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The effects of three botanical oils on management of onion thrips, *Thrips tabaci* (Lind) (Thysanoptera: Thripidae) and some ecological aspects, Gezira state, Sudan

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Abstract
Onion thrips *(Thrips tabaci (*Lindeman) is the most serious insect pest causing damage to the crop. This study aimed to evaluate the effects of some botanical oils including cotton, castor bean and bitter cucumber oils on thrips infesting onion. Field experiments were conducted at Gezira state during two winter seasons (2015/16-2016/17). Two experiments were conducted in the first season (2015/16) at the experimental farm of the University of Gezira and in the Gezira Research Station Farm (GRSF) of the Agricultural Research Corporation (ARC). The third experiment was conducted in the second season (2016/17) for confirmatory studies at the (GRSF) in (ARC) and observation plot of 20 X 40 m2 was used to study the population dynamics of the thrips and natural enemies. The design of the experiments was randomized complete block (RCBD) with four replications. Cotton oil, castor bean oil and bitter cucumber oil were applied at a concentration of 2.5% in the first season (2015/16). In the second season 50% upper and lower concentrations of castor oil and bitter cucumber oil were applied at the rates of (1.25%, 2.5% and 3.75%). The onion variety used was Saggai. The results indicated that all oil treatments were effective against the onion thrips compared to the untreated control. Significant differences at $p< 0.01$ in the mean number of insects were found. This study show that the bitter cucumber oil was the most effective in reducing the number of thrips compared to the other two oils, as well as the control treatment. A large number of natural enemies of thrip were found in the (GRSF) of (ARC), while, *Orius* bug and jumping spider were most available and by the end of the season these natural enemies had a role in decreasing the number of onion thrips. No significant difference was observed between treatments in yield. This study recommends that bitter cucumber crude oil at 1.25% concentrations can be used to reduce the population of onion thrips.

Keywords: *Thrips tabaci*, *Allium cepa*, mortality, biological evaluation

Introduction
Onion (*Allium cepa* L.) is one of the most popular and important vegetable crops in the worldwide which use as daily diet. It is the most economically important cultivated species as a major commodity in the international trade with total world production approximately estimated as 32 million tons. Onion production and consumption are steadily increasing globally. The world leading onion producing countries, in order of importance are: China, India, U.S.A, Turkey, Russia, Japan, Iran, Netherlands, Mexico and Spain. The main onion producing countries in Africa include Egypt, Morocco, Niger, Kenya, Tanzania, Ghana and Sudan (Donna and Megan, 2007) [43] Onion, *Allium cepa* L. is a monocotyledonous plant belonging to the family Liliaceae which include over 500 species (Malik, 1994) [106]. The Centre of origin of onion is believed to be the South East Asia i.e North Western India, Afghanistan, Tajikistan, and Uzbektan (Lorenz and Maynard, 1988) [100]. Onions are the oldest vegetables in continuous cultivation dating back to at least 4000 B.C. (Boyhan *et al*., 2002) [25]. Onion has been cultivated for food, medicine and religious purposes since prehistoric times (Mc Ccollum, 1976) [111]. Onion (*Allium cepa* L.) also ranks first among vegetable crops in Sudan. Production area is approximately 84.000 hectares as winter crop with average production of 15-20 ton\fed which is about 33 per cent of the total area of vegetables cultivated. The Main production areas in descending order are: River Nile State which is the first state for onion production in Sudan presenting 26%, Khartoum state (25%)

Gezira (18%) and great Darfour (13%) (Mohamedali, 2009) [84]. Onion is the main vegetable crop in the Gezira State, which represents about 42% of the total vegetables area grown in the Gezira Scheme (Hala, 2001) [72]. The area under onion in the Gezira State annually is around 22,000 feddans (Eltahir, 1997) [52]. Under Sudan condition onion crop in the field suffers from attacking by a number of pests and diseases, which significantly reduces the yield production both in quality and quantity. The most serious insect pest that causes infestation and tremendous losses to the crop is onion thrips (*Thrips tabaci* (L). The primary effect of thrips feeding is reduction of chlorophyll which results in reduced photosynthesis and that causes reduction in yield because of reduced bulb size (Edelson *et al*.,1989) [48]. Integrated pest management(IPM) strategies component were directed towards implementation of various control practices, such as cultural, biological, chemical measures and resistant cultivars to reduce the pests and diseases without disturbance the biological equilibrium and intoxication to the environment (Abdelrahman *et al*., 1992) [2]. The currently effective practiced measures depend on the use of insecticides, but, the use of chemicals have a negative impact i.e increased cost of production, development of insecticides resistance in the target insects, food contamination with insecticide residues and environmental pollution. Since the chemicals have this above-mentioned negative side effects, the IPM component encourages to find alternative methods of control. However, the primary objectives of this study were to: Evaluate the efficacy of some plant oil extracts on of onion thrips on onion. Study the population dynamics of thrips under natural condition of winter season. Study the relationship between the population of onion thrips and it's most important natural enemies.

Materials and Methods

The experiments of this study were conducted at Gezira state during seasons (2015/16─2016/17) at two sites. In the first season (2015/16), one experiment was conducted in the experimental farm of the University of Gezira and repeated in the Gezira Research Station Farm (GRSF) of the Agricultural Research Corporation (ARC). This experiment was done to evaluate the performance of three botanical oils on thrips.

The material used in this experiment include: castor bean oil (*Ricinus Communis*), bitter cucumber oil (*Citrullus colocynthis*) and cotton oil (*Gossypium hirsutum*). Castor bean seed and bitter cucumber seed were collected from Khartoum and Wad Medani local markets, while Egyptian cotton was obtained from Agriculture Research Corporation (ARC). All plant seeds have been extracted in National Oil seed Processing Research Institute of the University of Gezira by mechanical extraction and the oil seed was crushed and slightly moistened and put in the presser and pressed hardly to separate oils from cakes. Each oil was used at the rate of 2.5% concentration in the first season (2015 ─/16). While, castor bean oil and bitter cucumber oil at (1.25%, 2.5% and 3.75%) concentrations was used in the second season (2015/16). Oils were diluted with water and applied as aqueous solutions mixed with 30 ml drops of liquid soap as emulsifying agent and 80 g of Arab gum as sticking agent per liter of water. A knapsack sprayer was used in spraying, during the two seasons, which emit a spray volume of 20 gallons/feddan. Onion variety; The variety of onion used was Saggai obtained from a Known source at Wad Almagdoub and Kariba farms in Wad madani, Sudan. The experiments were laid out in a randomized complete block design (RCBD) with four replications. In each replicate the plot size was 4 x 6 m^2 with five ridges in each plot. Each ridge consists of 6.0 m long with 0.80 m spacing between ridges. A distance of two meters was left between plots within the replicates to avoid the effect between plots. Each ridge was planted with 4 rows with 5─10 cm between plants.

In each site the experimental area was prepared according to the standard recommended land preparation procedures adopted by farmers for successful onion production (Kannan and Mohmed, 2001) [84]. The fields have been selected according to the history of the known density of onion thrips in this area beside of the Regime of A.R.C. Cultural practices such as hand weeding, irrigation and fertilization were carried out as recommended by Agricultural Research Corporation (ARC), for onion production. Onion was transplanted on 6th December 2015 in the first season and at 13 November 2016 in the second season which was 45 days old. Pendimethalin 50% EC was applied as a pre-emergence herbicide at transplanting time at 5th December 2015 and at 14 November 2016 for weed control. Further supported hand weeding was practised when necessary to minimize competition between the weed and the crop. The fertilization of the soil was done with 50 kg of super mono granular phosphate during land preparation with some tillage options (Ploughing, ridging and leveling). Nitrogen fertilizer was applied in two doses. The first after three weeks from transplanting and the second was in the four weeks later. Foliar liquid fertilizer (NPK) was added twice. Irrigation interval between 7─10 days was maintained throughout the growing season and the irrigation was stopped three weeks before harvesting. No chemical control of insects was applied.

The data collection had been attained through regular periodical surveys early in the morning. Five plants per plot were taken randomly from the inner rows for assessing thrips population of both adults and nymphs for the various treatments. Each leaf was thoroughly examined under a binocular in the laboratory for adult and nymphs of thrips. Later on, data were expressed in term number of thrips / 5 plants. Application of plant extracts i.e oil treatments was implemented when thrips number reached the economic threshold level (7-10 insects/plant) recommended by A.R.C. Efficacy of the tested products was evaluated against thrips at pre and post-spray counts at regular intervals of 2, 4, 7, 10, 14 and 21 days after spraying.

Evaluation of the biological efficacy after each spray was based on the reduction of adult +nymph numbers performed by each product. Overall general performance was evaluated for each spray between the tested products with the untreated control, and the treatments were compared collectively.

On top of that: A population dynamics survey and monitoring of its natural enemies on onion was done weekly basis on selected four onion unsprayed plots of 20 X 40 m2 during season 2016/17, beginning when thrips infestation appeared till the end of the season. Natural enemies collected from the field were taken to national museum at Gezira Research station for identification. The data for thrips and natural enemies were expressed as means/number of plants and later on graphs were used to show the relation between them. Bulb weight was similarly recorded and

estimated from the central rows in each subplot and yield (tons) per feddan was calculated for all treatments. The data was analyzed using MSTAT. Analysis of variance (ANOVA) was used to test for significant difference between treatments and Duncan multiple range test was used to separate means.

Results

Effects of some selected botanical oils on thrips population was evaluated in two sites: i.e. Experimental farm of Gezira University and Gezira Research Station Farm at Agricultural research corporation (ARC) of two different seasons. The results of the site one experiment was preliminary assessed shown that the onion thrips infestation was high and damage level on the crop was increased during late January to the end of February 2016. The efficacy of some botanical oils and the role of natural enemies in four unsprayed onion plots under field condition, was determined to assess the reduction of infestation level of the thrips on onion. Data presented in table 1 shows the first season 2015/16 data in site one of Experimental farm of Gezira University and displayed variable performance of different oil treatments at the different concentrations as to the pest incidence. It was clearly shown that the bitter cucumber oil at the concentration of 2.5% gave significant reduction in the number of thrips (24.0) insects/ 5plants. In the first and second spray counts (9.0) compared to the other oil treatment oils, castor bean oil and cotton seed oil and the control (41.0, 31 and 47.0) respectively, Although there was no significant difference between treatments bitter cucumber oil, castor bean oil, cotton seed oil and the control in the third spray counts (14.3, 14.5, 14.3 and 14.0 insects/ 5plants) respectively. But, in the fourth spray counts all oil treatments were apparently effective against the onion thrips (Table 1) and there is a significant difference between these treatments compared to the control (47.0). while, in university experiment the mean number of pest populations rapidly declined were bitter cucumber oil in the first, second and fourth spray gave the best performance in reduction of thrips number (24.0, 9.0, and 24.0 insects/5plants) respectively and significantly difference was shown compared to other oil treatments i.e castor bean oil (41.0, 17.0 and 41.0) respectively, cotton oil (31.0, 30.0 and 31.0, respectively) as well as the control treatment (47.0, 15.0, and 47.0, respectively).

The data presented in table 2 declared the first season 2015/16 data in site two of Gezira research Station Farm in Agricultural Research Corporation (ARC) and this data indicated a variable performance of the means of onion thrips. Significant differences between treatments were observed. It was noticed that castor bean oil showed significantly a minimum number of thrips (12.0) in the first spray counts compared to bitter cucumber oil (23.5) and cotton oil (39.0) treatments. While both castor bean oil (12.0) and bitter cucumber oil (23.8) significantly different from cotton oil (39.0) and no significant difference between bitter cucumber oil (23.5) and untreated control (18.8). In the second spry counts there was not significant differences between the castor bean oil (35.0), bitter cucumber oil (35.5) and cotton oil (40.5), but, there was significant difference between these treatments and the control (27.8). In the third spray counts the results indicated that; no significant difference between the two oils, castor bean oil (28.0) and bitter cucumber oil (29.3) and the control (26.0), while, there is significant differences between these treatments and cotton oil treatment (34.8). But, the treatment of cotton oil gave low performance to the reduction of thrips number compared to other treatments (castor bean oil, and bitter cucumber oil). In the fourth spray counts there is no significant different between all treatments, castor bean oil (23.0), bitter cucumber oil (22.5), cotton oil (24.8) and the control (22.0). The overall mean numbers of pest populations in ARC experiment was rapidly declined comparing to the University experiment and the use of castor bean oil in the first, and the third spray gave best performance in reduction of thrips number (12.0, and 28) respectively. In the second spray counts no significant difference between all treatments compared to untreated control, and in the fourth spray counts showed that no significant different between all oil treatments and the untreated control.

Data presented in table 3 representing the second season data 2016/17 in Experimental farm of Gezira University which displayed variable performance of different oil treatments at the different concentrations as to the pest incidence. Since both bitter cucumber oil and castor bean oil gave best performance for thrips management than cotton oil in all post spray counts in both sites of season 2015/16 they were taken for second season with split doses of 50% upper and lower concentrations and an observation plot of 20X40 M^2 was used to study the population dynamics of the thrips and its natural enemies.

In the second season, the general performance of the two oil treatments obtained from the post spray counts were significantly managed the thrips comparing to untreated control as (Table 3) shows. Both bitter cucumber and castor bean oil displayed variable performance at different concentrations as to the pest incidence. The treatment of bitter cucumber oil at the concentration of 1.25% decreased significantly the thrips population (13.3, 16.0, 14.5 insects/5 plants) in all post spray assessments and there was no significant difference between all treatments of the bitter cucumber oil 1.25%, bitter cucumber oil 2.5%, bitter cucumber oil 3.75%, castor bean oil 1.25%, castor bean oil 2.5 and castor bean oil 3.75% (13.3, 17.8, 15.0, 15.5, 15.5 and 17.5, insects/5 plants) respectively. While, there is a significant difference between all treatments and the control (25.0). In the second post spray counts, the treatment of bitter cucumber oil at the concentration of 1.25 Significantly registered the minimum number of thrips population (16.0 insects/5 plants) compared to the other treatments of bitter cucumber oil 2.5%, bitter cucumber oil 3.75%, castor bean oil 1.25%, castor bean oil 2.5% and castor bean oil 3.75% (18.8, 17.5, 20.8, 19.0, and 21.8, insects/ 5 plants) respectively. There is a significant difference between all treatments and the control (31.8 insects/5 plants). It was observed in the third post spray counts that, the bitter cucumber oil at the concentration of 1.25 gave lower number of thrips population (14.5 insects/5 plants) compared to other treatment followed by bitter cucumber oil at 2.5%, and bitter cucumber oil at 3.75% concentrations and significantly recorded good performance of the thrips mean number (17.0 and 17.8 insects/5 plants) respectively. While, other treatments, castor bean oil 1.25%, castor bean oil 2.5% and castor bean oil 3.75% gave significant reduction to the mean number of thrips (22.0, 19.5 and 20.3 insects/5 plants) respectively and all treatments had significantly gave lower number of thrips than the three

castor oil treatments (Table 3). All treatments (bitter cucumber oil and castor bean oil) were significantly better in reduction of thrips number than untreated control. As these results showed, comparisons between castor bean oil and bitter cucumber oil concentrations in the all post spray counts showed that bitter cucumber oil is better than castor bean oil in prolong effect.

Table 1: General performance of four spray counts of the first season in the University of Gezira, Mean Number of thrips/5 plants

Treatment	Pre1st Spray	1st spray	2nd spray	3rd spray	4th spray
Castor bean	29.8	41.00 b	17.00 b	14.500 a	41.00 b
Bitter cucumber	31.625	24.00 d	9.000 c	14.250 a	24.00 d
Cotton	31.875	31.00 c	30.0 a	14.250 a	31.00 c
Control	21.65	47.00 a	15.0 b	13.750 ab	47.00 a
SE±		1.5	0.95	0.74	0.57
CV%		14.9	10.7	10.4	9.8

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$

Table 2: General performance of four spray counts of the first season in ARC Mean number of thrips/5 plants.

Treatment	Pre 1st Spray	1st spray	2nd spray	3rd spray	4th spray
Castor bean	23.2	12.00 c	35.00 a	28.00 b	23.00 a
Bitter cucumber	32.475	23.75 b	35.50 a	29.25 b	22.50 a
Cotton	26.25	39.00 a	40.50 a	34.75 a	24.75 a
Control	25.95	18.75 b	27.75 b	26.00b	22.00 a
SE±		1.9	1.9	1.6	1.4
CV%		15.6	11.02	10.7	11.5

* Means in the same column followed by the same letter (s) are not significantly different according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

Table 3: General performance of three spray counts in the second season in GRSF (Mean No of thrips/5 plants).

Treatment	Pre 1st spray	1st spray	2nd spray	3rd spray
Castor bean 3.75%	34.1	17.50 b	21.75 b	20.25 bc
Castor bean 2.5%	29.4	15.50 b	19.00 bc	19.50 bc
Castor bean 1.25%	17.6	15.50 b	20.75 bc	22.00 b
Bitter cucumber 3.37%	18.1	15.00 b	17.50 bc	17.75 cd
Bitter cucumber 2.5%	30.95	17.75 b	18.75 bc	17.00 cd
Bitter cucumber 1.25%	21.2	13.25 b	16.00 c	14.50 d
Control	29.45	25.00 a	31.75 a	37.25 a
SE±		1.5	1.6	1.1
CV%		17.34	15.58	10.10

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

Study of thrips population dynamics and the role of its Natural enemies: Natural enemies, such as lacewings, lady bird beetles, big-eyed bugs, minute pirate bugs, syrphid larvae, predator thrips, and parasitic wasps, may help to regulate thrips populations. However, these biological control agents seldomly reduce thrips populations below the economic injury level. The onion thrips, *Thrips tabaci* (Lind) in central Sudan will not become abundant until the end of February. As Beije and Kawther (1997) [35] said the natural enemies in Centre of Gezira distinguished to early season thrips predators as spiders. Coccinellids and *Chrysoperla* spp which mostly appear after early February when thrips population built up. Some predators of the thrips appear at late season such as Plant bugs, *Orius* bugs, Laius beetles, and ants. In this field observations it was apparent that the predator populations was normally very low in January. *Orius* bugs and spiders can be considered as the main predators which prevent or slow down thrips population development during the season. Data presented in table 10 of four unsprayed onion plots (with mediocre cultural practices) showed that thrips populations reached a peak of 103.9 thrips/ plant on 17 February. Before that time thrips numbers did not exceeded 46 insects / plant in 29 January, while, predator numbers had been relatively low. Main predators, like plant bugs and jumping spiders peaked relatively at the same time as the thrips pest with 2.3 predators per 25 plants as well as *Chrysoperla* which recorded 1.25 predators/25 plants on 17 February. This study was consistent with a study of Beije and Kawther (1997) [35] who conducted a study in Centre of Gezira which indicated that thrips level of around 30/ plant could probably be tolerated after mid-January and up to 90 thrips/plant after Mid- February. It was found that 20-30 predator specimens per 30 plants can control sever thrips outbreaks. The predators registered in this observation plots reveal that the total of all predator numbers from 5th February till 30th March, were ant-lion, ladybird beetle, ants, common green lacewing, plant bugs, variegated ladybird, (7, 12, 21, 24, 44 and 43 predator/100 plants) respectively were recorded high numbers of prey on thrips total number (274.4). While, jumbing spiders and *Orius* bugs gave high score of 184, 317 predator/100 plants respectively and was most effective ones to manage onion thrips. This study showed that *Orius* is the most effective one as a biological control agent for *Thrips tabaci* from February to the end of March. Monitoring of thrips population and its natural enemies started when the thrips infestation appeared on 8 January 2017 and the presence of predators and parasitoids of thrips started and continued till the end of the season.

Table 4: Onion thrips and the main predators in four unsprayed onion plots in GRSF

	Thrips/plant	Predator number/100 plant							
Sampling date	**No of insects/Plant**	**Ant lion**	**Lady bird beetle**	**Ant**	**Common green lacewing**	**Plant bugs**	**Variegated ladybird**	**Jumping Spiders**	***Orius* bugs**
Feb. 5	68.8	3	5	1				3	3
Feb. 17	103.9	2		1	5	9	1	9	5
Feb. 23	33.0		6	2	8	6	3	14	26
Mar. 2	43.0			5	2	13	11	15	92
Mar. 11	12.9	1	3	3	6	9	9	20	117
Mar. 17	3.1			3	1	6	4	37	41
Mar. 24	8.1	1		2	2	1	12	51	30
Mar. 30	1.6			4			3	35	3
Tot	274.4	7	12	21	24	44	43	184	317
Av.	34.3	0.9	1.5	2.6	3	5.5	5.4	23	39.6

The predators appeared on thrips from Feb.5 up to March. 30 are shown in table (10). *Orius* bugs was the most abundant predator which appeared in big number starting from the beginning of March up to 24 of March. It was followed by jumping spiders which appeared in big number in 17 March up to the end of March. Various Variegated ladybird, plant bugs and common green lace wings appeared in medium number from Feb.17 up to 24 March. Whereas, ants, ladybird beetles and ant lion appeared in very few numbers. The classification of all predators appeared on thrips during season 2016/17 are shown on Table 5. Data presented on this figure explored the relationship between thrips pest and its most abundant natural enemies (Spiders and *Orius*). A long periodical survey made during season (2016/17) reveals that spider predator and *Orius*-bug gave significant effect for the reduction of onion thrips. It is apparently clear that *Orius* predator number gradually increased when the thrips number build up and decreased when the pest number was declined which reveal that *Orius* predator dependently related to the persistent of the thrips and considered the main predator of *Thrips tabaci*. While the predator spider mite maintained and increasing trend until the end of the season.

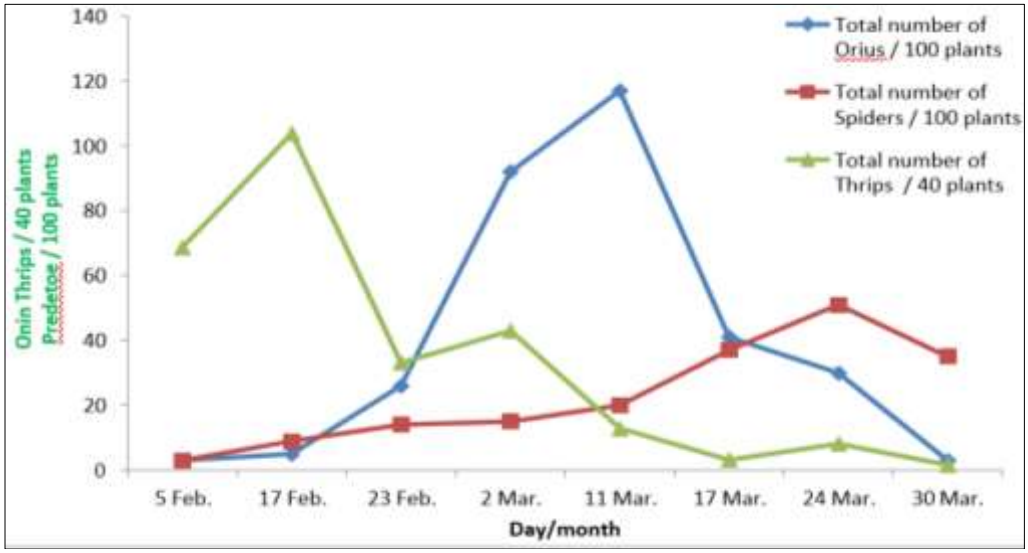

Fig 1: Onion thrips and two main predators (Spiders and *Orius*) in four unsprayed plots

Assessment of onion yields

Despite the fact of natural products are less effective in thrips control comparing to pesticides, yield variation between oil treatments and control may be unclear. The bulb yield results are shown in the table 5, 6 and table 7 for two seasons 2015/16 and 2016/17. The data presented in table 5 showed that the yield of all oil treatments, castor bean oil, bitter cucumber oil, cotton oil at the 2.5% concentration in the university experiment gave relative performance due to reduction of thrips number (1.2, 1.6,1. 4 ton/feddan). Although there is no significant difference between all oil treatments and the control (1.3 ton/feddan), but, bitter cucumber oil gave high yield (1.6 ton/feddan). The data presented in table 6 indicated that the yield of all oil treatments, castor bean oil, bitter cucumber oil, cotton oil at the 2.5% concentration in the ARC experiment recorded a relative performance for the diminishing of thrips population number (1.4, 1.4 and 1.2. ton/feddan) respectively. Although there is no significant difference between all oil treatments and the control (1.1 ton/feddan), but, castor bean oil and bitter cucumber oil gave the highest yield (1.4 and 1.4 ton/feddan) respectively as the table showed. The data presented in table 7apparently explained that the yield of all oil treatments, bitter cucumber oil 1.25%, bitter cucumber oil 2.5%, bitter cucumber oil 3.75%, castor bean oil 1.25%, castor bean oil 2.5% and castor bean oil 3.75% concentration in the ARC experiment at the season of (2016/17) recorded a relative performance for the decreasing of thrips population number (1.7, 1.5, 1.5, 1.5, 1.7 1.8 ton/feddan,) respectively. Although there is no significant difference between all oil treatments and the control one (1.7), but castor bean oil at 3.75 and bitter

cucumber oil at 1.25 concentration were the highest in yield. (1.8 and 1.8 tone/feddan) respectively as the table showed. Due to the fact that dust accumulation on onion leaves sprayed with different oils, the plants were very much affected negatively in their food assimilation. For this reason the yield was very much negatively affected by this phenomena which interfere with the effect of thrips on yield.

Table 5: Mean onion bulb yield (T/F.). Season 2015/16 in the University of Gezira

Treatment	Mean weights of onion bulbs(T/fed)
Castor bean oil	1.2
Bitter cucumber oil	1.6
Cotton oil	1.4
Control	1.3
SE±	1.0
CV%	20.74

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

Table 6: Mean onion bulb yield (T /F). Season 2015/16 in the GRSF

Treatment	Mean weights of onion bulbs(T/F)
Castor bean oil	1.4
Bitter cucumber oil	1.4
Cotton oil	1.2
Control	1.1
SE±	1.13
CV%	21.9

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$

Table 7: Mean onion bulb yield (T/F.). Season 2016/17 in GRSF

Treatment	Mean weights of onion bulbs (T/F)
Castor oil 3.75%	1.8
Castor oil 2.5%	1.7
Castor 1.25%	1.5
Bitter cucumber oil 3.37%	1.5
Bitter cucumber oil 2.5%	1.5
Bitter cucumber oil 1.25%	1.8
Control	1.7
SE±	1.1
CV%	20.4%

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$

Conclusion

These results conclude that the crude oil of the two plant extracts (Castor bean oil and bitter cucumber oil) were effective in reduction of thrips infestation during the study period, whereas the bitter cucumber oil apparently was the most effective crude oil throughout the experimental study. A large number of natural enemies exist on thrips in nature, but *Orius* bug and Jumbling spider were the most available and by the end of the season they were able to manage onion thrips population.

Recommendations

According to this experiment conducted during the two seasons, this study suggest the: Using of bitter cucumber crude oil to manage onion thrips at 1.25% concentrations. Testing of the two crude oil extracts, castor bean oil and bitter cucumber oil on the different vegetables insect pests. Onion should be planted much earlier to allow early development of natural enemies, so that they can be effective in managing thrips numbers. Further study and investigations of different bitter cucumber species are needed to obtain the most effective species on onion thrips.

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