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# Thiamethoxam Efficiency Applied with Two Spray Techniques against *Bemisia tabaci* (Genn.) on Cucumber Plants Production Under Greenhouse Conditions and It Is Residues in Soil, Leaves, and Fruits

**Gamal M. Abdelatef *[1,] Nahed M.M. Selim [2] and Mona M. Abd EL-Wanis [3]**

1- Plant Protection Research Institute, Agricultural Research Centre.
2- Pesticides Analysis Research Dept., Central laboratory pesticides, Agricultural Research Centre.
3- Protected Cultivation Research Horticulture Research Institute, Agricultural Research Centre.

E-mail* : gamal.abdelatef@arc.sci.eg

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**ABSTRACT**

Thiamethoxam application to control White flay *Bemisia tabaci* on cucumber plants under greenhouse conditions showed acceptable efficacy. Moreover, the application of thiamethoxam with ultra-low volume (ULV) spray technique caused a significant average reduction to White flay population reached 90.17 and 91.03 % in both working seasons respectively when compared with low volume (LV) which caused average reduction reached to 87.37 and 86.50 %, respectively. Additionally, the ultra-low volume spray technique significantly reduced thiamethoxam residues in soil and cucumber leaves and fruits when compared with the low volume spray technique. Lengths and weights of cucumber fruits treated with (ULV) technique increased significantly than those treated with (LV) technique. Both spray techniques caused a significant increase in cucumber fruit yield per plant.

## INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a very important vegetable crop belonging to the family Cucurbitaceace, it is considered an excellent resource of nutrition. In Egypt, the cultivated area of cucumber in 2017 was 95328.151 feddan and the production was 488723 tonnes (FAO, 2019). Cucumber cultivations are susceptible to many phytophagous pests either in an open field or under greenhouses conditions such as White flay; *Bemisia tabaci* (Genn.). *B. tabaci* could cause direct damage by sucking the sap from the plant foliage, while indirectly through the transmission of plant pathogenic viruses and the excretion of honeydew which is known as a good media for Sooty mould growth (Hanafy *et al.*, 2014). Thiamethoxam (EZ -3 (3(2-chloro 1,3 thiazole 5 –yl methyl -5- methyl -1,3,5 – oxadiazinane 4 –ylidene (nitro) amine is neonicotinoid insecticide which active against numerous sucking and biting pests and insects. Its acts against insect's nicotinic acetylcholine receptors (Tomizawa and Caside 2005). Recently thiamethoxam registered under many trade names for control of Whitefly in many vegetable crops including Cucumber, according to Egyptian Agricultural Pesticides Committee recommendations. Liquid pesticides are traditionally


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applied by using a conventional ground motor sprayer with spray volume equal to 400-600 L/fed, also it may be applied using a motorized knapsack mist blower with spray volume equal to 20-160 L/fed (Bakr *et al.*, 2009 and 2014 and Ibrahim *et al.*, 2016). However, both spray techniques produce a wide range of droplet sizes, which leads to losing a large amount of spray solution and decreases the efficacy of the pesticide. On the contrary ultra-low volume (ULV) spray technique produces homogeneous very small droplets and is more efficient in control operations (Ali *et al.*, 2011). However, this technique requires oil-based formulations to avoid evaporation of spray droplets; on other hand, water-based formulations could be applied using ULV spray technique by dissolving a water-based formulation in a 30% Propylene glycol water mixture (Abdelatef, 2021). The widespread use of neonicotinoids at various stages of agricultural cultivation and during postharvest storage could give rise to a serious risk to the health and safety of consumers. The MRLs for cucumber were 0.01 mg/Kg. Therefore, evaluation and monitoring of the residues are essential for the proper assessment of human exposure to the pesticide through food. The aim of the present study is to evaluate the effectiveness of two spray techniques of thiamethoxam application, on white flay attacking cucumber plants under greenhouse conditions, also thiamethoxam residues in soil and cucumber fruits and leaves, as well as cucumber fruit yield and quality.

## MATERIALS AND METHODS

**Cucumber Plantation:**

The present study was carried out during two successive seasons of 2019 and 2020 under greenhouse conditions at the experimental farm of Kaha Vegetable Research Station, Horticulture Research Institute, Agricultural Research Centre (ARC), Quluobia Governorate, Egypt. Cucumber, Hesham Hybrid F1 (Seminis Seed Company) seeds were sown on the 12$^{th}$ and 10$^{th}$ of November in 2019 and 2020, respectively in seedling trays with 84 cells, filled with a mixture of peat moss and vermiculite at the ratio of 1:1 (V/V). Three hundred grams of ammonium sulphate, 400 g. of calcium superphosphate, 150 g. of potassium sulphate, 50 ml of nutrient solution, and 50 g. of a fungicide were added for each 50 Kg. of the used peat moss in the greenhouse nursery. The seedling was transplanted to the greenhouse on the 3$^{rd}$ and 1$^{st}$ of December in 2019 and 2020, respectively, into two rows in the bed, (each row was 7 m in length and 1 m in width. The conventional agricultural practices, i.e. irrigation, fertilization and weeding followed the standard commercial practices and were carried out as recommended by the Ministry of Agriculture and land reclamation, Egypt for cucumber production. Plants were trained and pruned by removing the side shoots and flowers up to the fourth internodes and then the side shoots were preserved, but they were pruned leaving two internodes.

**Thiamethoxam Application:**

White flay *B. tabaci* population check started 15 days after sowing. A sample of 10 leaves/replicate, 3 replicates/treatment was inspected randomly in the early morning each week until the harvest. The control operation started with the first appearance of whitefly in both seasons and was repeated after 30 days from 1$^{st}$ application. Thiamethoxam (Tulbert24% SC) was applied with the recommended rate using two spray techniques: low and ultralow volume (LV and ULV), by using motorized knapsack mist blower, where normal spray nozzle was used for LV application and Micronair AU8000 head was attached to the air hoes for ULV application. In the case of LV technique thiamethoxam was diluted in the water while in ULV technique it was diluted in 30% Propylene glycol (Pg) water mixture, Spray solution flow rates and swath width, were measured according to (Dobson, 2001 and Cressman and Dobson 2001), using water-sensitive papers manufactured by

Syngenta at the same spray condition as possible. Application criteria are presented in Table (1). Each treatment was replicated three times.

**Table 1:** Application criteria of thiamethoxam sprayed as LV and ULV spray technique.

| Criteria | LV | ULV |
|---|---|---|
| Diluent | water | 30% (Pg) water mixture |
| Flow rate (L/min.) | 1.25 | 0.6 |
| Track spacing (m) | 5 | 10 |
| Speed (km/hr) | 2.4 | |
| Spray volume (l/fed) | 26.26 | 6.30 |
| Spray height (m) | 0.5 | |
| Temperature (C) | 18-25 | |

**Estimation of White Flay Reduction:**

White flay individuals were counted in the early morning before spray and after 1,7 and14 days post spray, on 25 randomly selected plants from treated and untreated plots considering the top middle and bottom of plants, White flay reduction was estimated using Henderson and Tilton equation (1955).

**Determination of Thiamethoxam Residues:**

Representative samples (about 1kg) of plants leaves, fruit and soil (0-30 cm depth) were collected for thiamethoxam residues determination, after 3-, 7- and 14-day post spray. The samples were transferred immediately in the icebox to the laboratory. Then stored at -4 $C^{\circ}$ until analysis. 20 g of samples were mixed with 60 ml of methanol, the mixture was shacked mechanically using an electrical shaker for one hour for separation of water from methanol extract. The extract was partitioned successively with methylenechloride in a separatory funnel. The combined methylenechloride phase was dried by filtration through filter paper and anhydrous sodium sulphate, and then evaporated just to dryness on a rotary evaporator. The solvent was then evaporated to dryness. The extracts were cleaned by a reversed-phase C18 (SPE) cartridge according to (FAO/WHO 1993). Residues were dissolved in 1 ml methanol and then determined by HPLC, conditions for determination and mean recoveries obtained from tested samples fortified with known quantities of the above tested ranged from 82 to 100%. A high-performance liquid chromatography (Agilent 1100 HPLC system, USA), with a quaternary pump, thermostat compartment for the column and photodiode array detector was used. Separation was carried out on a carbon 18 (250 4.6 mm, 5 lm). The mobile phase was acetonitrile: water (60/40 v/v) at a flow rate of 0.7 mL min 1. The detection wavelength was set at 254 nm. The retention time of thiamethoxam was about 4.05 min. Residues were estimated by comparison of peak area of standards with that of the unknown or spiked samples run under identical conditions.

**Fruit Yield and Quality:**

Harvesting started 75 days after transplanting, cucumber fruits were harvested twice weekly, 10 plants were selected randomly from each replicate, mean weight of fruit, fruit length, fruit diameter and yield (kg/plant) were recorded.

**Statistical Analysis:**

Data were subjected to the analysis of variance (ANOVA) to compare the effects of foliar application treatments (Snedicor and Cochran, 1980). When significant differences occurred, the means were separated using the least significant difference test (LSD, $P < 0.05$).

## RESULTS AND DISCUSSION

**Thiamethoxam Efficacy against *Bemisia tabaci*:**

Performance of thiamethoxam against *B. tabaci* was estimated as reduction percentages in population after 1-, 7-, and 14-days post-treatment. Data in the table (1) reviled that the initial mortality of thiamethoxam applied as low volume spray techniques were 77.2 and 76.2 % at 1st and 2nd spray application for the first season, while related reduction percentages were 76.8 and 77.4 %, respectively for the second season. Although, these percentages of thiamethoxam applied as ultra-low volume were 80.2, 83, 82.4, and 83 %, respectively. It is clear that reduction percentages increased gradually as time post-application increased in both spray techniques. As a general conclusion, thiamethoxam action on *B. tabaci* was better when applied as ultra-low volume technique, where mean reduction percentage of ultra-low volume during the first and second season were significantly higher than those of low volume spray technique.

The effectiveness of thiamethoxam against *B. tabaci* was proved by many authors, (Abdel-Hamid *et al.*, 2016, Wahba *et al.*, 2017, Ismail *et al.*, 2020 and Ammar *et al.*, 2021). Using the same ULV technique Abdelatef, 2021 reported that it was effective to control locusts and grasshoppers due to resulting smaller homogenous droplets of spray solution. Small droplets may be more effective due to many factors such as sufficient spray coverage, under leaves settlement and a huge chance to come across with the pest, (Ford and Salt, 1987, Adams et al., 1990 and Hall and Fox 1996).

**Table 1:** Mortality percentages of *Bemisia tabaci* treated with two spray techniques of Thiamethoxam twice on cucumber plants during two successive seasons.

| Spray Technique | Reduction percentages after spraying | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1st spray application | | | 2nd spray application | | | Mean |
| | 1st day | 7th day | 14th day | 1st day | 7th day | 14th day | |
| | 2019 season | | | | | | |
| Low volume | 77.2 | 89.8 | 96.2 | 76.2 | 90.4 | 94.4 | 87.37 b |
| Ultra-low volume | 80.2 | 91 | 95.8 | 83 | 93 | 98 | 90.17 a |
| | 2020 season | | | | | | |
| Low volume | 76.8 | 89 | 93.4 | 77.4 | 89 | 93.4 | 86.50 b |
| Ultra-low volume | 82.4 | 93.2 | 97 | 83 | 92.6 | 98 | 91.03 a |
| L.S. D | | | | | | | 1.00 |

**Thiamethoxam Residues:**

Residues of thiamethoxam were measured in both working seasons after 3-, 7-, and 14-days post-treatment in the first and second spray applications. Data in the table (2) show thiamethoxam residues in soil samples, where the residues in case of low volume technique were 0.309, 0.238 and 0.115 ppm in first spray application after 3-, 7- and 14-day post-treatment respectively, while in the second spray application were 0.308, 0.237 and 0.111 ppm respectively, for the first season, and for the second season, it was 0.309, 0.235, 0.109, 0.306, 0.237 and 0.109 ppm respectively. It could be noticed that ultra-low volume spray technique caused significant reduction in thiamethoxam residues in both season and first and second spray application, such residues were 0.220, 0.162, 0.094, 0.238, 0.162, 0.093, 0.218, 0.161, 0.092, 0.226, 0.163 and 0.090 ppm respectively.

The same trend was observed for residues of thiamethoxam in cucumber leaves where the Ultra-low volume spray technique caused a significant reduction in these residues as shown in table (3). Thiamethoxam residues decreased gradually in samples taken on the 3rd day by telling 14th-day post-treatments it reached 0.100 and 0.101 ppm in case of low volume technique at 1st and 2nd spray application respectively in the first season, while in the second season it were 0.099 and 0.101ppm respectively. In case of ultra-low volume technique, those values were 0.082, 0.082, 0.084 and 0.080 ppm respectively.

**Table 2:** Thiamethoxam residues (ppm) in the soil after application with two spray techniques twice during two successive seasons against *Bemisia tabaci* on cucumber plants.

| Spray Technique | 1st spray application | | | 2nd spray application | | |
|---|---|---|---|---|---|---|
| | 3rd day | 7th day | 14th day | 3rd day | 7th day | 14th day |
| | 2019 season | | | | | |
| Low volume | 0.309 a | 0.238 a | 0.115 a | 0.308 a | 0.237 a | 0.111 a |
| Ultra-low volume | 0.220 b | 0.162 b | 0.094 b | 0.238 b | 0.162 b | 0.093 b |
| | 2020 season | | | | | |
| Low volume | 0.309 a | 0.235 a | 0.109 a | 0.306 a | 0.237 a | 0.109 a |
| Ultra-low volume | 0.218 b | 0.161 b | 0.092 b | 0.226 b | 0.163 b | 0.090 b |
| L.S.D | .00899 | | | | | |

**Table 3:** Thiamethoxam residues (ppm) in cucumber leaves after application with two spray techniques twice during two successive seasons against *Bemisia tabaci* on cucumber plants.

| Spray Technique | 1st spray application | | | 2nd spray application | | |
|---|---|---|---|---|---|---|
| | 3rd day | 7th day | 14th day | 3rd day | 7th day | 14th day |
| | 2019 season | | | | | |
| Low volume | 0.206 a | 0.153 a | 0.100 a | 0.204 a | 0.152 a | 0.101 a |
| Ultra-low volume | 0.192 b | 0.121 b | 0.082 b | 0.191 b | 0.121 b | 0.082 b |
| | 2020 season | | | | | |
| Low volume | 0.205 a | 0.154 a | 0.099 a | 0.204 a | 0.152 a | 0.101 a |
| Ultra-low volume | 0.189 b | 0.121 b | 0.084 b | 0.190 b | 0.119 b | 0.080 b |
| L.S.D | 0.0032 | | | | | |

Thiamethoxam residues in cucumber fruits (Table 4) were significantly reduced in the case of ultra-low volume technique, furthermore, it was gradually decreased and it was undetectable by the 14th-day post-treatment in both working seasons as well as 1st and 2nd spray application, while in case of low volume technique thiamethoxam residues reached to 0.013 and 0.020 ppm by the 14th-day post-treatment in the first season on 1st and 2nd spray application respectively. While in the second season, they were 0.013 and 0.013 ppm respectively.

In the present study, thiamethoxam residues in soil were significantly higher in the case of low volume spray technique when compared with ultra-low volume spray technique, these may be due to the larger spray droplets resulting from (LV) spray technique runoff leaves' surface to the soil and increase soil contamination with Thiamethoxam, (Bakr *et al.*, 2009 and 2014 and Ibrahim *et al.*, 2016). The same trend was observed in the case of thimethoxam residues in cucumber leaves and fruits, maybe due to that (ulv) spray technique produce great amounts of spray droplets with small size which have life span long enough to contact with *B. tabaci* and cause mortality but evaporate quickly before it penetrates cucumber leaves and fruits, (Ramsey *et al.* 2005, Yu *et al.* 2009 and Xu *et al.* 2011.

**Table 4:** Thiamethoxam residues (ppm) in cucumber fruits after application with two spray techniques twice during two successive seasons against *Bemisia tabaci* on cucumber plants.

| **Spray Technique** | **1st spray application** | | | **2nd spray application** | | |
|---|---|---|---|---|---|---|
| | **3rd day** | **7th day** | **14th day** | **3rd day** | **7th day** | **14th day** |
| | 2019 season | | | | | |
| Low volume | 0.230 a | 0.180 a | 0.013 | 0.220 a | 0.186 a | 0.020 |
| Ultra-low volume | 0.197 b | 0.130 b | UND | 0.196 b | 0.130 b | UND |
| | 2020 season | | | | | |
| Low volume | 0.230 a | 0.173 a | 0.013 | 0.220 a | 0.180 a | 0.013 |
| Ultra-low volume | 0.190 b | 0.110 b | UND | 0.193 b | 0.130 b | UND |
| L.S.D | 0.0052 | | | | | |

**Fruit Yield and Quality:**

Data in the table (5) demonstrate fruit length (cm.), diameter (cm.), weight (g.) and yield (Kg. /plant) as affected by *B. tabaci* control with thiamethoxam. It is clear that the ultra-low volume technique caused a significant increase in fruit lengths and weights, on the other hand, the low volume technique was significantly higher than control in the same parameters in both working seasons. In the case of fruit diameter, the ultra-low volume technique caused a significant reduction than the low volume technique in the first season, while in the second season there were no significant differences between both spray technique and control. Both spray techniques caused a significant increase in fruit yield than control.

**Table 5:** Effect of *Bemisia tabaci* control with thiamethoxam after application with two spray techniques twice during two successive seasons on cucumber fruits yield and quality.

| **Spray Technique** | **Fruit length (cm.)** | **Fruit diameter (cm.)** | **Fruit weight (g.)** | **Yield (Kg. /plant)** |
|---|---|---|---|---|
| | 2019 season | | | |
| Control | 13.03 c | 2.53 ab | 105.50 c | 1.23 b |
| Low volume | 13.30 b | 2.63 a | 107.87 b | 1.33 a |
| Ultra-low volume | 13.80 a | 2.40 b | 111.60 a | 1.34 a |
| | 2020 season | | | |
| Control | 13.10 c | 2.50 a | 104.90 c | 1.24 b |
| Low volume | 13.53 b | 2.60 a | 109.23 b | 1.34 a |
| Ultra-low volume | 13.80 a | 2.46 a | 110.93 a | 1.37 a |
| L.S. D | 0.238 | 0.144 | 2.84 | 0.043 |

Whitefly infestation causes great damage to cucumber plants through extracting a large amount of leaves sap, as well as excreting honeydew that leads to growth of sooty mould fungi, finally resulting in leaves inefficacy and reduction in plant growth. (Oliveira *et al.* 2001)

In the present study whitefly, *B. tabaci* control operation caused significantly higher cucumber fruits quality and yield per plant. Such results may be due to the reduction of Whitefly *B. tabaci* infestation, the same result was obtained by (Ghongade and Sangha

2021), who reported a significant increase in cucumber yield as a result of *B. tabaci* reduction.

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## ARABIC SUMMARY

**كفاءة مادة الثياميثوكسام عند رشها باستخدام تقنيتي رش ضد *Bemisia tabaci* (Genn.) على إنتاجية نباتات الخيار تحت ظروف الصوب ومتبقياتها في التربة والأوراق والثمار**

**جمال محمد عبد اللطيف [1] وناهد محمد مصطفى سليم [2] ومنى محمد عبد الونيس**

1- مركز البحوث الزراعية-معهد بحوث وقاية النباتات.
2- مركز البحوث الزراعية-المعمل المركزي للمبيدات-قسم بحوث تحليل المبيدات.
3- مركز البحوث الزراعية-معهد بحوث البساتين-قسم الزراعة المحمية.

أدى رش مادة الثياميثوكسام لمكافحة الذبابة البيضاء على نباتات الخيار تحت ظروف الصوب الى خفض في التعداد مقبول. بالإضافة الى ذلك رش الثياميثوكسام بتقنية الرش بالحجوم المتناهيه في الصغر (ULV) الى خفض عام معنوى وصل الى 90.17 و91.03 % خلال موسمى الدراسة على الترتيب مقارنة باستخدام تقنية الرش بالحجوم الصغيره (LV) حيث كانت نسبة الخفض العام 87.37 و86.50 % على الترتيب. بالإضافة الى ذلك تقنية الرش بالحجوم المتناهية في الصغر أدت الى خفض معنوى في متبقيات الثياميثوكسام في التربه وأوراق وثمار نباتات الخيار بالمقارنه بالرش بتقنية الحجوم الصغيرة. أيضا زادت اطوال واوزان ثمار الخيار التي تمت معاملتها بتقنية الحجوم المتناهية في الصغر مقارنة بتقنية الحجوم الصغيره. أدى الرش بكل من تقنيتي الرش المستخدمه الى زيادة معنويه في محصول نباتات الخيار مقارنة بتلك غير المعاملة.