Evaluation of botanicals for onion thrips, *Thrips tabaci* Lindeman, (Thysanoptera: Thripidae) control at Gum Selassa, South Tigray, Ethiopia

Ibrahim Fitiwy[1]*, Abraha Gebretsadkan[2] and Kiros-Meles Ayimut[2]

[1]Department of Dry land Crop and Horticultural Sciences, College of Dryland Agriculture, P.O. Box 231, Mekelle University, Mekelle, Ethiopia (*ibrahimfit2013@gmail.com).

[2]Department of Dry land Crop and Horticultural Sciences, College of Dryland Agriculture, P.O. Box 231, Mekelle University, Mekelle, Ethiopia.

ABSTRACT

Field studies were conducted for two consecutive years (2013 and 2014) to determine the effectiveness of different plant extracts and synthetic chemical insecticides for the control of onion thrips (*Thrips tabaci*) at Adigudom, Southern Tigray, Ethiopia. Two chemical insecticides including *dimethoate* 40% E.C and Lambda-cyhalothrin (Karate 5 EC), and five botanical extracts obtained from neem (*Azadirachta indica* A. Juss), Mexican marigold (*Tagetus minuta L.)*, tree tobacco (*Nicotiana glauca* Graham) and Jimson weed (*Datura stramonium L.)* were tested for their controlling effect on onion thrips. The population dynamics of the thrips was monitored and population counts were made before and after the application of each of the treatments. The two years combined analysis indicated that there was a significant difference ($p<0.05$) in onion bulb yield where dimethoate, Tree tobacco, Karate, and Mexican marigold recorded significantly higher onion bulb yield than the control. Thirty and 37% more bulb yield was obtained in the Tree tobacco and dimethoate treated plots than in the control. Karate has had the highest effect in reducing thrips pest population in year one, though was on par with that of dimethoate, did well in the second year contributing to significant yield improvement against the control. There was no statistically significant difference among treatments in plant height, leaf number and bulb weight. From among the botanicals tested, tree tobacco had the best performance in controlling onion thrips and was comparable to those of dimethoate and Karate.

Keywords: Onion thrips, *Thrips tabaci*, Botanical insecticide, Chemical insecticide, Ecofriendly, Gum Selassa, Adigudem, Tigray, Ethiopia.

1. INTRODUCTION

Onion is a very important food and cash crop in Ethiopia (Kahsay et al., 2013; Shiberu et al., 2013) predominantly grown by smallholder farmers under irrigation with the total area covered with onion increasing from time to time (CSA, 2011; Kahsay et al., 2013). Onion bulb yield in Ethiopia has remained very low at 10.7 t/ha, whereas the current average world yield stands at 19 t/ha with the highest average onion bulb yields of 42 to 64 t/ha. Several constraints such as poor cropping system, lack of resistant varieties (Kahsay et al., 2013), disease and insect pests (Lee et al., 2001) contribute to the lower per hectare onion bulb yield in the country. Onion thrips

(*Thrips tabaci*) is one of the major insect pest of onion (Afifi and Haydar, 1990; Nault and Hessney, 2010), known to incur huge loses, 30–50% annually (Nault et al., 2012). *T. tabaci* is a cosmopolitan pest of onion and is considered as an indirect pest of dry onion bulb because it feeds on leaves rather than the bulb (Nault and Hessney, 2009). Thrips feeding on onion causes silvery leaf spots that turn into white blotches along the leaves followed by the development of silvery patches and curling of leaves. This injury reduces the photosynthetic ability of the plant by destroying chlorophyll-rich leaf mesophyll (Lewis, 1973 and 1997) which may interfere with transportation of nutrients to the bulb (Kendall and Bjostad, 1990; Parrella and Lewis, 1997). In Ethiopia, *T. tabaci* is an important onion insect pest (Shiberu et al., 2013) that destroys onion fields, especially in the dry seasons. Onion bulb yield loses due to onion thrips reported ranged between 10 to 85% (Abate, 1985; Merene, 2005; Bekelle et al., 2006).

Several synthetic insecticides have been widely used to control onion thrips in the field (Mayer et al., 1987) and though effective in bringing down pest populations, these chemical insecticides are costly and unsafe to both humans and the environment (Nault et al., 2012; Jensen and Simko, 2001) particularly to smallholder farmers who fail to follow the practices of safe handling and application of pesticide. Moreover, as most smallholder famers may not afford the ever increasing costs of pesticides, alternative non-chemical insecticides, such as botanicals (Ayalew, 2005; Shiberu et al., 2013), are found to be the best option for smallholder vegetable production. Use of botanical insecticides is ideal for organic farming and is safe for both the environment and human health, and is affordable where the materials are locally available. Therefore, a study was conducted at Gum Selassa irrigated vegetable production area, around Adigudom town in Hintalo-Wajirat woreda (district), southern Tigray, Ethiopia, with an objective of identifying effective botanical insecticides against onion thrips from different plant species with known insecticidal properties. Geographically, the area lies between $13^0$81’40” N and $39^0$83’2” E at an altitude of 2,100m above mean sea level. The soil in the area is vertisol, dominated by clay minerals, sticky upon wetting, and cracks when dries (Gebreegziabher et al., 2009).

2. METHODOLOGY

The experiment was conducted on irrigated farmlands close to the Gum Selassa micro-dam in the dry season for two consecutive years (2013-2014).

Onion seedlings ("*Adama" red*) were purchased from onion grower farmers and the plant species identified as botanicals with insecticidal properties were collected from the Mekelle University Campus and surrounding areas for use as insecticides.

The experiment was set in randomized complete block design **(**RCBD) with three replications. The plot size was 3 x 3 m, with row to row and plant to plant spacing of 50 cm and 10 cm respectively. The experiment contained eight treatments, i.e., five botanicals, Mexican marigold, *Tagetus minuta*, jimson weed, *Datura Stramonium*, tree tobacco, *Nicotinia glauca*, neem, *Azadirachta indica*, leaf powder and neem seed powder, and two synthetic chemical insecticides, dimethoate 40% EC and Karate 5% EC, and non-treated control where only water was applied (Table 1).

Table 1. List of treatments with their rate and time of application.

Treatment Code	**Treatment name**	**Rate of application**	**Time of application after planting**
NL	Neem, *Azadiractha indica*, leaf	50 gm/ l of water	22 days after planting
NS	Neem, *A. indica*, seed	50 gm/ l of water	22 days after planting
TM	Mexican marigold, *Tagetes minuta*, leaf	50 gm/ l of water	22 days after planting
TT	Tree tobacco, *Nicotinia glauca*, leaf	50 gm/ l of water	22 days after planting
DS	Jimson weed, *Datura stramonium*, leaf	50 gm/ l of water	22 days after planting
Ka	*Lambda-cyhalotrin (K*arate 5% EC)	1.2 litre/ ha	22 days after planting
Dim	Dimethoate 40% EC	1 litre/ ha	22 days after planting

2.1. Method of Botanicals Extraction

Neem leaves were dried in the lab for three days and grounded using electrical blender to make coarse powder. The powder was then mixed with water at a rate of 50 gm/l and left overnight as described by Keshav and Singh (2013). The next day the mixture was filtered using cheese cloth and made ready for spraying. In a similar manner, leaf extracts for the other three plant species Mexican marigold, jimson weed and tree tobacco were prepared using freshly collected leaf materials and blended using household blender. The resulting leaf juice was filtered through muslin and adjusted to required concentration for spraying.

The dried fruits of neem were also prepared by removing the kernels and blended using electrical blender. The resulting powder was mixed with water at a rate of 50 gm per liter and soaked overnight to be sprayed on the plots. The next morning the mixture was filtered through cheesecloth and made ready for application. Ten ml of liquid soap was added to all preparations to serve as an emulsifying agent before application.

2.1.1. Spraying Frequency of Botanicals in the Field

Each of the botanical preparations and the chemical insecticides were sprayed five times during the crop growth period at two weeks interval in the field: 37, 51, 67, and 86 days after transplanting.

2.2. Data Collection

Number of leaves per plant and plant height measurements were taken from randomly selected 10 plants from each of the treatment plots one week before harvesting. The level of infestation by onion thrips was assessed at an interval of 10 to 20 days starting from 37 days after transplanting, right before spraying. This assessment was done to observe the effect of the different botanicals and the chemical insecticides on the population dynamics of the pest. Data on the thrips population was collected from 10 randomly selected plants from each of the treatment plots before and after each of the spray applications of the botanicals and the chemical insecticides. Bulb weight per plant was calculated by dividing the total onion bulb weight per plot by the total number of plants harvested from that plot. Yield per plot was determined by weighing the total harvested bulbs in each plot.

2.2.1. Data Analysis

Data collected were analyzed using SAS 9.0 software and least significant difference (LSD) was used for treatment mean comparison.

3. RESULTS AND DISCUSSION

3.1. Effect of Botanicals and Chemical Insecticides on Population Dynamics of Onion Thrips

3.1.1. First Year (2013)

On the first year, the thrips population was observed increasing from time to time possibly due to the re-infestations from neighboring onion fields. Over the crop growth period in the first year, the thrips population in the control plots, where only water was sprayed during each spraying time (37, 51, 67, and 86 days after planting), was relatively higher than the rest of the treatments.

The Karate treated plots had the lowest thrips population across all assessment dates (Fig 1). On the third spraying time (67 days after transplanting), Dimethoate and Karate had significantly lower population (p<0.05) than the rest of the treatments.

On the last assessment date (85 days after transplanting), only plots sprayed with Karate had statistically significant lower number of thrips per plant (p <0.05) than the rest of the treatments, while Dimethoate treated plots had statistically lower thrips count (p <0.05) than only the control treatment. Leaf extracts of neem and tree tobacco had also significantly lower thrips infestation on the assessment date than the control treatment. This is clearly shown in (Fig 1) where the thrips population growth was particularly lower in plots treated with Karate than the rest of the treatments.

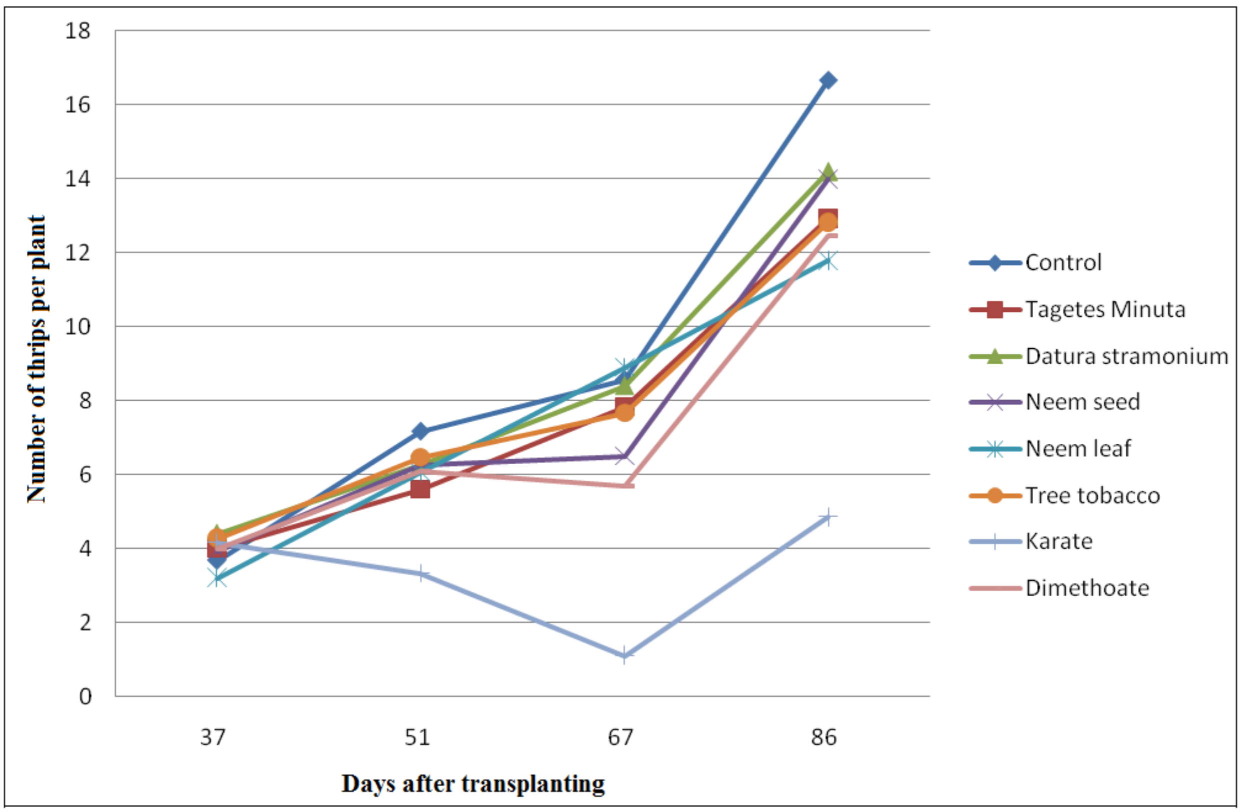

Figure 1. Onion thrips population dynamics as influenced by chemical and botanical insecticide sprays (thrips population counts were done just before spraying of the different treatments 35, 51, 67 and 86 days after transplanting).

In line with our findings, a preliminary data from the Queensland trial confirmed the efficacy of Karate against onion thrips in a similar way. Jianhua (2004) showed that Karate was the best performing insecticide shortly after spraying and in a separate trial comparing the relative effectiveness of Karate and dimethoate, Karate was four times more effective than dimethoate on adults and 14 times more effective on juveniles. Thoeming et al. (2003) have also investigated in a similar way on the systemic effects of neem against western flower thrips larvae on primary bean leaves and observed with maximum corrected mortality of 50.6%.

3.1.2. Second Year (2014)

Population density of onion thrips was statistically different (*P<0.05*) among treatments (Fig 2). The difference among botanicals, chemicals and control significantly increased from the time of third spray.

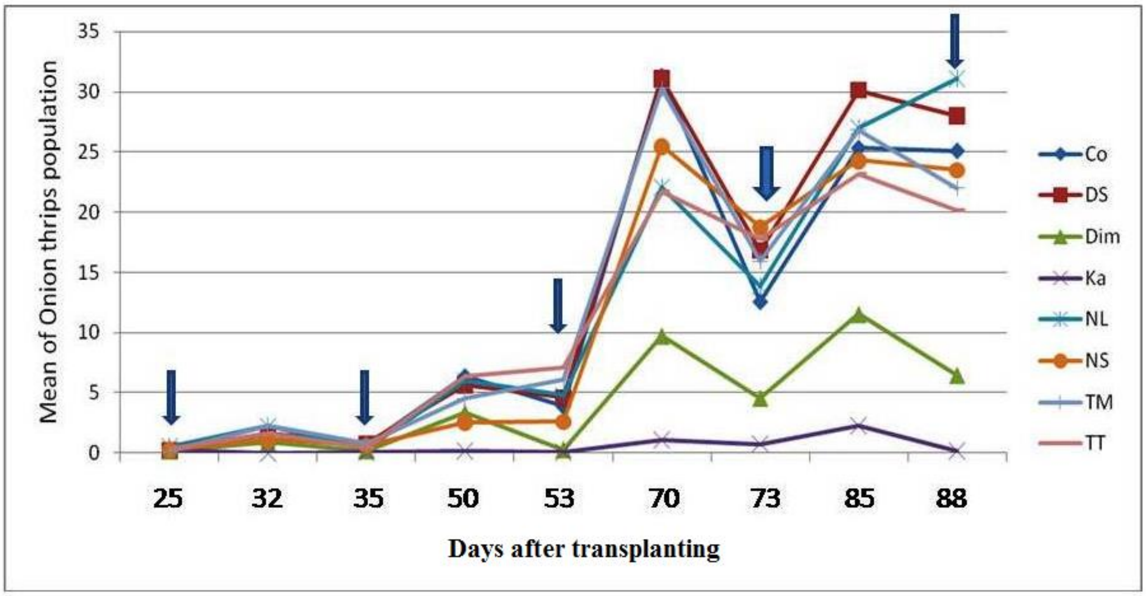

Figure 2. Thrips population count just before spraying and three days after spraying (down arrow indicate population count three days after spraying) (Co = control only water sprayed, NL = neem leaf, NS = neem seed, TM =Tagetes minuta , TT= tree tobacco, DS= *Datura stramonium*, Ka= Karate 5% EC and Dim = Dimethoate 40% EC).

The thrips population was consistently and significantly the least in Karate treated plots across all assessment dates and both before and after each application. The mean number of onion thrips highly decreased in plots sprayed with Karate 5% EC (0.55) compared to the control (11.88). Dimethoate 40% EC treated plots on the other hand, also had significantly lower thrips population density starting at the third sprays in a range of 0.3 to 11.53 than the rest of the plots treated with the control, 3.87 to 31.3. Next to the insecticides in a similar manner, application of tree tobacco and neem seed reduced the thrips population from 6.4 to 23.13 and 2.57 to 25.5 as compared to control, respectively. However, the performance of these botanicals in terms of lowering the thrips population across all assessment dates was not consistent with the plots that received the remaining botanical extracts. This is probably due to re-infestations from the neighboring onion fields where no insecticides were applied during the growing period.

Khaliq et al. (2014) evaluated the effectiveness of three botanical insecticides (neem, datura and bitter apple), and three synthetic insecticides against onion thrips (*Thrips tabaci*). In line with our findings regarding to the effectiveness of botanical insecticides, they indicated that, a) all the botanicals and chemical insecticides tested caused significant reductions (45-70%) in thrips populations; b) the botanicals gave more than 60% control of thrips compared to the chemical insecticides where acephate was found to be the most effective followed by spirotetramat and spinetoram; and c) the insecticides gave better control than the botanicals.

3.2. Effect of Chemical Insecticides and Botanical Extracts on Onion Yield and Yield Components

3.2.1. Year One (2013)

There was a significant difference in plant height among the different treatments with Karate treated plants which reached 49 cm in height followed by *N. glauca* and neem leaf compared to the control (Table 2). Number of leaves per plant also varied among the different treatments where again Karate treated plots had significantly higher mean number of leaves per plant than the rest, except the plots treated with neem leaf and tree tobacco.

Table 2. Onion bulb yield and yield components of the different insecticidal treatments.

Treatments	**Parameters**			
	Plant height (cm)	**Leaf number per plant**	**Yield (kg/ha)**	**Bulb weight per plant (kg/plant)**
Co	35.667^{e}	9.800^{c}	9163^{f}	0.036^{c}
TM	36.883^{e}	10.233^{c}	12593^{cde}	0.066^{c}
DS	42.407^{cd}	12.366^{b}	10741^{ef}	0.070^{c}
NS	42.100^{cd}	12.166^{b}	11852^{def}	0.043^{c}
NL	44.407^{bc}	13.253^{ab}	15589^{abc}	0.130^{bc}
TT	45.427^{b}	13.333^{ab}	16783^{ab}	0.203^{b}
Ka	49.213^{a}	14.646^{a}	18618^{a}	0.486^{a}
Dim	41.317^{d}	12.586^{b}	14445^{bcd}	0.433^{a}
CV (%)	3.499	8.293	13.666	36.817
LSD(0.05)	2.5844	1.786	3284.3	0.1185

(Note: Co = control only water spray, NL = neem leaf, NS = neem seed, TM =*Tagetes minuta*, TT= tree tobacco, DS= *Datura stramonium*), Ka= Karate 5% EC, and Dim = Dimethoate 40% Ec.)

The yield per plot obtained was also significantly different among the different treatments with significantly higher bulb yield obtained in plots that received Karate, neem leaf extract and tree tobacco extract (Table 2). The control plot, as expected, had the lowest bulb yield than the rest of the treatments.

3.2.1.2. Bulb Weight

Dimethoate and Karate treated ones had significantly higher bulb weight than all other treatments, followed by the tree tobacco treated ones which had better bulb weight than other botanicals except the neem leaf.

3.2.2. Year Two (2014)

3.2.2.1. Leaf number, plant height, yield and bulb weight

The result showed that all parameters were found to be statistically non-significant (Table 3).

Table 3. Mean comparison of the effect of insecticidal treatments on leaf number, plant height, yield and bulb weight of onion crop.

Mean comparison for 2014				
Treatments	***Leaf number/plant***	***Plant height (cm)***	***Yield (kg/ha)***	***Bulb weight (kg/Plant)***
Co	8.13	38.54	12435.41	0.90
DS	9.20	38.32	17037.03	1.27
Dim	9.27	38.43	12592.59	1.03
Ka	9.37	42.27	13444.44	1.23
NL	8.67	40.24	13518.51	1.17
NS	8.40	35.70	13296.29	1.03[a]
TM	9.33	38.38	14000.00	1.17
TT	9.37	39.72	15740.74	0.93
P-value	0.99	0.869	0.2161	0.25
CV	7.30	14.60	6034.0	0.552

(Note: Co = control only water spray, NL = neem leaf, NS = neem seed, TM = *Tagetes minuta*, TT= tree tobacco, DS= *Datura stramonium*), Ka= Karate 5% EC, and Dim = Dimethoate 40% EC)

3.3. Summary- Year one (2013) and Year Two (2014)

The combined analysis of the two years result (Table 4) indicates that there was a significant difference in the yield and the performance of dimethoate has been outstanding, where the increase was by 37% compared to the control. This was followed by a promising botanical, the tree tobacco, where the increased was by 30%. Karate, very known for its highest effect the previous year, is also on par with dimethoate, doing well even the second year contributing to a significant yield improvement against the control. Mohammad and Naqvi (2000) compared dimethoate against sucking pests of thrips and found out that the insecticide has proved to be more toxic but its effect lasted for four days only while the neem product was less toxic but its effect lasted for six days. The findings are comparable with our results that dimethoate has given good yield compared to neem and other botanicals however, neem product is much safer and non-polluting.

Table 4. Bulb yield and associated parameters differences among plots treated with botanicals and chemical insecticides.

Summary of the two years report (2013 and 2014)					
Treatments	**Leaf no. per plant**	**Plant height (cm)**	**Yield (kg/ha)**	**Bulb weight per plant (kg/plant)**	**% bulb yield difference to that of control**
Control	10.092[a]	39.878[ab]	11040.83[c]	**0.386[b]**	-
Dimethoate (Ethiothoate 40% EC)	10.083[a]	38.611[b]	**15166.67[a]**	0.663[a]	+37.4
Datura stramonium	10.816[a]	40.420[ab]	11666.67[c]	0.551[ab]	+5.7
Lambda-cyhalotrin (Karate 5% EC)	10.266[a]	**43.011[a]**	13611.11[ab]	0.646[a]	+23.3
Neem leaf	10.233[a]	40.886[ab]	12722.22[c]	0.613[a]	+15.2
Neem seed	10.283[a]	38.901[ab]	12574.07[c]	0.536[ab]	+13.9
Tagetus minuta	9.783[a]	37.630[b]	**13296.30[bc]**	0.616[a]	+20.4
Tree tobacco	10.283[a]	41.145[ab]	**14351.85[ab]**	0.506[ab]	+30.0
p-value	0.988	0.284	**0.048**	0.269	-
LSD	2.33	4.287	2417	0.17	-
CV	18.52	9.13	15.76	24.27	-

The rest of the parameters such as plant height, leaf number and bulb weight, though statistically non-significant among treatments possibly because the thrips population was low compared to the previous year, shows a similar trend being better in the yield changes to the control. Reddy et al. (2007) determined the efficacy of indigenous botanical extracts like neem seed kernel extract for the management of the onion thrips in a farmer's field at Kalshettihalli village of Chikmagalur district of Karnataka State, India. The authors reported that the neem extract was superior than wild tobacco leaf extract and carbosulfan (250g.a.i./hactare) in controlling the thrips on onion, obtain higher bulb yield and cost: benefit ratios in both the seasons. Their findings were in contrary to our botanical extract results that show the reverse and the bulb weight was found to be non-significant.

Lal and Verma (2006) reported that the tree tobaccowas found to be very effective against the thrips by 67-75% compared to the untreated control. In line with our findings, Kambou and Guissou (2011) described that an aqueous extracts from tree tobacco make it possible to produce yields equivalent to those after the application of Deltamethrin and therefore, represents an alternative to chemical insecticides. In another study Solangi et al. (2014) also showed that the efficacy of tobacco based biopesticides against whitefly was 70.88%, against thrips 57.27% and against aphid 60.40%.

4. CONCLUSIONS

From the first year results, it can be concluded that across all parameters, the chemical insecticide, Karate 5% EC and tree tobacco from the botanicals showed a significance effect in reducing the damage of onion thrips. This saves the farmers yield and its value appreciably.

The combined, two years data showed still a significant yield increment in both treatments insecticides and botanicals particularly the tree tobacco. Thus, it provides a better and wide control options, locally available, ecologically sound and cost effective solutions.

4.1. Recommendations

The starting year of the research finding was showing great results which clearly displays significant differences between the parameters that are of interest to the farmers. However, since the population dynamics of the pest compared to the previous years, appears to be less in number for different reasons as the change among all parameters of the second year except the yield have had no significant effect. This indicates that the research should continue at least for the next one year to come up with better/concrete results.

5. ACKNOWLEDGEMENTS

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APPENDIX-1

Average number of Thrips per plant on 37, 51. 67 and 86 days after planting at Gum Selasa, 2013.

Treatment	Days after planting			
	37	51	67	86
Control	3.67[a]	7.17[a]	8.57[abc]	16.67[a]
Mexican marigold	4.00[a]	5.60[a]	7.83[bcd]	12.93[b]
Jimson weed	4.40[a]	6.27[a]	8.40[bc]	14.200[ab]
Neem seed	3.93[a]	6.27[a]	6.50[cd]	14.00[ab]
Neem leaf	3.2[a]	6.07[a]	8.900[ab]	11.80[b]
Tree tobacco	4.27[a]	6.47[a]	10.73[a]	12.83[b]
Karate	4.17[a]	3.33[b]	1.10[e]	4.87[c]
Dimethoate	4.00[a]	6.10[a]	5.70[d]	12.47[b]
CV (%)	21.21	16.12	18.04	16.79
LSD (0.05)	1.47	1.67	2.28	3.67

APPENDIX-2

Mean comparison of onion Thrips population before and after application of five botanicals (NL = neem leaf, NS = neem seed, TM = *Tagetes minuta*, TT = tree tobacco, DS = *Datura stramonium*) and two chemicals (Ka= Karate 5% EC and Dimethoate) of 2014.

Level of Treatment	A1spr	B2spr	A2spr	B3spr	A3spr	B4spr	A4spr	B5spr	5d Asp
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Co	0.167	1.633	0.60	6.36	3.86	31.30	12.57	25.33	25.1
DS	0.2	1.633	0.80	5.66	4.63	31.07	16.8	30.10	27.93
Dim	0.167	0.90	0.20	3.33	0.30	9.733	4.56	11.53	6.46
Ka	**0.267**	**0±0**	**0.10**	**0.16**	**0.10**	**1.06**	**0.76**	**2.267**	**0.2±**
NL	0.533	2.233	0.33	5.96	4.76	22.00	13.83	27.03	31.1
NS	0.27	1.167	0.6	2.56	2.60	25.5	18.77	24.3	23.53
TM	0.133	2.233	0.80	4.50	6.03	30.3	15.93	26.83	22
TT	0.367	1.633	0.50	6.40	7.10	21.7	17.8	23.13	20.13
P-value	0.770	0.176	0.34	0.016	0.043	0.007	0.001	<.000	0.000
LSD				3.5016	4.562	15.773	7.8508	8.7955	11.801
CV	115.77	68.33	83.03	46.28	71.71	42.21	35.91	23.87	34.8