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Study on the comparative efficacy of different insecticides for management of onion thrips *Thrips tabaci* (Thysanoptera: Thripidae) and its yield in Afghanistan

Mohammad, Hussain Falahzadah[1] ; Mohammad, Salim Rahimi[1]; Asadullah, Azam[1] and Khan, Aziz Sahak[2]

[1]*Plant Protection Department of Agriculture Faculty, Kabul, Afghanistan.*
[2]*National Agrochemical Specialis, Afghanistan Agricultural Inputs Project (AAIP) /MAIL.*

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Abstract:

This study was conducted to determine the effects of different insecticide applications on onion thrips *Thrips tabaci* (Lindeman) (Thysanoptera: Thripidae), management, and onion yield in two different locations. The study was carried out at the research farm of Agriculture faculties of, Kabul and Nangarhar Universities, during 2019. The experiment was laid out in Randomized Complete Block Design (RCBD) using carbaryl WP 950 g/ hectare, lambda-cyhalothrin EC 900 ml/ hectare, cypermethrin EC 900 ml/ hectare, emamectin benzoate EC 900 ml/hectare, acetameprid SL 950 g/hectare and chlorpyrifos SL 900 g/hectare. Twenty four hours prior to insecticide application, the experimental plots were first recorded in the presence of thrips population and at 24 hours, 3 days, and 7 days post application. The results showed that acetamiprid SL was the most effective insecticide to reduce the onion thrips population and increase the yield followed by chlorpyrifos SL and carbaryl WP, while emamectin benzoate EC was the least effective. The same trend of the effectiveness of insecticides was observed in both experimental sites. Our study showed that the efficacy of acetameprid SL, chlorpyrifos SL and carbaryl WP were significantly higher in comparing to emamectin benzoate EC, lambda-cyhalothrin EC and cypermethrin EC respectively.

Introduction

Onion, *Allium cepa* (L.) is one of the most important products all around the world. It is an important condiment and vegetable for Afghans. The green leaves and bulbs are eaten either raw or used in the preparation of several recipes. In the Afghan food market, onion has a high value among other vegetables (Minoia *et al*., 2015). It is widely grown in most European, American, Asian and some African countries (Duchovskiene, 2006; Gholami *et al*., 2015 and Shang *et al*., 2016).

Several pests attack the onion plant, but onion thrips *Thrips tabaci* (Lindeman) (Thysanoptera: Thripidae) is considered one of the very important pests (Ananthakrishnan, 1993; Ashghar *et al*., 2018 and Azazy *et al*., 2018). The onion thrips is a polyphagous insect that is widespread on all continents and is recognized as a harmful economic pest of field and greenhouse crops all around the world (Fernandes *et al*., 2015; El-Naggar and Zidan, 2013 and Bielza *et al*., 2009).

Dry and hot weather can increase

the population of onion thrips and the severity of damage to onions. The reason for this is probably due to a combination of factors, such as lower generation time and reduced rainfall and plant pathogen mortality (Badillo-Vargas *et al*., 2015; Demirozer *et al*., 2012 and Broughton *et al*., 2011). Heavy rains have been shown to wash onion thrips from plants (De Brujin *et al*., 2006) . Additionally, water stress may impact the nutritional quality of onion plants and also increase the attractiveness of the plants to thrips (Cannon *et al.*, 2007; Din *et al*., 2016 ; Jacobson *et al*., 2016 and Brunner *et al.*, 2004). The larval stages of the onion thrips can transmit virus diseases such as Tomato spotted wilt virus (TSWV*)*, Iris yellow spot virus (IYV) that is caused by the tospovirus (El-Wakeil *et al*. , 2010; Gill *et al*., 2015 and Fernandes *et al*., 2015) . Iris yellow spot virus (IYSV) has emerged in recent years as high priority, invasive or potential threats to sustainable onion production (Nault and Shelton , 2010 ; Jacobson, 2016 and Gao *et al.*, 2012). The immature stages of *T. tabaci* prefer to live in the central leaves of the plant and reduce their photosynthetic ability. Onion thrips has a wide host range that is reported to feed on more than 300 plants (Guillén *et al*., 2014 ; Hussain *et al*., 1997; Hodges *et al*., 2009 and Kaur *et al*., 2017). For example, in Hawaii, 66 plants from 25 families were found to be attacked by onion thrips (Jones *et al*., 2005; Khaliq *et al*., 2016 and Kudom *et al*., 2015). It has been found that the vegetables such as cabbage, cantaloupe, carrot, cauliflower, asparagus, bean, beet, celery, cowpea, cucumber, garlic, kale, leek, mustard, parsley, pea, pepper, squash, sweet potato, tomato, turnip, pigeon pea, potato, pumpkin and spinach more attacked by thrips (Kay and Herron, 2010 ; Khan *et al*., 2017 and Loomans, 2003). Under the field conditions, thrips cause the most damage to the onion, followed by edible-podded pea and cabbage (Khaliq *et al*., 2014; Kadri and Goud, 2006; Lopez *et al*., 2008 and Maliniak *et al*., 2012).

Vegetables such as cucumber and tomato are grown in the greenhouse, onion thrips can sometimes cause serious damage. Field crops, especially cotton, oats, alfalfa, sugar beets, soybeans, tobacco, and wheat may also be affected by onion thrips. Ornamental crops like carnation and rose may be supported, especially when planted under greenhouse conditions (Maniania *et al*., 2003; Mautino *et al*., 2012; Nikolova and Georgieva, 2014 and Mandi and Senapati, 2009). Leaves of onion are curled, wrinkled and dried after being infected with onion thrips. This pest is very active at flowering time which adversely affects seed yield and viability (Sonderholm, 2010; Pourian *et al*., 2009 and Sedaratian *et al*., 2010). Nutrition of *T. tabaci* destroys the epidermal cells of the onion causing the leaf whitening due to sucking of the sub epidermal cell contents by adults and larvae (Sharma, 2014 and Shelton *et al*., 2009) . In general, onion thrips feeds most when the onion is young, and when the bulbs are rapidly enlarging (Sonderholm, 2010 ; Srivastava *et al*., 2014 ; Shelton *et al*., 2008; Zezlina and Blazic, 2003 and Sadozai *et al*., 2009). Falling water from damaged leaf surfaces can cause stress and reduce plant growth and accelerate leaf aging, both of which may shorten the period of bulbs enlargement (Toda and Murai, 2007 and Ullah *et al*., 2010). In New York, a 30-50% decrease in bulb yield (Smaller bulbs sizes) may occur due to severe thrips damage. Thrips may also feed onion bulbs after harvesting and storage, and this can cause scarring, which may affect the appearance and quality of the bulbs (Ananthakrishnan, 1993; Bielza *et al*., 2009 and Gandhale *et al*., 1984) .

The current experiment was conducted to study the population of *T. tabaci* in the Agriculture Faculty of Kabul University and, in the Agriculture Faculty of Nangarhar University to find out the efficacy of various chemical insecticides for the management of *T. tabaci* that will result in the increasing onion yield.

Materials and methods

1. Experimental sites:

An onion variety "White Ghorbandi" was obtained from the research farm of agriculture faculties of Kabul and Nangarhar Universities and planted on May 31, 2019, at the research farm of Agriculture Faculty of Kabul and on January 8, 2019 at Nangarhar University at latitude 34.5281296 and 34.4264717 and longitude 69.1723328 and 70.4515305, in the northern hemisphere, respectively. The experiment was designed in a Complete Randomized Block Design (CRBD) with seven treatments and five replications. The total number of plots was 35 and each plot size was 2 × 2.5 m. The distance between plant-plant and row-row was kept 35 cm and 50 cm, respectively. The main irrigation channel of 1.0 m, Sub-irrigation channel of 1.0 m, and width of bund 0.5 m were kept. The total length of the experimental area was 39 m^2 with the gross cultivated area of 378 m^2.

2. Fertilizers and insecticides:

The insecticides were purchased from the local markets and applied to the experimental area at the recommended rate. The crops were carefully observed at the weekly intervals to monitor the number of thrips and insecticides were applied when the population reached the economic threshold level (ETL) (39.6 thrips /plant). The insecticide application rate was as follows: Carbamate (Carbaryl 950 g/ hectare), organophosphorus OP (Chlorpyrifos 900 ml/hectare), synthetic pyrethroids (Lambda-cyhalothrin 2.5% EC 900 ml, cypermethrin EC10% 900 ml/hectare), neonicotinoid (Acetamiprid 20% SL 950g/hectare) and antibiotic group (Emamectin benzoate 1.9% EC 900 ml/ hectare). Only water was applied as a control treatment. Insecticides were applied with a knapsack sprayer three times during the growing season within 38 day intervals (From 29 February to 5 April in Nangarhar province and 18 July to 25 August in Kabul province). The rate of DAP and Urea was used as 80 kg/ha and 120 kg/ha, respectively.

3. Determining the thrips population:

The number of thrips was counted three times before the spraying. After the application of insecticides, the number of thrips was recorded at 1, 3, and 7-days interval. Before using insecticides, the number of onion thrips was recorded at regular intervals by selecting five onion plants from each sampling unit. The post spray data were recorded at 1, 3, and 7 days post-application.

4. Yield assessment:

At the end of the growth period and complete drying of the onion leaves, the performance of all cultured treatments was examined separately. Onion tubers were mechanically harvested, and the total product weight was calculated per hectare.

5. Data analysis:

The mean data from 5 replications were analyzed with one-way analysis of variance (ANOVA) using Statistical Analysis Software (SAS) (SAS Institute, 2002) and the means were compared with the least significant difference (LSD) for significant differences between the variables. The bio-efficacy percentage was calculated by using the method reported previously by Shiberu and Negeri (2012).

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

$$\text{Reduction efficacy \%} = \frac{\text{Control count} - \text{Post spray count}}{\text{Control count}} \times 100$$

Results and discussion

1. Determining the thrips population:

Thrips populations were recorded before and after the insecticide application in both experimental areas. The analyses of variance indicated that there were no significant differences between treatments before application of insecticides in both sites (Kabul and Nangarhar) ($F_{6,055}$=0.073; P < 0.001 and $F_{6,06}$= 0.085; P < 0.001) respectively. However, the significant difference was observed after three times application of insecticides i.e. after 24h of recording showed that treatment was applied insecticide significantly reduced ($F_{6,105.73}$= 0.0001; P < 0.001 and $F_{6,112.32}$= 0.0001; P < 0.001), in comparison to the control, so after 3- days of recoding the population of onion thrips significantly ($F_{6,162.32}$ = 0.0001 P < 0.001 and $F_{6,98.93}$ = 0.0003 P < 0.001) higher in control plot and finally, after 7-days of recording indicated that the plots which applied insecticides the population of onion thrips significantly ($F_{6,22.4}$ =0.004; P < 0.001 and $F_{6, 67.43}$ = 0.0001; P < 0.001) lower than control plot. (Figure 1 A and B).

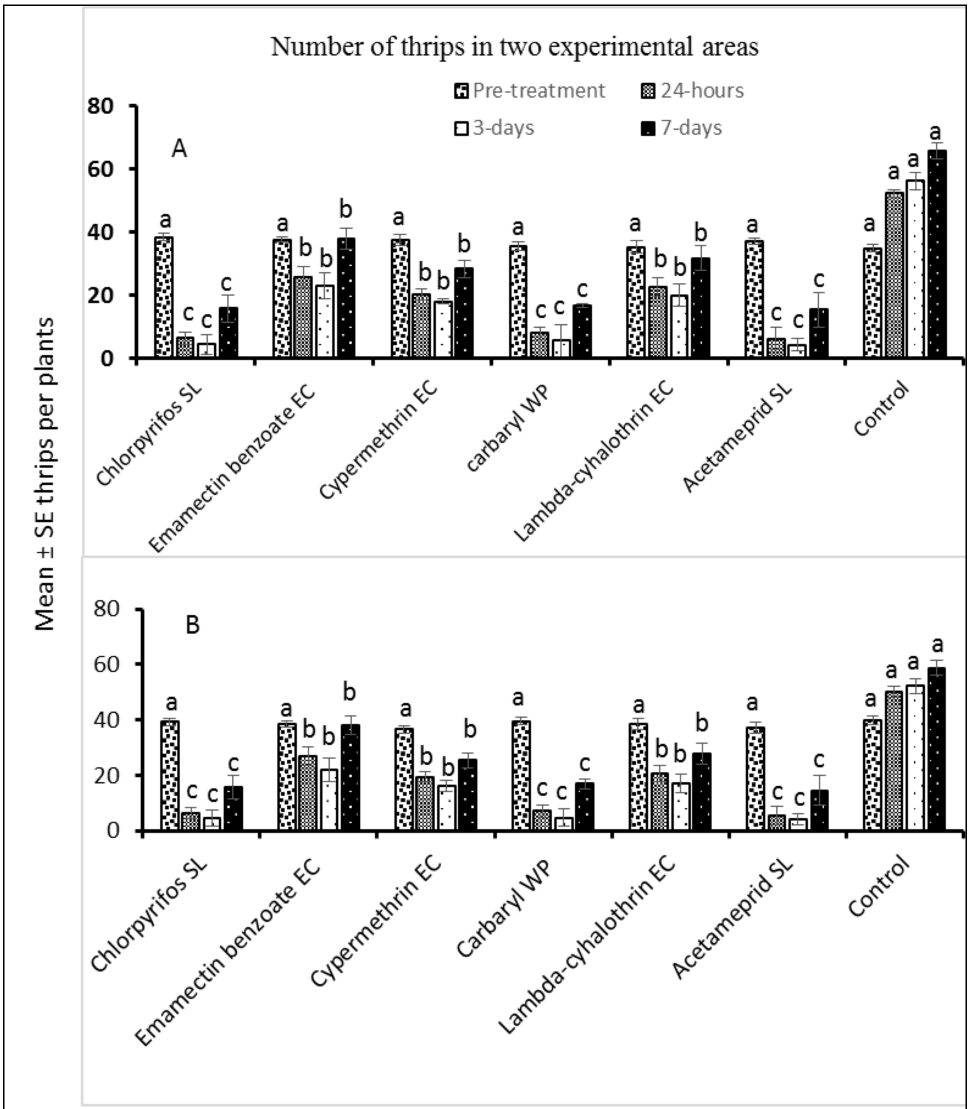

Figure (1): Shows the onion thrips populations pre- and post-application of the insecticides in two locations i.e. Kabul (A) and Nangarhar (B) universities. Different letters indicate that there is no significant difference between treatments before insecticide use and there is a significant difference between treatments after insecticide use in both sites according to Tukey LSD. Bars indicate standard error of the means.

The same trend in the effectiveness of insecticides was observed at both sites (Kabul and Nangarhar). The lowest density of thrips after application of insecticides was recorded in acetamiprid SL, followed by chlorpyrifos SL and carbaryl WP while the high density was recorded in emamectin benzoate followed by EC, lambda-cyhalothrin EC, and cypermethrin EC. Result of the Tukey's test indicated that the density of thrips was much lower at 3-days post-treatment in compared to 24 hrs. and 7 days. Data on the number of thrips per plant showed that percentage and reduction percentage was significantly higher in plots treated with acetamiprid SL, chlorpyrifos SL and carbaryl WP than plots treated with cypermethrin EC, lambda-cyhalothrin EC and emamectin benzoate in both sites after application of insecticides at 24hrs, 3-days and 7-days. (Tables 1 and 2).

2. Yield assessment:

More number of dead thrips and increasing yield were observed in plots treated with acetamiprid SL followed by chlorpyrifos SL, and carbaryl WP and in the same way the lowest dead onion thrips and decreasing yield were found in plots treated with emamectin benzoate among all insecticides (Table 1).

Table (1): The percentage mortality of onion thrips after spraying and weight yield per plot and total yield per hectare in two locations (Kabul and Nangarhar provinces).

Treatments	Times of data recorded			Yield/plot (Kg)	Yield/hectare (Ton)
	24-hours	3-days	7-days		
Kabul province					
Acetamiprid SL	77.8 ± 2.5[a]	84.4 ± 4.3[a]	51.4 ± 3.2[a]	8.10 ± 0.8[a]	16.20 ± 0.7[a]
Chlorpyrifos SL	77.3 ± 3.4[a]	84.0 ± 4.0[a]	52.2 ± 0.9[a]	7.83 ± 0.4[b]	15.66 ± 0.5[b]
Carbaryl WP	73.3 ±1.3[a]	80.9 ± 6.7[a]	48.9 ±2.1[a]	7.84 ± 0.6[b]	15.68 ± 0.9[b]
Cypermethrin EC	58.3 ± 5.1[b]	60.6 ± 4.3[b]	30.7 ± 4.3[b]	7.13 ± 1[c]	14.26 ± 0.6[c]
Lambda-cyhalothrin EC	56.5 ± 0.7[b]	59.3 ± 4.2[b]	28.4 ± 2.1[b]	6.93 ± 0.9[c]	13.86 ± 1.1[c]
Emamectin benzoate EC	48.0 ± 5.8[c]	52.2 ± 8.9[c]	25.4 ± 1.1[c]	6.63 ± 0.6[d]	13.26 ± 0.8[d]
Control	-1.8 ± 0.4[d]	-9.8 ± 1.1[d]	-28.2 ± 2.2[d]	6.13 ± 0.3[e]	12.26 ± 0.4[e]
LSD	10.321	9.120	17.59	0.244	0.642
CV	10.99	9.24	19.7	1.90	2.05
F	77.56	110.81	12.49	82.10	97.13
P	0.0001	0.0001	0.0005	0.0001	0.0001
Nangarhar province					
Acetamiprid SL	76.7 ± 1.5[a]	86.9 ± 1.3[a]	58.7 ± 0.7[a]	7.20 ± 0.5[a]	14.40 ± 0.5[a]
Chlorpyrifos SL	75.3 ± 2.4[a]	84.8 ± 3.1[a]	56.9 ± 0.5[a]	6.93 ± 0.7[b]	13.86 ± 0.4[b]
Carbaryl WP	74.5 ±1.3[a]	83.3 ± 2.4[a]	56.3 ± 1.1[a]	6.94 ± 0.4[b]	13.88 ± 0.4[b]
Cypermethrin EC	57.3 ± 3.1[b]	61.6 ± 1.3[b]	34.7 ± 1.7[b]	6.35 ± 1.2[b]	12.70 ± 0.9[b]
Lambda-cyhalothrin EC	52.5 ± 0.7[c]	58.6 ± 1.2[bc]	32.9 ± 2.7[bc]	6.57 ± 0.7[b]	13.14 ± 0.6[b]
Emamectin benzoate EC	50.3 ± 2.2[c]	52.7 ± 3.9[c]	28.4 ± 1.6[c]	5.69 ± 0.6[c]	11.38 ± 0.7[c]
Control	-3.5 ± 0.8[d]	-9.8 ± 1.3[d]	-28.2 ± 1.2[d]	5.13 ± 0.6[d]	10.26 ± 0.5[d]
LSD	9.761	10.120	15.123	1.142	0.642
CV	8.09	13.290	13.321	7.564	2.05
F	85.59	120.81	11.97	69.10	97.13
P	0.0001	0.0001	0.0006	0.0001	0.0001

Different lowercase case letters indicate that there is significant difference between treatments after insecticides applied in both sites according to Tukey LSD.

Table (2) : Mean reduction percentage of onion thrips population in Kabul and Nangarhar provinces.

Treatments	Times of data recoded in Kabul province			Times of data recorded in Nangarhar province		
	24-hrs.	3-days	7-days	24-hours	3-days	7-days
Acetamiprid SL	88.3 ± 2.5^{a}	91.1 ± 4.1^{a}	71.8 ± 3.2^{a}	89.3 ± 1.3^{a}	93.1 ± 4.1^{a}	74.2 ± 1.7^{a}
Chlorpyrifos SL	87.6 ± 1.2^{a}	90.7 ± 1.3^{a}	71.6 ± 4.9^{a}	87.4 ± 2.6^{a}	91.2 ± 1.3^{a}	72.9 ± 5.2^{a}
Carbaryl WP	84.0 ± 2.8^{a}	89.2 ±1.8^{a}	68.6 ± 5.1^{ab}	85.5 ± 3.1^{a}	90.4 ±1.8^{a}	68.6 ± 2.8^{ab}
Cypermethrin EC	54.3 ± 5.3^{b}	59.6 ± 4.5^{b}	48.9 ± 3.6^{c}	52.8 ± 2.2^{b}	59.6 ± 4.5^{b}	48.9 ± 3.6^{b}
Lambda-cyhalothrin EC	53.0 ± 3.1^{b}	57.9 ± 1^{b}	46.5 ± 4.2^{b}	51.3 ± 2.3^{b}	58.9 ± 1^{b}	41.9 ± 2.9^{c}
Emamectin benzoate EC	51.1 ± 8.5^{b}	54.2 ± 7.9^{b}	42.4 ± 3.7^{c}	48.1 ± 3.7^{b}	53.2 ± 7.9^{b}	41.4 ± 3.3^{c}
LSD	8.5512	7.6941	14.30	12.7812	9.6341	8.390
CV	8.72	7.08	18.68	9.790	10.78	15.645
F	108.74	162.75	14.61	143.789	173.796	140.619
P	0.0001	0.0001	0.0004	0.0001	0.0001	0.0001

The different lowercase letters indicate that there is a significant difference between the treatments after insecticides utilized on both sites according to Tukey LSD.

Chemical insecticide application against onion thrips population is generally one of the prevalent methods because of their rapid effect on the pest population. The result of the preliminary assessment of the study areas showed that the onion thrips infestation was high and specifically; the damage was increased on the crop in Nangarhar province of Afghanistan during the late February to April and in Kabul province during the mid-July to August 2019. Culture practices, including intercropping of several crops such as chili, cotton, tomato, and okra are a more important components of eco-friendly management of many economic pests, especially onion thrips and reported that intercropping can successfully reduce the damage of onion thrips (Kay and Herron , 2010) .

It has been reported that carbosulfan, cypermethrin EC deltamethrin+ triazophos, bifenthrin, and dimethoate reduced the *T. tabaci* population for more than 2 weeks and the effect of imidacloprid was better than cyhalothrin (Ashghar *et al*., 2018) . Majority of the farmers extensively applying synthetic pyrethroides and contact insecticides and also synthetic insecticides for the management of the pest. Therefore, repeated use of the same group of chemicals is not a desirable practice as this could lead to undesirable resistance problems. After three years of research on onion variety NHRDF Red -2, the result indicated that chlorantraniliprole 0.4% @ 10kg/ha and subsequently sequential sprays of carbosulfan @ 0.2%, fipronil @ 0.1%, spinosad @ 0.03% and profenofos @ 0.1% at ten days interval is very effective for controlling of thrips and increasing the yield of onion seed with highest cost benefit ratio (1:4:19) at Nashik, Maharashtra (Pathak *et al.* , 2018). El-Wakeil *et al*. (2010), applied imidacloprid and thiamethoxam against the sucking insect including whitefly, thrips, and cotton aphid, and reported that imidacloprid reduced the pest number better than thiamethoxam. Ullah *et al*. (2010), also applied thiodan®, confidor®, tracer®, megamos®, and actara® for the management of onion thrips on crops and except for actara®, the remaining insecticides were successful in reducing the population of onion thrips. Sadozai *et al*. (2009) found that after application of karate®, thiodan®, confidor®, curacron®, and crown® for the control of onion thrips, they showed a significant reduction of thrips with the highest reduction rate by thiodan® and followed by curacron® and karate®.

Zezlina and Blazic (2003) , applied several insecticides for the management of *T. tabaci* and indicated that malathion, methomyl and phenthoate can control onion thrips at 14 days intervals. It demonstrated that the pesticide residue lasted for 14 days, which confirm the finding of studies, also different insecticides were utilized in different agro-ecological regions and utilized some chemical insecticide on onion thrips and indicated the residues could last for a period of one week or so. Since all the insecticides applied lost their effect after 15 days, it is assumed that pre harvest period is supposed to be somewhat longer than twenty days. Therefore, instrumental residual analysis studied is needed for the definite and safe pre-harvest period.

Hodge *et al.* , 2009 , applied various insecticides for the management of onion thrips and reported that methamidophos had the best effect and followed by dicotrophus and endosulfan, while the lowest efficacy was recoded in cypermethrin and monocrotophos. Mandi and Senapati (2009), applied different insecticides for the management of onion thrips and reported that acetamiprid and thiamethoxam had the highest mortality rate of 93.3% and 89.9%, respectively. Mallik *et al*. (2003)//// reported 42.2%, 17.2% and 6.8% thrips mortality with extracts of milkweed, datura, and bitter apple, respectively.

Similarly, Kadri and Goud (2006) recorded significant reductions in onion thrips with neem extracts. Like this efficacy of neem extract against thrips were reported by Mishra *et al.* (2007) and cited by Khaliq *et al.*, 2016 . Shelton *et al*., 2008 , applied acetamiprid, dimethoate, spinosad, imidacloprid, and lambda-cyhalothrin against thrips on cabbage and showed that except lambda-cyhalothrin, the others had good effect on thrips. (Kudom *et al*., 2015) , used acetamiprid, imidacloprid and emamectin benzoate against onion thrips and reported that these insecticides significantly reduced the thrips population. In this study, we examined the effect of six chemical insecticides as mentioned above that are among the different chemical classes. The results showed that acetamiprid SL had a higher efficacy followed by chlorpyrifos SL and carbaryl WP , while emamectin benzoate EC had the lower efficacy (Tables 1 and 2).The results of our present research are in agreement with the results of previously conducted studies particularly with (Kudom *et al*., 2015; Hodges *et al.*, 2009 and Ashghar *et al*., 2018).

The findings of this research indicated that acetamiprid SL, chlorpyrifos SL and carbaryl WP presented the best result in compared to other chemical insecticides against *T. tabaci*. It resulted in the lower population of thrips/plant and highest reduction percentage in all data recording intervals among the applied insecticides. Therefore, it can be concluded that acetamiprid SL, chlorpyrifos SL and carbaryl WP can be safely used in favorable times for the management of thrips population.

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