on a scale of 1–5. Where 1 = no damage, 2 = up to 25%, 3 = 26–50%, 4 = 51–75%, and 5 = > 75% damage.

Relative yield loss

The relative yield loss in yield components of each variety was determined as a percentage of the sprayed plots of the respective varieties. The losses were determined separately for each of the treatments with different levels of damage by using the formula given by (Shiberu & Negeri, 2014) as in Eq. 3.

$$\text{Relative Loss (\%)} = \frac{\text{Protected treatment – untreated treatment}}{\text{Protected treatment}} \times 100 \quad (3)$$

Method of data analysis

The Data were subjected to a two-way analysis of variance since they have an interaction effect using the PROC-GLM procedure of SAS version 9.1. The means were compared using Fisher's

LSD test at a 5% or 1 % level of significance.

Economic analysis

The analysis of the economic data was conducted by abiding by CIMMYT (1988) and used to determine the income and expenses of every management employed in the study. The various costs of this study, including seeds, insecticides, and labor, have been considered. Pesticide costs were obtained from pesticide companies and local distributors. The purchase cost of seeds was 1300 and 1200 Kg/Birr for the Adama and Bombay red varieties, respectively. The cost of daily labor was 150 birr per day. The selling price of the marketable outcome at harvesting season on the local market was birr 43 per kg^{-1}. The total cost of all treatments was calculated. Management was graded in ascending fashion of total variable cost and net profit was determined. Dominance analysis was used to eliminate treatments that were the most expensive but had a lower net benefit than the next lowest-cost treatment. To calculate gross income, Yields obtained from each treatment were used by ten percent and subjected to a partial budget analysis. The following formula was used to compute the partial budget analysis, as in Eq. 4.

$$\text{Net field benefits (NBs)} = \text{Gross field benefits (GB)} - \text{Total variable costs (TVC)} \qquad (4)$$

For the calculation of the marginal rate of return, the following formula was applied as in Eq. 5.

$$\text{MRR} = \text{DNI}/\text{DIC} \qquad (5)$$

DNI= difference in net income compared with the control, DIC= difference in input costs compared with the control.

RESULTS AND DISCUSSION

The population of onion thrips is influenced by varieties and insecticides

In different treatments, the onion thrip population (both nymphs and adults) per plant varied from 4.33 to 5.66 a day before treatment application **(Table 1)**. The analysis of variance revealed that varieties showed no significant effect on onion thrip numbers ($p > 0.05$). However, the major influence of insecticide application and the communication effect of varieties and insecticides consist of a very highly considerable ($p < 0.001$) effect on the number of onion thrips **(Table 2)**. After one and two days of insecticide application, the number of onion thrips on untreated plots varied from seven on the Bombay diversity to eight on the Adama variety **(Table 1)**. The lowest number of onion thrips and the highest mortality percentages of 3 and 30% were recorded from both varieties treated with *A. indica*, followed by Karate 5% EC with a mean population of four and a mortality percentage of 24.43%. In the control plot, however, the onion thrips population increased by 29.5% and 39.15% for the Bombay and Adama varieties, respectively.

After 3 and 7 days, results found that the Adama red variety treated with *D. stramonium* showed the least thrips population/plant (3 and 1.66) and mortality percentages of 40% and 65.46%, respectively, followed by the Bombay red variety treated with *A. indica* with a mean population of 3 and 2, and a mortality percentage of 30 and 53.33, respectively. On the other hand, there was an increase of 40% and 79% in the thrips population in the control plot, respectively. Among the insecticide treatments used, botanicals had the lowest population of thrips and plants and the highest mortality percentage across all data recording intervals. The efficacy of synthetic insecticide treatments decreased with an increase in data collection intervals. In the case of botanicals, the efficacy of plant extracts increased with the increase in the data collection interval. Several researchers have reported that botanicals presented a considerable effect in decreasing the injury of onion thrips (Bradford *et al*., 2020; Begna, 2022; Shettima *et al*., 2022). The overall mean population of thrips recorded on the onion crop ranged from 1.66 to 10 per plant. The number of onion thrips increased daily in the untreated control plot, which had 4.33–10 thrips per plant in each treatment. After seven days, plots treated with botanical and synthetic insecticides showed the maximum reduction in thrips populations. The maximum mortality rate was recorded for treatment with *D. stramonium* (65.46%), and the least was recorded for Karate (24.43%)-treated plots. The treatment of *D. stramonium* was the most efficient (65.46% mortality) in reducing the onion thrips population on onion crops, followed by *A. indica* (53.33%) and dimethoate 40% EC (50%). These results showed a greater reduction in insecticide-treated plots, and infestation increased in untreated plots. Thus, all treatments were significantly superior to untreated controls, causing 24.43-65% or more thrips mortality. Khaliq *et al*. (2014) reported that neem, Datura, and bitter apple caused significant reductions (45-70%) in onion thrips populations. Shettima *et al*. (2022) also showed that neem seed, neem oil, and fresh ginger are effective against onion thrips. Iglesias *et al*. (2021) concluded that biopesticides are an important component of an onion thrips management program. It has been also reported that carbosulfan, cypermethrin EC deltamethrin+ triazophos, bifenthrin, and dimethoate reduced the *T. tabaci* population for more than two weeks and the effect of imidacloprid was better than cyhalothrin (Ashghar *et al*., 2018).

Table 1. Effect of Varieties and Insecticides on Population and percentage mortality of onion thrips

Variety	Insecticides	Before Treatment	No. of population After treatment				Mortality Percentage after Treatment			
		1day	1day	2 days	3 days	7days	1day	2 days	3 days	7 days
Adama	Nonspray	5.66^{a}	7.33^{a}	7.66^{a}	8^{a}	10^{a}	-29.5^{bac}	-36.15^{b}	- 40.93^{ba}	-79.03
	D. stramonium	5^{a}	3.66^{b}	3.66 ^{b}	3^{b}	1.66^{c}	26.16^{bac}	26.66^{cb}	39.26^{ab}	65.46^{bac}
	A .indica	4.33^{a}	3^{b}	3 ^{b}	3^{b}	2.33^{cb}	30^{bac}	30^{cb}	30^{bc}	46.66^{d}

	Karate	5.33^{a}	4^{b}	4 ^{b}	4^{b}	3b	24.43^{bc}	24.43^{c}	24.43^{c}	24.43
	Dimethoate	4.33^{a}	3^{b}	3 ^{b}	3^{b}	2^{cb}	30^{bac}	3o^{cb}	30^{bc}	50^{bdc}
Bombay	Nonspray	5.33^{a}	7^{b}	8^{a}	8^{a}	9^{a}	-30.53^{ba}	-50^{a}	-50^{a}	- 69.4^{ba}
	D. stramonium	5^{a}	4^{b}	3.66^{b}	3^{b}	2.33^{cb}	20^{c}	26.66^{cb}	40^{ba}	53.33^{bdc}
	A .indica	4.33^{a}	3^{b}	3^{b}	3^{b}	2^{cb}	30^{bac}	30^{cb}	30^{bc}	53.3^{bdc}
	Karate	5.33^{a}	4^{b}	4^{b}	4^{b}	3^{b}	24.43^{bc}	24.43^{c}	24.43^{c}	24.43
	Dimethoate	4.66	3^{b}	3.33^{b}	3.33^{b}	2.33^{cb}	35^{a}	28.33^{cb}	28.33^{bc}	50^{dc}
LSD		1.35	1.33	1.32	1.38	1.09	10.06	9.7	13.37	16.67
CV		20.95	18.55	17.87	19.12	17.02	20.95	18.46	23.11	17.44

Onion thrips infestation is influenced by the interaction of varieties and insecticides

A highly significant difference between the treatments was observed after insecticide application **(Table 2)**. The analysis of variance showed that varieties had no significant effect on onion thrips infestations. However, the main effect of insecticide application and the interaction effects of varieties and insecticides had a very highly significant ($p = 0.001$) effect on thrips infestation.

On the first days of treatment application (62 days), the maximum mean infestation (56.6%) was observed in the untreated plot of the Adama variety, and the minimum (30) onion thrips infestation was recorded in the Bombay variety treated with *D. stramonium,* and *A. indica.* After a week of treatment application (69 Days), the infestation was 70% at the Bombay variety, 73.3 at the Adama variety on untreated plots, 20 at the Bombay variety treated with *D. stramonium,* and 30 at the Adama variety treated with *A. indica*.

After the second week of treatment application (76 days), the infestation was 76.6% at the Adama variety,80 at the Bombay variety on untreated plots, and 30 at the Adama variety and the Bombay variety treated with *A. indica.* A substantial dissimilarity in thrips infestation was detected between the unsprayed plots (80) and *A. indica.* Treated plots represented 43.3% of all varieties after the third week of treatment application (83 days) and at the final week (90 days) of application of insecticides, 100% infestation was observed on untreated plots of the Adama red, and a minimum of 20% was recorded from the Bombay red treated with *A. indica* **(Table 2)**. Thrips infestation was significantly higher in unprotected plots than in protected plots. Onions sprayed with neem oil had fewer *T. tabaci* and produced higher yields than onions unsprayed, regardless of the onion cultivar (Iglesias *et al*., 2021). Botanicals possessed considerable differences in mortality rate and the efficacy of botanical showed that neem seed powder was significantly superior in efficacy (Tesfaye *et al*., 2021). Controlling thrips populations with botanicals can increase onion production yield, even though botanicals are not equally effective as chemical insecticides in reducing thrips populations and reducing associated losses (Begna, 2022).

The difference in onion thrips infestation between sprayed and unsprayed plots might be due to insecticide effectiveness. The highest thrips infestation was recorded on untreated plots than on treated plots. Abdul *et al*. (2014) tested the effectiveness of three botanicals (Neem, Datura, and Bitter Apple) and three synthetic insecticides (Acephate, Spirotetramat, and Spinetoram) against onion thrips in an experimental field in Pakistan. He found that thrips populations were significantly reduced by all botanicals and chemical insecticides tested (45–70%), with botanicals controlling more than 60%.

Table 2. Effect of varieties and insecticides on onion thrips infestation on different days

Treatments		**Percentage of infestation on different days**				
Variety	Insecticide	62	69	76	83	90
Adama	Nonspray	56.6^{a}	73.3^{a}	76.6^{a}	80^{a}	100^{a}
	D. stramonium	33.3^{b}	33.3^{b}	36.6^{b}	50^{b}	23.3^{b}
	A. indica	30.0^{b}	30.0^{b}	30 ^{b}	43.3^{b}	23.3^{b}
	Karate	36.6^{b}	33.3^{b}	33.3^{b}	53.3^{b}	26.6^{b}
	Dimethoate	30^{b}	30^{b}	30^{b}	43.3^{b}	20^{b}
Bombay	Nonspray	53.3^{a}	70^{a}	80^{a}	80 ^{a}	90^{a}
	D. stramonium	30^{b}	20^{b}	30^{b}	50 ^{b}	26.6^{b}
	A. indica	30^{b}	30^{b}	30 ^{b}	43.3^{b}	20^{b}
	Karate	36.6^{b}	36.6^{b}	33.3^{b}	53.3^{b}	30^{b}
	Dimethoate	30^{b}	33.3^{b}	30 ^{b}	46.6^{b}	23.3^{b}
LSD		10.5	13.9	13.5	16.6	12.4
CV%		16.8	20.3	19.2	17.8	18.9

Onion thrips damage severity scale influenced by varieties and insecticide application

Extended leaf damage scores had significant differences between treatments. The analysis of variance revealed that varieties had no significant effect on the thrips damage severity scale. However, the main effect of insecticide application and the interaction effect of varieties and insecticides had a very highly significant ($p < 0.001$) effect on the damage severity scale.

At 62, 69, 76, and 83 days after treatment applications, the highest leaf damage (51–75%) was observed from the untreated plot of the Bombay red variety, while the least (26–50%) was recorded from the treated plots of both varieties. In the final week (90 days) of application of insecticides, the highest leaf damage (> 75%) and lowest leaf damage (51–75%) were shown on the unsprayed plots of the Adama, and Bombay varieties respectively. Whereas Bombay red treated with *Azandirachta indica* and Adama variety treated with dimethoate showed the least leaf damage (up to 25%) **(Table 3)**. All insecticides have control characteristics that can reduce onion thrips populations below threshold levels. Most growers are concerned about leaf damage, so insecticides are generally considered the most effective way to protect crops against insect damage. Biopesticides reduce *onion thrips* densities in onions. Reductions in thrips densities of 17.2% using Datura species extracts have been reported (Fitiwy *et al*., 2015; Davani *et al.,* 2022).

Table 3. Effect of insecticides and varieties on onion thrips damage severity scale at various weeks

Treatment		Damage severity scale on different days				
Variety	**Insecticide**	**62**	**69**	**76**	**83**	**90**
Adama	Nonspray	3.2^{b}	4.3^{a}	4.3^{a}	4.3 ^{a}	5^{a}
	D. stramonium	3^{c}	3^{b}	3^{b}	3.3^{b}	2.3^{cb}
	A. indica	3^{c}	3^{b}	3^{b}	3 ^{b}	2.3^{cb}
	Karate	3^{c}	3^{b}	3^{b}	3.3^{b}	2.6^{cb}
	Dimethoate	3^{c}	3^{b}	3^{b}	3 ^{b}	2^{c}
Bombay	Nonspray	4^{a}	4.3^{a}	4.6^{a}	4.3^{a}	4.66^{a}
	D. stramonium	3^{c}	3^{b}	3^{b}	3 ^{b}	2.6^{cb}
	A. indica	3^{c}	3^{b}	3^{b}	3 ^{b}	2^{c}
	Karate	3^{c}	3^{b}	3^{b}	3.3^{b}	3^{b}
	Dimethoate	3^{c}	3^{b}	3^{b}	3 ^{b}	2.3^{cb}
LSD		0.31	0.68	0.43	0.89	0.74
CV%		5.8	12.2	7.6	15.4	14.9

Effect of varieties and insecticides integration on relative yield losses

A maximum grain yield loss of 38.66% on the Bombay red variety during the study season was recorded. The Adama red variety showed a grain yield loss of 31.86% **(Table 4)**. The level of infestation and the extent of yield losses due to thrips on onions were reported by various researchers differently. Damage levels could be higher on untreated onion crops. The current study was in line with Gebremedhn *et al*. (2018) reported significant differences within varieties for marketable bulb yield in onions. Apart from these, damage by thrips results in inferior quality at harvest, which in turn fetches low prices.

Table 4. Effect of Varieties and Insecticides on Relative yield losses, and Growth Parameters

Treatment		**Marketable yield (kg/ha)**	**Relative yield loss (%)**	**Plant height in cm**	**Number of leaf/ plant**
Adama	Nonspray	6250^{dc}	0	10.96dc	22.6dc
	D. stramonium	7350^{bc}	7.25	11.3dc	35.56b
	A. indica	5400^{e}	31.86	8.33f	17e
	Karate	6950^{bc}	12.3	12.66ba	24.23c
	Dimethoate	7200^{bc}	9.14	11.5bc	20.1de
Bombay	Nonspray	5550de	35.46	9.7e	18.03e
	D. stramonium	6525^{dc}	24.12	13.2a	33.7b
	A. indica	5825de	32.26	10.86dce	21.76dc
	Karate	8600^{a}	0	11.96bc	43.03a
	Dimethoate	5275^{e}	38.66	10.13de	20.26de

LSD	1.28	3.3	1.23	3.3
CV%	9.37	7.51	6.49	7.51

Effect of varieties and insecticides integration on growth parameters of onion

Plant height

The analysis of variance revealed that the main factor of variety was not significant. However, the main effect of insecticide application and the interaction effect of varieties and insecticides had a very highly significant ($p < 0.001$) effect on plant height. The tallest plants (13.2 cm) and (12.6 cm) were observed in a variety of Bombay treated with *Datura stramonium* and the Adama variety treated with Karate 5% EC, respectively **(Table 4)**. Shetimma *et al*. (2022) revealed that neem seed was recorded with the highest plant height followed by fresh ginger while the control was recorded with the lowest plant height followed by pepper seed.

Number of leaves

The current result revealed that the main effect of insecticide application had a significant ($p < 0.05$) effect on leaf number per plant. However, the main effect of varieties was not significant. The interaction effect of varieties and insecticides had a highly significant ($p < 0.01$) difference in leaf number per plant. The maximum number of leaves per plant (43.03) was recorded on the Bombay variety treated with *Datura stramonium* while the minimum number of leaves per plant was observed on the Adama variety treated with *Azadirachta indica* **(Table 4)**. Shetimma *et al*. (2022) show that control appeared with the highest number of leaves affected followed by pepper seed while the least leaves damage was recorded under fresh ginger followed by neem Seed. However, there is no damage left recorded under the plot treated with neem seed.

Effects of insecticides and varieties integration on yield components of onion

The analysis of variance showed that a variety was not significant ($p > 0.05$) on marketable and total yield ha^{-1}. But, the application of insecticide and the interaction effect of varieties and insecticides had a very highly significant ($p < 0.001$) effect on marketable, and total yield ha^{-1}. The main effects of insecticide application, variety, and the interaction effect of varieties and insecticides had a very highly significant ($p < 0.001$) effect on biomass weight in kg ha-1. The highest biomass weight in kg/ha-1, 9166.6 kg/ha, was recorded in Bombay, treated with karate. Similarly, the highest marketable yield in kg ha-1 (8600), the total yield in kg ha-1 (9441.6), and the lowest unmarketable yield in kg ha-1 (833.3) were recorded on Bombay treated with karate, followed by Adama treated with *D. stramonium* biomass weight in kg ha-1 (8609), marketable yield in kg ha-1 (7350), total yield in kg ha-1 (9025), and unmarketable yield in kg ha-1 (966.6). Similarly, the smallest measurements of Biomass weight in kg ha-1(5833.3) on Bombay treated with *A. indica*, marketable yield, and the total yield in kg ha-1, 5400, and 6108, respectively was observed on Adama variety treated with *A. indica* **(Table 5)**.

Yields of control plots were significantly lower than those of all other insecticides tested. Onion thrips damage can reduce onion yields by 9-25% compared to controls **(Table 5)**. These results are consistent with those of Ibrahim *et al*. (2015) found significant differences in onion yield between dimethoate 40°, wood tobacco, karate 5°, Mexican marigold, and control groups. Plots treated with wood tobacco and karate 5 achieved tuber yields of > 30% compared to controls. Many studies have reported that higher bulb yields were obtained with insecticides that reduced thrip density (Negash *et al*., 2020; Bahri *et al.*, 2022). When onion thrips infestations remained above economic threshold levels, crop damage, and lower yields occurred. Therefore, in the present study, the control plot yielded a lower yield. When thrips population densities exceeded the economic threshold level, onion bulb yield was negatively correlated with the thrips population.

Table 5. Effect of varieties and insecticides on yield and yield components of onion

Treatment		Biomass yield (kg/ha)	Marketable yield (kg/ha)	Unmarketable yield (kg/ha)	Total yield (kg/ha)
Variety	Insecticide				
Adama	Nonspray	7666.6^{cd}	6250^{dc}	966.6^{ba}	8325^{bac}
	D. stramonium	8609.1^{cb}	7350^{bc}	1250^{a}	9025^{ba}
	A. indica	6525^{ed}	5400^{e}	833.3^{b}	6108^{e}
	Karate	83333.3^{cb}	6950^{bc}	966.6^{ba}	7916^{bc}
	Dimethoate	8608cb	7200^{bc}	966,6^{ba}	7916.6^{bc}
Bombay	Nonspray	6666.6^{ed}	5550de	833.3^{b}	6383.3^{e}
	D. stramonium	7633.3^{cd}	6525^{dc}	1250^{a}	7775^{dc}
	A. indica	5833.3^{e}	5825de	1108.3^{ba}	6666.6^{ed}
	Karate	9166.6^{b}	8600^{a}	833.3^{b}	9441.6^{a}
	Dimethoate	6525^{ed}	5275^{e}	966.6^{ba}	6383.3^{e}
Least significance difference		1.72	1.28	0.36	1.36

Coefficient of variation %	10.5	9.37	17.9	9.99

Economic analysis

The result of the economic analysis showed that the maximum net benefit (ETB 327,520 ha-1) with an acceptable marginal rate of return was obtained on the Bombay variety treated with Karate 5% EC insecticide **(Table 6)**. This has resulted in a net benefit of 128,624 for the *birr* (the Ethiopian currency) over the least beneficial treatment (Bombay unsprayed), with a net benefit of 198,896. 5. The treatment combinations of the Adama variety with *D. stramonium* (278,945 ETB ha-1), Adama with dimethoate 40% EC (272,990 ETB ha-1), and Adama with Karate 5% EC (263,265 ETB ha-1) insecticide likewise possess the most net benefit close to the Bombay diversity treated with Karate 5% EC. So it was yielded in the net benefit of *Birr* 80049, 74094, and 6436 over the lowest benefit action (Bombay unsprayed), respectively **(Table 7)**.

Nonetheless, other treatments were excluded by the superiority analysis because net benefits achieved decreased as costs increased (CIMMYT, 1988). Thus, the Bombay variety treated with Karate 5% EC insecticide is preferred in the study area due to the satisfactory marginal rate of reoccurrence and the huge net benefit seen between all the varieties and insecticides tested.

Based on CIMMYT (1988), all treatments with a net benefit less than or equal to the previous treatment are prioritized and excluded from future analysis. Accordingly, a maximum net benefit of 327,520 *Birr* ha^{-1} with a production cost of 5300 *Birr* ha^{-1} was documented from a conduct combination of the Bombay diversity and Karate insecticide application. This was followed by the Bombay variety treated with *Datura stramonium*. Negash (2020) reported higher net returns from more effective insecticides imidacloprid against *T. tabaci* on onion. Abaynew *et al*. (2020) as well as Yechale *et al*. (2021) showed similar results and revealed the importance of partial budget analysis in economic inquiry.

Table 6. Partial budget analysis for the management of onion thrips on onion

Cost-benefit data	Adama* Nonspray	Adama* *D. stramonium*	Adama* *A. indica*	Adama* Karate	Adama* Dimethoate	Bombay* Nonspray	Bombay* *D. stramonium*	Bombay* *A. indica*	Bombay* Karate	Bombay* Dimethoate
Adjusted Marketable yield (kg/ha)	5625	6615	4860	6255	6480	4995	5872.5	5242.5	7740	4747.5
Sale ETB (kg^{-1})	43	43	43	43	43	43	43	43	43	43
Gross return (ETBha^{-1})	241875	284445	208980	268965	278640	214785	252517	225427	332820	204146.5
Cost of Insecticide (ETB ha^{-1})	0	0	0	500	450	0	0	0	500	450
Cost of Labor (ETBha^{-1})	0	300	260	0	0	0	300	260	0	0
Cost of seed (ETB ha$^{-1)}$)	5200	5200	5200	5200	5200	4800	4800	4800	4800	4800
TVC (ETB ha^{-1})	5200	5500	5460	5700	5650	4800	5100	5060	5300	5250
Net benefit (ETB ha^{-1})	239375	27894	203520	263265	272990	209985	247417	220367.5	327520.5	198896.5
Cost-benefit ratio	1:46	1:50.7	1:37.2	1:46.1	1:48.3	1:43.7	1:48.5	1:43.5	1:61.8	1:37.8

Table 7. Effect of Varieties and Insecticides on the dominance analysis of onion yield

Treatment combinations	Total variable cost	Net Benefit	Dominance
Bombay +un spray	4800	209985	
Bombay + *A. indica*	5060	220367.5	
Bombay + *D. stramonium*	5100	247417	
Adama+ unspray	5200	239375	Dominated
Bombay + Dimethoate	5250	198896.5	Dominated
Bombay + Karate	5300	327520	Dominated
Adama+ *A. indica*	5460	203520	
Adama+ *D. stramonium*	5500	278945	Dominated
Adama + Dimethoate	5650	272990	Dominated
Adama + Karate	5700	263265	Dominated

CONCLUSION

Evaluation of insecticides and onion varieties' reactions to onion thrips performed when treated with four insecticides Significant differences in yield and yield-related parameters of onions were recorded because of onion varieties and insecticide application; especially, the application of Karate 5% EC on Bombay gave high and comparable yields. From this study, the Bombay variety was the best performer, which might be due to its ability to withstand the agroecology of the area. Nevertheless, the present results focus on the practical evaluation of insecticides and onion varieties for better yields of onions and suggest that the application of Karate (5%) EC to the Bombay variety was the most effective in the study area. Therefore, the selection of appropriate insecticides and varieties of onion is one of the issues to be considered in the future to maintain the yield of onions in the region.

ACKNOWLEDGMENTS: We would like to thank the Koga Irrigation Scheme Site workers for their technical support in the fieldwork.

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

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