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# Effects of neonicotinoids and sulfoxaflor application against sucking pests infesting watermelon and their associated predators

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**Abstract:**

Field studies were carried out during 2018 and 2019 summer seasons, at Nubarya district, El-Beheira Governorate to evaluate the effects of some neonicotinoid insecticides (Imidacloprid, clothianidin, thiamethoxam and acetamiprid) compared with sulfoxaflor, at recommended rates against sucking pests infesting watermelon and their associated predators. Results showed that, all treatments exhibited excellent and fast action activity against *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and the least reduction percentages were recorded by acetamiprid at both seasons. Under the same conditions, neonicotinoid insecticides have toxic effect on predators; *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae), *Paederus alfierii* Koch. (Coleoptera: Staphylinidae) and *Coccinella* spp.) (Coleoptera: Coccinellidae) while, sulfoxaflor has slightly toxic effect. The present study suggests neonicotinoid insecticides can be disruptive to natural and biological control by reducing insect predators populations, so the population of *Tetranychus urticae* Koch. (Acari: Tetranychidae) will be increased during both seasons. Yet, sulfoxaflor is also reported as being slightly harmful to biological control agents, it as a preferred insecticide, with less harmful effects on the fitness components of natural enemies, for integrated pest management of sucking insects (*B. tabaci*) on watermelon plantations.

## Introduction

Watermelon, a popular summer vegetable crop worldwide (Wu *et al*., 2014) is an important crop and provides phytochemicals. However, watermelon is susceptible to numerous diseases and pests, such as *Tetranychus urticae* Koch. (Acari: Tetranychidae), *Aphis gossypii* Glover (Hemiptera: Aphididae), *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and *Spodoptera* sp. (Lepidoptera: Noctuidae) larvae (Wu *et al*., 2012). The sweet potato whitefly, *B. tabaci* attacks watermelon and a wide range of other plant species and on a global scale. In addition to injuries from direct feeding, problems from this pest are intensified because its vectors over 100 plant viruses (Jones, 2003 and Simmons *et al*., 2010). As it is farmed primarily by protected and successive cultivation techniques, many pesticides are required for the control of pests (Park *et al.,* 2010).

Neonicotinoid insecticides represent the fastest-growing class of insecticides introduced to the market since the launch of pyrethroids (Nauen and Bretschneider, 2002) and are the most used class of insecticides for controlling sucking insects (Jiang *et al.*, 2019). Neonicotinoids interfere with the nicotinic acetylcholine receptor and therefore have specific activity against the insect nervous system (Maienfisch *et al*., 2001). It is considered an important group of insecticides being used against sucking insects for several years (Muhammad *et al.*, 2011), especially active on hemipteran pest species such as aphids, whiteflies, thrips, leaf miners and plant hoppers, but also commercialized to control many coleopteran and some lepidopteran pest species (Elbert *et al*., 1998 and Nauen *et al.,* 2003). Due to the potent systemic characteristics, they can be absorbed via the roots and transferred to almost all parts of targeted crops (Jeschke and Nauen, 2008). But this irreversible uniting effect may not vary much between target and non-target species, inducing similar detrimental impacts on the biocontrol agents (predators) (Cloyd and Bethke, 2011). Currently, global concerns about the negative influence of neonicotinoids on non-target organisms (particularly bees) and human have led to the regulation by the European Union (EU) since 2013, to date, the use of three typical neonicotinoids i.e. imidacloprid, thiamethoxam and clothianidin has been totally banned on field crops by EU (Jiang *et al.*, 2019).

The sulfoximines are a new class of insecticides targeting sap-feeding insects including the aphids, whiteflies, hoppers, and lygus (Nawaz *et al*., 2018; Babcock *et al*., 2011 and Zhu *et al*., 2011), that are resistant to other classes of insecticides, and that are resistant to the neonicotinoids (Sparks *et al*., 2013). Sulfoxaflor is the initial compound in this class selected for commercial development and is an agonist at insect nicotinic acetylcholine receptors (nAChRs) (Liao *et al*.,2017; Watson *et al*., 2017 and Sparks *et al*., 2013). Yet, sulfoxaflor is also reported as being slightly harmful to biological control agents, including *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae), *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae), and *Adalia bipunctata* (L.) (Coleoptera: Coccinellidae) (Sparks *et al.* ,2013; Wanumen *et al*., 2016 and Nawaz *et al*., 2018).

Therefore, two field experiments were carried out during 2018 and 2019 summer seasons, at Nubarya district, El-Beheira Governorate to evaluate the side effect of sulfoxaflor and some neonicotinoids treatment against sucking pests infesting watermelon and their associated predators at recommended rates.

## Materials and methods

### 1.Tested compounds:

Sulfoxaflor (Closer 24% SC) was provided by Dow Agro Sciences Co., Ltd. Imidacloprid (Gaucho® 70%WS) was provided by Bayer Crop Science. Clothianidin (Supertox-1® 48%SC) was provided by Jiangs Jiag chemical industry Co. Ltd China. Thiamethoxam (Actara 25% WG) provided by Syngenta Company. Acetamiprid (Mospilan 20% SP) provided by Nippon Soda Chemical Industry Co. Ltd.

**2. Field trials:**

Field experiments were carried out throughout two successive seasons (2018 and 2019) during summer plantation in Nubarya district, El-Beheira Governorate. These experiments were cultivated with watermelon. The experimental site was divided into 24 plots, each plot 1/100 feddan (42m²). Randomized complete blocks design was used with four replicates for each treatment with the control plots. Field concentrations were 40ml, 60gm, 1000ml, 60gm and 50gm/200 liter per feddan for sulfoxaflor, imidacloprid, clothianidin, thiamethoxam, and acetamiprid, respectively. The insecticides were sprayed by Knapsack sprayer equipment (CP3). For counting the numbers of whiteflies, *B. tabaci* (immature stages), and *T. urticae*, samples of 25 leaves (from three different levels of the plants) were collected at random in the morning for both diagonals of the inner square area of each experimental plot. Pre-treatment counts were done in the early morning just before application while post-treatment counts were done on 1, 4, 7and 10 days after treatment. In the same time, sample of 25 watermelon plants were examined and the number of the aphid lion, *C. carnea*, the rove beetle, *Paederus alfierii* and the lady birds, *Coccinella* spp. were counted. Counts were done by the lenses in the early morning when flight activity is minimal according to **Butler *et al*. (1988)**. Percentage of pest reduction numbers were calculated according to **Henderson and Tilton equation (1955)** and subjected to analysis of variance (ANOVA) **(CoStat Statistical software,1998).**

**Results and discussion**

In this study, field evaluation of some insecticides treatments against *B. tabaci* immature stages on watermelon plantation at 2018 and 2019 seasons was carried out. The % reductions of *B. tabaci* caused by sulfoxaflor, imidacloprid, clothianidin, thiamethoxam, and acetamiprid formulation were summarized in Table (1). Mean of % reduction was 95.47, 95.35, 91.25, 92.87 and 85.25%, respectively at 2018, while were 95.62, 91.17, 93.27, 92.97 and 79.72%, respectively at 2019 season. In both seasons, the highest reduction percentages were achieved sulfoxaflor where the least reduction percentages were recorded by acetamiprid.

**Table (1): Efficacy of certain treatments against *Bemisia tabaci* immature stages on watermelon plantations.**

| Season | Tested compounds | Rate / feddan | %Reduction After | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1-day | 4-days | 7-days | 10-days | Mean |
| 2018 | Sulfoxaflor | 40ml | 85.4 | 96.5 | 100.0 | 100.0 | 95.47a |
| | Imidacloprid | 60g | 88.5 | 94.5 | 98.4 | 100.0 | 95.35a |
| | Clothianidin | 1000ml | 82.2 | 92.3 | 96.5 | 94.0 | 91.25b |
| | Thiamethoxam | 60g | 81.5 | 94.2 | 97.4 | 98.4 | 92.87b |
| | Acetamiprid | 50ml | 77.4 | 85.1 | 88.7 | 89.8 | 85.25c |
| 2019 | Sulfoxaflor | 40ml | 88.1 | 94.4 | 100.0 | 100.0 | 95.62a |
| | Imidacloprid | 60g | 78.2 | 90.2 | 96.3 | 100.0 | 91.17a |
| | Clothianidin | 1000ml | 80.5 | 96.3 | 100.0 | 96.3 | 93.27a |
| | Thiamethoxam | 60g | 81.3 | 100.0 | 96.3 | 94.3 | 92.97a |
| | Acetamiprid | 50ml | 72.3 | 80.0 | 84.3 | 82.3 | 79.72b |

**Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$ for the same season.**

This result indicates that, neonicotinoids provides excellent control *B. tabaci* (Kuhar *et al*., 2002). Muhammad *et al*. (2011 and 2013) reported that, *B. tabaci* has developed resistance to some of neonicotinoids. Sulfoxaflor is also effective against a wide range of sap-feeding insect pests that are resistant to other classes of insecticides, including many that are resistant to the neonicotinoids (Zhu *et al*., 2011; Sparks *et al*., 2013; Jeschke *et al.*, 2015; Liao *et al*., 2017 and Wang *et al.*, 2017).

In this study, field evaluation of the side effect of certain treatments against some predators (*C. carnea*, *P. alfierii and Coccinella* spp.*)* and spider mites (*T. urticae*) on watermelon plantations at 2018 and 2019 seasons.

Data from Tables (2, 3 and 4) indicated that, reduction percentages of *C. carnea*, *P. alfierii* and *Coccinella* spp. caused by sulfoxaflor, imidacloprid, clothianidin, thiamethoxam, and acetamiprid. For *C. carnea* were 31.47, 49.55, 47.67, 44.55 and 37.50%, respectively at 2018 and 30.15, 48.85, 54.52, 43.10and 33.90%, respectively at 2019, and for *P. alfierii* were 28.35, 28.90, 43.00, 42.75 and 38.17, respectively at 2018 and 35.85, 49.37, 51.15, 47.27 and 45.47%, respectively at 2019. While reduction percentages of *Coccinella* spp. caused by sulfoxaflor, flupyradifurone, clothianidin, thiamethoxam, and acetamiprid were 29.60, 34.50, 47.77, 45.80 and 31.77%, respectively at 2018 and 39.20, 51.55, 53.55, 52.02 and 46.85%, respectively at 2019. Concerning data, all treatments have toxic effect on natural enemies except sulfoxaflor have slightly toxic effect.

**Table (2): Side effect of certain treatments against *Chysoperla carnea* on watermelon plantations.**

| Season | Tested compounds | Rate / feddan | %Reduction After | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1-day | 4-days | 7-days | 10-days | Mean |
| 2018 | Sulfoxaflor | 40ml | 32.4 | 34.3 | 30.4 | 28.8 | 31.47c |
| | Imidacloprid | 60g | 44.4 | 52.6 | 52.6 | 48.6 | 49.55a |
| | Clothianidin | 1000ml | 42.5 | 55.3 | 48.2 | 44.7 | 47.67ab |
| | Thiamethoxam | 60g | 45.5 | 45.5 | 54.5 | 32.7 | 44.55ab |
| | Acetamiprid | 50ml | 34.4 | 40.2 | 36.3 | 39.1 | 37.50bc |
| 2019 | Sulfoxaflor | 40ml | 28.2 | 33.6 | 32.4 | 26.4 | 30.15d |
| | Imidacloprid | 60g | 44.6 | 52.6 | 50.0 | 48.2 | 48.85b |
| | Clothianidin | 1000ml | 55.3 | 60.2 | 52.6 | 50.0 | 54.52a |
| | Thiamethoxam | 60g | 39.1 | 42.4 | 46.5 | 44.4 | 43.10c |
| | Acetamiprid | 50ml | 32.2 | 44.6 | 28.4 | 30.4 | 33.90d |

**Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$ for the same season.**

**Table (3): Side effect of certain treatments against *Paederus alfierii* on watermelon plantations.**

| Season | Tested compounds | Rate / feddan | %Reduction After | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1-day | 4-days | 7-days | 10-days | Mean |
| 2018 | Sulfoxaflor | 40ml | 26.3 | 34.4 | 28.2 | 24.5 | 28.35c |
| | Imidacloprid | 60g | 30.2 | 34.4 | 26.6 | 24.4 | 28.90c |
| | Clothianidin | 1000ml | 44.5 | 46.5 | 42.4 | 38.6 | 43.00a |
| | Thiamethoxam | 60g | 40.0 | 46.4 | 44.4 | 40.2 | 42.75a |
| | Acetamiprid | 50ml | 33.3 | 42.5 | 40.5 | 36.4 | 38.17b |
| 2019 | Sulfoxaflor | 40ml | 32.2 | 34.4 | 40.2 | 36.6 | 35.85c |
| | Imidacloprid | 60g | 42.5 | 50.0 | 50.0 | 55.0 | 49.37ab |
| | Clothianidin | 1000ml | 50.0 | 56.4 | 50.0 | 48.2 | 51.15a |
| | Thiamethoxam | 60g | 46.5 | 50.0 | 48.2 | 44.4 | 47.27ab |
| | Acetamiprid | 50ml | 40.2 | 45.3 | 50.0 | 46.4 | 45.47b |

**Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$ for the same season.**

Insecticides can be disruptive to natural and biological control by reducing natural enemy populations (Johnson and Tabashnik, 1999 and Nasr and Keratum, 2009). Our results were comparable with Rizk *et al*. (1999) and Omar and El-Kholy (2001), where they reported that, the possibility of controlling sucking pests by a combination of biological and chemical methods had proved to be less costly, safe on the environmental constituents. Neonicotinoid insecticides are considered an important group of insecticides being used against sucking, but also commercialized to control many coleopteran and some lepidopteran pest species. But this irreversible uniting effect may not vary much between target and non-target species (predators) (Cloyd and Bethke, 2011).

**Table (4): Side effect of certain treatments against *Coccinella* spp. on watermelon plantations.**

| Season | Tested compounds | Rate / feddan | %Reduction After | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1-day | 4-days | 7-days | 10-days | Mean |
| 2018 | Sulfoxaflor | 40ml | 22.2 | 28.4 | 34.4 | 33.4 | 29.60c |
| | Imidacloprid | 60g | 32.5 | 35.4 | 36.6 | 33.5 | 34.50b |
| | Clothianidin | 1000ml | 44.5 | 48.2 | 50.0 | 48.4 | 47.77a |
| | Thiamethoxam | 60g | 40.2 | 50.0 | 48.6 | 44.4 | 45.80a |
| | Acetamiprid | 50ml | 28.4 | 32.5 | 34.0 | 32.2 | 31.77bc |
| 2019 | Sulfoxaflor | 40ml | 38.4 | 42.4 | 40.0 | 36.0 | 39.20c |
| | Imidacloprid | 60g | 50.0 | 55.3 | 52.5 | 48.4 | 51.55a |
| | Clothianidin | 1000ml | 52.5 | 55.4 | 56.3 | 50.0 | 53.55a |
| | Thiamethoxam | 60g | 46.5 | 52.2 | 57.1 | 52.3 | 52.02a |
| | Acetamiprid | 50ml | 44.6 | 48.2 | 48.2 | 46.4 | 46.85b |

**Means within the same column followed by the same letters are not significantly different according to the $LSD_{0.05}$ for the same season.**

Predators are very effective and practical in biological control programs against sucking insect pests such as, *C. carnea* and *Coccinella* spp. (Brook and Barnard, 1990). Sparks *et al.* (2013); Wanumen *et al*. (2016) and Nawaz *et al*. (2018) reported that, sulfoxaflor is slightly harmful to biological control agents, including, *C. carnea* and *Clitemnestra bipunctata* (Say) ( Hymenoptera: Crabronidae).

Neonicotinoids have negative impact coccinellids through several routes of entry, including: topical contact, residual contact, inhalation of volatiles, ingestion of toxified plant products and ingestion of toxified prey tissues (Ruberson *et al*., 1998; Johnson and Tabashnik, 1999 and Moser and Obrycki, 2009).

The field evaluation of the side effect of certain treatments against *T. urticae* on watermelon plantations at 2018 and 2019 seasons was carried out (Figures, 1 and 2). All treatments have not toxic effect on spider mites at a long time, except sulfoxaflor have slightly toxic effect at short time period. In both seasons, the highest mean numbers of *T. urticae* on watermelon plantations achieved by clothianidin where 91.1 and 96.5/25 leaves at were 2018 and 2019, respectively. The least mean numbers recorded at untreated plants followed by sulfoxaflor and acetamiprid at the both of seasons.

Biological control approach is considered as a main component of the integrated pest management programs (IPM). Natural enemies are usually efficient in regulating population of pests, especially in balanced ecosystem. Pesticides alone will not solve the problem for controlling pests. Insecticides can be disruptive to natural and biological control by reducing natural enemy populations (Johnson and Tabashnik, 1999), so the population of *T. urticae* on watermelon will be increased. *C. carnea*, *P. alfierii and Coccinella* spp. are known that aphidophagous, consume different food types because aphids are abundant only during a restricted time period. Besides this there are other arthropod prey items documented in the literature, e.g. Acari, Thysanoptera, and larvae of Diptera, Coleoptera, and Lepidoptera (Hodek, 1967, 1970 and Singh *et al*., 1991).

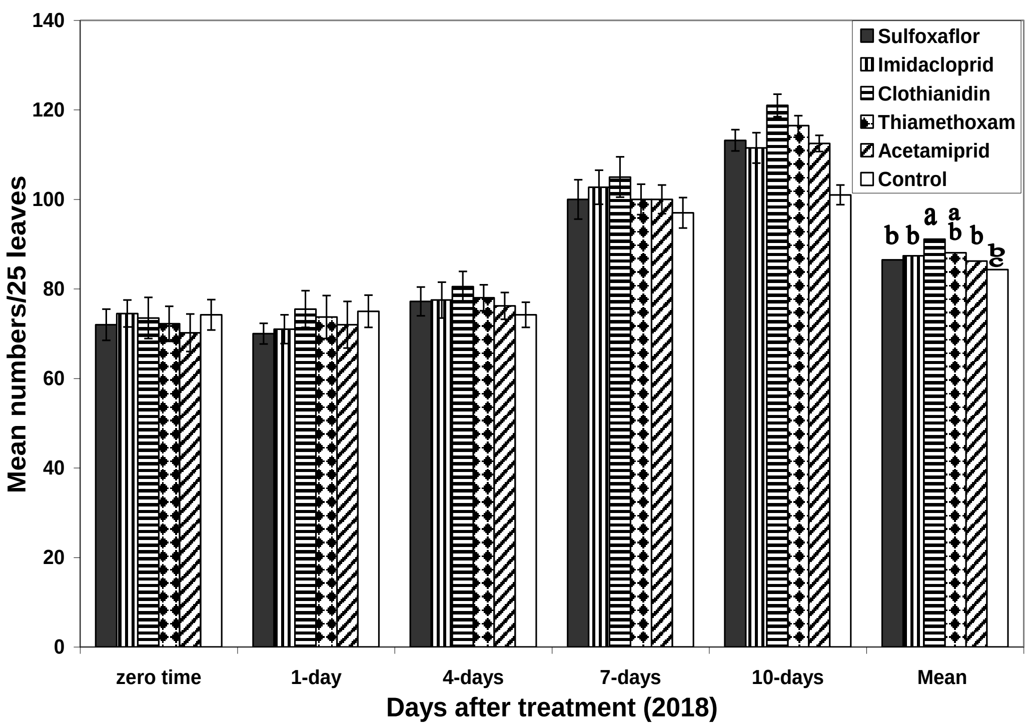


**Figure (1): Side effect of certain treatments against *Tetranychus urticae* on watermelon plantations during 2018 season.**

**Error bars represent standard deviation of four replications. Columns within a group with the same letter are not significantly different according to (LSD at P<0.05).**

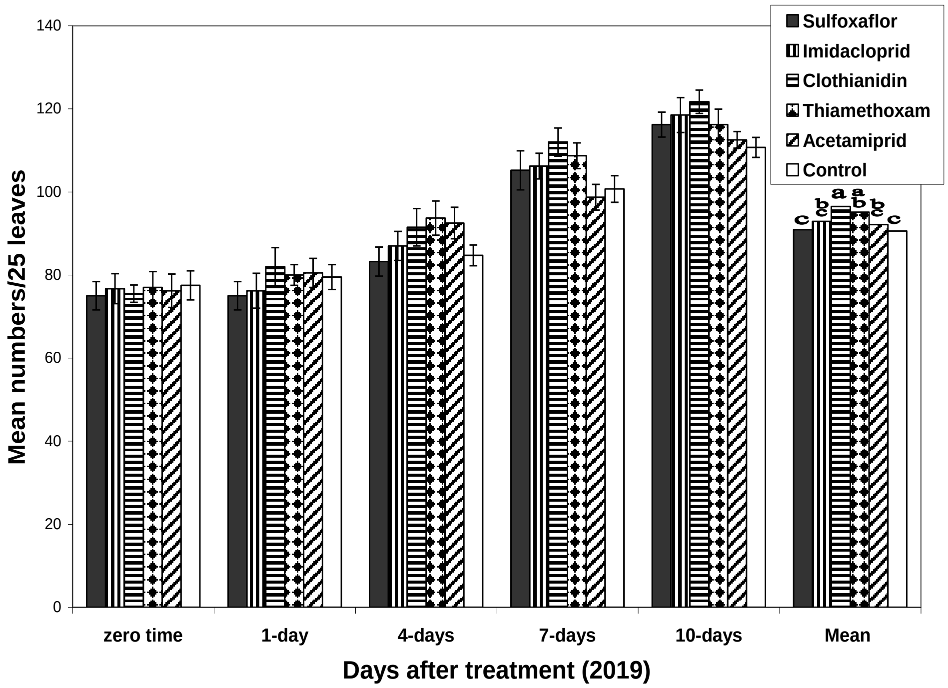


**Figure (2): Side effect of certain treatments against *Tetranychus urticae* on watermelon plantations during 2019 season.**
**Error bars represent standard deviation of four replications. Columns within a group with the same letter are not significantly different according to (LSD at P<0.05).**

## References

**Babcock, J.M.; Gerwick, C.B. ; Huang, J.X.; Loso, M.R.; Nakamura, G.; Nolting, S.P.; Rogers, R.B.; Sparks, T.C.; Thomas, J.; Watson, G.B. and Zhu, Y. (2011):** Biological characterization of sulfoxaflor, a novel insecticide. Pest Manag. Sci., 67: 328–334.

**Brook, S. S. and Barnard, P. C. (1990):** The Green Lacewing of World: A Generic Review (Neu. Chrysopidae). Bulletin of British Museum (Natural History), London, England.

**Butler, G. D.; Coudriet, D. L. and Hennebery, T. V. (1988):** Toxicity and repellence of soybeans and cottonseed oils to the sweet potato whitefly and the aphids on cotton in greenhouse studies. Southwest, Entomol., 13: 81-96.

**Cloyd, R.A. and Bethke, J.A. (2011):** Impact of neonicotinoid insecticides on natural enemies in greenhouse and interiorscape environments. Pest Manag. Sci., 67:3–9.

**CoStat Statistical Software (1998):** Microcomputer program analysis version 6.400, CoHort Software, Berkeley, CA.

**Elbert, A.; Nauen, R. and Leicht, W. (1998):** Imidacloprid, a novel chloronicotinyl insecticide, biological activity and agricultural importance, in: I.Ishaaya, D.Degheele (Eds.), Insecticides with Novel Modes of Action, Mechanism and Application, Springer, Berlin., 50–73.

**Henderson, C. F. and Tilton, E. W. (1955):** Test with acaricides against the brown wheat mite. J. Econ. Entomol., 48: 157-161.

**Hodek, I. (1967):** Bionomics and ecology of predaceous Coccinellidae. Annu. Rev. Entomol., 12: 79-104.

**Hodek, I. (1970):** Coccinellids and modern pest management. Bioscience**,** 20: 543-552.

**Jeschke, P. and Nauen, R. (2008):** Neonicotinoids – from zero to hero in insecticide chemistry. Pest Management Science, 64: 1084–1098.

**Jeschke, P.; Nauen, R.; Gutbrod, O.; Beck, M. E. and Matthiesen, S.; Haas, M. and Velten, R. (2015):** Flupyradifurone (Sivanto™) and its novel butenolide pharmacophore: Structural considerations. Pestic. Biochem. and Physiol., 121: 31–38.

**Jiang, J.; Xiao Liub; Xueping Huanga; Xin Yub; Wenwen Zhangb; Xianxia Zhangb and Wei Mua (2019):** Comparative ecotoxicity of neonicotinoid insecticides to three species of *Trichogramma* parasitoid wasps (Hymenoptera: Trichogrammatidae). Ecotoxicology and Environmental Safety, 183: 1-7.

**Johnson, M.W. and Tabashnik, B.E. (1999):** Enhanced biological control through pesticide selectivity. In: Bellows, T.S., Fisher, T.W. (Eds.), Handbook of Biological Control; Principles and Applications of Biological Control. Academic Press, New York, NY, USA.

**Jones, D. (2003):** Plant viruses transmitted by whiteflies. Eur. J. Plant Pathol.,109: 195-219.

**Kuhar, P. T.; Stivers-Young, L. J.; Hoffmann, M. P. and Taylor, A. G. (2002):** Control of corn flea beetle and Stewart's wilt in sweet corn with imidacloprid and thiamethoxam seed treatments. Crop Protection, 21:25-31.

**Liao, Z.; Mao, K.; Ali, E.; Zhang, X.; Wan, H. and Li, J. (2017):** Temporal variability and resistance correlation of sulfoxaflor susceptibility among Chinese populations of the brown planthopper *Nilaparvata lugens* (Stål). Crop Protection, 102: 141-146.

**Maienfisch, P.L.; Huerlimann, H.; Rindlisbacher, A.; Gsell, L.; Dettwiler, H.; Haettenschwiler, J.; Sieger, E. and Walti, M. (2001):** The discovery of thiamethoxam: a second-generation neonicotinoid. Pest Management Science, 57: 165–176.

**Moser, S.E. and Obrycki, J.J. (2009):** Non-target effects of neonicotinoid seed treatments; mortality of coccinellid larvae related to zoophytophagy. Biological Control, 51: 487–492.

**Muhammad, B.; Ali, H. S.; Mushtaq, A. S. and Saeed, S. (2011):** Cross-resistance, inheritance and stability of resistance to acetamiprid in cotton whitefly, *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae). Crop Protection, 30: 705-712.

**Muhammad, B.; Saeed, S.; Mushtaq, A. S. and Ali, H. S. (2013):** Can resistance in *Bemisia tabaci* (Homoptera: Aleyrodidae) be overcome with mixtures of neonicotinoids and insect growth regulators? Crop Protection, 44: 135-141.

**Nasr, H. M. and Keratum, A. Y. (2009):** Field evaluation of certain oils, plant extracts, pesticides and bio—insecticides and their mixtures on some sucking pests infesting watermelon and pepper plantations. J. Pest Cont. and Environ. Sci., 17:103-121.

**Nauen, R. and T. Bretschneider (2002).** New modes of action of insecticides, Pestic. Outlook, 12: 241.

**Nauen, R.; Kintscher, U. E.; Salgado, V. L. and Kaussmann, M. (2003):** Thiamethoxam is a neonicotinoid precursor converted to clothianidin in insects and plants. Pesticide Biochemistry and Physiology,76: 55–69.

**Nawaz, M.; Hafeez, M.; Mabubu, J. I.; Dawar, F. U.; Li, X.; Khan, M. M.; Hua, H. and Cai, W. (2018):** Transcriptomic analysis of differentially expressed genes and related pathways in Harmonia axyridis after sulfoxaflor exposure. International Journal of Biological Macromolecules, 119: 157–165.

**Omar, B. A. and El-Kholy, M. T. (2001):** Comparative bio-efficacy of certain traditional and nontraditional insecticides against thrips infesting onion. J. Agric. Mansoura Univ., 26: 2373-2381.

**Park, S.; Lee, S.J.; Kim, H.G.; Jeong, W.Y.; Shim, J.; El-Aty, A.M.A.; Jeong, S.W.; Lee, W.S.; Kim, S.T. and Shin, S.C. (2010):** Residue analysis of multi-class pesticides in watermelon by LC-MS/MS. J. Sep. Sci., 33 (4–5):493–501.

**Rizk, M. A.; El-Sisi, A. G.; Badr, N. A. and Abdel-Halim, S. M. S. M. (1999):** Controlling of cotton sucking pests using safe materials.2nd Conf. Pest Control. Mansoura, Egypt, Sept.,211-221.

**Ruberson, J. R.; Nemoto, H. and Hirose, Y. (1998):** Pesticides and conservation of natural enemies in pest management. In: Barbosa, P. (Ed.) Conservation Biological Control. Academic Press, New York, NY, USA, 207-220.

**Simmons, A. M.; Kousik, C. S. and Levi, A. (2010):** Combining reflective mulch and host plant resistance for sweet potato whitefly (Hemiptera: Aleyrodidae) management in watermelon. Crop Protection, 29: 898-902.

**Singh, T.V.K.; Singh, K. M. and Singh, R. I. N. (1991):** Influence of intercropping: Ill. Natural enemy complex in groundnut. Indian J. Entomol., 53: 333-368.

**Sparks, T. C.; Watson, G. B.; Loso, M. R.; Geng, C.; Babcock, J. M. and Thomas, J. D. (2013):** Sulfoxaflor and the sulfoximine insecticides: Chemistry, mode of action and basis for efficacy on resistant insects. Pestic. Biochem. and Physiol., 107: 1–7.

**Wang A. W.; Wang, S.; Han, G. G.; Du, Y. and Wang, J. J. (2017):** Lack of cross-resistance between neonicotinoids and sulfoxaflor in field strains of Q-biotype of whitefly, *Bemisia tabaci*, from eastern China. Pestic. Biochem. and Physiol.,136: 46–51.

**Wanumen, A.C.; Sánchez-Ramos, I.; Viñuela, E.; Medina, P. and Adán, Á. (2016):** Impact of feeding on contaminated prey on the life parameters of Nesidiocoris tenuis (Hemiptera: Miridae) adults. J. Insect Sci., 16: 103.

**Watson, G.B.; Olson, M.B.; Beavers, K.W.; Loso, M.R. and Sparks, T.C. (2017):** Characterization of a nicotinic acetylcholine receptor binding site for sulfoxaflor, a new sulfoximine insecticide for the control of sap-feeding insect pests.

Pestic. Biochem. Physiol., 143: 90–94.

**Wu, H.S.; Zhou, X.D.; Shi, X.; Liu, Y.D.; Wang, M.Y.; Shang, X.X.; Gu, D.L.; Wang, W.Z. and Wu, C.W. (2014):** In vitro responses of Fusarium oxysporum f.sp.niveum to phenolic acids in decaying watermelon tissues. Phytochem. Lett. 8: 171–178.

**Wu, J.X.; Wang, K. and Zhang, H.Z. (2012):** Dissipation and residue of acetamiprid in watermelon and soil in the open field. Bull. Environ. Contam. Toxicol., 89 (3): 644–648.

**Zhu, Y.; Loso, M.R.; Watson, G.B.; Sparks, T.C.; Rogers, R.B.; Huang, J.X.; Gerwick, B.C. ; Babcock, J.M.; Kelley, D.; Hegde, V.B. ; Nugent, B.M.; Renga,; I. Denholm, J.M.; Gorman, K.; Deboer, G.J.; Hasler, J.; Meade, T. and Thomas, J.D. (2011):** Discovery and characterization of sulfoxaflor, a novel insecticide targeting sap-feeding pests. J. Agric. Food Chem., 59: 2950–2957.