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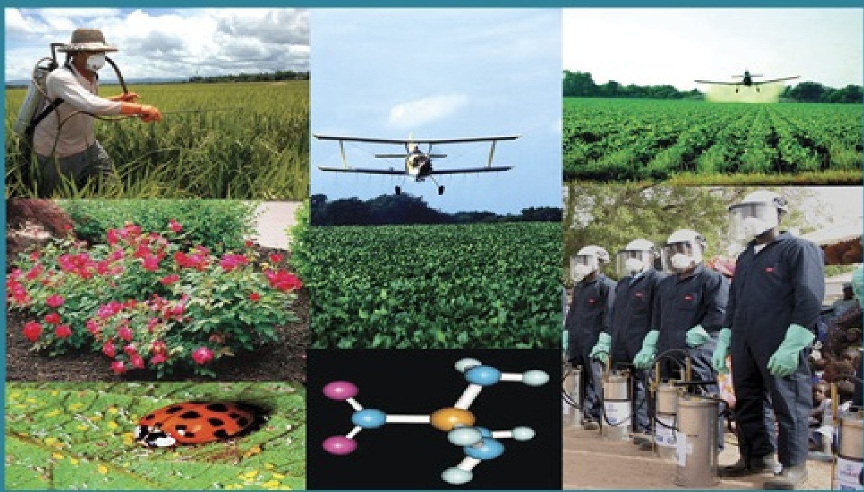

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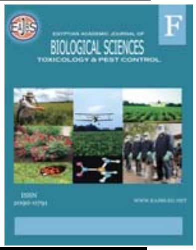

Comparative Susceptibility of Tomato Leafminer, *Tuta absoluta* (Lepidoptera: Gelechiidae) to Common Used Chemical Synthetic Pesticides and Biopesticides in Egypt.

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ABSTRACT

Tomato plants are the most important vegetable crop grown in Egypt. Larvae of the tomato leafminer, *Tuta absoluta*, are the most important and destructive pest of tomato, capable of causing up to 100% of tomato yield loss in some regions. Effectiveness of chemical control of *T. absoluta* is limited due to the insect's nature of damage as well as its rapid capability to develop resistance to diverse insecticides. A few synthetic pesticides have shown relative impact in decreasing field populations. Susceptibilities of L2/L3 larvae of tomato leafminer were assessed to common used chemical synthetic pesticides such as Chlorfenapyr, Imidacloprid, Acetamiprid, Chlorantraniliprole, Indoxacarb and common used biopesticides such as Spinetoram, Abamectin, Emamectin benzoate and Milbemectin under controlled laboratory conditions using impregnated romaine lettuce leaves in leaf dipping technique. Results support that Larvae of *Tuta absoluta* were highly susceptible to Chlorantraniliprole followed by Chlorfenapyr. However, Moderate susceptibility were shown up toImidacloprid, Acetamiprid, Indoxacarb, Spinetoram and Milbemectin, but slight susceptibility were detected to Abamectin and Emamectin benzoate which showed low levels of activity at affordable concentrations.

Statistical analyses did not detect any significant differences at LC_{50} level between Chlorantraniliprole and Chlorfenapyr as the highly effective ones, or between Spinetoram, Milbemectin as moderate effective biopesticides or among Indoxacarb, Imidacloprid and Acetamiprid as moderate efficient chemical synthetic pesticides. No significant differences were found between Abamectin and Emamectin benzoate as slightly efficient biopesticides.

However, significant differences were emphasized between both of them and other tested pesticides.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is the second most important vegetable crop next to potato. World production of tomatoes is about 123.032.774 million tons fresh fruit produced on 3.7 million hectares. Tomato production has been reported for 144 countries (FAOSTAT Database, 2010). Tomato is one of the most important "protective foods" because of its special nutritive value.

It is one of the most versatile vegetable with wide usage for soup, pickles, ketchup, puree, sauces and in many other ways it is also used as a salad vegetable. Tomato has very few competitors in the value addition chain of processing.

In Egypt, Tomato is the most important vegetable crop grown, with total annual planted area at approximately 251838 ha at 2009 (FAOSTAT Database, 2010). The harvested planted area with tomatoes was decreased with about 14.1% in one year to be 216385ha at 2010. Therefore the total producing was sequentially declined about 16.9 % from of 10.278539 at 2009 to 8.544990 million ton representing productivity about 39.49 ton/ha at 2010 after 40.81 ton/ha at 2009, Tomato leafminer has been considered the most responsible reason to diminish harvested tomatoes area for about 15.4 % at 2013. Egypt is occupying the Fifth producer of tomatoes over the world and it was producing about 6.95 % of tomatoes world production at 2009. In Egypt, tomato production is about 55.88% of total vegetative production (FAOSTAT Database, 2015). Tomato plants are liable to attack with many key pests amongst is tomato leafminer, *Tuta absoluta* (Meyrick 1917) (Lepidoptera: Gelechiidae) that proved one of the most important and destructive pests in so many countries over the world and it is one of the most devastating insect pests for tomato production. This leafminer also attacks other Solanaceae crops such as potatoes. It is originated from South America and has been mentioned in literature since about 45 years ago (Bahamondes and Mallea 1969). Recently it has been considered the most threat to tomatoes production in the Mediterranean region since it has the potential to spread to Spain (Urbaneja *et al.* 2007) and then other European countries such as: France (EPPO 2009a ⁄ article47), Netherlands (EPPO 2009b⁄ article 255) and the United Kingdom, (EPPO 2009c ⁄ article 340),Malta (EPPO 2009d ⁄ article 395), and Italy (EPPO 2010/ article 303). It was not hard for this cosmopolitan and highly adapted pest, *Tuta absoluta*, to invade North African countries such as Algeria, Morocco, Tunisia (Desneux *et al*. 2010). This invasive insect has the capability to cross the boarders and devastate tomato production both protected and open fields (http://www. tutaabsoluta.com). Thus, at the end of 2009 *Tuta absoluta* has been detected in tomato fields in Egypt and we believe that it came across the *Mediterranean* Sea or across the border from Libya. Since 2010 *T. absoluta* was becoming a cosmopolitan pest with no preventive breaks. Due to its capability to attack tomato plants in three different levels started with mine the young leaves and then penetrate the stems and branches and then piercing flowers and fruits. This unique behavior affects the crop directly, producing losses between 60 and 100% of the total production (Ca´ceres 1992; Cely *et al*. 2006; Va´squez *et al*. 1997). It is extremely difficult to control once it has established itself in the Agro-ecosystem. It has a high reproductive potential, with up to 12 generations per year (De Vis *et al.* 2001; Ve´lez 1997) but this may vary among countries and the original climate.

Tuta absoluta is a very challenging pest to control. Effectiveness of chemical control is limited due to insect's nature of damage as well as its rapid capability of development of insecticide resistance. The use of biological factors are still largely under development and not ready to combat this pest effectively and in a cost effective way. Sex pheromone trap is using as an early detection tool. Mass trapping using lure and Kill application of pheromone has been found to be effective to decrease the population. IPM strategies are being developed to control *Tuta absoluta*. Various active substances can be applied in combination with biorational control tactics (http://www. tutaabsoluta.com),

Last five years, while there was no highly effective management tools for this leafminer, farmers tend to intensive use of chemical synthetic insecticides to the extent of frequent use every day which may cause adverse environmental effects including water pollution, eradication of beneficial wildlife and human health problems (Desneux *et al.* 2007; Estay and Bruna 2002; Lietti *et al.* 2005) and for sure they develop resistance mechanisms to existing recommended insecticides. For these reasons, there is great interest to find efficient and economical control alternatives that allow sustainable tomatoes production.

The objectives of this study were to assess the susceptibility of this invasive pest, *Tuta absoluta*, to common used chemical synthetic pesticides in Egypt such as Challenger® 36 SC (Chlorfenapyr), Coragen® 20 SC (Chlorantraniliprole), Mospilan® 25 SP(Acetamiprid), *Admire® 20S*C (Imidacloprid), Avaunt® 15 EC (Indoxacarb) and common used biopesticides such as Radiant® 12 SC (*Spinetoram*), Milbeknock®1 EC (Milbemectin), Vertimec® 1.8 EC (Abamectin) and *Proclaim*® 5 WDG (Emamectin benzoate).

MATERIALS AND METHODS

Tested Pesticides

Five different chemicalsyntheticpesticides belong to four different chemical classes, Chlorfenapyr belongs to Arylpyrrole produced by BASF limited Egypt, Chlorantraniliprole belongs to anthanilic diamid and Indoxacarb belongs to oxadiazines both produced by DuPont Crop Protection Middle East & Africa and both Imidacloprid and Acetamiprid are belonging to neonicotinoids class were produced by Bayer Crop Science and Sumitomo Corporation Egypt, respectively, and Four different bacterial fermentation derivatives biopesticides belong to two different chemical classes. Spinetoram belongs to Spinosyn produced by Dow Agro Science, both Abamectin and Emamectin benzoate are belong to Avermectins and produced by Syngenta agro Egypt. Milbemectin is belong to Avermectin class and produced by Sumitomo Corporation Egypt. All tested pesticides were individually investigated in a same comparative toxicity protocol in order to determine their efficiency in controlling tomato leafminer.

Bioassay

A leaf-dip bioassay technique was used to evaluate the susceptibility of L2/L3 larvae of *Tuta absoluta* to all tested formulations. Leaves of Romaine lettuce were placed individually in each tested concentration and in double distled water for untreated (Control) for 30 seconds with gentle agitation, ensuring the entire surface is immersed equally and then allowed to air dry for 1 h and then supplied as the sole food source to larvae. Concentrations of 10, 20, 30, 40, and 50 ppm were used for testing the mortality of both Chlorfenapyr and Chlorantraniliprole pesticides. Concentrations of 25, 40, 55, 70, 85 and 100 ppm were used for Imidacloprid, Acetamiprid and Indoxacarb. Concentrations of 20, 40, 60, 80, and 100 ppm were used for testing the bioactivity of Spinetoram and Milbemectin. However, for Abamectin we used seven concentration of 30, 50, 70, 90, 110, 130 and 150 ppm. Concentrations of 30, 50, 70, 90, 110 and 130 ppm were used in the bioassay of Emamectin benzoate, all these concentrations were used after preliminary bracketing bioassays suggested them. The various diluted concentrations were applied in 100 ml of double distilled water and thoroughly vortexed before immersing the Romaine lettuce leaves. Control solutions consisted of double distilled water.

Replicates consisted of a Petri dish (100 mm x 15 mm) containing a lightly moistened filter paper, onto which half a leaf (dependent upon size) were placed and inoculated with 10 L2/L3 stage larvae. These were maintained under controlled environmental conditions (26 ± 2 °C, 16 L: 8 D photoperiod) and mortality was assessed after 48 h. Larvae were counted as dead if when stimulated with a fine paintbrush, there was either no movement, or if movement was uncoordinated and they were unable to move a distance equal to double their body length. Each bioassay experiment was repeated thrice with three replicates of each concentration per experiment. Mortalities of each formulation were pooled and subjected to statistical data analysis.

Statistical Analysis

Mortalities of every three experiments and three replicates in each were pooled together then subjected to Probit analysis using the Statistical Analysis System Version 9.4 program PROC PROBIT (SAS Institute 2013). Control mortalities (%) were 5.5, 3.3, 4.4, 8.8,5.5,5.5,5.5, 3.3and8.8for the nine tested pesticides, Chlorfenapyr, Chlorantraniliprole, Acetamiprid, Imidacloprid, Indoxacarb, Milbemectin, Spinetoram, Abamectin and Emamectin benzoate, respectively. When comparing LC_{50} values, a failure of 95% confidence limits to overlap was used as a measure to determine significant differences between treatments (Robertson and Preisler 1992). In all cases the likelihood ratio (L.R.) chi-square goodness-of-fit values indicated that the data adequately conformed to the Probit model (Robertson and Preisler 1992).

RESULTS AND DISCUSSION

Efficacy of all tested pesticides either the chemical synthetic or the bacterial fermentation derivatives biopesticides were assessed after 48hrs depending on the statistically calculated LC_{50}'s and LC_{90}'sof each pesticide. LC_{50}'s of 17.7 Chlorantraniliprole, 20.2 Chlorfenapyr, 40.5 Acetamiprid, 42.3 Indoxacarb, and 44.9 Imidacloprid (Table 1). These datarevealed that among the chemical synthetic pesticides Chlorantraniliprole was the most efficient one with the lowest LC_{50} value followed by Chlorfenapyr.

Table 1: Statistical toxicity values of common chemical synthetic pesticides, Chlorantraniliprole, Imidacloprid, Acetamiprid, Chlorfenapyr and Indoxacarb to Egyptian population of Tomato leafminer, *Tuta absoluta*.

Pesticide Formulation	n	Slope	χ^2(df)[c]	LC_{50}[ab] (95% FL)	LC_{90}[ab] (95% FL)	Toxicity Index[d]
Chlorantraniliprole	450	3.8 (0.73)	18.8(3)	17.7a (9.7 – 24.4)	38.2 a (27.2 – 100.3)	100
Imidacloprid	540	4.7 (0.53)	8.7(4)	44.9 b (38.3 – 51.2)	83.6 a (71.2 – 108.5)	39.4
Acetamiprid	450	4.6 (0.40)	5.8(3)	40.5 b (37.5 – 43.4)	76.9 a (71.5 – 89.8)	43.7
Chlorfenapyr	450	3.9 (0.77)	21.3 (3)	20.2 a (11.7 – 27.9)	42.4 a (30.1 – 119.1)	87.6
Indoxacarb	540	4.6 (0.52)	8.8 (4)	42.3 b (35.4 – 48.5)	80.3 a (68.2 – 105.1)	41.8

[a] $LC_{50's}$ and LC_{90}'s reported in ppm.
[b] $LC_{50's}$ and LC_{90}'s followed by the same letter are not significantly different based on overlap of their 95% fiducial limits ($P< 0.05$). Each pesticide formulation was analyzed separately.
[c] L.R. chi-square goodness-of-fit values. Tabular values at $P = 0.05$ for 3 df = 7.81, 4 df = 9.49
[d] Toxicity index (Sun, 1950) = (LC_{50} of the most efficient tested compound as Standard (Chlorantraniliprole) / LC_{50} of the other tested compound) *100

Spinetoram was the most effective biopesticides among the tested ones at the lowest LC_{50} of 40.7 ppm followed by Milbemectin at LC_{50} of 41.6 (Table 2). Moderate susceptibility of tomato leafminer larvae was recorded to Neonicotinoids; oxadiazines pesticides represented by the common tested ones

Acetamiprid, Imidacloprid and Indoxacarb. Spinetoram and Milbemectin had a moderate level of bioactivity to control larvae of *Tuta absoluta* if they compared with the highly effective ones.

Data in Table 2 emphasized that the lack of susceptibility was obvious to Abamectin and Emamectin benzoate; they are the most slightly bioactive agents among tested pesticides, though they are very active against other insect pests. Statistical analysis declared that larvae of *Tuta absoluta* were highly susceptible to Chlorantraniliprole and Chlorfenapyr where there were no significant differences has been detected between both of them. Chlorantraniliprole and Chlorfenapyr were the most effective among all tested pesticides.

$LC_{90}$of each of them was approximately close to the value of LC_{50} of the moderate effective tested pesticide and it is approximate to half value of $LC_{50's}$ of slightly efficient tested pesticides. Failure of 95% confidence limits to overlap was proofed that there were no significant differences shown up at $LC_{50's}$ level between Chlorantraniliprole and Chlorfenapyr as highly effective pesticides group among all tested pesticides, or between Acetamiprid, Imidacloprid, Indoxacarb, Spinetoram and Milbemectin as moderate effective tested pesticides group, or between Abamectin and Emamectin benzoate as slightly effective tested pesticides group. However, significant differences were detected between Abamectin or Emamectin benzoate and other tested pesticides. No significant differences were shown upon $LC_{90's}$ among highly effective and moderate effective pesticides. Meanwhile, significant difference is still obvious between all of them and Abamectin or Emamectin benzoate.

Toxicity index of each formulation was calculated according to the equation of Sun, 1950 where the standard is the most efficient formulation among tested ones. Toxicity index values demonstrated a relative toxicity between the most efficient formulation (Chlorantraniliprole) as standard and other pesticide formulations (Table1&2). Susceptibility of larvae to Chlorantraniliprole was approximately 2.5 fold of their susceptibility to Acetamiprid, Imidacloprid, Indoxacarb, Spinetoram and Milbemectin.

Table 2: Statistical toxicity values of common used biopesticides, Abamectin, Milbemectin, Emamectin benzoate and Spinosad to Egyptian population of Tomato leafminer, *Tuta absoluta*.

Pesticide Formulation	**n**	**Slope**	**χ^2(df)^c**	**LC_{50}^{ab} (95% FL)**	**LC_{90}^{ab}(95% FL)**	**Toxicity Index ^{d}**
Abamectin 1.8% EC	630	3.8 (0.76)	36.3 (5)	73.6 c (53.8 – 94.8)	159.5 b (117.2 – 354.3)	24.04
Milbemectin 1% EC	450	4.2 (0.50)	6.6(3)	41.6 b (32.5 – 50.2)	83.9 a (67.3 –125.2)	42.5
Emamectin benzoate 5 % WDG	540	3.5 (0.59)	15.2 (4)	65.6 c (51.8 – 81.3)	149.1 b (111.4 – 295.2)	26.9
Spinetoram	450	3.9 (0.32)	5.2 (3)	40.7 b (37.2 – 44.3)	85.5 a (76.7 – 98.1)	43.5

[a] $LC_{50's}$ and LC_{90}'s reported in ppm.
[b] $LC_{50's}$ and LC_{90}'s followed by the same letter are not significantly different based on overlap of their 95% fiducial limits ($P< 0.05$). Each pesticide formulation was analyzed separately.
[c] L.R. chi-square goodness-of-fit values. Tabular values at $P = 0.05$ for 3 df = 7.81, 4 df = 9.49 and 5 df = 11.07
[d]Toxicity index (Sun, 1950) = (LC_{50} of the most efficient tested compound as Standard (Chlorantraniliprole)/LC_{50} of the other tested compound) *100

Meanwhile, it was almost 4 fold of susceptibility to Abamectin or Emamectin benzoate. Chlorantraniliprole is registered for control of tomato pinworm on tomato in the United States (Dupont, 2008) due to its capability of root uptake, translocation in tomato plants and its privilege translaminar activity of tomato leaves and fruits. Lahm, 2009, reported that

Chlorantraniliprole controls pest populations that are resistant to other insecticides. That may explain why is Chlorantraniliprole is the most efficient pesticide. In Egypt, Tomato leafminer has been considered a catastrophic pest for tomato farmers since 2010. Cultivators have lost their yield up to 100% in the outbreak season of *Tuta absoluta*. Therefore they intended to frequent use of pesticides every dayand they have spent a lot of money in managing this devastating pest without any kind of output. The non-judicious application of insecticides led to the development of resistance and may show a cross resistance (USDA, 2011). Tomato leafminer has acquired a resistance to many insecticides such as Deltamethrin and Abamectin (Lietti *et al*., 2005). Also resistant to Cartap, Permethrin and Methamidophos (Siqueira *et al*., 2000), and Acephate (Branco *et al*., 2001). That may interpret the lack of susceptibility to Abamectin and Emamectin benzoate. So that it is the time for the newer insecticide classes that provide efficiency against the tomato leafminer (IRAC, 2009a), However, the modes of action need to be conserved by implementing resistance management. Rotation of controlling agents with different modes of action, usually provides a sustainable and effective approach to managing insecticide resistance (IRAC, 2009b). Indoxacarb is one of the newer insecticide classes and it is been considered of the reduced risk pesticide (EPA, 2000) that enters the insect through the cuticle or digestive system and acts by blocking sodium channels. Indoxacarb, spinosad, imidacloprid, deltamethrin, and *Bacillus thuringiensis* var. *kurstaki,* were the most applied insecticides in controlling *Tuta absoluta* in Spain (FERA, 2009; Russell IPM, 2009). This serious pest led people to use all kind of pesticides even if they are not registered to be applied on tomato plants to manage outbreak infestations (Garzia *et al*., 2009). Chlorfenapyr is one of the newer insecticide classes; it has been used to control *Tuta absoluta* in Brazil (IRAC, 2007). Chlorfenapyr has a unique mode of action because it is a pro-insecticide that is converted to the active metabolite in the midgut of insects and mites (Yu, 2008). The metabolite affects the ability of cells to produce ATP which results in the death of the insect. Chlorfenapyr is registered in the United States for control of tomato pinworm on greenhouse grown tomatoes, peppers and eggplant (CDMS, 2010). Also, it is effective against larvae and nymphs of spider mites, whiteflies, thrips, leafminers, and aphids in numerous crops (Yu, 2008). Unique mode of actions of Chlorantraniliprole and Chlorfenapyr is reflected why they were the most efficient pesticides in Egypt and interpreted the high susceptibility of tomato leafminer larvae to both of them. Although, Acetamiprid and Imidacloprid are the most widely used neonicotinoid's insecticide due to their systemic action and their long residual activity where they mimic the action of acetylcholine in insects causing hyper excitation and death but they are primarily effective against sucking insects (Yu, 2008). Indoxacarb, Imidacloprid, Spinosad are highly recommended for use in France (FREDON-Corse, 2009) and in Brazil(IRAC, 2007) due to its selectively targets of lepidopteran pests and its efficacy in controlling outbreaks of tomato leafminer (FERA, 2009; Picanço, 2006; Sixsmith, 2009). Milbemectin is a mixture of milbemycin A3 and Milbemycin A4 which they are metabolites of *Streptomyces hygroscopicus subsp aureolacrimousa*. It is highly effective against a wide variety of pest mites and leafminers due to its translaminar activity (Mitsui Chemicals Agro 2000).Our results indicated that Acetamiprid, Imidacloprid, Indoxacarb, Spinetoram and Milbemectin exhibited moderate activity levels to the tested larvae of *Tuta absoluta*. This might explain how much the intensive and indiscriminate use of pesticides has been done in Egypt since 2010. Emamectin benzoate is highly potent to a broad spectrum of lepidopteran insect pests but it is about 8- to 15-fold less toxic to the serpentine leafminer, Liriomyza trifolii (Burgess) (Cox *et al*., 1995a&b). Though, Emamectin benzoate has the potential to penetrates leaf tissues by translaminar movement and it has been recommended for control tomato leafminer in some countries such as Algeria (Gacemi and Guenaoui 2012) and in Greece (Roditakis *et al.,* 2012) but it showed low levels of activity at affordable concentrations in our comparative susceptibility of tomato leafminer larvae to common frequent sprayed pesticides in Egypt. We believe each country should re-evaluate the efficacy of the registered pesticide on Tomato crops routinely because this invasive pest, *Tuta absoluta* has an exponential development of resistance and it may vary among countries due to the legislation and the regulations of using pesticides and also this might be affected with the culture of each country and their way in dealing with the chemical compounds. Our results trend support the use of either Chlorantraniliprole or Chlorfenapyr individually or within a rotation to control *T. absoluta* and to delay resistance evolution. The individual use of Indoxacarb, Acetamiprid, Imidacloprid from chemical synthetic pesticide group or Spinetoram and Milbemectin from biopesticides group is not recommended, but they may be used in programs to increase efficiency in controlling *T. absoluta* larvae. We believe that we are in need to apply the Integrated Crop Management (ICM) for tomato plants in order to get the best management for *Tuta absoluta.* Also, Integrated Pest Management will be the most sustainable managing tool that count on different types of control not just pesticides and not just applied at the outbreak but it will be earlier.

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ARABIC SUMMERY

مقارنة حساسية حشرة ناخرة أوراق الطماطم "توتا أبسولوتا" للمبيدات المخلقة كيميائيا وكذلك المبيدات الحيوية شائعة الإستخدام في مصر

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تحتل نباتات الطماطم المرتبة الثانية من حيث الأهمية بين محاصيل الخضر المنزرعه بمصر. وتعد حشرة ناخرة أوراق الطماطم أكثر الأفات من حيث الأهمية الإقتصادية لقدرتها البالغه علي تدمير المحصول واحداث خسائر تصل لنسبة 100% في بعض المناطق. إن طبيعة الضرر الذي تحدثه الحشرة وقدرتها السريعه علي تطوير صفة المقاومة لمجابهة المبيدات كان له تأثيرا شديداً علي خفض كفاءة المكافحة الكيميائية لها. ولقد أظهر قليل من المبيدات المخلقة كيميائياً تأثيراً نسبياً في خفض تعداد الحشره في حقول الطماطم. تمت هذه الدراسة بهدف تقييم حساسية يرقات حشرة توتا أبسولوتا تجاه بعض المبيدات المخلقة كيميائياً وشائعة الإستخدام في مصر مثل الكلورفينابير ، الكلورانترانيليبرول، الإيميداكلوبرايد، الأسيتامبريد، الإندوكساكارب. وكذلك تقييم حساسية اليرقات تجاه بعض المبيدات الحيوية شائعة الاستخدام في مصر مثل الإسبينيتورام ، الأبامكتين، الإيمامكتين بنزوات ، الميلبمكتين وذلك تحت ظروف معملية متحكم فيها حيث استخدمت أوراق خس الرومين المشبعه بمحلول المبيد عن طريق الغمر. أوضحت النتائج أن يرقات العمر الثاني والثالث لحشرة توتا أبسولوتا كانت شديدة الحساسية لمبيدي الكلورانترانليبرول والكلورفينابير حيث كانا شديدا الفاعليه بناء علي قيمة التركيز النصفي المميت 17.7، 20.2 جزء في المليون علي الترتيب. ولقد سجل كلا من الأسيتامبريد ، الإندوكساكارب، الإيميداكلوبريد، الإسبينيتورام ، والميلبمكتين فاعليه متوسطه تجاه اليرقات حيث كانت قيم التركيز النصفي المميت هي (40.5، 42.3 ، 44.9 ، 40.7 ، 41.6 جزء في المليون) علي الترتيب. أظهرت النتائج أن هناك ضعف في حساسية اليرقات لمبيدي الأبامكتين والإيمامكتين بنزوات بشكل ملحوظ وبالتلي انخفاض فاعلية المبيدين حيث كانت قيمتي التركيز النصفي المميت لهم 73.6 ، 65.6 جزء في المليون علي الترتيب. أكدت التحليلات الإحصائية عدم وجود فرق معنوي بين اكثر المبيدات فاعليه ، الكلورانترانيليبرول والكلورفينابير. كمان أنه لا توجد فروق معنويه بين مجموعة المبيدات متوسطة الفاعلية (الأسيتامبريد، الإندوكساكارب، والإيميداكلوبريد، الإسبينيتورام والميلبمكتين). كما أنه لا توجد فروق معنويه بين أقل المبيدات كفاءة الأبامكتين والإيمامكتين بنزوات بعضهم لبعض. ولكن هناك فروق معنويه مؤكدة بين كلا منالأبامكتين والإيمامكتين بنزوات وجميع المبيدات الأخري.