Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2019 16(2):1153-1160. **OPEN ACCESS**

Effect of sulphur dust application on some insect predators naturally occurring in Okra fields

Mamdouh Maher Matter, Amany Ramadan Ebeid, Shahira Saad El-Din Marei, Ola Omar El-Fandary, Nagi Abdellatef Farag and Mohamed Ahmed Gesraha.

Pests and Plant Protection Department, National Research Centre, Dokki, Cairo, **Egypt**

.

***Correspondence:** mgesraha@gmail.com **Accepted: 09** Mar. 2019 **Published online:** 22 April. 2019

This work was carried out to check the impacts of sulphur powder (Agricultural Sorell-98%) on two main insect predators naturally found in open fields. Results indicated that sulphur formulation can be considered as a repellent material against both *Coccinella* and *Chrysoperla* adults. The reduction in the adult predator’s number reached its maximum for both tested predator adults 2 hours post treatment. It is obvious that adult predators wander to the nearest untreated plants to avoid sulphur effects. Gradually, the number of adult predators increased in the treated area after more than one week post application.

Keywords: Slphur formulation, ladybird, lacewing, okra.

INTRODUCTION

For sake of environmental safety, many sulphur formulations were recommended in many IPM programmes to protect, particularly, edible vegetables and fruit trees (A Guide to Managing Tree Fruit Pests in Home Garden, 2017) from insect and mite pests as well as plant pathogenic diseases. Such formulations, at the recommended application rates proved safe to mammals.

Regarding their safety to beneficial arthropods, diversified results were reported. Authors reported that, sulphur was moderately toxic to *Aphelinus mali* (Haldeman), a parasite of the woolly apple aphid *Eriosoma lanigerum* (Hausmann), under laboratory conditions (Cohen et al., 1966). Araya et al., (1997b) mentioned that, sulphur application at the middle of the flowering period had a little effect on *Rachiplusia nu* larvae, but was repellent against nabids and coccinellids. Others found that wettable powder of sulphur is toxic to the most important predator of mite, *Hersutella thompsonia* in India Kumar and Singh (2002). While Newman et al. (2004) considered that lime sulphur residues caused 80-90% mortality of the leaf rollers parasitoid, *Dolichogenidae tasmanica* adults in New Zealand.

On the other side, some researches has showed that the repellency of the hymenopterous parasitoid, *Polistes bussoni* of *Rachiplusia nu* (Guenee) caused by sulphur applications is slight and caused insignificant reduction in the parasitoid population (Araya et al., 1997a). Sulphur product NAB caused slight reduction (0 - 17%) of parasitisation of *Trichogramma dendrolimi* Matsumura as compared with parathion who reduced 85-99% of the parasitoid (Wetzel and Dickler, 1994).

The objective of this work is to explore any side effects of tested sulphur formulation on the population density of the most efficient natural enemies prevailing in some vegetable crops. Observing the fluctuation density of such insect predators in treated areas as well as untreated areas surrounding the treated ones.

MATERIALS AND METHODS

Materials

Agricultural Sorell-98%, Sulphur dust powder, produced by Kafr El-Zayat Pesticides & Chemicals Co. (KZ), Egypt, and was recommended by the Ministry of Agriculture, Egypt for vegetable crops against plant diseases and piercing sucking insects (aphis, whiteflies, thrips) and mites. Chapin 5000 16-Ounce Hand Rose and Plant Duster Sprayer - Model #5000 duster was used 30 days post sowing.

Field application

1- Treated area

Field experiment was carried out in Manawat district, Giza Governorate, Egypt. The experiment was undertaken in Okra fields during season (2016/2017). Two similar rectangle areas each about 700m^2 were chosen. The first area was divided longwise into 2 halves, each half divided horizontally into 4 plots; where all agricultural practices were carried out as usual. Sorell-98%, at rate of 30 Kg/Feddan was applied 30 days post plantation according to the Ministry of Agriculture recommendations.

2- Check area

Similar plots at the 2nd area (check area) was chosen far enough from the treated one and similarly prepared (but, without sulphur application). The average number of each natural enemy per time interval and per cent increase and/or decrease in the population density was calculated.

Fifty plants were inspected/plot/time interval in treated and untreated areas. The average number of each natural enemy and percentage of increase and/or decrease in the population density were calculated at each time interval in the treated and the untreated plots

Statistical analysis

Analysis of variance (ANOVA) F-test was applied. Duncan multiple Range test (Duncan, 1955) was carried out to differentiate between means. Student T-test was applied to compare percentages of increase/decrease between untreated plots in 1st & 2nd areas. Percentage of increase or decrease was calculated using a free online tool to calculate percentages (https://percentagecalculator.net/).

RESULTS

Effect of sulphur dust on *Coccinella undecimpunctata*

Data illustrated in Table (1) shows the effect of sulphur dust application at 30Kg/Feddan (recommended rate) on *C. undecimpunctata* population in okra cultivations. The average density in the treated plot at 0-time (7am) was 14.75 adults/50 plant/plot. The corresponding figure in untreated plot, adjacent to the treated one, was 11.25 adults. Two hours latter (at 9am), a sharp decrease in the predator number was 2.25 adults, represent (-84.75%) reduction. In the untreated area, the corresponding decrease at 9am was slight (-27.78%). Thereafter, densities in treated plot showed reduced in population number ranged between (-28.81%) and (-57.63%) within 2 days after application; this figure was only (-6.78%) after one week. This is contrary to that occurred in untreated plot adjacent to treated one as the average densities of the predator was (+62.22) and (+97.78%) increase in the population density within the same period, respectively, then reached (+6.67%) after one week (Table 1 and Fig.1).

However, comparing the density of the predator in treated and untreated adjacent treated plots and untreated 2nd area showed that, at 0 hour of treatment, there was insignificant difference ($F_{2,12}$=1.606) (Table 1). The same trend was observed at 48, 72 hours and one week post treatment, where the mean number of population was statistically insignificant too ($F_{2,12}$=3.118, 1.729 and 0.258, respectively)(Table 1). On the other hand, starting from 2 to 24 hours post treatment, the significant differences was detected between the three examined plots, where the treated plot recorded the least mean number ($F_{2,12}$=15.429**, 15.742** and 38.813**, respectively). In addition, it could be observed that, the mean number of the recorded adults occurred in the untreated plots of the 1st area was increased significantly than that of the untreated 2nd area at 12 and 24 hours post treatment, this phenomenon could be explained as follows: when the treated plot was sprayed most of the prevailing adults migrate to the untreated plot escaping from the dust to other clean plants (in untreated plot or other surrounding plants) then they returned back gradually to the treated plot after more than one week (Table 1 and Fig. 1).

In other word, when comparing the untreated plots and the untreated area (Table 2), it was noticed that, statistical insignificant differences were observed at all inspection intervals, except in case of 12 and 24 hours post treatment, where both of them were statistically different significantly with other inspection intervals (Table 2).

Table 1. Population densities of *Coccinella undecimpunctata* adults in untreated and sulphur treated Okra cultivations

Inspection periods (Hours)	First area				Second area		F-value (1)
	Average number of adults/50 plant/plot ± SE						
	Treated plot	% increase	Untreated plot	% increase	Untreated area	% increase	
(-) 0	14.75±1.80 aA	---	11.25±1.32 aB	---	13.50±0.96 aA	---	1.606 NS
(+) 2	2.25±0.85 bE	- 84.75	12.75±1.11 aB	+ 13.33	9.75±1.93 aA	- 27.78	15.429 **
(+) 12	6.25±0.85 cD	- 57.63	20.25±1.25 aA	+ 80.00	12.75±2.66 bA	- 5.56	15.742 **
(+) 24	7.25±0.95 cCD	- 50.85	22.25±1.49 aA	+ 97.78	15.25±1.11 bA	+ 12.96	38.813 **
(+) 48	10.50±1.19 aBC	- 28.81	18.25±1.03 aA	+ 62.22	16.50±3.66 aA	+ 22.22	3.118 NS
(+) 72	14.00±0.41 aAB	- 5.08	10.75±1.65 aB	- 4.44	13.50±1.56 aA	0.00	1.729 NS
(+) 7 days	13.75±1.38 aAB	- 6.78	12.00±2.16 aB	+ 6.67	11.25±2.69 aA	- 16.67	0.258 NS
F-value (2)	17.294 **		10.432 **		1.010 NS		

Before application (-) After application (+) (df 1=2,12) (df 2=6, 28)
** Highly significant NS = Insignificant
In a row, mean followed with the same small litter(s) is insignificantly different (*P* at 5%)
In a column, mean followed by the same capital litter(s) is insignificantly different (*P* at 5%)

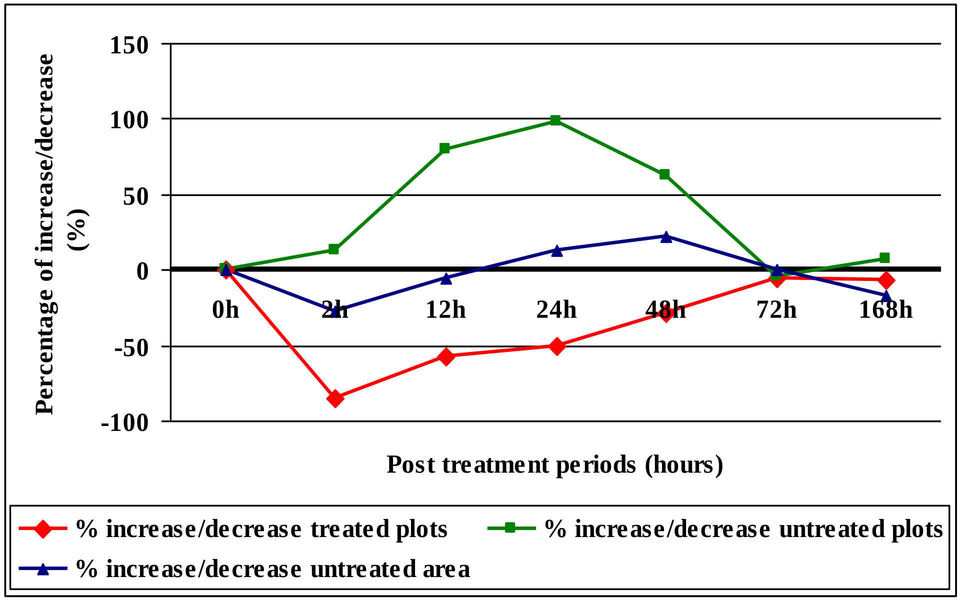

Figure. 1. Percentage of density fluctuations of *Coccinella undecimpunctata* adults in untreated and sulphur treated okra cultivations

This observation gave other indication about the migration of the adults at the treated plots to other clean plants especially the adjacent untreated area (Table 2).

2- Effect of sulphur dust on *Chrysoperla carnea*

Generally, the prevailing predator's number of *Chrysoperla* adults was les than that occurred for *Coccinella* adults. Table (2) clarify the effect of sulphur dust application on *C.carnea*. The mean number of the predator in the treated plots at 0-time was 4.40 adults/50 plant/plot. The corresponding number in untreated plots, adjacent to the treated one, was 3.60 adults, while at the untreated area it was 3.80 adults. Two hours after application, the recorded predator's number averaged 0.20 adults, which represent about (-95%) reductions in population. In the untreated area, the corresponding figure at 9 am was also (-31.58%) decreases in population number. Thereafter, densities in treated plots showed change in population ranged between (-86.36) and (+9.09%) within 2 days post application and continuously increased to reach about (+90.91%) after one week.

Table 2. Population densities of *Coccinella undecimpunctata* adults in untreated plot adjacent to sulphur treated plot and untreated far away area for Okra cultivations

Inspection periods	First area	Second area	
	Average number of adults/50 plant/plot ± SE		
	Untreated plots	Untreated area	T-value
(-) 1 hour	11.25±1.31 a	13.50±0.96 a	1.383 NS
(+) 2 hours	12.75±1.11 a	9.75±1.93 a	1.347 NS
(+) 12 hours	20.25±1.25 a	12.75±2.66 b	2.554 *
(+) 24 hours	22.25±1.49 a	15.25±1.11 b	3.764 **
(+) 48 hours	18.25±1.03 a	14.00±1.96 a	1.921 NS
(+) 72 hours	10.75±1.65 a	13.50±1.56 a	1.513 NS
(+) 7 days	12.00±2.16 a	11.25±2.69 a	0.217 NS

** Highly significant * Significant NS = Insignificant

In a row, means followed with the same litter(s) are not significantly different (*P* at 5%)

Table 3. Population densities of *Chrysoperla carnea* adults in untreated and sulphur treated Okra cultivations

Inspection periods (Hours)	First area				Second area		F-value (1)
	Average number of adults/50 plant/plot ± SE						
	Treated plot	% increase	Untreated plot	% increase	Untreated area	% increase	
(-) 0	4.40±0.24 aC	---	3.60±0.24 aC	---	3.80±0.49 aBC	---	1.444 NS
(+) 2	0.20±0.20 bE	- 95.45	4.40±0.93 aBC	+ 22.22	2.60±0.68 aC	- 31.58	9.794 **
(+) 12	0.60±0.24 cE	- 86.36	5.40±0.51 aABC	+ 50.00	3.80±0.37 bBC	0	38.957 **
(+) 24	3.00±0.32 aD	- 31.82	3.60±0.40 aC	0	4.00±0.71 aBC	+ 5.26	1.000 NS
(+) 48	4.80±0.37 aC	+ 9.09	4.20±0.66 aBC	+ 16.67	5.40±0.75 aA	+ 42.11	0.947 NS
(+) 72	6.00±0.45 aB	+ 36.36	6.00±0.71 aAB	+ 66.67	4.80±0.37 aA	+ 26.32	1.714 NS
(+) 7 days	8.40±0.51 aA	+ 90.91	7.00±0.32 aA	+ 94.44	7.40±0.51 aA	+ 94.74	2.516 NS
F-value (2)	69.333**		4.896 **		7.171 **		

Before application (-) After application (+) (df 1=2,12) (df 2=6,28)

** Highly significant NS = Insignificant

In a row, means followed with the same small litter(s) are not significantly different (*P* ≥ 5%)

In a column, means followed with the same capital litter(s) are not significantly different (*P* ≥ 5%)

Table 4: Population densities of *Chrysoperla carnae* adults in untreated plot adjacent to sulphur treated plot and untreated far away area for Okra cultivations

Inspection periods	First area	Second area	T-value (df-8)
	Average number of adults/50 plant/plot ± SE		
	Untreated plot	Untreated area	
(-) 1 hour	3.60±0.25 a	3.80±0.49 a	0.365 NS
(+) 2 hours	4.40±0.93 a	2.60±0.68 a	1.567 NS
(+) 12 hours	5.40±0.51 a	3.80±0.37 b	2.530 *
(+) 24 hours	3.60±0.40 a	4.00±0.71 a	0.492 NS
(+) 48 hours	4.20±0.66 a	5.40±0.75 a	1.200 NS
(+) 72 hours	6.00±0.71 a	4.80±0.37 a	1.500 NS
(+) 7 days	7.00±0.32 a	7.40±0.51 a	0.667 NS

* Significant NS = insignificant
In a row means followed with the same litter are not significantly different (($P \geq 5\%$)

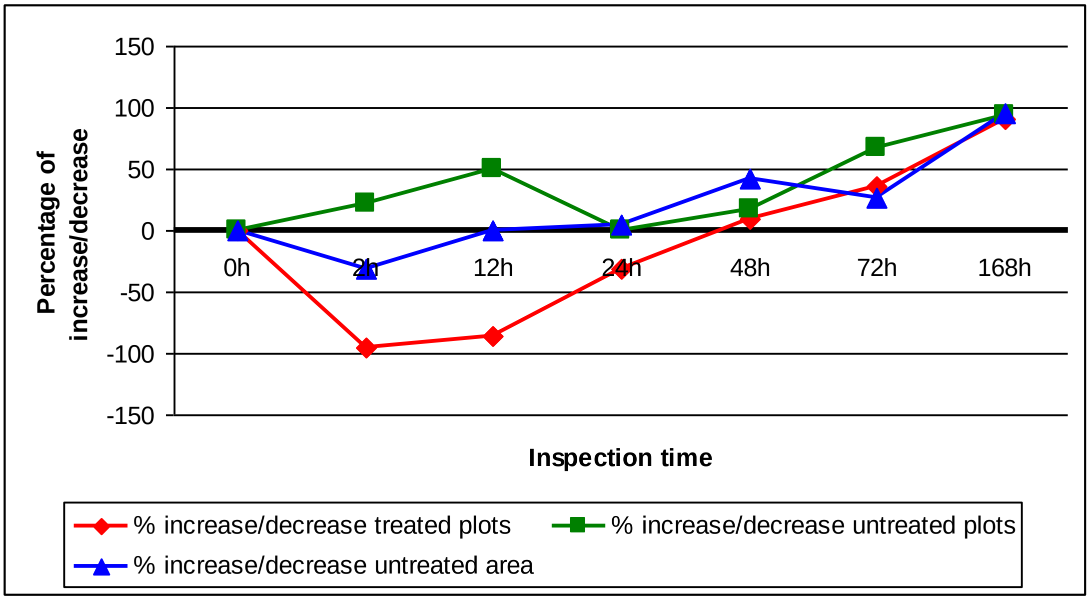

Figure. 2. Percentage of density fluctuations of *Chrysoperla carnea* adults in untreated and sulphur treated Okra cultivations.

This was different to that occurred in untreated plot adjacent to treated one as the average of the predator was (+22.22 to 0%) increase in the population density within the same period, respectively, then reaching (+94.44%) after one week (Table 3 & Fig. 2).

On the other hand, the population density of *Chrysoperla* adults in the untreated 2nd area recorded decrease reached -31.58 & 0% within the period from 2 & 12 hours post treatment, while the rest of other inspection interval – from 24 hour to 7 day post treatment–increased from (+5.26 to +94.74%), respectively (Table 3 & Fig. 2).

Comparing the density fluctuations of the predator in treated and untreated plots and untreated in the 2nd area using analysis of variance test showed that, only at either 2 or 12 hours post treatment, there were significant differences between the treated, untreated plots and the untreated area as well ($F_{2,12}$=9.794**, 38.957**, respectively)(Table 3). While the rest of all inspection periods, statistically exhibits insignificant differences between the treated plots, untreated plots and the untreated area as well.

The average of the recorded adults occurred in the untreated plots of the 1st area was somewhat increased or nearly as the same number compared to the untreated 2nd area

(Table 4). The only difference was detected after 12 hours of treatment, where the average of lacewings adults was higher in untreated plots than that of untreated area (Table 4).

It could be explained that, when the treated plots were sprayed most of the prevailing adults migrate to the untreated plots escaping from the dust to other clean plants (in untreated plots and/or other surrounding plants) then they returned back gradually to the treated plot after less than 48 hours, then increased gradually (Table 3 & Fig. 2).

DISCUSSION

1- *Coccinella undecimpunctata*:

Results were in accordance with that reported so as to, sulphur treatment applied at the flowering period had a slight effect on *Rachiplusia nu* larvae, but had a repellent action against nabids and coccinellids (Araya et al.,1997b). Also, was matched with that mentioned for their work on *Nesidiocoris tenuis* as a natural enemy (predator) for *Tuta absoluta* in tomato plantation using two sulphur formulations (Zappala, et al., 2012). In the side effect experiment, only dustable sulphur being moderately harmful as a fresh residue and slightly harmful as a 7-day-old residue; but had no effects were recorded when exposing the predator to 14-day-old sulphur residues. The obtained results were partially matched with the results for their work on the predator *Orius laevigatus* (Biondi et al., 2012), where they mentioned that wettable sulfur was harmless (Ex < 30%, IOBC class 1), mortality and reproductive levels similar to what recorded in untreated control group. In addition, the obtained results were in accordance with that, powder sulphur (a.i. 95%) was harmless to the coccinellid predator *Cryptolaemus montrouzieri* (Taskin et al., 2014).

On the other side, our results were in contrast with that reported for their work to estimate the effects of lime sulphur on predaceous mites, especially *Typhlodromus pyri*, in field trails on apple, vine and plums to control some pests (the red spider mite, *Panonychus ulmi*, the two spotted spider mite (*Tetranychus urticae*) and thrips (Thysanoptera)) (Daniel et al., 2001). The significant reduction of *T. pyri* and larvae of predaceous gall midges, the complete loss of mite-diversity and the possible enhancement of *P. ulmi* and other harmful mites (*i.e. Colomerus vitis*) are clear disadvantages of lime sulphur. Also, conflicted with Sutherland et al., whom examined the interference in the field, population density of naturally occurring mycophagous coccinellid, *Psyllobora vigintimaculata* (Sutherland et al., 2010). They mentioned that Wettable sulfur was toxic to adults and larvae of *P. vigintimaculata* in the laboratory conditions, resulting in complete cohort mortality 24 h after application. Vineyard density of *P. vigintimaculata* was reduced in vines receiving applications of sulfur. The obtained results were also conflicted with Ndakidemi et al., (2016) whom reported that some examined pesticides had killing effects on predacious ladybird beetles after application.

2- *Chrysoperla carnea*:

Our obtained results was in accordance with that reported by Moura et al., (2010, 2012) in their research on *Chrysoperla externa*, they reported that, when they examined some pesticides applied to adults, they found that abamectin, sulfur and trichlorfon were harmless, while methidathion, carbaryl and fenitrothion were harmful, according to the classification of IOBC. In field studies to control powder mildew and mites in Autralia (Emmett, 2003) indicated that sulphur application persist on leaves more than 40 days post application. This finding matched, more or less, with our results where the adult predators still away from the treated marrow more than 10 days.

The obtained results were matched with Silva et al. (2012) about the non-toxicity of sulphur on our natural enemies. They examined 6 pesticides on eggs and other immature stages of *Chrysoperla externa* under laboratory conditions. They reported that Sulfur (4.00 g/L), copper oxychloride (5.00 g/L) and azociclotin (0.31 g/L) were classified as harmless (Ex < 30%, IOBC class 1), selective to eggs of *C. externa* and do not affect the subsequent developmental stages. On the other side, they mentioned that their effects on the adult stage for mortality was insignificant compared to the control. These results were matched with our results about the non-toxicity of sulphur on our natural enemies.

CONCLUSION

The obtained results clarify that using of sulphur formulations in vegetable fields in order to control some sucking insect pests and plant diseases, reflects more or less some harmful effects towards the adult predators, so, it could be more favourable to keep the environment clean and non-polluted.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

The authors are very grateful to all colleges, especially to Mr.\ Hussein Saad Hussein, Laboratory assistant, Pests and Plant Protection Department, National Research Centre, for their valuable help.

AUTHOR CONTRIBUTIONS

Matter M.M. proposed the experiments, reviewed the manuscript and finalized the article. Ebeid, A.R., Marie, S.S. and El-Fandary, Ola O. collected the publications needed, shared in constructing the tables & figures, shared in interpreting the results, in editing manuscript and revised the final form. Farag, N.A. share in executing field experiments and gathering data and publications needed. Gesraha, M.A. carried out the statistical analysis, interpreted the analyzed data and obtained results, constructed the tables & figures and edited the manuscript. All authors read and approved the final manuscript.

REFERENCES

A Guide to Managing Tree Fruit Pests in Home Garden. BC Ministry of Agriculture 200-1690 Powick Rd Kelowna BC V1X 2H2 (2017). https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health/fruitspray.pdf

Araya, C.; Arretz, V.P.; Guerrero, S.M.A. and Lamborot, C.L. 1997a. Observation of *Polistes buyssoni* (Brethes)(Hymeniptera: Vrspidae), predator of *Rachiplusia nu* (Guenee)(Lepidoptera: Noctuidae) larvae on field beans in the metropolitan region, Chile. Investigation Agricola (Santiago), 17 (1/2):19-23.

Araya, J.E.; Arretz, V.P.; Lamborot, C.L. and Guerrero, S.M.A. 1997b. Natural control by predators of *Rachiplusia nu* (Guenee) (Lepidoptera: Noctuidae) on Phaseolus beans in central Chile. Zeitschrift fur pflanzenkrankheiten und pflanzenschutz, 104: 147-152.

Biondi, A.; Desneux, N.; Siscaro, G. and Zappalà L. 2012. Using organic-certified rather than synthetic pesticides may not be safer for biological control agents: Selectivity and side effects of 14 pesticides on the predator *Orius laevigatus*. Chemosphere, 87: 803–812.

Cohen, H.; Horowrrz, A.R.; Nestel, D. and Rosen, D. 1996. Susceptibility of the Woolly Apple Aphid parasitoid, *Aphelinus mali* (Hym.: Aphelinidae), to common pesticides used in apple orchards in Israel. Entomophaga, 41(2): 225-233.

Daniel, C.; Haeseli, A. and Weibel, F. 2001. The side effects of lime sulphur on predaceous arthropods, *i.e. Typhlodromus pyri*, and other leaf occupying arthropods. http://www.fibl.net/archiv/pdf/daniel-et-al-2001-lime-sulphur.pdf

Duncan, D.B. 1955. Multiple ranges and multiple F-test. Biometrics, 11:1-42.

Emmett, R.W. 2003. Strategic use of sulphur in disease and pest management programs for dried vine fruit production. 2003; Final report to Horticulture Australia LTD, Project No. DG 01002, July 2003).

Kumar, P.S. and Singh, S.P. 2002. Wettable sulphur is toxic to *Hirsutella thompsonii*, the most important natural enemy of the coconut mite. Indian Coconut Journal. Coconut Development Board, Kochi, India, 33(1): 1-2.

Moura, A.P.; Carvalho, G.A.; Botton, M. 2012. Residual effect of pesticides used in integrated apple production on *Chrysoperla externa* (Hagen) (Neuroptera: Chrysopidae) larvae. Chilean J Agric Res., 72(2) 217-223.

Moura, A.P.; Carvalho, G.A.; Moscardini, V.F.; Lasmar, O.; Rezende, D.T. and Marques, M.C. 2010. Selectivity of pesticides used in integrated apple production to the lacewing, *Chrysoperla externa.* J Insect Sci., 10(121): 1-20.

Ndakidemi, B.; Mtei, K. and Ndakidemi, P.A. 2016. Impacts of Synthetic and Botanical Pesticides on Beneficial Insects. Agric Sci., 7: 364-372.

Newman, I.C.; Walker, J.T.S. and Rogers, D.J. 2004. Mortality of the leafroller parasitoid *Dolichogenidae tasmanica* (Hym.: Braconidae) exposed to orchard pesticide residues. New Zealand Plant Protection, 57:

8-12.

Silva, R.A.; Carvalho, G.A.; Carvalho, C.F. and Silva, D.B. 2012. Effects of pesticides on eggs of *Chrysoperla externa* (Neuroptera: Chrysopidae) and consequences on subsequent development. Revista Colombiana de Entomología, 38 (1): 58-63.

Sutherland, A.M.; Gubler, W.D. and Parrella, M.P. 2010. Effects of fungicides on a mycophagous coccinellid may represent integration failure in disease management. Biological Control, 54: 292–299.

Taskin, E.; Lamaj, F.; Verrastro, V. and Baldacchino, F. 2014. Laboratory efficacy of natural substances on *Planococcus ficus* (Sign.) and their impact on its two natural enemies. Fifth International Scientific Agricultural Symposium "Agrosym 2014", 483-490.

Wetzel, C. and Dickler, E. 1994. Side effects of sulphur and natural pyrethroid on *Trichrogramma dendrolimi* Matsumura (Hym., Trichogrammatidae) in apple orchards. Bull OILB/SROP, 17(10): 123-131.

Zappala, L.; Siscaro, G.; Biondi, A.; Molla, O.; Gonzalez-Cabrera, J. and Urbaneja, A. 2012. Efficacy of sulphur on *Tuta absoluta* and its side effects on the predator *Nesidiocoris tenuis*. J Appl Entomol, 136: 401–409.