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Improving Efficiency of Insecticides for Controlling Thrips Insects (*Thrips tabaci* L.) Infesting Onion Plants (*Allium cepa* L.) in Egypt

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ABSTRACT

Field experiments were conducted for two successive seasons to investigate the effect of an surfactant on the efficiency of six insecticides against immature and adult stages of onion thrips, *Thrips tabaci* at Al- Nubaria region, Beheria governorate, Egypt. Tested insecticides were Bio-Catch® (*Verticillium lecanii*), Tracer®(spinosad), Admire® (imidacloprid),Emacit® (emamectin benzoate), Nimbecidine®(azadirachtin) and Actellic® (pirimiphos-methyl).Insecticides were applied at the full recommended doses, the half of the recommended doses and the half of the recommended doses mixed with an surfactant. Results of the two seasons revealed that the best reduction of thrips adults after seven days of application using the full recommended dose occurred by of Nimbecidine® (Azadirachtin) (94.64a%), followed by Tracer®(spinosad) (93.65a%), Whereas, the best reduction using the half dose occurred by Admire® (imidacloprid) (88.54a%). While, Tracer ® (spinosad) (97.48a%) plus the surfactant Stanowet® (silicon polyether blend 50% W/V) caused that the best reduction of applications using the insecticide at the half dose mixed with the surfactant.

Key word: Insecticides, silicon polyether, thrips and onion

Introduction

Onion, *Allium cepa* L., is among the most valuable vegetable crops in Egypt. The area harvested during the season of 2012 was about 60000 (Ha) according to Ministry of Agriculture Statistics, Egypt. while, the national production was about 2,024,881tons (FAO, STAT.2012). Onion thrips, *Thrips tabaci* Lindeman, is a polyphagus pest which has been recorded on 29 plant families in particularly Brassicaceae, Liliaceae and Solanaceae (Penzes*et al*., 1996; Theunissen and Schelling, 1998; Richter *et al*., 1999). Onion thrips feed by scraping the plant surface and sucking out the cell contents (Commegys and Schmitt, 1965). Onion thrips is one of the most important insect pests of onion in the Hispaniola Island and the Caribbean (Cabrera *et al*., 1997; Schmutterer, 1990; Shelton *et al*., 1987).

Cabrera and Velez (2000) reported yield losses of 50% due to thrips infestations. Heavy infestation leads to decrease of quality as well as quantitative losses in the yield (Kendall and Capinera 1987; Vierbergen and Ester 2000).Feeding damage in bulbs lowers bulb quality and value for export, and has been an important issue for New Zealand onion exporters since 1997 (Wood, 2001).

Therefore, all the botanicals and chemical insecticides tested caused significant reductions (45–70%) in thrips populations Abdul Khaliq *et al*. (2014).

As a result of the presence of a waxy layer on the green leaves of onion it leading to the plant surface be hydrophobic, and it also reduce the sticky of pesticide spraying on the leaves surface which leads to reduce the efficiency of insecticides, so to solve this problem by improving the pesticides formulation properties through addition a surfactants like (Blend of silicon polyether) Therefore, experimental trials were established in the field at Al- Nubaria region, Beheria governorate, Egypt during two successive seasons 2012 and 2013 to evaluate the influence of certain botanical, chemical and bio- insecticides individuals and mixed with bland of silicon polyether (as surfactants) against immature and adult stages of onion thrips, *Thrips tabaci* with a recommended and half doses .Thus, the objective of this paper is to enhance the bio- efficiency of botanical, chemical and bio- insecticides against immature and adult stages of onion thrips, *Thrips tabaci* by improving the formulation properties through addition of surfactants.

Materials and Methods

The field trials were conducted by cultivating onion (*Allium cepa,* L.) during the two successive seasons; 2012 and 2013 at the Al-Alamia company farm, Nubaria region, Beheria governorate, Egypt.

The experimental area was divided into plots, each of one 100 m^2 .Plants were grown along distance of 8 cm apart and in rows of 120 cm width. The experimental areas were treated according to the normal agricultural practices and recommendation guidance. Seedlings were grown on 1st January in both 2012 and 2013, seasons.

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To evaluate the fatal effect of the tested spry able insecticides on the incidence of thrips population, plants were sprayed with certain insecticides to show what extent they might be included in an IPM program of Onion. Treatments included the six insecticides plus an untreated check control. Treatments were applied using a knapsack sprayer (20 L) at the rate of 200 Liters / Feddan, to give a complete coverage of all plants. The insecticides were used according to their recommended field rates. The same treatments were repeated in the half dose of insecticides lone or mixed with the surfactant Stanowet ® **(**Silicon Polyether Blend 50% W/V)

Two rows were used as a barrier between the each treatment and others. Treatments were arranged in a complete randomized block design with three replicates for each. Samples were inspected out at periods of 0, 2, 5, and 7 days post treatment to determine the numbers of Thrips on 10 plants from each plot. The degree of infestation was estimated by counting the number of living insects (immature and adult stages). The percentages of infestation reduction were calculated according to Henderson and Tilton's equation (1955) as follows:

Reduction % = $(1- (\frac{A}{b} \times \frac{c}{d}) \times 100)$

Where:

a = Population in treatment after spraying

b = Population in treatment before spraying

c = Population in check untreated (control) before spraying

d = Population in check untreated after spraying

Reduction percentages were calculated after 2, 5 and 7 days after treatment for adult and the immature stages.

Table 1: List of pesticides and their rates of application during two onion growing seasons of 2012and 2013.

Trade name	Formulation type	Common name	Recommended dose Rate/ 1 L water
Bio-Catch®	in liquid (1x109CFU's/ml)	*Verticillium lecanii*	5 Cm^3
Tracer ®	24% SC	spinosad	0.25 Cm^3
Admire®	24 % FL	imidacloprid	0.5 Cm^3
Emacit®	5% SG	emamectin benzoate	0.20g
Nimbecidine®	0.03% EC	azadirachtin	5 Cm^3
Actellic®	50% EC	pirimiphos-methyl	5 Cm^3

SC=Suspension Concentrate, FL=Flowables, SG = Soluble Granule.and ,EC = Emulsifiable Concentration

Data were subjected to the analysis of variance test (ANOVA) via Randomized Complete Block Design (F. test). The least significant differences (LSD) at the 5% probability level were calculated according to computer program Costat and Duncan's Multiple Range testes modified by Steel and Torrie (1981) to compare the average numbers of inspected pest infestations.

Results and Discussion

A. Season of 2012:

A.1. Full recommended doses:

The lethal effect of the recommended doses of the tested insecticides on thrips populations immature and adult stages during the first season 2012 is shown in (Table 2). The number of immature and adult thrips insects per plant was significantly lower than in the untreated control. The results cleared that highest reduction percentage was achieved by pirimiphos-methyl followed by spinosad and imidacloprid showing the values of "95.74a%", "88.36b%" and "85.6c%", respectively after two days from application.

Table 2: Average numbers of onion thrips (immature and adult stages) after the application of the recommended doses during the season of 2012.

Treatments	Pre- spray	Average no. of insects(Days)			Reduction percentages (Days)		
		2 days	5 days	7	2	5	7
Bio-Catch®	10.9	8.1	5.9	6.5	68.15e	82.34f	84.57c
Tracer ®	21	5.7	4.9	5	88.36b	92.39b	93.65a
Admire®	12.5	4.2	3.2	5	85.6c	91.65c	89.65b
Emacit®	15	6	5.2	6	82.85d	88.69e	89.65b
Nimbecidine®	29	12	8	6	82.26d	91.00d	94.64a
Actellic®	16.3	2	2.5	4	95.74a	94.99a	93.65a
Control	15	35	46	58	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level A.2.Half of the recommended doses

The residual effect of pesticides after five days cleared significant reduction by all treatments but, the highest reduction percentage was occurred by pirimiphos-methyl "94.99a%" followed by spinosad "92.39b%" and imidacloprid "91.65c%". After seven days from application, azadirachtin "94.64a%", showed the most effective reduction comparing with the rest insecticides while *Verticillium lecanii* "84.57c%" was had the least effect. Generally all the evaluated insecticides approved to be effective against onion thrips.

The half doses of the same insecticides were applied against the thrips insect (*Thrips tabaci* L). Data in (Table3) cleared a positive relationship between the insecticide concentrations and the reduction percentages of onion thrips. The best reduction percentage of onion thrips occurred by emamectin benzoate "79.72a%" followed by imidacloprid "72.87b%"after two days of application. While, after, five days of application, emamectin benzoate **a**nd imidacloprid showed the best reduction values comparing with the other insecticides "85.67a%" and "84.52 ab%", respectively.

After seven days of application the highest values of reduction percentage of onion thrips occurred by imidacloprid "88.54a%" but, the least reduction percentage was achieved by *Verticillium lecanii* "76.48b%".

Table 3: Average numbers of onion thrips (immature and adults stages) after the application of the half recommended doses during the season of 2012

Treatments	Pre- spray	Average no. of insects(Days)			Reduction percentages(Days)		
		2 days	5 days	7	2	5	7
Bio-Catch®	11	9	8	10	64.93^{e}	76.28^{c}	76.48^{b}
Tracer ®	21	15	12	13	68.38^{cd}	81.36^{abc}	83.99^{a}
Admire®	31.6	20	15	14	72.87^{b}	84.52^{ab}	88.54^{a}
Emacit®	29.6	14	13	15	79.72^{a}	85.67^{a}	86.89^{a}
Nimbecidine®	22.5	16	13	10	69.52^{c}	81.15^{abc}	88.50^{a}
Actellic®	13	10	8	7	67.03^{d}	79.93^{bc}	86.07^{a}
Control	15	35	46	58	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level A.3. Half of the recommended doses mixed with the surfactant

Mixing the half dose of the insecticides with a surfactant caused more reduction percentages of thrips populations. Data in (Table 4) showed that there were significant differences between the treatments at all inspection times after application. After two days from application the highest reduction percentage of thrips populations occurred by emamectin benzoate + silicon polyether blend "96.35a%" followed by imidacloprid + silicon polyether blend "93.34b%". Whereas, after five days from application the best reduction of thrips population was achieved by spinosad + silicon polyether blend "95.38a%" followed by emamectin benzoate + silicon polyether blend "93.81b%".

Finally, after seven days from application, the highest reduction percentage of thrips population was achieved by spinosad+ silicon polyether blend "97.78a %" but, the lowest reduction percentage was achieved by pirimiphos-methyl + silicon polyether blend "84.40c%".

Table 4: Average numbers of onion thrips (immature and adults stages) after the application of the half recommended doses mixed with surfactant during the season of 2012.

Treatments	Pre- spray	Average no. of insects(Days)			Reduction percentages(Days)		
		2 days	5 days	7 days	2 days	5 days	7
Bio-Catch® +Stanowet®	13.8	6	3.7	3.6	81.36e	90.25c	93.25b
Tracer ®+Stanowet®	22.6	4.8	3.2	2.2	90.89c	95.38a	97.48a
Admire®+Stanowet®	32.2	5	6.4	8.4	93.34b	93.51b	93.25b
Emacit®+Stanowet®	30.6	2.6	5.8	7.8	96.35a	93.81b	93.40b
Nimbecidine®+Stanowet®	23.6	5.4	4.6	3.4	90.19c	93.64b	96.27a
Actellic®+Stanowet®	12.6	4.8	5.7	7.6	83.67d	85.24d	84.40c
Control	15	35	46	58	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level

B. Season of 2013:

B.1. Full recommended dose:

During the second season, 2013, the results showed that there were significant differences among the treatments and at the different inspection times. Data in (Table 5) showed that the highest reduction percentage of thrips insects after two days of application was recorded by pirimiphos-methyl "92.27a %" followed by imidacloprid"91.72a %" and spinosad "87.94b %". On the other hand, the lowest reduction percentage of thrips

insects was referred to the application of *Verticillium lecanii* "67.72d %".Whereas, the highest reduction percentage of thrips achieved by azadirachtin "91.82a%" but, the lowest reduction percentage occurred by of *Verticillium lecanii* "83.06c %". Finally, the greatest reduction percentage of adult thrips after seven days from application occurred imidacloprid "93.19a %", on the contrary, the lowest value was achieved by *Verticillium lecanii* "89.02d%".

B.2. Half of the recommended doses:

Using the half of the recommended doses of the insecticides showed that the highest reduction percentage of thrips population were achieved by Azadirachtin "76.31a %"followed by Emamectin benzoate "75.11a %" and Admire "72.69b %" after two days of application.

Table 5: Average numbers of onion thrips (immature and adults stages) after the application of the recommended doses during the season of 2013.

Treatments	Pre- spray	Average no. of insects(Days)			Reduction percentages(Days)		
		2	5	7	2	5	7
Bio-Catch®	12.2	10.5	6.2	5.8	67.72d	83.06c	89.02d
Tracer ®	14	4.5	3.9	4.4	87.94b	90.71ab	92.74ab
Admire®	19	4.7	5.3	5.6	91.72a	90.70ab	93.19a
Emacit®	13.9	6.2	4.3	5.2	83.27c	89.68b	91.36bc
Nimbecidine®	13	5.7	3.4	5.1	83.55c	91.82a	90.94c
Actellic®	17	3.5	4	6	92.27a	91.15a	91.85abc
Control	15	40	45	65	-	-	-

- *Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level*

After, five days from application the insecticides the highest reduction percentage of thrips was achieved by spinosad "80.95a %" But, the lowest reduction percentage of thrips occurred bypirimiphos-methyl "73.33b %". Frankly, after seven days of the application, the highest reduction percentage of thrips population occurred by spinosad "88.13a %" followed by *Verticillium lecanii* "85.57ab %" and emamectin benzoate "83.66abc %", (Table 6).

Table 6: Average numbers of onion thrips (immature and adults stages) after the application of the half recommended doses during the season of 2013

Treatments	Pre- spray	Average no. of insect s(Days)			Reduction percentages (Days)		
		2 days	5 days	7 days	2 days	5 days	7 Days
Bio-Catch®	16	13	10	10	70.53c	79.16a	85.57ab
Tracer ®	17.5	13	10	9	72.14b	80.95a	88.13a
Admire®	20.6	15	16	17	72.69b	74.11b	80.95bc
Emacit®	22.6	15	14	16	75.11a	79.35a	83.66abc
Nimbecidine®	19	12	15	16	76.31a	73.68b	80.56bc
Actellic®	15	10	12	13	75a	73.33b	80c
Control	15	40	45	65	-	-	-

- Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level

B.3. Half of the recommended doses mixed with the surfactant:

Data in (Table, 7) cleared that there were significant differences between the treatments using the half of the recommended doses mixed with the surfactant at each of inspection times. After two days from application the highest reduction percentage of thrips populations occurred by Emamectin benzoate + silicon polyether blend "95.60a %" followed by imidacloprid + silicon polyether blend (92.53b %". Whereas, after five days from application the best reduction of thrips population was achieved by Emamectin benzoate + silicon polyether blend "94.46a %"followed by Azadirachtin + silicon polyether blend "93.58b %". Finally, after seven days from application the highest reduction percentage of thrips population was achieved by spinosad + silicon polyether blend “97.58a %" but, the lowest reduction percentage of thrips population was achieved by Pirimiphos-methyl + silicon polyether blend “82.01d %".

The obtained results will add a great advantage to IPM programs depending on using modern insecticides with an surfactant which gives the highest control potential with lowest environmental pollution and application cost.

Table 7: Average numbers of onion thrips (immature and adults stages) after the application of the half recommended doses mixed with surfactant during the season of 2013.

Treatments	Pre- spray	Average no. of insects (Days)			Reduction percentages (Days)		
		2	5	7	2	5	7
Bio-Catch® +Stanowet®	15.4	9	3.3	5.5	78.08e	92.85e	91.75c
Tracer ®+Stanowet®	18.9	5	3.8	2.8	91.07bc	93.29d	97.58a
Admire®+Stanowet®	22.6	4.5	4.5	7.1	92.53b	93.36c	92.75bc
Emacit®+Stanowet®	25.6	3	4.3	8	95.60a	94.46a	92.78bc
Nimbecidine®+Stanowet®	18.2	4.8	3.5	3.2	90.10c	93.58b	95.94ab
Actellic®+Stanowet®	12.7	6.2	6.2	9.9	82.69d	83.72f	82.01d
Control	15	40	45	65	-	-	-

- *Means followed by the same letter(s) in each column are not significantly different at P ≤ 0.05 level*

Our, results are quite in conformity with the findings of previous investigators (Gandhale *et al.*, 1984; Kisha, 1979; Hussain *et al*., 1997) who used synthetic insecticides for the management of onion thrips in different parts of the world and got a considerable knockdown effect. Kisha (1979) reported that onion thrips can be controlled by methomyl (0.53 a.i. kg ha-1), malathion (1.0 kg ha-1) and phenthoate (1.08kg ha-1), if applied at 14 days interval. He showed that the residue lasted for 14 days, which confirms the finding of the present studies, although different insecticides were used in different agro- ecological zones. Gandhale *et al*., (1984) reported a good control of onion thrips and the residual effect could last for a period of one week or so. Since the examined insecticides lost their effect after 15 days, it is assumed that pre harvest interval supposed to be somewhat longer than over twenty days. However, instrumental residual analysis studies are needed for definite and safe pre-harvest period. Hussain *et al.* (1997) found that methamidophos was the most effective insecticides for controlling *Thrips tabaci* followed by dicrotophos, endosulfan. cypermethrin and monocrotophos. Mahmoudand Osman (2007) found that Spinosad®, Mectin®, Neemix® and Biofly® gave the best control and continued to give significant reduction in thrips populations till 21 days of treatment compared to the other insecticides.

Also, Sadozai *et al.*(2009) found that Karate 2.5, Thiodan 35 EC, Confidor 20 SL, Curacron 500 EC and Crown 200 SL were significantly better than untreated check in reducing onion thrips on onion bulb crop population. Thiodan proved to be the best one followed by Curacron and Karate. Whereas, Abdul Khaliq*et al*., (2014) reported that all the botanicals (neem, datura and bitter apple) and chemical insecticides (acephate, spirotetramat and spinetoram) tested caused significant reductions (45-70%) in thrips populations; the botanicals gave more than 60% control of thrips, while among chemical insecticides, acephate was found to be the most effective followed by spirotetramat and spinetoram, respectively, and these insecticides gave better control than the botanicals. Also, mixing an surfactant to the half dose of insecticides increases the viscosity of the spray solution , reduces the drift and increases the retention of spray solution on the surface of plant (Bod *et al*., 1976).Somasundaran *et al.* (2006) reported that silicone polymers are a class of hybrid organic/inorganic polymers, that show desirable surface properties such as low surface energy and high flexibility, which enables even a very high molecular weight chain to achieve optimal orientation at the interface. They have excellent physical properties such as water repellency, heat stability, and high resistance to chemical and UV attack. So, after using the mixing between silicon polyether and insecticides the results were improved. Also, Barakat and Kordy (2013) found that Admire® was the most efficient among the tested insecticides gave (98.08%) followed by Nimbecidine® (94.88%) and Tracer ® gave (94.34%) against thrips adults after seven days of application.

Generally, differences among different treatments in our study can be attributed to different modes of actions of the insecticides and also to the developmental stage of onion thrips, *T. tabaci*. The best overall results were obtained with the recommended dose of imidacloprid, azadirachtin and spinosad that provide excellent control through 7 days period at the recommended rates. Whereas, the half dose of spinosad+ silicon polyether blend caused the highest reduction percentage of thrips population comparing with the half doses of the other insecticides. At all events the bio-rational insecticides look promising and could be alternative insecticides in future for controlling onion thrips and be safe at the same time for natural enemies.

References

Abdul Khaliq, A.A. Khan, M. Afzal, H.M. Tahir, A.M. Raza and A.M. Khan, 2014.Field evaluation of selected botanicals and commercial synthetic insecticides against *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) populations and predators inonion field plots. Crop Protection, 62: 10-15.

Barakat, A.S.T. and A.M. Kordy, 2013. New approaches for IPM program to control thrips insect (*Thrips tabaci L.*) infesting Onion plants (*Allium cepa,* L.) in Egypt.Egyptian J. Appl. Sice., 28(12): 270-277.

Bode, L.E., R.J. Bufler and C.E. Georing, 1976. Spray thickener, nozzle type and nozzle pressure. Trans. ASAE, 75: 213-218.

Cabrera, I. and A. Velez, 2000. Manejointegrado de *Thrips tabaci* L. y Liriomyza sp. en la cultivo de cebolla (*Allium cepa*) en Puerto Rico .Resumenes XLVI Reunion del PCCMCA. pp: 217.

Cabrera, I., E. Vargas and C. Torres, 1997. Manejo de *Thrips tabaci* L. y Liriomyza sp. en la variedad commercial de cebolla Mercedes utilizando diferentes insecticidas .Proc. Caribbean Food Crops Soc., 33: 343-348.

Comegeys, G.R. and J.B. Schmitt, 1965. A list of the Thysanoptera or thrips of New Jersy. J NY Entomol. Soc., 73: 198–222.

FAO, 2012. Food and Agriculture Organization Statistics Division.

Gandhale, D.N., A.S, Paattil, B.G. Swate and L.M. Naik, 1984. Evaluation of certain insecticides for control of onion thrips in Maharashatra. J. Maharashatra Agric. Univ., 9(1): 104-105.

Henderson, C.F. and E.W. Tilton, 1955. Tests with acaricides against brown wheat mite. J Econ Entomol, 48: 157–161.

Hussain, T., M. Iqbal, Farmanullah and M. Anwar, 1997. Population trend. Varietal preference and chemical control of garlic thrips (*Thrips tabaci* L.). Sarhad J. Agric., 13(2): 175-180.

Kendall, D.M. and J.L. Capinera, 1987. Susceptibility of onion growth stages to onion thrips (Thysanoptera: Thripidae) damage and mechnical defoliation. Environ. Entomol, 16: 859–863.

Kisha, J.S.A., 1979. Insecticides for the control of *Thrips tabaci*on onion in Sudan. PANS, 25(1): 19-24.

Mahmoud, F.M., A.M. Osman, 2007. Relative toxicity of some bio-rational insecticides to second instar larvae and adults of onion thrips (*thrips tabaci* lind.) and their predator oriusalbidipennis under laboratory and field conditions. J. Plant Protec. Res., 47(4): 391:400.

Pénzes, B., S.Z. Szani and A. Ferenczy, 1996. Damage of *Thrips tabaci* on cabbage varieties in Hungary. Folia Entomol. Hung., LVII (Suppl.), pp: 127–137.

Richter, E., M. Hommes, J.H. Krauthausen, 1999. Investigations on the supervised control of *Thrips tabaci*in leek & onion crops. IOBC Bull., 22 (5): 61–72.

Sadozai, A., Q. Zeb, T. Iqbal, S. Anwar, H. Badshah, A. Ali, M. Ahmad and M. Tahir, 2009.Testing the efficacy of different insecticides against onion thrips in Tarnab, Peshawar. Sarhad J. Agric., 25(2): 269-271.

Schumeterer, H., 1990. Crop pests in the Caribbean .DeuscheGesellschaft fur Teschnische Zusammenarbeit (GTZ).TZ-VerlagsgesellschaftmbH. Rossdorft, Germany.

Shelton, A.M., J.P. Nyrop, R.C. Petzoldt and R. Foster, 1987. Development and use of dynamic sequential sampling program for onion thrips .*thrips tabaci* (Thysanoptera:Thripidae), on onion . J. Econ. Entomol, 80(5): 1051-1056.

Somasundaran, P., S.C. Mehta, P. Purohit, 2006. Silicone emulsions. Advances in Colloid and Interface Science, 128–130: 103–109.

Steel, R.G.D. and J.H. Torrie, 1981. Principles and procedures of statistic. A biometrical approach. 2nd Ed. McGraw. Hill Kogahusha Ltd, pp: 633.

Theunissen, J. and G. Schelling, 1998. Infestation of leek by *Thrips tabaci*as related to spatial and temporal patterns of undersowing. Biocontrol, 43: 107–119.

Vierbergen, G. and A. Ester, 2000. Natural enemies and sex ratio of *Thrips tabaci* (Thysanoptera: Thripidae), a major pest of *Allium porrum*in the Netherlands. Med. Fac. Landbouww. Univ. Gent, 65(2a): 335–342.

Wood, R. J., 2001. Control of onion thrips. Grower, 56: 5