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Biological Forum – An International Journal 14(3): 353-362(2022)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

# Evaluation of efficacy of botanical and chemical insecticides and residues estimation of pyrethroids against thrips, *Thrips tabaci* (Lindeman) on onion

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*(Received 13 May 2022, Accepted 05 July, 2022)*
*(Published by Research Trend, Website: www.researchtrend.net)*

**ABSTRACT: Onion is very important vegetable crop used for flavor, cuisine and medical purposes. Thrips are the major pest on onion with losses ranged between 30-100 % and its transmit 'Iris Yellow Spot Virus. A field experiment was conducted at Research Farm of Department of Vegetable Sciences, CCSHAU, Hisar, to study efficacy of chemical and botanical insecticides against onion thrips (*Thrips tabaci* L.) and residues estimation in/on onion bulbs and leaves. Nine insecticides including botanicals, Cypermethrin 25 EC, Fenvalerate 20 EC, Lambda-cyhalothrin 5 EC all @ 37.5 g a.i ha$^{-1}$, Malathion 50 EC @ 375 g a.i ha$^{-1}$, Neem seed kernel extract (NSKE) and garlic extract (5 and 10 %) and untreated control were tested in RBD with three replication. For the management of thripslambda – cyhalothrin @ 37.5 ga.i ha$^{-1}$ (4.97 thrips/ plant) and cypermethrin @ 37.5 ga.i. ha$^{-1}$ (5.34) were the superior and persistent treatments followed by fenvalerate @ 37.5 ga.i. ha$^{-1}$ (5.79). Cypermethrin residues dissipated below maximum residue limit (MRL) on 7 and 0$^{th}$ day, hence safe waiting period recorded was 7 and 1 day for onion leaves and bulbs respectively. In case of fenvalerate, the Theoritical Maximum Residue Concentration (TMRC) reached below Maximum Permissable Intake (MPI) on zero day in/on onion leaves and bulbs. Therefore the safe waiting period was one day for both leaves and bulbs.**

**Keywords:** Insecticides, Residues, Thrips, Onion.

## INTRODUCTION

Onion (*Allium cepa* L.) belonging to family Liliaceae is one of the most popular bulb vegetables originating from Central Asia (Brewster, 1994). It has special qualities which add taste and flavour to food as well as medicinal value and hence it is mainly used in India for cuisine and culinary preparations. After China, India is the second largest producer of onion in the world (FAOSTAT, 2019; HSD, 2018). In 2017, the harvested area, yield, and production of dry onion crop was 1.3 million ha, 17.17 tones/ha, and 20.7 million t, respectively (FAOSTAT, 2019). Worldwide, in 2016, India exported 1.83 mt of dry onions thereby generating revenue of US dollar 382.19 million (FAO, 2019). Production of onion is influenced by various biotic (pests and diseases), abiotic (environmental factors: rainfall, temperature, humidity, excess of nitrogen fertilizers, and light). This crop is attacked by numerous insect pests but thrips are the major pest and reported to cause significant economic losses upto 30-50% (Nault and Shelton 2012), but can reach upto 100 %, if they are transmitting 'Iris Yellow Spot Virus' which is a to spovirus causing adverse effects on bulb and seed yield of onion crop (Diaz *et al*., 2011). Thrips are cosmopolitan in distribution and polyphagous which attack alliaceous crops (onion, garlic and leek) and Cucurbitaceae (cucumber, pumpkin, melon and watermelon) (ModarresAwal, 2001; Fekrat *et al*., 2009), cotton (Nath*et al*., 2000; Khan *et al*., 2008), cereals especially wheat. Nymphal and adult stages of thrips feed by scratching tissues of plant resulting in release of cell sap which they feed by sucking. This behavior leads to removal of leaf chlorophyll causing white to silver patches and streaks. Therefore, it is important to protect the onions from thrips damage throughout the entire crop growth period.

In earlier investigations, bioefficacy, dissipation, and residue dynamics of pyrethroid insecticides have been studied in brinjal (Kaur *et al*., 2014; Pal, 2018), tea (Samanta *et al*., 2017), onion (Sumalatha *et al*., 2017) and chilli (Reddy *et al*., 2017). Insecticides should be persistent enough to control the pest effectively. But longer persistence of insecticides may affect natural enemies, aggravate the problems of resurgence, resistance and residues. The increasing concern for environmental safety and global demand for pesticide residue free commodities have evolved a keen interest and necessitated a deep insight into methods of processing of the bulbs and leaves in such manner that insecticides residues are washed off .

## MATERIALS AND METHODS

*A. Efficacy of the test insecticides against onion thrips*

Field experiment was conducted at the Research Area of Department of Vegetable Sciences located at CCS Haryana Agricultural University, Hisar, India. A total of 30 days old seedlings of onion (cv., Hisar-2) were transplanted in the plots of 25 $m^2$ and standard package of practices were followed to raise the crop. Nine treatments comprising of Cypermethrin 25 EC, Fenvalerate 20 EC, Lambda-cyhalothrin 5 EC all @ 37.5 g a.i $ha^{-1}$, Malathion 50 EC @ 375 g a.i $ha^{-1}$ , Neem seed kernel extract (NSKE) and garlic extract (5 and 10 %) and untreated control were laid down in the randomized block design (RBD) with three replications. Insecticide applications were commenced with the visibility of initial symptoms (72 days after transplanting) and repeated after 10 days using knapsack sprayer. Separate sprayers were used for every plot for avoiding the intermixing of pesticides. The pest population data was taken at early morning from 10 randomly selected onion plants from each experimental plots on 0, 3, 7 and 10 days after spray (DAS). The selected onion plants were observed visually from neck portion for estimation of thrips (nymph and adult) population.

*B. Field study for persistence and residue dissipation*

The field applications of the agricultural formulations of cypermethrin 25 EC and fenvalerate 20 EC @ 37.5 g a.i $ha^{-1}$ for persistence and residue dissipation studies were carried out at the location described above. The onion samples (about 1 kg) were collected at random from each replicate of the treated and control plots separately at regular time interval on 0 (2 h after spraying), 3, 7 , 10 days and at harvest. Fruits showing signs of infestation of insect pests, diseases or any physiological disorders were not included in sampling. The samples from each treatment plot were pooled and mixed thoroughly on a sheet of polyethylene in the field. A subsample of about 250 g was taken from each pooled sample from each treatment plot and transported to the laboratory, and a representative 50 g was processed immediately after the subsample reached the laboratory. The onion bulbs and leaves were used for residue analysis directly without processing and after simple processing procedures (washing, peeling etc.).

*C. Preparation of analytical standard solutions*

The standard solutions of cypermethrin and fenvalerate were prepared by dissolving 1 mg of cypermethrin and fenvalerate using 100 ml of n-hexane in a volumetric flask. The resulting stock solution was used to prepare working solution. Standard solution was kept in refrigerator at -4°C. Cypermethrin and fenvalerate stock solution was used to prepare solutions of different concentrations for the fortification of control samples for recovery experiments. Standard curve data for cypermethrin and fenvalerate was obtained by injecting 0.25 to 2 µg $ml^{-1}$standard GC calibration solutions and plotting different amounts injected against X-axis and area of corresponding amounts against Y-axis.

*D. Residue analysis and dissipation study*

**Extraction and cleanup.** The samples were processed and analyzed at Pesticide Residue Analysis Laboratory, Department of Entomology, CCS Haryana Agricultural University, Hisar. A representative 50 g sample of chopped and macerated onion was dipped separately overnight into 100 mL acetone in a flask for 24 h. The extract was filtered into a 1-L separatory funnel along with rinsing of acetone. The content was shaken for one hour on mechanical shaker and filtered through a 2-3 cm thick bed of anhydrous sodium sulphate. The filterate was taken in 1 l separating funnel and diluted with 600ml of 10 per cent brine solution. The mixture was extracted thrice with 50, 30, 20 ml portions of hexane with vigorous shaking each time for 1 minute and the upper organic layer was collected in 500 ml flask. This extract was concentrated on rotatary vacuum evaporator at 40°C and further clean-up was done. For this purpose, glass column (60 cm × 2.2 cm ID) was used. Neutral alumina and activated charcoal (5: 1 w/w) were used as adsorbent for clean up. For preparation of column, a cotton plug was put at the bottom of column over which a 5 cm anhydrous sodium sulphate layer was laid. After tapping 10 times, the adsorbent mixture of neutral alumina and activated charcoal (5 g neutral alumina + 0.1 g activated charcoal) was added to the column and tapped again for 10-15 minutes. Above the mixture a layer of anhydrous sodium sulphate (about 5 cm) was made and pre-wetted the column with hexane+acetone, then extract was added and eluted the column with 100 ml hexane: acetone (9:1 v/v) mixture. The cleaned elutes were concentrated on rotary vacuum evaporator. Samples were analysed by GC equipped with electron capture detector $^{63}Ni$ and capillary column.

**Gas chromatographic analysis.** The GLC (Gas Liquid Chromatography) technique employing ECD$^{63}$Ni for multi residue analysis of pesticides in vegetables was adopted for analysis of cypermethrin and fenvalerate in/on onion was carried out on a gas liquid chromatography (GLC) (Shimadzu Model GC-2010) supplied by M/S Shimadzu Corporation, Kyoto, Japan. A capillary column HP-1 (30 m×0.25 mm i.d. × 0.25-μm film thickness) with split ratio 1:10 was used for estimation of the insecticides. GC operating parameters were as follows: with carrier gas (N) flow rate, 60 mL $min^{-1}$; temperature of the injection port, 280 °C; temperature of the detector, 300 °C; and column temperature, 270 °C. The residues of insecticides were estimated by comparing the peak area of the standards with that of the unknown or spiked sample, run under identical experimental conditions. Insecticides residue in mg $kg^{-1}$ was calculated as follows:-

Residue (mg $kg^{-1}$) = $(A_1 \times V_1 \times C) / (A_2 \times V_2 \times W)$

where, $A_1$ = area of field sample in the chromatogram

$A_1$ = area of analytical standard in the chromatogram

$V_1$= total volume of sample in mL

$V_2$ = injected volume in μL

C = concentration of analytical standard in mg $kg^{-1}$

W = weight of the sample in g.

*E. Dissipation kinetics*

Dissipation of cypermethrin and fenvaletare in onion was studied by subjecting the data to first–order kinetic equation (Hoskins, 1961)

$$C_t= C_0e^{-kt}$$

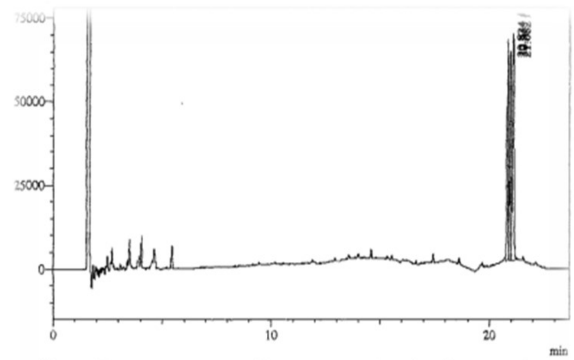
where, $C_t$ is the concentration at time t, $C_0$ is the initial concentration, k is the rate constant for insecticide dissipation, and t is the time.

For calculating half–life ($t_{1/2}$) of the parent compounds, the residue data was subjected to statistical analysis (Hoskins, 1961) as per the following equation.

$t_{1/2} = \ln 2/k$

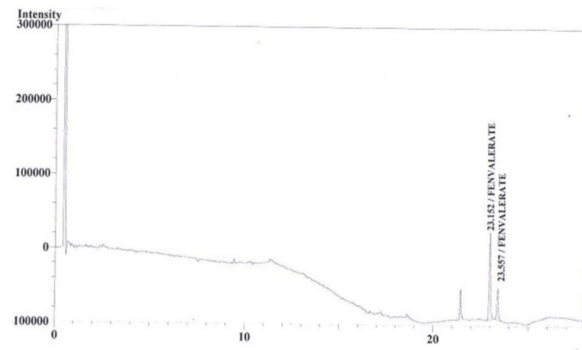
*F. Standards and calibration*

The analytical techniques recommended for estimation of microquantities of cypermethrin and fenvalerate was standardized under laboratory conditions before adoption for residue estimation in test samples. Retention times (Rt) observed for cypermethrin was 20.835, 20.955 and 21.082 min. and for fenvalerate were 23.152 and 23.557 min. Chromatograms for cypermethrin and fenvalerate are shown in fig. 1 and 2, respectively. In the present study, analytical data obtained by processing known amount of standard cypermethrin and fenvalerate indicated a linear relationship between area and amount injected as shown in calibration curves. The repeatability of responses, sharp and well resolved peaks of cypermethrin and fenvalerate, the analytical technique was considered satisfactory for adoption in the present investigations.



| Peak# | Ret.Time | Area | Height | Conc. | Unit | Mark | ID# | Cmpd Name |
|---|---|---|---|---|---|---|---|---|
| 1 | 20.834 | 252255 | 65986 | 0.000 | | V | | |
| 2 | 20.955 | 242071 | 62086 | 0.000 | | V | | |
| 3 | 21.082 | 380317 | 67448 | 0.000 | | V | | |

**Fig. 1.** Chromatogram of cypermethrin.



| Peak# | Ret.Time | Area | Height | Cmpd Name |
|---|---|---|---|---|
| 1 | 23.152 | 615266 | 116692 | FENVALERATE |
| 2 | 23.557 | 229122 | 41933 | FENVALERATE |
| Total | | 844388 | 158625 | |

**Fig. 2.** Chromatogram of fenvalerate.

## RESULTS AND DISCUSSION

*A. Efficacy of some botanical and chemical insecticides against thrips Thrips tabaci(Lindeman) on onion ($1^{st}$ spray)*

The data on thrips population was started 72 days after transplanting. The effectiveness of various treatments has been recorded on the basis of per cent reduction in thrips population after the spray. The first spray on onion was done at 72 days after transplanting and the second spray was done at 10 days interval after the first spray. Thrips population reduction on 0 DAS, just after first spray ranged from 26.83 to 62.74 % (Table 1). It was highest in cypermethrin @ 37.5 g a.i $ha^{-1}$ (62.74 %) and minimum in control (26.83 %). The next best treatment was fenvalerate @ 37.5 g a.i $ha^{-1}$ (60.21 %) followed by NSKE 10 % (58.08 %) and lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ (57.28 %). Malathion @ 375 g a.i. $ha^{-1}$ found to be least effective (52.13 %) among all the chemical treatments. Cypermethrin @ 37.5 g a.i $ha^{-1}$, fenvalerate @ 37.5 g a.i $ha^{-1}$ and lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ were statistically at par.

**Table 1: Efficacy of chemical and botanical insecticides on onion thrips after first spray.**

| Treatment | Dose (g a.i. $ha^{-1}$) | Thripspopln. before spray | Thrips population/ plant (DAS) | | | | Reduction in thrips population (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 3 | 7 | 10 | 0 | 3 | 7 | 10 | Average (%) | (%) Reduction over control |
| **Cypermethrin 25EC** | 37.5 | 27.63 (5.35) | 10.26 (3.36)* | 2.93 (1.98) | 3.20 (2.05) | 5.0 (2.45) | 62.74 (52.37)** | 89.46 (71.07) | 88.37 (70.05) | 81.85 (64.77) | 80.60 (63.84) | 53.00 |
| **Fenvalerate 20 EC** | 37.5 | 27.00 (5.29) | 10.70 (3.42) | 3.27 (2.03) | 5.1 (2.47) | 4.1 (2.26) | 60.21 (50.58) | 88.08 (70.22) | 81.00 (64.15) | 84.70 (66.96) | 78.49 (62.37) | 51.72 |
| **Lambda –cyhalothrin 5 EC** | 37.5 | 25.23 (5.12) | 10.67 (3.41) | 2.13 (1.76) | 3.0 (2.0) | 4.1 (2.26) | 57.28 (49.18) | 91.32 (73.01) | 87.98 (69.72) | 83.63 (66.12) | 80.05 (63.49) | 52.66 |
| **Malathion 50 EC** | 375 | 24.70 (5.06) | 10.67 (3.46) | 5.60 (2.56) | 3.43 (2.09) | 5.0 (2.48) | 52.13 (46.17) | 75.81 (60.73) | 85.12 (67.49) | 77.71 (62.04) | 72.69 (58.71) | 47.87 |
| **Neem seed kernel extract (aq.)** | 5% | 25.80 (5.19) | 11.10 (3.47) | 6.56 (2.75) | 7.13 (2.85) | 6.1 (2.66) | 56.63 (48.81) | 74.15 (59.49) | 71.54 (57.89) | 75.66 (60.59) | 69.49 (56.52) | 45.47 |
| **Neem seed kernel extract (aq.)** | 10% | 26.73 (5.17) | 10.73 (3.42) | 6.76 (2.79) | 5.90 (2.63) | 5.5 (2.54) | 58.08 (49.64) | 73.54 (59.04) | 76.83 (61.24) | 78.45 (62.34) | 71.72 (57.87) | 47.16 |
| **Garlic extract (aq.)** | 5% | 25.97 (5.20) | 12.86 (3.72) | 9.23 (3.20) | 8.20 (3.03) | 6.4 (2.72) | 50.80 (45.49) | 64.52 (53.42) | 68.11 (55.72) | 75.38 (60.23) | 64.70 (53.54) | 41.43 |
| **Garlic extract (aq.)** | 10% | 30.03 (5.55) | 14.16 (3.89) | 9.13 (3.21) | 8.8 (2.89) | 6.2 (2.68) | 52.00 (46.13) | 68.27 (55.74) | 74.98 (60.00) | 78.97 (62.71) | 68.55 (55.90) | 44.72 |
| **Control** | | 29.67 (5.53) | 25.77 (5.17) | 21.30 (4.72) | 18.83 (4.46) | 6.4 (3.58) | 26.83 (31.09) | 28.00 (31.66) | 36.49 (37.11) | 60.24 (50.89) | 37.89 (37.96) | --- |
| **SE(m) ±** | | 0.20 | 0.07 | 0.12 | 0.07 | 0.03 | 2.63 | 2.24 | 1.77 | 1.32 | 1.62 | ---- |
| **C.D.** (p=0.05) | | NS | 0.21 | 0.35 | 0.22 | 0.08 | 7.96 | 6.77 | 5.35 | 4.00 | 4.89 | ---- |

*Fig. in parentheses are square root transformed values  ** Fig. in parentheses are angular transformed values  DAS -Days after SprayNS-Non-significant

Among botanical treatments, NSKE 5 and 10 % observed to statistically at par to all the chemical treatments 0 DAS. Both these treatments were found to be statistically at par with all the chemical treatments. Among all the chemical and botanical treatments garlic extract 5 and 10 % proved to be least effective (50.80 and 52 % respectively). All the treatments were better than control where thrips population reduction (26.83 %) was observed. Data on per cent reduction in thrips population damage on number basis 3 DAS revealed highest thrips population reduction in cypermethrin @ 37.5 g a.i. $ha^{-1}$ (88.37 %) followed by lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ (87.98 %), malathion @ 375 g a.i. $ha^{-1}$ (85.12 %) and fenvalerate @ 37.5 g a.i. $ha^{-1}$ (81 %). Among botanical treatments NSKE 10 % (76.83 %), garlic extract 10 % (74.98 %) and NSKE 5 % (71.54 %) were statistically at par and it was followed by garlic extract 5 % (68.11 %). All the treatments were statistically better than control (36.49 %). After 7 days of first spray thrips population reduction varied from (28 %) in control to (91.32 %) in lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$. Lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ (91.32 %), cypermethrin @ 37.5 g a.i. $ha^{-1}$(89.46 %) and fenvalerate @ 37.5 g a.i. $ha^{-1}$ (88.08 %) were at par. Malathion @ 375 g a.i. $ha^{-1}$ (75.81 %) was found to be least effective among all the treatments. Malathion @ 375 g a.i. $ha^{-1}$ (75.81 %), NSKE 5 % (74.15 %) and NSKE 10 % (73.54 %) were at par and followed by garlic extract 5 and 10 % (64.52 and 68.27 % respectively). At 10 DAS the thrips population reduction varied from 60.24 % in control to 84.70 % in fenvalerate. After first spray, at 10 DAS it was observed that fenvalerate @ 37.5 g a.i. $ha^{-1}$ proved to be best (84.70 %). Fenvalerate @ 37.5 g a.i. $ha^{-1}$ (84.70 %), lambda- cyhalothrin @ 375 g a.i. $ha^{-1}$ (83.63 %) and cypermethrin @ 37.5 g a.i. ha-1 (81.85 %) were statistically at par. Malathion @ 375 g a.i. $ha^{-1}$ proved to be least effective (77.71 %) among chemical treatments and found statistically at par with all the botanical treatments. Garlic extract 10 % (78.97), NSKE 10 % (78.45 %), malathion @ 375 g a.i. $ha^{-1}$ (77.71 %), NSKE 5 % and garlic extract 5 % (75.38 %) were statistically at par. All the treatments proved to be better than control (60.24 %).

*B. Efficacy of some botanical and chemical insecticides against thrips Thrips tabaci (Lindeman) on onion (2nd spray)*

The second spray was done at 10 days interval after the first spray. The average reduction (%) in thrips population was highest in cypermethrin @ 37.5 g a.i $ha^{-1}$ (80.60 %) followed by lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ (80.05 %) and fenvalerate @ 37.5 g a.i $ha^{-1}$ (78.49 %). These treatments were statistically at par and followed by malathion @ 375 g a.i $ha^{-1}$ (72.69 %). NSKE 5 and 10 % was statistically at par (69.49 and 71.72 %) respectively and better than garlic extract 5 and 10 % (64.70 and 68.55 % respectively). All the treatments were better than control (37.89 %). Thrips population reduction on 0 DAS, just after first spray ranged from 3.12 to 74 %. It was highest in malathion @ 375 g a.i $ha^{-1}$ (74 %) and minimum in control (3.12 %). The next best treatment was cypermethrin @ 37.5 g a.i $ha^{-1}$ (70 %) followed by fenvalerate @ 37.5 g a.i $ha^{-1}$ (63.41 %), NSKE 10 % (61.81 %) and lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ (60.97 %). Among botanical treatments, NSKE 5 and 10 % observed to be better (61.81 and 59.01 % respectively), followed by NSKE 5 % (56.63 %). Both these treatments were found to be statistically at par with all the chemical treatments. Among all the chemical and botanical treatments garlic extract 5 and 10 % proved to be least effective (50.80 and 52 % respectively). All the treatments were better than control. Data on per cent reduction in thrips population damage on number basis 3 DAS revealed highest thrips population reduction in cypermethrin @ 37.5 g a.i. $ha^{-1}$ (88.37 %) followed by lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ (87.98 %), malathion @ 375 g a.i. $ha^{-1}$ (85.12 %) and fenvalerate @ 37.5 g a.i. $ha^{-1}$ (81 %). Among botanical treatments NSKE 10 % (76.83 %), garlic extract 10 % (74.98 %) and NSKE 5 % (71.54 %) were statistically at par and it was followed by garlic extract 5 % (68.11 %). After 7 days of first spray, thrips population reduction varied from (36.49 %) in control to (91.32 %) in cypermethrin @ 37.5 g a.i. $ha^{-1}$. At 7 DAS all the chemical treatments were better than botanical treatments. NSKE proved to be better than garlic extract treatments. NSKE 10 % was to better than NSKE 5%. Garlic extract 10 % proved statistically better than garlic extract 5 %. All the treatments were better than control. At 10 DAS the thrips population reduction varied from 6.25 % in control to 96 % in cypermethrin. After first spray, it was observed that cypermethrin @ 37.5 g a.i. $ha^{-1}$ was observed to be most effective (96 %). Among all the treatments cypermethrin @ 37.5 g a.i. $ha^{-1}$ (96 %) proved to be best followed by lambda-cyhalothrin @ 375 g a.i. $ha^{-1}$(90.24 %) and fenvalerate @ 37.5 g a.i. $ha^{-1}$ (90.24 %). Among chemical treatments malathion @ 375 g a.i. $ha^{-1}$ proved to be least effective (60 %). At 10 DAS, NSKE 5 and 10 % (67.21 and 67.27 % respectively) were observed to be better than malathion and were statistically at par. Garlic extract 5 and 10 % were less effective among all the treatments (59.37 and 61.29 % respectively). After two sprays, cypermethrin @ 37.5 g a.i. $ha^{-1}$, lambda-cyhalothrin @ 37.5 g a.i. $ha^{-1}$ and fenvalerate @ 37.5 g a.i. $ha^{-1}$ were statistically at par followed by malathion @ 375 g a.i. $ha^{-1}$. Among chemical treatments malathion @ 375 g a.i. $ha^{-1}$ was least effective. All the chemical treatments were statistically more effective than botanical treatments.

**Table 2: Efficacy of chemical and botanical insecticides on onion thrips after second spray.**

| Treatment | Dose (g a.i. $ha^{-1}$) | Thripspopln. before spray (thrips/plant) | Thrips population / plant (DAS) | | | | Reduction in thrips population (% ) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 3 | 7 | 10 | 0 | 3 | 7 | 10 | Average Reduction (% ) | (%) Reduction over control |
| **Cypermethrin 25 EC** | 37.5 | 5.0 | 1.5 (1.58)* | 0.90 (1.38) | 1.00 (1.41) | 0.20 (1.09) | 70.00 (56.77)** | 82.00 (64.87) | 80.00 (63.41) | 96.00 (78.49) | 82 (64.87) | 77.24 |
| **Fenvalerate 20 EC** | 37.5 | 4.1 | 1.5 (1.58) | 1.0 (1.41) | 0.35 (1.16) | 0.40 (1.18) | 63.41 (52.76) | 75.60 (60.37) | 91.46 (72.98) | 90.24 (71.77) | 80.17 (63.53) | 76.72 |
| **Lambda-cyhalothrin 5 EC** | 37.5 | 4.1 | 1.60 (1.61) | 0.80 (1.34) | 0.30 (1.14) | 0.40 (1.18) | 60.97 (51.32) | 80.48 (63.75) | 96.05 (78.50) | 90.24 (71.77) | 81.93 (64.21) | 77.22 |
| **Malathion 50 EC** | 375 | 5.0 | 1.3 (1.52) | 0.95 (1.40) | 2.00 (1.73) | 2.0 (1.72) | 74.00 (59.32) | 81.00 (64.14) | 60.00 (50.75) | 60.00 (50.75) | 68.75 (56.05) | 72.85 |
| **Neem seed kernel extract (aq.)** | 5% | 6.1 | 2.50 (1.87) | 2.00 (1.73) | 2.30 (1.82) | 2.50 (1.87) | 59.01 (50.17) | 67.21 (55.04) | 62.29 (52.09) | 67.21 (55.04) | 63.92 (51.85) | 70.80 |
| **Neem seed kernel extract (aq.)** | 10% | 5.5 | 2.10 (1.76) | 1.80 (1.67) | 2.00 (1.73) | 1.80 (1.67) | 61.81 (51.81) | 67.27 (55.08) | 63.63 (52.84) | 67.27 (55.08) | 64.91 (53.41) | 71.25 |
| **Garlic extract (aq.)** | 5% | 6.4 | 2.80 (1.95) | 2.50 (1.87) | 2.30 (1.82) | 2.6 (1.90) | 56.25 (48.57) | 60.93 (51.29) | 64.06 (53.14) | 59.37 (50.38) | 60.15 (50.83) | 68.97 |
| **Garlic extract (aq.)** | 10% | 6.20 | 2.60 (1.90) | 1.90 (1.70) | 2.30 (1.82) | 2.4 (1.84) | 58.06 (49.62) | 69.35 (56.36) | 62.90 (52.45) | 61.29 (51.50) | 62.90 (52.45) | 70.33 |
| **C.D. (p=0.05)** | | _ | 0.07 | 0.05 | 0.16 | 0.06 | 0.56 | 0.64 | 0.51 | 0.96 | 2.60 | — |
| **Control** | | 6.40 | 6.20 (2.68) | 5.50 (2.55) | 4.20 (2.28) | 6.0 (2.64) | 3.12 (21.87) | 23.61 (29.06) | 41.66 (40.18) | 6.25 (58.17) | 18.66 (23.29) | — |
| **SE(m)±** | | _ | 0.02 | 0.02 | 0.05 | 0.02 | 0.18 | 0.21 | 0.17 | 0.32 | 0.86 | — |

*Fig. in parentheses are square root transformed values ** Fig. in parentheses are angular transformed values DAS -Days after SprayNS-Non-significant

NSKE treatments were more effective than garlic extract treatments. NSKE 10 % was better than NSKE 5 % and garlic extract 10 % was better than galic extract 5 %. NSKE 5 % was at par with garlic extract 10 %. All the treatments proved to be better than control.

These results also confirmed the earlier reports of Suresh *et al*. (2006) who conducted in vivo experiment to evaluate efficacy of some insecticides on onion in which the most effective treatment was dimethoate 30 EC at 1ml/litre (73.25) followed by neem oil 3% (64.14), neem gold at 2ml/litre (57.17) & NSKE 5 % (56.06) in controlling thrips. Our results were in conformation with findings of Sule *et al*. (2008) who observed that all the insecticides were effective against the pest but lambda-cyhalothrin was the most effective, as it recorded the lowest cumulative thrips count (2.63 and 3.62).

Our findings were in the conformity with Upadhyay *et al*. (2008) who observed that maximum yield recorded in treatment cypermethrin 10 EC @ 0.05 % (130.96 q $ha^{-1}$). Our findings were in favour of Rudramuni *et al*. (2011) who used the neem-based formulations named Neemazal, Nimbicidine, Vijayneem, Neemplus, Neemgold, Nimbobas, Multineem, Nimbex and Neem seed kernel extract against sucking pests (aphids, leaf hoppers and thrips) and bollworms and found that all the treatments were superior to the untreated control. Our results were in line with the findings of Ekantaramayya *et al.* (2012) who studied the efficacy of selective botanicals and entomopathogens against *S. dorsalis* on rose and found that among the botanicals, 2 % Neem Seed Kernel Extract (NSKE) was found suitable, which controlled 69.08 % thrips.

*B. Residues estimation*

**Validation of the method.** The calibration curves obtained from the matrix matched standards of onion extracts presented good linearity with coefficients of determination ($R^2$) around 0.945 for all the analytes. The method has been validated by determining LOD, LOQ, and accuracy and precision in terms of recovery. LOD and LOQ of cypermethrin and fenvaletare was found to be 0.01 and 0.05 mg $kg^{-1}$, respectively. The percent recovery of cypermethrin and fenvaletare of two spiking levels (0.25 and 0.50 mg $kg^{-1}$) ranged between 86.18-89.63 and 90.15.10-95.10 %, both in case of onion leaves and bulbs. The values of % RSD ranged from 2.28-3.45 % and 0.55-1.28 % for the analytes, in cypermethrin and fenvalerate, respectively for both onion leaves and bulbs proved that satisfactory precision of the methodology was followed. These recoveries were within the acceptable range and are in accordance to international guidelines (EC, 2007; Sante, 2017).

| | **Cypermethrin** | | **Fenvalerate** | |
|---|---|---|---|---|
| **Spike level (mg $Kg^{-1}$)** | **Recovery (%) ± SD (% RSD)** | | **Recovery (%) ± SD (% RSD)** | |
| | **onion leaves** | **onion bulbs** | **onion leaves** | **onion bulbs** |
| **0.1** | 86.18 ± 2.01(2.33) | 87.11 ±2.05(2.35) | 93.10 ± 1.20(1.28) | 95.10 ± 1.10(1.15) |
| **0.05** | 88.26 ± 2.02(2.28) | 89.63 ± 3.10(3.45) | 90.15 ± 0.50(0.55) | 91.57 ± 0.50(0.54) |

**Dissipation kinetics:** After a foliar treatment of a substrate (e.g., leaf surface, fruit, plant, soil) with a pesticide, the residue level on the substrate dissipates at an overall rate, and the dissipation kinetics of the pesticide residues is the combination of many factors *i.e* volatilization, photolysis, washing off, leaching, hydrolysis, microbial degradation, and other processes (Seiber and Kleinschmidt 2010). The rate kinetics could be pseudo–first, first, or second order depending on rapid [Phase 1: a linear plot with $R^2 > 0.85$] or slow [Phase 2: two or more non–linear plots with $R^2 \leq 0.85$] dissipation of the pesticide resulting in small or extended half–lives (Whitmyre *et al*., 2004). Although there is no scientific basis for limiting the interpretation of dissipation data to first–order kinetics, the standard approach used by regulatory agencies has been to apply first–order kinetics to the entire dissipation period. Federal guidelines indicate that special consideration should be given to pesticides that exhibit biphasic dissipation kinetics (USEPA, 1999).

In present study, the dissipation kinetics of the cypermethrin and fenvalerate in onion showed first–order kinetics with good correlation coefficients in all the samples (Fig. 3 A-B). Several literature reports also follow first–order kinetics for dissipation for cypermethrin and fenvalerate (Janghel *et al*., 2007).

Untreated samples of onion bulbs and leaves were fortified at 0.25 and 0.50 mg $Kg^{-1}$ levels.

Average recoveries of cypermethrin from samples of onion bulbs and leaves were 87.11 ± 2.05 and 89.63 ± 3.10 per cent, respectively. The average recovery was calculated to be 88.37 per cent. The recovery data of fenvalerate in onion bulbs and leaves fortified at 0.25 and 0.50 mg $Kg^{-1}$ levels were 95.10 ± 1.10 and 91.57 ± 0.50 per cent, respectively and overall recovery was calculated to be 93.33 per cent.

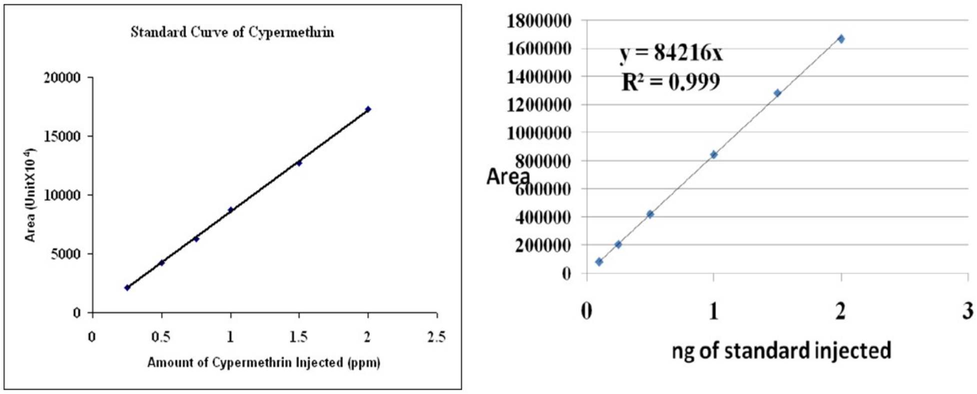



**Fig. 3.** Standard curve of A) Cypermethrin B) Fenvalerate.

**Table 3: Residue dissipation parameters of cypermethrin and fenvaletare in onion.**

| Dose rate | Cypermethrin | Fenvalerate |
|---|---|---|
| MRL | 0.1mgKg$^{-1}$ | ------- |
| T ½ | 2.41days | 2.55 days |
| ADI | 0.05 mgKg$^{-1}$ | 0.02 mgKg$^{-1}$ |
| Regression equation | 2.5961-0.1247x | 2.8526-0.1178x |
| $R^2$ | 0.9456 | 0.9357 |

In order to know the extent of persistence and dissipation of cypermethrin and fenvalerate residues in/on onion bulbs and leaves, samples were taken at zero, three, seven and ten days from the treated plots. The experimental data indicate that the application of cypermethrin @ 37.5 g a.i ha$^{-1}$ on onion bulbs in the field resulted an initial deposit to the extent of 0.03 mg kg$^{-1}$ and fenvalerate @ 37.5 g a.i ha$^{-1}$ resulted in an initial deposit to the extent of 0.03 mg kg$^{-1}$, respectively. The insecticides dissipated very fast just after its application and fell abruptly to the level of 0.016 and 0.02 mg kg$^{-1}$ on 3rd day. From 3rd day onwards, there was a gradual degradation / dissipation of cypermethrin residues till 10th day. The dissipation rate was slightly slower but kept on increasing day by day and about 95 per cent of residues were found dissipated by end of 10th day. The dissipation of cypermethrin on onion bulbs followed first order kinetics. From the studies conducted, it may be concluded that the residues of cypermethrin was below Maximum Residue Limit (MRL) of 0.1 ppm on 0 day. Henceforth from consumer health point of view, a safe waiting period of 1 day is suggested before the treated onion bulbs are consumed. The experimental data indicate that the application of cypermethrin @ 37.5 g a.i ha$^{-1}$ on onion leaves in the field resulted an initial deposit to the extent of 0.19 mg kg$^{-1}$ and fenvalerate @ 37.5 g a.i. ha$^{-1}$ resulted in an initial deposit to the extent of 0.15 mg kg$^{-1}$, respectively. The insecticides dissipated very fast just after its application and fell abruptly to the level of 0.12 and 0.10 mg kg$^{-1}$ on 3rd day. From 3rd day onwards, there was a gradual degradation / dissipation of cypermethrin residues till 10th day. The dissipation rate was very slow but kept on increasing day by day and about 95 per cent and 87 percent of residues of cypermethrin and fenvalerate respectively were found to be dissipated by end of 10th day. The dissipation of cypermethrin on onion leaves followed first order kinetics. From the studies conducted, it may be concluded that the residues of cypermethrin in onion leaves reached below Maximum Residue Limit (MRL) of 0.1 ppm on 7th day. Henceforth from consumer health point of view, a safe waiting period of 7 days is suggested before the treated onion leaves are consumed. Therefore the safe waiting period was one day for both leaves and bulbs (Table 6 and 7).

Our findings were in confirmation with Duara *et al*. (2003) who reported 0.31 and 0.58 mg/kg initial deposits of cypermethrin on brinjal fruits when applied @ 22.5 and 45.0 g a.i. ha$^{-1}$. The present findings confirmed closely to the earlier findings of Kole *et al*. (2002) who reported that brinjal fruits were contaminated with cypermethrin (0.01-1.32 ppm residues) and decamethrin (0.05-0.92 ppm).

**Table 4: Persistence and dissipation of cypermethrin residues (37.5 ga.i $ha^{-1}$) on onion leaves and bulbs.**

| Onion leaves | | | | | Onion bulbs | | | |
|---|---|---|---|---|---|---|---|---|
| **Days** | **$R_1$** | **$R_2$** | **$R_3$** | **Average residues (mg $Kg^{-1}$)** | **$R_1$** | **$R_2$** | **$R_3$** | **Average residues (mg $Kg^{-1}$)** |
| **0** | 0.20 | 0.17 | 0.20 | 0.19 (00.00) | 0.02 | 0.04 | 0.03 | 0.03 (00.00) |
| **3** | 0.11 | 0.13 | 0.12 | 0.12 (36.84) | 0.018 | 0.015 | 0.015 | 0.016 (46.66) |
| **7** | 0.04 | 0.06 | 0.05 | 0.05 (73.68) | 0.01 | 0.01 | 0.01 | 0.01 (66.66) |
| **10** | 0.01 | 0.01 | 0.01 | 0.01 (0.01) | BDL | BDL | BDL | BDL |
| **Harvest** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |

**Table 5: Persistence and dissipation of fenvalerate residues (37.5 ga.i. $ha^{-1}$) in/on onion leaves and bulbs.**

| Onion leaves | | | | | Onion bulbs | | | |
|---|---|---|---|---|---|---|---|---|
| **Days** | **$R_1$** | **$R_2$** | **$R_3$** | **Average residues (mg $Kg^{-1}$)** | **$R_1$** | **$R_2$** | **$R_3$** | **Average residues (mg $Kg^{-1}$)** |
| **0** | 0.17 | 0.14 | 0.14 | 0.15 (00.00) | 0.03 | 0.04 | 0.02 | 0.03 (00.00) |
| **3** | 0.09 | 0.11 | 0.10 | 0.10 (33.33) | 0.02 | 0.03 | 0.01 | 0.02 (33.33) |
| **7** | 0.07 | 0.08 | 0.06 | 0.07 (53.33) | 0.01 | 0.01 | 0.01 | 0.01 (63.33) |
| **10** | 0.02 | 0.01 | 0.03 | 0.02 (86.66) | BDL | BDL | BDL | BDL |
| **Harvest** | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |

**Table 6: Maximum permissible intake (MPI) and Theoretical Maximum Residue Concentration (TMRC) values for fenvalerate in/on onion leaves.**

| **Insecticide** | **ADI (mg $Kg^{-1}$)** | **MPI (mg $Kg^{-1}$)** | **Dose (g a.i. $ha^{-1}$)** | **TMRC** | | | | **Safe Waiting Period** |
|---|---|---|---|---|---|---|---|---|
| | | | | **0 Day** | **3 Days** | **7 Days** | **10 Days** | |
| Fenvalerate | 0.02 | 1 | 37.5 | 0.038 | 0.025 | 0.017 | 0.005 | **1 day** |

MPI (mg per person per day) = ADI × Average body weight (50 kg); TMRC (mg per person per day) = Residues × Average daily consumption (250 g); residues safe when TMRC < MPI

**Table 7: Maximum permissible intake (MPI) and Theoretical Maximum Residue Concentration (TMRC) values for fenvalerate in/on onion bulbs.**

| **Insecticide** | **ADI (mg $Kg^{-1}$)** | **MPI (mg $Kg^{-1}$)** | **Dose (g a.i. $ha^{-1}$)** | **TMRC** | | | | **Safe Waiting Period** |
|---|---|---|---|---|---|---|---|---|
| | | | | **0 Day** | **3 Days** | **7 Days** | **10 Days** | |
| Fenvalerate | 0.02 | 1 | 37.5 | 0.008 | 0.005 | 0.003 | - | **1 day** |

**Acknowledgements.** The authors are thankful to Head of the Department of Entomology, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The work was also supported by my advisor and other committee members.

**Conflict of interest.** The authors do not have any conflict of interest.

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**How to cite this article:** Ruby Garg, Bishan Singh, Sangeeta Tiwari, Sunita Yadav, Dalip Kumar and Bajrang Lal Sharma (2022). Evaluation of efficacy of botanical and chemical insecticides and residues estimation of pyrethroids against thrips, *Thrips tabaci* (Lindeman) on onion. *Biological Forum – An International Journal*, *14*(3): 353-362.