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COMPARATIVE EFFICIENCY OF NEW INSECTICIDE FORMULATIONS AGAINST TOMATO LEAFMINER, *Tuta absoluta*, MEYRICK (LEPIDOPTERA: GELECHIIDAE) IN EGYPT

Mashtoly, T. A. [1] **and Nesreen A.S. Helal** [2]
1-Dept. of Plant Protec., Fac. of Agric. Ain Shams Univ., Cairo, Egypt.
E-mail: telmashtoly@agr.asu.edu.eg
2-Dept. of Horticulture, Fac. of Agric. Ain Shams Univ., Cairo, Egypt.
Email: nesreenas@hotmail.com

ABSTRACT

Tomato plants are the second most important vegetable crop grown in Egypt. Larvae of the tomato leafminer, *Tuta absoluta*, Meyrick 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. However, these synthetic pesticides are not offered at economically affordable cost to many farmers. Two new formulations with more affordable cost, designed as Mash-T 15 EC and Mash-V 25 EC were prepared in our laboratory for control of *T. absoluta*. Physicochemical properties were in accordance with the FAO/WHO specifications 2010. Bioassay of commonly used pesticides against *T. absoluta* in Egypt, including Coragen® 20 SC (Chlorantraniliprole), Avaunt® 15 EC (Indoxacarb), and Proclaim®5 WDG (Emamectin benzoate) in comparison with Mash-T and Mash-V against L2/L3 larvae using impregnated romaine lettuce leaves in leaf dipping technique was done. Results support that Chlorantraniliprole was the most effective formulation against *T. absoluta* larvae, followed by Mash-V. Mash-T and Indoxacarb had moderate activity levels, but emamectin benzoate showed low levels of activity at affordable concentrations. Statistical analyses did not detect any significant differences at LC_{50} level between Chlorantraniliprole and Mash-V, or between Indoxacarb and Mash-T. However, significant differences were found between emamectin benzoate and other tested pesticides.

Keywords: Tomato leafminer, *Tuta absoluta*, Bioassay, Efficiency, Insecticides.

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 millionton representing productivity about 39.49 ton/ha at 2010 after 40.81 ton/ha at 2009, Tomato leafminer has been considered the most destructive reason to harvested tomatoes area which diminish it for about 15.4 % at 2013. Egypt is occupying the Fifth producer of tomatoes over the world and it produces 6.95 % of tomatoes world production. In Egypt, tomato production is about55.88% of total vegetative production in Egypt (FAOSTAT Database, 2015). Tomato plants are liable to attack with many key pests amongst is tomato leafminer, *T. absoluta* that proved one of the most important and destructive pests in so many countries over the world. The tomato leafminer, Tuta absoluta (Meyrick 1917) (Lepidoptera: Gelechiidae), 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), Italy (EPPO 2010/article 303), Malta (EPPO 2009d ⁄ article395), Netherlands (EPPO 2009b⁄ article 255) and the United Kingdom, (EPPO 2009c ⁄ article 340). 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 tocross 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. The tomato leafminer has the capability to attack tomato plants in three 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). It is extremely difficult to control once it has established itself in the 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.

T. 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 resistant strains. 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 and lure and Kill application of pheromone has been found to be effective to decrease the population of *T. absoluta*. IPM strategies are being developed to control *T. absoluta*. Various active substances can be applied in combination with bio-rational control tactics (http://www. tutaabsoluta.com).

Last five years, while there was no highly effective management tools for the leafminer, farmers tend to intensive use of chemical 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 (Estay and Bruna 2002; Lietti et al. 2005, Desneux et al. 2007;) and for surethey develop resistance mechanisms to existing recommended insecticides.For these reasons, there is great interest to find efficient, economical control alternatives that allow sustainable tomatoes production.

The objectives of this study were to determine the efficiency of common used insecticides to control T. absoluta, such as Coragen® 20 SC (Chlorantraniliprole), Avaunt® 15 EC (Indoxacarb), and Proclaim® 5 WDG (Emamectin benzoate) in comparison with two new lap prepared formulations Mash-T 15 EC and Mash-V 25 ECunder laboratory bioassays.

MATERIALS AND METHODS

Preparation of formulations: two new formulations were designated as Mash-T 15 EC and Mash-V 25 EC at the Research and Development Center of Eid Company for manufacturing technical grade pesticides, Quwesna, Menoufia, Egypt.Lambda-Cyhalothrin TC 97% and Chlorpyrifos TC96% and Emamectin benzoate TC 70% and Abamectin TC 97% were used to prepare both formulations.Inert Surfactant mixture Ionic and Non-ionic emulsifier, spreading agents, organic hydrocarbon silicon as synergistic agent were used as adjuvant (Imported from China). The differences between both formula Mash-T and Mash-V were in the active ingredient matrix used, concentrations and types of adjuvant used. Mash- T formula is consisted of 6.2% Lambda-Cyhalothrin, 3.6 % Abamectin, 5.2% of Emamectin benzoate, 20 % inert surfactants and adjuvants and 65% solvents. Matrix ingredient of Mash-V formula consisted of 8.7% of Lambda-Cyhalothrin, 6.3 % Chlorpyrifos, 5.4% Abamectin, 4.6% Emamectin benzoate and 25 % inert surfactant and Adjuvant and 50 % solvents. Each formula were subjected to determine the emulsion stability test as indicator for the physicochemical properties.

Physicochemical properties: new prepared tested formulations were subjected to determine the physicochemical properties according to FAO/WHO specifications 2010. Persistent foam of each tested pesticides and free oil portions were measured according to CIPAC F 2012 MT75 and MT 47.1 respectively.

Emulsion stability test: (FAO/WHO Specification 2010 and CIPAC MT 36.3 2012). Emulsion stability for the new lab-mad formulations, Mash-V and Mash-T was measuredusing three types of water, soft,hard and tap water. Hard water was prepared by dissolving 0.304g of anhydrous calcium chloride and 0.139g of magnesium chloride hexahydrate in double distilled water and made up to one liter. This provides total hardness equivalent to 342 ppm of calcium carbonate. Soft water was prepared by mixing one volume of hard water with five volumes of double distilled water to provide water hardness of 57 ppm according to CIPAC MT 73 (2012). Emulsion stability test was carried out using 100 ml-glass graduated stopper tubes, three tubes for each tested pesticide, one tube was filled with freshly prepared hard water, Second tube was filled with freshly prepared soft water and the third was filled with freshly tap water up to level 95 ml, calculated EC pesticides required to prepare 100 ml was added. The tubes were up-settled to 180^{o}at the rate of complete cycle per 2 sec, 30 complete cycles were done. Separation or precipitation at either top or bottom of the graduated tube were measured and recorded after 0, 0.5, 2hrs. and re-emulsification was done again after 24 and the stability was measured after 24.5 hour. Persistent foam was measured for each sample after 1 min. of emulsification and detected free oil portions were measured and registered either after 2 and 24.5 hrs.(FAO/WHO specification 2010). Emulsion stability test was repeated thrice and three replicates for each.

Tested Pesticides: three different pesticides belong to three different chemical classes, Coragen® Chlorantraniliprole 20 SC belong to anthanilic diamid class and Avaunt® Indoxacarb 15 EC belong to oxadiazines were produced by DuPont Crop Protection Middle East & Africa., Proclaim® Emamectin benzoate 5 WDG produced by Syngenta Egypt., were used in comparison to the lab-made formulations bioassay.

Bioassay: a leaf-dip bioassay technique was used to evaluate the susceptibility of L2/L3 larvae of *T. absoluta* to all tested formulations. Leaves of *Romaine lettuce* were placed individually in each tested concentration and in 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 5, 10, 15, 20, 25 and 30 ppm were used for testing the mortality of both Chlorantraniliprole and lab-mad formulation Mash-V. Concentrations of 30, 40, 50, 60, 70 and 80 ppm were used for both Indoxacarb and lab-mad formulation Mash-T. Six concentrations of 40, 60, 80, 100, 120 and 140 ppm were used for testing the bioactivity 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 vortexes 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, on to which half a leaf (dependent upon size) were placed and inoculated with about 20 L2/L3 stage larvae. These were maintained under controlled environmental conditions (26 ± 2 ^{o}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 2012). Control mortalities (%) were 8.8, 4.4, 6.6, 7.7 and10 for the five tested pesticides, Chlorantraniliprole,Indoxacarb,Emamectin benzoate,Mash-T and Mash-V,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

Persistence foam, free oil portions and emulsion stability& re-emulsification values for the new lab-made formulations, Mash-T and Mash-V were in accordance with the FAO/WHO specifications 2010 (Table 1). After 1 min. of the complete initial emulsification at zero time, persistence foam has been recorded as 9 ml and 7 ml for Mash-T and Mash-V respectively. Traces of oil were found on the top of emulsion after 2 h for both tested formula. However, the free oil has increased after re-emulsification at 24h up to 0.3 ml for Mash-T. Creamy layer was varied from 0.6 to 2.3ml and 0.5 to 1.4 ml from 0h to 24.5 h. for Mash-T and Mash-V, respectively. Data of the emulsion stability were shown as a maximum average in between thrice trials at three replicates of each using CIPAC Standard Water A & D. LC_{50}'s and LC_{90}'sof eachpesticide were assessed after 48hrs, 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. LC_{50}'s of 13.3 Chlorantraniliprole, 14.7 Mash-V, 52.1 Indoxacarb, 47.5 Mash-T and 81.7 ppm of Emamectin benzoate.LC_{90}'swere 32.8, 32.7, 85.7, 78.5 and 201.1 ppm for Chlorantraniliprole, Mash-V, Indoxacarb, Mash-T and Emamectin benzoate, respectively (Table 2). Data emphasized that Chlorantraniliprole was the most effective pesticides with a lower LC_{50} and LC_{90} to *T. absoluta* followed by Mash-V. LC_{90} of each of them was approximately close to the half value of $LC_{50}$of the other tested pesticide formulations. Emamectin benzoate was the lowest formulation in activity to the tested larvae. Failure of 95% confidence limits to overlap was proofed thatthere were no significant differences shown up at $LC_{50's}$ level between Chlorantraniliprole and Mash-V, or betweenIndoxacarb and Mash-T. However, significant differences were detected between Emamectin benzoate and other tested pesticides. No significant differences were shown upon $LC_{90's}$ among Chlorantraniliprole, Mash-V, Indoxacarb and Mash-T. However, significant difference is still obvious between all of them and Emamectin benzoate. Toxicity index values demonstrated a relative toxicity between the most efficient formulation (Chlorantraniliprole) as standard and other formulations (Table.2). Efficiency of Chlorantraniliprole to tomato leafminer larvae was approximately 4 fold of the efficacy of Indoxacarb and Mash-T. Meanwhile, it was more than 6 fold of the efficiency of Emamectin benzoate. Our data support that chlorantraniliprole was the most efficient formulation against *T. absoluta* larvae, followed by Mash-V. Chlorantraniliprole is registered for control of tomato pinworm on tomato in the United States (Dupont, 2008) due tocapability ofroot uptake, translocation in tomato plants and its privilegetranslaminar activity of tomato leaves and fruits. Lahm, 2009, reported that Chlorantraniliprole controls pest populations that are resistant to other insecticides. Mash-V has the potential to play a vital role in controlling tomato pests such as *T. absoluta* due to its unique matrix of composition. We believe that the bioactivity of Mash-V, which is statistically competing with Chlorantraniliprole, comes from the mixture of the active ingredient that shows a multi-mode of action, types of adjuvant and synergistic agents used. 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 *T. absoluta*, and they have spent a lot of money in managing this devastating pest without any kind of output. The effective insecticides to this pest are really expensive to the Egyptian farmer. Mash-V is a promising formula at affordable economically cost. 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, abamectin, permethrin and methamidophos (Siqueira *et al*., 2000), and acephate and deltamethrin (Branco *et al*., 2001). So that it is the time for the newer insecticide classes that provideefficiency 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 insecticidesin controlling *T. absoluta* in Spain (FERA, 2009; Russell IPM, 2009). Although, Chlorpyrifos, is not registered on tomato fruits in Italy, andthiacloprid, lufenuron are not registered on tomato fruits in Malta, and Metaflumizone is not registered on crops in Spain (MARM, 2010), they have been used as recommended pesticides in the outbreak infestation and/or with rotation of Pyrethrins in Italy (Garzia *et al.,* 2009) or with sequence with Abamectin, Indoxacarb, Spinosad, Imidacloprid,and *Bacillus thuringiensis* (*Btk*) in Malta (Mallia, 2009). In Spain it was just for restricted period because existing control methods were insufficient to control *T. absoluta* in some regions of Spain (MARM, 2010). Although, Chlorpyrifos is banned for use on tomatoes in the United States (EPA, 2006) it is the most widely used pesticide in Egypt in controlling insect pests on vegetable crops. Indoxacarb is highly recommended foruse in France (FREDON-Corse, 2009) andin Brazil (IRAC, 2007) due to its selectively targets of lepidopteran pests and its efficacy in controlling outbreaks of tomato leafminer (Picanço, 2006; FERA, 2009; Sixsmith, 2009). Our results indicated that Indoxacarb and Mash-Thad 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 bio efficiency to tomato leafminer, *T. absoluta* in Egypt. We believe each country should re-evaluate the efficacy of the registered pesticide on Tomato crops routinely because this invasive pest, *T. 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. While statistical analyses proved that there was no significant differences at LC_{50}level and Fiducial limits 95% between Chlorantraniliprole and Mash-V, or betweenIndoxacarb and Mash-T. Significant differences were shown up between emamectin benzoate and each other tested pesticides. Our results trend support the use of either chlorantraniliprole or Mash-V individually or within a rotation to control *T. absoluta* and to delay resistance evolution. The individual use of Indoxacarb, Mash-T and emamectin benzoate is not recommended, but they may be used in programs to increase efficiency in controlling *T. absoluta* larvae. Integrated *T. absoluta* management is the best managing tool that count on different types of control not just pesticides and not just applied at the outbreak but it will be earlier.

Table 1. Emulsion stability and persistent foam of the new lab-made formulations, Mash-T 15% EC and Mash-V 25 % EC, using CIPAC standard waterat 30±2 ^{0}C

Parameters		Mash-T 15% EC	Mash-V 25 % EC
[a]Persistence foam after 1 Min.		9 ml	7 ml
[b]Emulsion Stability	0h	Complete emulsification	Complete emulsification
	0.5 h	Maximum Cream 0.6 ml	Maximum Cream 0.5 ml
	2.0 h	Maximum Cream 1.5 ml	Maximum Cream 0.9 ml
[c]Free Oil	2.0 h	Trace	Trace
Re-Emulsification	24 h	Complete re-emulsification	Complete re-emulsification
	24.5 h	Maximum Cream 2.3 ml	Maximum Cream 1.4 ml
Free oil	24.5 h	0.3 ml	Trace

[a, b, c] - Values reported as the maximum mean of measurements using different CIPAC standard water (Hard, Soft and Tap water).

Table 2. Toxicity values of common used pesticides to *Tuta absoluta* in Egypt in comparison with the lab-mad formulations Mash-T 15% EC and Mash-V 25 % EC

Pesticide Formulation	n	Slope	χ^2 (df)[c]	LC_{50}[ab] (95% FL)	LC_{90}[ab] (95% FL)	Toxicity Index [d]
Chlorantraniliprole 20% SC	1080	3.2 (0.69)	54.9(4)	13.3a (8.3 – 18.6)	32.8 a (22.2 – 108.8)	100
Indoxacarb 15 % EC	1080	5.9 (1.05)	38.4(4)	52.1 b (43.9 – 61.1)	85.7 a (70.2 – 142.3)	25.5
Emamectin benzoate 5 % WDG	1080	3.3 (0.43)	13.1(4)	81.7 c (77.1 – 105.3)	201.1 b (154.6 – 339.1)	16.3
Mash-T 15 % EC	1080	5.8 (0.62)	13.7(4)	47.5 b (42.9 – 51.8)	78.5 a (69.3 – 96.2)	28
Mash-V 25 % EC	1080	3.7 (0.75)	55.9(4)	14.7 a (9.9 – 20.2)	32.7 a (22.9 – 92.6)	90.5

[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 4 df = 9.49
[d] Toxicity index (Sun, 1950)=(LC_{50} of the most efficient compound (as Standard) /LC_{50} of the other tested compound) *100

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مقارنة كفاءة مستحضرات حشرية حديثة ضد ناخرة أوراق الطماطم (رتبة حرشفية الأجنحة) في مصر

تامر عبدالله المشتولى[1] و نسرين أحمد صبرى هلال[2]

١ - قسم وقاية النبات – كلية الزراعة – جامعة عين شمس

٢ - قسم البساتين – كلية الزراعة – جامعة عين شمس

تعد حشرة ناخرة أوراق الطماطم (توتا أبسولوتا) إحدى أهم الآفات الإقتصادية لنباتات الطماطم في كثير من دول العالم ولاسيما في مصر نظراً لقدرتها الفائقة علي تطوير ميكانيكيات المقاومة تجاه العديد من المبيدات شائعة الإستخدام. وجدير بالذكر ان المبيدات القليلة التي اظهرت نتائج نسبية في خفض تعداد الحشرة تقدم للمزارع بأسعار باهظة لا يتحملها كثير من المزارعين رغم الإحتياج الشديد لها لحماية المحصول. تمت هذه الدراسة بهدف مقارنة كفاءة بعض المبيدات شائعة الإستخدام في مصرضد حشرة ناخرة أوراق الطماطم مثل الكلورانترانيليبرول، الإندوكساكارب و الإيمامكتين بنزوات بمستحضرين جديدين تم تصميمهما وتجهيزهما بالمعمل ماش-تي وماش-في ، كمستحضرات بديلة منخفضة التكلفة الإقتصادية. تم اختبار الخصائص الفيزيوكيميائية للمستحضرين الجديدين باتباع الطرق القياسية ومقارنة نتائجهما بالمواصفات القياسية الدولية لمنظمتي الأغذية والزراعة ومنظمة الصحة العالمية. تم التقييم الحيوي تحت ظروف معملية متحكم فيها من حيث الحرارة والرطوبة حيث استخدمت أوراق خس الرومين المشبعه بمحلول المبيد عن طريق الغمر. أوضحت النتائج أن كلا من مبيدي الكلورانترانيليبرول وماش-في كانا شديدا الفاعلية تجاه يرقات العمر الثاني والثالث لحشرة توتا أبسولوتا بناءً علي قيم التركيز النصفي المميت الذي سجل ١٣.٣، ١٤.٧ جزء في المليون علي الترتيب. بينما كلا من مبيدي الإندوكساكارب وماش-تي كانا متوسطا الفاعلية حيث سجلت قيمتي التركيز النصفي المميت لهما ٥٢.١ ، ٤٧.٥ جزء في المليون علي الترتيب. أظهرت النتائج أن مبيد الإيمامكتين بنزوات كان أقل المستحضرات المختبرة فاعلية تجاه اليرقات حيث كانت قيمة التركيز النصفي المميت ٨١.٧ جزء في المليون. أكدت التحليلات الإحصائية عند حدود الثقة ٩٥% ومستوي معنوية ٥% عدم وجود فرق معنوي بين كلا من مستحضري الكلورانترانيليبرول وماش-في. وكذلك عدم وجود فرق معنوي بين مستحضري الإندوكساكارب وماش-تي. في الوقت الذي وجد ان هناك فرق معنوي بين الإيمامكتين بنزوات وجميع المستحضرات المختبرة. تدعم النتائج امكانية استخدام اياً من المستحضرات شديدة الفاعلية كل على حده او بالتبادل لمكافحة يرقات التوتا ابسولوتا ولتأخير ظهور صفة المقاومة بينما تدعم استخدام المبيدات متوسطة الفاعلية ضمن برنامج الإدارة المتكاملة وعدم الإعتماد على اياً منها بمفرده لمكافحة ناخرة أوراق الطماطم. كما تؤكد النتائج علي ان المستحضر الجديد ماش-في يمكن الإعتماد عليه كبديل منخفض التكلفة لأعلي المبيدات كفاءة (الكلورانترانيليبرول) والذي لا يتوفر بسعر مناسب اقتصادياً للمزارع في مصر .