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RESEARCH ARTICLE

Efficacy of some compounds against *Thrips tabaci* Lind. infesting onion plants at Sohag Governorate, Egypt.

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Abstract

Onion, *Allium cepa* L., is one of the most valuable vegetable crops in Egypt. *Thrips tabaci* Lind. is the most damaging insect pest attacking onion plantations in the field. The present study was conducted at the Farm of Shandweel Agricultural Research Station, Sohag Governorate, Egypt during 2020/2021 and 2021/2022 seasons to evaluate the efficacy of some compounds against *T. tabaci* infesting onion plants. The effectiveness of three chemistry synthetic insecticides (emamectin benzoate, spinetoram and pyridalyl), two microbial insecticides (*Bacillus thuringiensis* and *Trichoderma longibrachiatum*) and two botanical extracts (garlic and chili), in addition to mineral oil against onion thrips was evaluated under field and laboratory conditions. In the field, data indicated that synthetic chemical insecticides gave higher reduction than other treatments in both seasons. Depending on the general mean, the highest reduction was observed on spinetoram in the two seasons. For safe materials, only chili extract gave reduction > 50%, with mean reduction percentage of 51.06% in 2021/2022 season. In laboratory, data clearly indicate that the tested compounds could be descendingly arranged based on LC_{50} values as follows: spintoram, emamectin benzoate, pyridalyl, chilli extract, Garlic extract, *Bacillus thuringensis*, *Trichoderama longibrachiatum*, mineral oil.

Keywords: *Bacillus;* chili; garlic; insecticides; onion; synthetic; thrips; *Trichoderma*.s

1. Introduction

Onion, *Allium cepa* L. (Amaryllidaceae (Alliaceae)), is one of the most important crop in Egypt. This is mainly due to the in-demand increase of the crop in local markets and for export. Onion becomes less important in exporting as a result of infestations with different insect pests in the field. *Thrips tabaci* (Thripidae) is one the major pests attacking onion in the field, plant leaves become yellow and dry finally leads to the death of the plant. At the seedling stage, the infestation could be sever and killed the young plants (Sabbour and Abbass, 2006). Onion thrips control mainly depending on the use of chemical insecticides. Many studies were conducted on the efficacy of synthetic insecticides against *T. tabaci* (Negash *et al.*, 2020; Khan *et al.*, 2022; Nadeem *et al.*, 2022 and Geremias *et al.*, 2022). Because of many problems resulting from the use of chemical pesticides, including the negative effects on non-target organisms and humans, in addition to development of insecticide resistant population the interest in finding other products of effective natural alternatives in pest control is necessary **(Bale *et al.*, 2008)**. To face these problems, microbial insecticides, plant extract and mineral oils have long been attracting attention as alternatives to chemical agents. Microbial insecticides contain microorganisms or their

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products as the active ingredients can use to control thrips (Mandi and Senapati, 2009; Salunkhe *et al.*, 2020 and Poveda, 2021). The effect of plant extracts were studied by many authors (El-Sappagh *et al.*, 2016; Patel and Kumar, 2017; Ihsan *et al.*, 2022; Qari *et al.*, 2020). Also, the use mineral oils as non-chemical insecticides were evaluated against onion thrips by Mahmoud (2011) and El- Roby (2018). Therefore, the purpose of this paper is to evaluate the effectiveness of three chemistry synthetic insecticides and five alternative materials against onion thrips infesting onion under field and laboratory conditions.

2. Materials and methods

2.1. Field studies

2.1.1. Design and experimental area

To evaluate efficacy of some compounds against *T. tabaci* infesting onion plants, field study was carried out at the Farm of Shandweel Agricultural Research Station, Sohag Governorate, Egypt during the two seasons of 2020/2021 and 2021/2022. Onion seedlings (variety Giza 6) were transplanted into field in 25th December in both seasons of the study. All experimental plots received the same agriculture practices and sprayed three times with a recommended fungicide. The onion plants were sprayed on 15th and 18th January for 2020/2021 and 2021/2022, respectively when the population of *T. tabaci* (adult and nymph) is known to be high.

Eight treatments were distributed in a complete randomized block design and replicated three times. Each plot consisted of five rows each of 3 m long with 10 cm between each other rows and 5 cm between plants, and plots were separated by approximately 1.0 m. to avoid drift of spraying. Other 3 plots were left without treatment as a control. Spraying of the materials was carried out in the early morning using hydraulic sprayer (control plots applied only with water).

2.1.2. Tested materials

As shown in Table (1), the used materials consisted of three chemistry synthetic insecticides, two microbial insecticides and two plant extracts in addition to mineral oil.

Table 1. List of the tested treatments and their common names, trade names, type of formulation and rates of application.

No	Common name	Trade name	Formulation	Rate/100 L
1	Garlic (*Allium sativum* L.)	-----	-----	10 ml
2	Chilli (*Capsicum annuum*)	-----	-----	10 ml
3	Mineral oil	Activcaple	EC	1 L
4	*Bacillus thuringiensis*	Bio Arc	6% WP	250 gm
5	*Trichoderma longibrachiatum*	Bio zeid	2.5% WP	250 gm
6	Emamectin benzoate	Prove plus	3.4% ME	40 gm
7	Spinetoram	Radiant	12% SC	120 cm^3
8	PyridalyL	Pleo	50% EC	50 cm^3

2.1.3. Preparation of extracts solutions

For extraction garlic (*Allium sativum* L.: Liliaceae), an amount of 250 gm. of garlic fresh bulbs were strained in grinder, however for chili (*Capsicum annuum* L.: Solanaceae), an amount of 100 gm. of chili dry fruits ground using a blender, then the produced powder. After that, the two plants were then the bulbs were soaked in one liter of distilled water for one hour, and then the mixture was filtered through Whatman's filter paper NO.1. The resulting (stock solution) was stored in brown bottle container and was kept in refrigerator (5 C°) to prevent any contamination for use.

2.1.4. Sampling method

For sampling method, randomly five plants were chosen from each plot. Alive adults and nymphs were counted before spraying and also after treatment with 1, 3, 7, 10 and 15 days. Samples were kept in plastic bags and then taken to the laboratory to count the thrips individuals using stereoscopic binocular. The reduction percentages were evaluated by Henderson and Telton formula (Henderson and Telton, 1955).

2.1.5. Statistical analysis

Statistical analysis was conducted by using one – way analysis of variance. 'F' test used to evaluate the significance of the difference between treatments. The Duncan's Multiple Range Test at P = 5% was used to separate the means (Gomez and Gomez, 1984).

2.2. Laboratory studies

This experiment was conducted in the laboratory of Plant protection, Shandweel Agricultural Research Station, Sohag Governorate, under room condition where ambient temperature ranged between 11 and 25 ◦C, and RH varied from 44% to 60%.

2.2.1. Insects and plants

A field strain was used to estimate the efficiency of the previous material against *T. tabaci*. Onion thrips adults were collected, using 5 cm long transparent glass tube from untreated onion crop at the Farm of Shandweel Agricultural Research Station, Sohag Governorate and transported to the laboratory. For the study, leaves of healthy onion plants (variety Giza 6) were collected from the onion cultivations at the same site.

2.2.2. Bioassay

Leaf dip application method was adopted for assessment the toxicity of the tested compound on onion thrips. For each material, five serial concentrations were used in the laboratory. Depending on the recommended dose used in the field, the laboratory concentrations were 25%, 50%, 100%, 200% and 400% of the field concentration. The leaves of onion (5 cm long) were dipped in prepared concentration for a period of 10 seconds then left for complete dryness, then the leaves were placed on Petri dishes (9 mm diameter), while ten leaves dipped in tap water were used as control. Three replicates were used for each concentration. Ten healthy nymphs of thrips were placed on the leaves of each Petri dish. After 24 hours, the mortality of thrips was recorded (thrips insect, which did not respond to a simple touch with a needle, were considered dead). Mortality data were corrected by Abbott's (1925) formula:

2.3. Statistical analysis

Mortality data were statistically analyzed according to the method adopted by Finney (1971). Regression lines were drawn on probit-log paper and the median lethal concentration LC_{50} and slope values were determined, by computerized probit analysis program (LdP Line Program). Toxicity index (T.I.): was calculated for each insecticide according to the equation of Sun (1950), as follow: T.I. = (LC_{50} of the most toxic insecticide / LC_{50} of other tested insecticide) x 100. Relative toxicity (R.T.) Folds: These values were measured according to the equation of Metcalf (1967), as follow: R.T. = (LC_{50} of the lowest toxic insecticide / LC_{50} of other tested insecticide) x 100.

3. Results and discussions

3.1. Efficacy of insecticides against onion thrips, T. tabaci in the field

Data in Tables (2) and (3) show the efficacy of certain compounds against onion thrips under the field conditions after 1, 3, 7, 10 and 15 days and general mean during 2020/2021 and 2021/2022 seasons, respectively. Data indicated that the differences between treatments were significant during all sampling dates and for general mean. Synthetic chemical insecticides gave higher reduction than other treatments in both seasons.

After 1 day from spray, spinetoram recorded the highest reduction percentage of 77.48 and 78.78% during the two seasons, with insignificant differences with emamectin benzoate in the two seasons and with pyridalyl in the second season. Whereas, the lowest reduction percentage (29.44% and 32.47%) was recorded on *B. thuringiensis* plots in the two seasons, respectively, by insignificant difference with *T. longibrachiatum* in the second season. Furthermore, the safe materials, only chili extract gave reduction > 50%, with mean reduction percentage of 54.69% in 2020/2021 season.

After 3 days from spray, spinetoram recorded the highest reduction percentage of 75.16 and 76.15% in the two seasons, respectively, with insignificant difference with emamectin benzoate in the second season. However, *T. longibrachiatum* (49.24%) and *B. thuringiensis* (42.86%) recorded the lowest reduction percentages in the two seasons, respectively, with insignificant between them in the first season. All safe compounds gave reduction percentages > 50% in both seasons of the study, except for *T. longibrachiatum* and *B. thuringiensis* in the first and the second seasons, respectively.

After 7 days from spray, spinetoram recorded the highest reduction percentage of 70.67% and 70.66% in the two seasons, respectively, with insignificant differences with emamectin benzoate and pyridalyl in both seasons. The lowest reduction percentage (40.30% and 38.46%) was recorded on mineral oil plots in the two seasons, respectively, by insignificant differences with garlic extract and *T. longibrachiatum* in the first season. For safe materials, *B. thuringiensis* gave reduction > 50% in 2020/2021 season with 53.82%, however, chili extract and *T. longibrachiatum* gave reduction > 50% in the second season with 54.12% and 50.37%, respectively.

After 10 days from spray, spinetoram recorded the highest reduction percentage of 67.63% and 64.84% in the two seasons, respectively, with insignificant difference with emamectin benzoate in both seasons. Mineral oil (28.04%) and *B. thuringiensis* (34.72%) recorded the lowest reduction percentages in the two seasons, respectively, by insignificant differences between them on side and with *T. longibrachiatum* on the other side in the second season.

After 15 days from spray, spinetoram recorded the highest reduction percentage (59.51% and 58.39%) in the two seasons, respectively, however, the lowest reduction percentage was observed in mineral oil (22.04%) and *B. thuringiensis* (26.80%) in the two seasons, respectively, by insignificantly between them in the second season.

Depending on the general mean, the highest reduction was observed on spinetoram plots (70.09 and 69.76%) in the two seasons, respectively, followed by emamectin benzoate (65.48 and 68.47% and pyridalyl (62.84 and 65.45%) in the two seasons, respectively, by insignificant differences between emamectin benzoate and pyridalyl in the first season and with spinetoram in second season. The lowest reduction was observed on mineral oil (36.60%) and *B. thuringiensis* (36.40%) plots, in the two seasons, respectively. For safe materials, only chili extract gave reduction > 50%, with mean reduction percentage of 51.06% in 2021/2022 season.

Many investigators studied the control of thrips by synthetic insecticides, (Allam *et al.*, 2020; Negash *et al.*, 2020; Khan *et al.*, 2022; Nadeem *et al.*, 2022; Geremias *et al.*, 2022; Ihsan *et al.*, 2022), they reported that spinetoram, emamectin benzoate and pyridalyl were the most effective against *T. tabaci*. The effect of alternative materials as safe compounds for onion thrips control has been studied by many authors. For bio pesticides, Mandi and Senapati (2009) found that *B. thuringiensis* was found moderately effective 43.43% against *T. tabaci*.. Also. Salunkhe *et al.* (2020) found that all biopesticides were recorded significantly superior in suppressing the pest population over untreated control. Poveda (2021) reported that *Trichoderma* is capable of controlling insect pest. In regard to mineral oils, Mahmoud (2011) and El- Roby (2018) revealed that mineral oil showed the lowest effectiveness. The use of plant extracts as effectives materials against thrips was suggested by many investigators (El-Sappagh *et al.*, 2016; Patel and Kumar, 2017; Ihsan *et al.*, 2022; Qari *et al.*, 2020)

Table 2. Efficacy of certain compounds on *Thrips tabaci* on onion plants under field conditions during 2020/2021 season.

Treatments	Reduction% after					General mean
	1 day	3 days	7 days	10 days	15 days	
Garlic extract	45.85 c	54.56 d	44.82 cd	38.29 c	33.91 c	43.49 d
Chili extract	49.84 c	59.74 c	48.42 bc	44.54 c	36.56 c	47.82 c
Mineral oil	39.65 d	52.96 de	40.30 d	28.04 d	22.04 d	36.60 e
B. thuringiensis	29.44 e	51.10 ef	53.82 b	38.47 c	32.18 c	41.00 d
T. longibrachiatum	37.46 d	49.24 f	43.75 cd	37.95 c	34.03 c	40.49 d
Emamectin benzoate	74.68 ab	70.22 b	67.44 a	61.82 ab	53.25 b	65.48 b
Spinetoram	77.48 a	75.16 a	70.67 a	67.63 a	59.51 a	70.09 a
Pyridalyl	71.92 b	69.48 b	64.73 a	57.44 b	50.64 b	62.84 b
F. value	121.60*	97.74*	28.76*	35.36*	60.13*	147.46*

(*): The F value is significant at $P \leq 0.05$
Mean in the same column sharing similar letters are not significantly different by Duncan Test at P-0.05

Table 3. Efficacy of certain compounds on *Thrips tabaci* on onion plants under field conditions during 2021/2022 season.

Treatments	Reduction% after					General mean
	1 day	3 days	7 days	10 days	15 days	
Garlic extract	49.58 bc	57.84 d	48.54 c	40.79 cd	33.46 d	46.04 d
Chili extract	54.69 b	63.85 c	54.12 b	44.14 c	38.50 c	51.06 c
Mineral oil	44.56 c	53.39 e	38.46 d	35.21 e	30.12 de	40.35 e
B. thuringiensis	32.47 d	42.86 f	45.15 c	34.72 e	26.80 e	36.40 f
T. longibrachiatum	35.61 d	51.55 e	50.37 bc	37.90 de	32.29 d	41.54 e
Emamectin benzoate	77.91 a	74.39 ab	70.61 a	65.43 a	54.02 b	68.47 a
Spinetoram	78.78 a	76.15 a	70.66 a	64.84 a	58.39 a	69.76 a
Pyridalyl	77.46 a	71.65 b	68.30 a	59.07 b	50.75 b	65.45 b
F. value	115.28*	109.55*	53.23*	79.16*	72.92*	240.31*

(*): The F value is significant at $P \leq 0.05$
Mean in the same column sharing similar letters are not significantly different by Duncan Test at P-0.05

3.2. Laboratory studies

Data in Table (4) and Figure (1) represented the relative toxicity of the toxic Radiant (spinetoram), Prove plus (emamectin benzoate), Pleo (pyridalyl), Leaves extracts of two plants (garlic and chilli extracts), two microbial insecticides (*Bacillus thuringensis* and *Trichoderama longibrachiatum*) in addition to mineral oil (kapel 2) against adults of *T. tabaci* after 24 hours. Data clearly indicate that the tested pesticides could be descendingly arranged as follows: spintoram, emamectin benzoate, pyridalyl, chilli, garlic extracts, *Bacillus thuringensis*, *Trichoderama longibrachiatum* and Kapel oil. The corresponding LC_{50} values were 0.101, 0.35, 0.441, 1.52, 2.037, 2.089, 8,467 and 14.224 ppm, respectively. While, the LC_{90} values were 1.524, 4.797, 8,919, 36.022, 17.875, 39.868, 201.450 and 402.960 ppm, respectively.

The previous results were in agreement with Mahmoud *et al.* (2009) who found that, lethal concentrations LC_{10}, LC_{20}, LC_{50} and LC_{90} of spinetoram for adults of *T. tabaci* were 3.171, 5.439, 15.370 and74.490µg/ml, respectively. El-

Sheikh (2017) reported that the LC_{50} values were 0.9 x 10^5 and 2.9 x 10^6 conidia/ml. for *B. bassiana* and *M. anisopliae* isolates. Allam *et al.* (2020) stated that spinetoram was the most toxic compound against the black vine thrips with LC_{50} and LC_{90} values of 0.1 and 0.87 ppm, respectively, however, the lower toxicity was observed for KZ oil and garlic extract. Also, our results were found in the same line with those obtained by Chen *et al*. (2022), Kilaso (2022) and Rao *et al.* (2022).

Table 4. Toxicity of certain pesticides against ***Thrips tabaci***

No.	Compounds	LC_{50} ppm	Confidence limits of LC_{50} ppm		LC_{90} ppm	Slope ±SE	T. I.
			Lower	Upper			
1	Spintoram	0.101	0.062	0.167	1.524	1.087±0.257	100
2	Emamectin benzoate	0.35	0.208	1.119	4.797	1.127±0.278	28.85
3	Pyridalyl	0.441	0.234	2.541	8.919	0.981±0.275	22.90
4	chilli extract	1.52	0.882	5.273	36.022	0.932±0.259	6.64
5	Garlic extract	2.037	1.26	5.593	17.875	1.359±0.307	4.95
6	*B. thuringensis*	2.089	1.069	14.384	39.868	1.001±0.0282	4.83
7	*T. longibrachiatum*	8.467	4.662	40.788	201.450	0.931±0.265	1.19
8	Mineral oil	14.224	6.666	190.05	402.960	0.882±0.274	0.71

*T. I. : Toxicity Index (compared with Spintoram). * = ppm based on active ingredients*

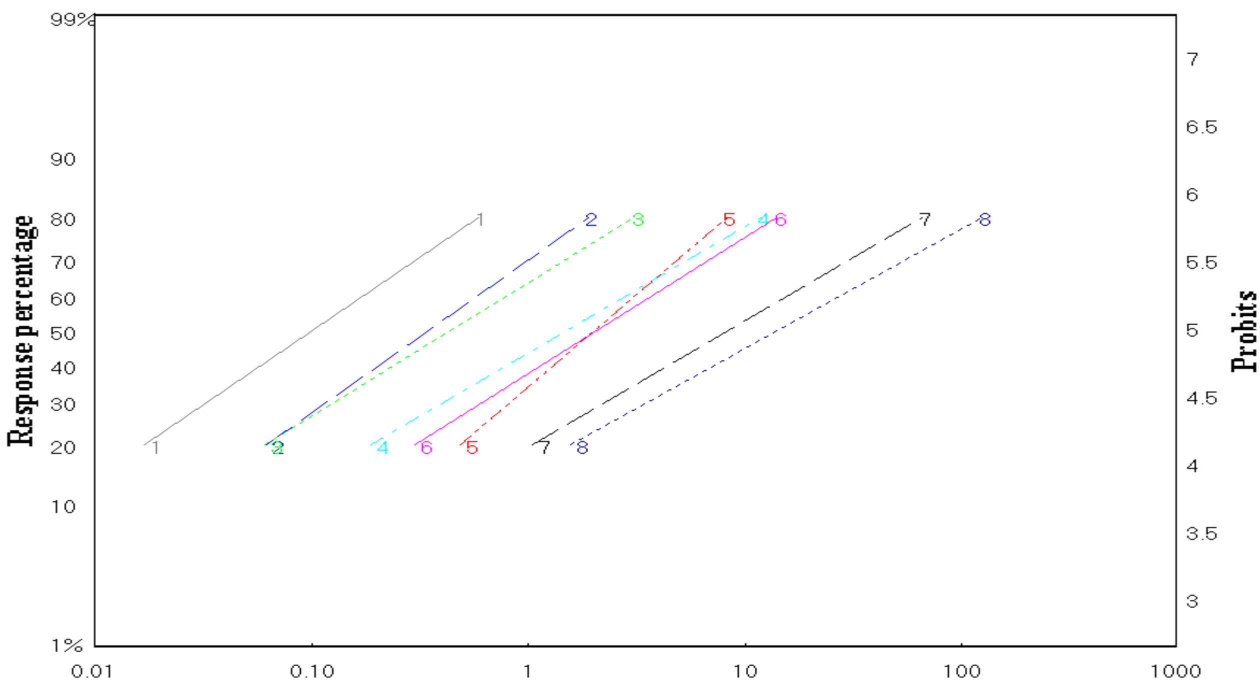

Figure 1. Toxicity of 1- Spintoram 2- Emamectin benzoate 3- Pyridalyl 4- chili extract 5- Garlic extract 6- *Bacillus thuringensis* 7- *Trichoderama longibrachiatum* 8- kapel oil against *Thrips tabaci*.

4. Conclusion

the tested compounds could be descendingly arranged based on LC_{50} values as follows: spintoram, emamectin benzoate, pyridalyl, chilli extract, Garlic extract, *Bacillus thuringensis*, *Trichoderama longibrachiatum*, mineral oil.

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Data presented in this study are available on fair request from the respective author.
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Conflicts of Interest
The authors disclosed no conflict of interest starting from the conduct of the study, data analysis, and writing until the publication of this research work.

5. References

Abbott, W.S. (1925). 'A method of computing the effectiveness of an insecticide', *Journal of the American Mosquito Control Association*, 3, pp. 302-303.

Allam, R. O. H., Badawy, A. M. M. M., Bakry, M. M. S. (2020). 'Evaluation of certain pesticides and their alternatives against the black vine thrips, *Retithrips syriacus* (Mayet) (Thysanoptera: Thripidae) infesting grapevine', *Int. J. Plant Sci. Hor.*, 2, pp. 23-31.

Bale, J.S., van Lenteren, J.C., Bigler, F. (2008). 'Biological control and sustainable food production', *Philos. Trans. R. Soc. B-Biol. Sci*., 363(1492), pp. 761-776.

Chen, J. C., Cao, L. J., Sun, L. N., Gao, Y. F., Cao, H. Q., Ma, Z. Z., Wei, S. J. (2022). 'Variation in the toxicity of a novel meta diamide insecticide, broflanilide, among thrips pest species and developmental stages', *Pest Management Science*, 78(12), pp. 5090-5096.

El- Roby, A. M. S. (2018). 'Evaluation of some plant extracts and chemical pesticides on garlic thrips *Thrips tabaci* and associated vegetative growth parameters in garlic fields', *Egypt. J. Agric. Res.*, 96 (1), pp. 39-46.

El-Sappagh, I. A., Gazia, E.F., Khalil, A.E.H., Badran, B. A. (2016). 'Impact of certain materials againist *Thrips tabaci* Lind. (Thysanoptera: Thripidae) in onion fields in Qalyubia governorate', *Annals of Agric. Sci., Moshtohor.*, 54(4), pp. 949–954.

El-Sheikh, M. F. (2017). 'Effectiveness of *Beauveria bassiana* (Bals.) Vuill. and *Metarhizium anisopliae* (Metsch.) (Deuteromycotina: Hyphomycetes) as biologicalcontrol agents of the onion thrips, *Thrips tabaci* Lind', *J. Plant Prot. and Path., Mansoura Univ.*, 8(7), pp. 319-323.

Finney, D. N. (1971). *'Probit analysis'*, 3rd Cambridge Univ. Press. London, 318.

Geremias, L D., Junior, J. C. L., Gonçalves, P. A. S. (2022). 'Evaluation of foliar insecticides for the control of *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) on onion field', Bio. Assay, 14, ba14001.

Gomez, K.A., Gomez, A.A. (1984). *'Statistical Procedures for Agricultural Research',* John Willey and Sons, New York, 2nd Ed.

Hendreson, C. G. and Tilton, E. W. (1955). Tests with acaricides against the brown wheat mite. J. Econ. Entomol., 48: 157-161.

Ihsan, A., Hussain, R., Sarwar, J., Ullah, N., Iqbal, T., Mujeeb, A., Ahad, H., Qamar, U., Haq, N. U. (2022). 'Manipulation of synthetic and aqueous herbal extracts for the management of onion thrips, *Thrips tabaci*, Lind (Thysanoptera: Thripidae)', *Journal of Xi'an Shiyou University, Natural Science Edition*, 18(9), pp. 696-710.

Khan, A. A., Kanwal, H., Batool, S., Hassan, Z., Shah, J. M., Aatif, H. M., Ishfaq, Y. (2022). 'Impact of predators and some commercial insecticides on *Thrips tabaci* Lindeman and *Amrasca biguttula* Ishida populations in *Bt* cotton under arid climate', *Pakistan Journal of Zoology*, 54 (1).

Kilaso, M. (2022). 'Toxicity for control of *Frankliniella schultzei* and *Selenothrips rubrocinctus* (Thysanoptera: Thripidae) of several common synthetic insecticides', *Florida Entomologist*, 105(2), pp. 155-159.

Mahmoud, H.H. (2011). 'Efficacy of some chemical and non-chemical insecticides against *Thrips tabaci* Lind. in onion fields, and onion bulb fly, *Eumerus amoenus* Loew. in onion stores', *Assiut J. of Agric. Sci.*, 42 (2), pp. 476-487.

Mahmoud, M. F., Osman, M. A. M., Bahgat, I. M., El-Kady, G. A. (2009). 'Efficiency of spinetoram as a biopesticide to onion thrips (*Thrips tabaci* Lindeman) and green peach aphid (*Myzus persicae* Sulzer) under laboratory and field conditions', *Journal of Biopesticides*, 2(2), pp. 223-227.

Mandi, N., Senapati, A. K. (2009). 'Integration of chemical botanical and microbial insecticides for control of thrips, *Scirtothrips dorsalis* Hood infesting chilli', *The Journal of Plant Protection Sciences*, 1(1), pp. 92-95.

Metcalf, R. L. (1967). 'Mode of action of insecticide synergists', *Ann. Rev. Entomol.*, 12, pp. 229-236. Ref.: https://bit.ly/31AQLM7.

Nadeem, A., Tahir, H. M., Khan, A. A., Idrees, A., Shahzad, M. F., Qadir, Z. A., Li, J. (2022). 'Response of natural enemies toward selective chemical insecticides; used for the integrated management of insect pests in cotton field plots', *Agriculture*, 12(9), pp. 1341.

Negash, B., Azerefegn, F., Ayalew, G. (2020). 'Insecticide resistance management against thrips (Thysanoptera: Thripidae) on onion in the central Rift Valley of Ethiopia', *Int. J. Trop. Insect Sci.*, 40, pp. 759-767.

Patel, V.D., Kumar, A. (2017). 'Field efficacy of certain botanical and chemical insecticides against chilli thrips [*Scirtothrips dorsalis* (Hood)] on Chilli (*Capsicum annuum* L.)', *Journal of Pharmacognosy and Phytochemistry*, 6(4), pp. 497-499.

Poveda, J. (2021). '*Trichoderma* as biocontrol agent against pests: New uses for a mycoparasite', *Biological Control*, 159, 104634.

Qari, S. H., Khalil, A. H., Abdelfattah, N. A. H., Shehawy, A. A. (2020). 'Effect of different plant extracts and nanoparticles on *Thrips tabaci* (Lind.) (Thysanoptera: Thripidae) under field conditions and their allelopathic potential on the onion, *Allium cepa* L. using bioassays and RAPD analysis', *Egyptian Journal of Biological Pest Control*, 30, 13.

Rao, N. A. V. E. E. N., Gaur, R. K., Kumar, R., Singh, S. A. T. N. A. M., Kamboj, R. A. J. A. N. (2022). 'Bioefficacy of insecticides against *Thrips palmi* in cotton (*Gossypium hirsutum*)', *Indian Journal of Agricultural Sciences*, 92(9), pp. 1119-1123.

Sabbour, M.M., Abbass, M.H. (2006). 'The role of some bioagent mixed with some fertilizers for the control onion pests', *Journal of Applied Sciences Research*, 2(9), pp. 624-628.

Salunkhe, S.A., Nevgi, S.A., Kapare, R.B. (2020). 'Evaluation of different insecticides and biopesticides against thrips (*Thrips tabaci* Lindeman) infesting onion', *Journal of Entomology and Zoology Studies*, 8(5), pp. 795-796.

Sun, Y. P. (1950). 'Toxicity index an improved method of comparing the relative toxicity of insecticides', *J. Econ. Entomol.*, 43, pp. 45-53.