Comparative Trends of Imidacloprid, Lambda-Cyhalothrin, and Profenofos Dissipation in Tomatoes Fruits

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Abstract: An effective analytical method for the residue analysis of three insecticides imidacloprid, lambda-cyhalothrin, and profenofos and its dissipation in tomatoes were studied. The three insecticides (imidacloprid, lambda-cyhalothrin, and Profenofos) residues were extracted from tomato samples and the extract was cleaned up according to QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) method and determined by (HPLC–DAD) and (GC-ECD and FPD). At fortification levels of (0.05 0.01 ,and 0.001 mg/kg) in tomato, it was shown that recoveries ranged from 94 % to 96.3 %. The limit of detection (LOD) and limit of quantification (LOQ) of imidacloprid, lambda-cyhalothrin, and profenofos were found to be (0.01 and 0.03 mg/ kg), (0.005 and 0.015 mg/ kg) and (0.01 and 0.03 mg/ kg), respectively. The dissipation half-life time of imidacloprid, lambda-cyhalothrin, and profenofos residues in tomato were 5.22, 1.7 and 2.88 days, respectively. According to maximum residue limit (MRL) of three insecticides imidacloprid, lambda-cyhalothrin, and profenofos were 0.5, 0.1 and 10 mg /kg, respectively. The pre harvest interval (PHI) of imidacloprid, lambda-cyhalothrin, and profenofos on tomato were 2, 6 and 1 days, respectively. The correlations of dissipation of three insecticides were the most between lambda-cyhalothrin and profenofos, followed by imidacloprid and profenofos then the least between lambda-cyhalothrin and imidacloprid.

Keywords: Tomatoes, Imidacloprid, Lambda-Cyhalothrin, Profenofos, Residues, Dissipations.

1.Introduction

Tomato, ***Lycopersicon esculentum Mill*** is an important vegetable crop grown throughout the world. It is the first horticultural crop in Egypt. Tomatoes are grown both under plastic covered greenhouses and in open field. **(Barakat *et al.*, 2015).** To date, more reliable and available data on the level of pesticides residues in tomatoes are required. It is one of the most important vegetable crops in Egypt with average production 9,956.56 thousand tons and consumption 6,488.92 thousand tons in 2015(**Ibrahim *et al*., 2016).**

Pesticides are essential for agricultural and horticultural crops production. Pesticides are commonly classified as insecticide, fungicide, herbicide, rodenticide, etc. These pesticides act against insects, rodents, weeds which are harmful in agricultural or horticultural planting. Normally, farmers use the pesticides following the instruction written in the package. In most cases, the pesticides are mixed with water and sprayed over the plants. One of the most important environmental pollutants is pesticide residues on food and feed commodities. Detailed and accurate information on food contamination with pesticide residues are essential to decision-makers to enable them to take corrective actions to minimize health hazards, adverse impact of pesticide use and overcome the exportation problems. Basically, after spraying fruits or vegetables with pesticide, a period of 10 to 14 days is required to allow the chemical to degrade. However, the full degradation of pesticide is not always achieved. In recent years, some farmers ignored to use the pesticide correctly and rationally. In order to chase a better insecticidal effect and the economic interests, the phenomenon of using pesticide excessively, or selling the fruits or vegetables just after spraying the pesticide in few days are not difficult to see. Moreover, the pesticides overdosing also have the potential to contaminate the soil, air, and river.**(Yankun Peng*et al*., 2012).**

Now with increasing consumer concern over pesticide residues in food and the impact of crop protection practices on the environment, pesticide residues in agricultural crops should not cause a real health threat. Organochlorine pesticides were used extensively in Egypt since the early 1950s. However, their use was officially banned in 1980. These compounds are characterized by persistence, high absorbance on sediments and soil, so their residues may still occur in certain foods such as potatoes. Organophosphorus compounds that have low persistence and are readily decomposed were used extensively during these years for pest control throughout the country as well as synthetic pyrethroid compounds which were used in cotton crop only**.**

One of the most important environmental pollutants is pesticide residues on food and feed commodities. Detailed and accurate information on food contamination with pesticide residues are essential to decision-makers to enable them to take corrective actions to minimize health hazards, adverse impact of pesticide use and overcome the exportation problems. The monitoring program for pesticide residues should be conducted routinely to evaluate actual food contamination, such

data would help in assessing the risk of human exposure to pesticides and in following up the implementation of the Good Agricultural Practices recommended for agricultural fields**.** The dissipation of the pesticide residues in/on crops depends on environmental condition, type of application, plant species, dosage, and interval between application, the relation between the treated surface and its weight and living state of the plant surface, in addition to harvest time .The acceptable levels, the maximum residue limits (MRLs), are established to ensure that the total amount of pesticide residues absorbed through food consumption will not exceed the acceptable daily intake (quantity of a pesticide humans can ingest in one day without any harmful effects) for a pesticide ,whichever it may be. MRL s are based on the maximum amount of residues that could be on the crop at harvest after a pesticide was applied in accordance with the use instructions found on the product's label. These limits are included in the Food and Drug Regulations and must not be exceeded.**(Boitshepo *et al.*, 2011).** The pre harvest interval (PHI) is a function of a pesticide's use pattern and of the amount of pesticide residues allowed on the crop at harvest. Residue levels on a crop are affected by the crop's growth, by environmental conditions (such as rain or UV radiation) and by the microorganisms on the plants and in the soil. The PHI must therefore be long enough to allow for the pesticide residues in the harvested crop to degrade to a level that is acceptable. It is important to respect the PHI so that the MRL for a given crop is not exceeded. Residues found in excess of the MRL on food would constitute a violation of the Food and Drug Regulations and could also pose a risk to consumers' health. In such situations; the harvested crop could be seized, destroyed or forbidden for export. Use pesticides only for the crops and pests listed on the product's label and make sure to follow the application rates, number of applications and PHI stated on the label **(Anomynous, 2007)**.

2.Materials and Methods

2.1.Insecticides used:

.2.1.1Synthetic Pyrethroid Compound:

A Common name : -lambda-cyhalothrin

Trade Name : |Karate and (Kendo 5% EC)

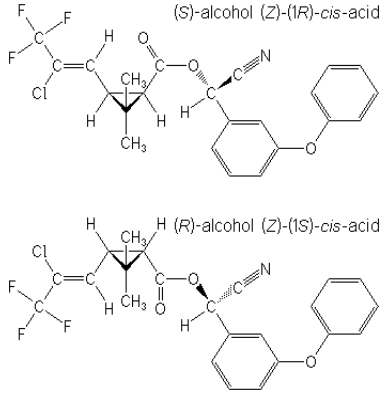

Fig. 1: Chemical structure of lambda-cyhalothrin.

2.1.2. Neonicotinoid compounds:

A Common name : -imidacloprid

Trade Name : Commando 35% SC

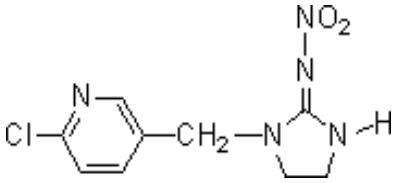

Fig. 2: Chemical structure of imidacloprid.

2.2.3.Organophosphorus compound:

Profenofos (Selecron 72% E C).

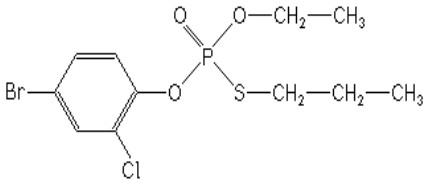

Fig. 3: Chemical structure of Profenofos.

2.2.Chemical and reagents:

All organic solvents were of HPLC grade and supplied by Merck, USA. Primary and secondary amine (PSA, 40 lm Bondesil) was purchased from Supelco (Supelco, Bellefonte, USA). Anhydrous magnesium sulphate was of analytical grade, purchased from Merck, USA, and was activated by heating at 250^{o}C for 4 h in the oven before use and kept in desiccators.

2.3.Test plant

Tomatoes seeds, Newcastle Varity were sown in seedling trays consisting of 120 small holes, filled with compost. After three weeks, the seedlings were transferred into greenhouse soil. This experiment was designed as plots area (6 x 7 m). Each tested insecticide has three replicates. Other three replicates were used as a control (treated with water). Plants were fertilized and all agriculture practices carried out. All plots were treated by tested insecticides three time and one week interval. A ten-litre knapsack sprayer was used in insecticides treatment.

2.4.Determination of tested insecticides residues in tomato

Fruit: After tomatoes fruit were emerged, all tested insecticides treated. Samples of tomatoes with similar ripening stage, size, and shape were located and tagged. Samples of tomatoes fruits were taken randomly during three applications after 1 h, 1, 3,5, 7,10,15and 21 days (Samples about 1 kg divided into three replicate) of each treatment.

A control sample was taken in each sampling time. Samples were transported to the laboratory immediately after collected (kept it in an ice box). Samples were kept in polyethylene pages in a deep freezer at -20°C till residue analysis.

2.5.Sample preparation to residue analysis:

2.5.1. Residue analysis.

Analysis of examined pesticides were carried out in the Central Agricultural Pesticides Laboratory, (CAPL), and Agricultural Research Center (ARC**).**

2.5.2. Sampling:

Representative samples from (2 kg) of tomatoes tomato fruits were taken at random after one hour, 1, 3, 5, 7, 10, 15 and 21days from treatment for pesticides residue analysis.

2.5.3. Sub-sampling:

Sub-samples were prepared where three representative samples of 15 g of treated tomato fruits were taken. Sub samples were kept in a clean Teflon tube and stored at -20˚c in a deep freezer until the time for residue analysis.

2.5.4.Extraction and clean-up processes:

The tomato fruits samples were prepared similarly to the original QuEChERS method**. Lehotay *et al*. (2010)**. The procedure involves the extraction of the sample (tomato fruits), which entailed the following steps: (i) homogenize around 500 g tomato sample (ii) weigh 15 g of thoroughly homogenized sample into a 50 mL Teflon centrifuge tube; (iii) add 15 mL acetonitrile (ACN); followed by a liquid–liquid partitioning step performed by adding (iv) 4 g anhydrous magnesium sulfate anhydrous ($MgSO_4$) plus 1 g sodium chloride (NaCl) (v) shake the sample vigorously for 1 min by hand; and (vi) centrifuge the tube at 3000 rcf (relative centrifugal force) for 5 min.

2.6.Clean-up process:

The primary secondary amine (SPE) cleanup was done for the three tested pesticides as follows: transfer 1 mL of extract (the upper layer) to a minicentrifuge tube containing 1.5 g anhydrous MgSO4+ 0.5 g PSA + 0.5 g graphitized carbon black (GCB); mix the extract with the sorbent/ desiccant for 20 sec. Centrifuge the tube at 3000 rcf for 5 min; and then filter through 0.45 µm filter. Then this extract was ready for analysis.

2.7.Method validation:

The validation of the proposed analytical method (HPLC-DAD and GC –ECD, FPD) was carried out according to the SANCO document 10684/2009. Linearity was evaluated by constructing matrix matched calibration curves in the range of 0.1-20 µg/L for HPLC-DAD. and GC – ECD ,FPD . Method sensitivity and recovery were determined by using samples spiked with the tested pesticides at three different levels (0.05, 0.01 and 0.001 mg/kg). Fortified samples were extracted as described earlier and the average recovery percentages for fortified samples were determined. Limits of detection (LOD) and quantification (LOQ) were evaluated as the pesticide concentration that produces a peak signal-to-noise ratio of 3:1 and 10:1, respectively .The previous procedures were presented in Table 1.Reference standards of all tested insecticides were of >98% purity and obtained from Central Agricultural Pesticides Laboratory (Egypt). Stock solutions of pesticides were prepared in acetonitrile and stored at 18°C. All HPLC grade organic solvents, methanol, and acetonitrile were purchased from Sigma (Sigma GmbH ,Germany). Primary secondary amine (PSA, 40 µm Bondesil) sorbent was purchased from Supelco (Supelco ,Bellefonte, USA). Sodium acetate and anhydrous magnesium sulfate were of analytical reagent grade and purchased from Merck Ltd. These were activated by heating at 150°C overnight and kept in desiccators.

2.8.Apparatus and chromatographic analysis:

Imidacloprid residue analysis was performed with Agilent technologies HP-1100 series high-performance liquid chromatographic system (Agilent Technologies,USA) equipped with a diode array detector and quaternary pump. The separation was performed on a C18 column (150×4.6 mm, 5 µm). The mobile phase, flow rate, and detection wavelength of each pesticide are mentioned in table 1. Data analysis was performed using Chemistation software.

The residues of lambda cyhalothrin in ethyl-acetate were estimated by GLC(Hewlett Packard 6890 series) gas chromatography system equipped with an Electron capture detector (ECD) and fitted with a capillary column: DB-17 (15 mxO.32 mm> 0.52 urn film thickness). Temperatures were 220, 320 and 3200 C for column, injector and detector, respectively. Gas flow rate of nitrogen was 4 mL/min. At these conditions, the retention time (RT) of lambda cyhalothrin was 7-10 min. Recoveries and limit of determination (LOD) were determined on samples at spiking levels 0.01–0.05 mg/ kg from the pesticide standard. The average recoveries ranged between 88% and 96%, and limit of determination was 0.005 mg/ kg. The results of analyses were corrected for recoveries. Blank samples were fortified with the pesticide and analyzed as a normal sample with each set of samples. The results were recorded on control charts.

GLC(Hewlett Packard 6890 series) gas chromatograph equipped with flame photometric detector operated in the phosphorus mode (525 nm filter) was used to determine profenofos insecticide residues under the following conditions: -

Column: Pyrex glass 1.5 m x 4 mm i.d., packed with 4 % SE-30 +6 % OV- 210 on gas chromosorb Q (80-100 mesh).Temperature (°C): injection 245, column 240 and detector 250. Gases flow rates (ml/min.): nitrogen 60, hydrogen 30 and air 30. Under the above-mentioned conditions the retention time of profenofos was 2.9 min.

LOD = Limit of Detection –**LOQ =** Limit of quantification.

2.9. Statistical analysis.

All obtained data were subjected to statistical and graphical analysis using **SigmaStat computer software (2016).** The half-lives ($t_{1/2}$) and tenth-lives ($t_{1/10}$) were calculated mathematically according to the following equations:

$t_{(1/2)}$ =Ln 2/k

$t_{(1/10)}$= Ln 10/k

$k_0 = (1/t_x).Ln\ a/bx.$

k_0: is the degradation rate constant at the intervals in an hour.

k: is the mean of k_0.

a: the residue level at the initial time (zero time).

bx: is the residue level at the successive intervals in an hour.

Table (1): HPLC & GC conditions and percent recovery from fortified tomato samples and the minimum detection limits (mg/ kg) for insecticides test.

Pesticide	Conditions	Flow rate (ml/min)	Detectors	Recovery %	LOD	LOQ	r^2
Imidacloprid	acetonitrile/ water = 40/60	0.8	DAD	96.3	0.01	0.03	0.996
Lambda cyhalothrin	Temperatures were 220, 320 and 320 ◦C for column, injector and detector,	nitrogen 4	ECD	96	0.005	0.015	0.998
profenofos	injection 245, column 240 and detector 250◦C	nitrogen 60, hydrogen 30 and air 30	FPD	94	0.01	0.03	0.995

2.10.Residue half-life estimation ($t_{1/2}$):

The rate of degradation (K) and half-life ($t_{1/2}$) values were obtained from the following equation of **(Gomaa and Belal,1975)**

Rate of degradation (K) =2.303 X slope

Half-life ($t_{1/2}$) =0.693/ (K)

3.Results and Discussion

The calibration curve of imidacloprid, lambda cyhalothrin and profenofos showed strong correlation between concentrations and area in the studied range (0 –100 ng/ mL) ($r^2 > 0.995$). The LODs and LOQs were sufficiently low; 0.05 µg / kg and 0.1 µg/ kg, respectively. These limits are, in all cases, below the maximum residue limits (MRLs) established by [EU] at 0.5, 0.1 and 10 mg/ for fruits, respectively. The limits of detection and quantification were found to be 0.01 ng /g and 0.03 ng/ g of tomato, respectively. The average recoveries ranged from 94- 96.3%.

Similar results was reported for insecticides, **Shiboob (2012)** reported that recovery percentage for imidacloprid were 114 and 102% in tomato and cucumber fruits, respectively. Also, **(Boitshepo *et al*. 2011)** found that the average rates of recovery for imidacloprid were 113.3, 88.0, 82.7 and 87.5% in cucumber, eggplant, lettuce and green pepper, respectively. Recovery percentages were used to correct data in residue studies for both insecticides.

3.1.The dissipation trends of imidacloprid:

The dissipation trends of imidacloprid in tomato fruit were shown in Table 2 imidacloprid dissipated rapidly after application. The concentration of imidacloprid 1 h after treatment was 0.61mg/kg. The residues amount decreased to 0.51mg/kg, in tomato fruit within the first 24 h after application .Following that period, imidacloprid residues in/on tomato fruit decreased to 0.45, 0.33, 0.19, 0.12 and 0.09 mg/kg, at 3, 5, 7,10 and 15 days after treatment, respectively. Samples taken 21 days after treatment contained no detectable amount of imidacloprid (below the quantification limit 0.003 mg/ kg) in tomato fruit. The dissipation rate of tomato fruit exhibited a first order kinetics. The half-life of imidacloprid calculated in tomato fruit treated at recommended dose was 5.22 days (Table 2). The dissipation of the pesticide residues in/on crops depends on environmental condition, type of application, plant species, dosage, and interval between application, the relation between the treated surface and its weight and living state of the plant surface, in addition to harvest time. European Union MRL for imidacloprid in tomato is 0.5 mg/kg. It can thus be concluded that the pre harvest interval (PHI) of imidacloprid on tomato was 2 days after the last treatment.

3.2.The dissipation trends of lambda-cyhalothrin :

The dissipation trends of lambda-cyhalothrin in tomato fruit were shown in Table 2. lambda-cyhalothrin dissipated rapidly after application. The concentration of lambda-cyhalothrin 1 h after treatment was 0.95mg/kg. The residues amount decreased to 0.69 mg/kg, in tomato fruit within the first 24 h after application. Following that period, lambda-cyhalothrin residues in/on tomato fruit decreased to 0.23 and 0.14 mg/kg, at 3and 5 days after treatment, respectively. Samples taken 7, 10, 15 and 21 days after treatment contained no detectable amount of lambda-cyhalothrin in tomato fruit. The dissipation rate of tomato fruit exhibited a first order kinetics. The half-life of lambda-cyhalothrin calculated in tomato fruit treated at recommended dose was 1.7 days (Table 2). The dissipation of the pesticide residues in/on crops depends on environmental condition, type of application, plant species, dosage, and interval between application, the relation between the treated surface and its weight and living state of the plant surface, in addition to harvest time. European Union MRL for lambda-cyhalothrin in tomato is 0.1 mg/kg. It can thus be concluded that the pre harvest interval (PHI) of lambda-cyhalothrin on tomato was 6 days after the last treatment.

3.3.The dissipation trends of profenofos:

The dissipation trends of profenofos in tomato fruit were shown in Table 2 profenofos dissipated rapidly after application. The concentration of profenofos 1 h after treatment was 11.56 mg/kg. The residues amount decreased to 9.68 mg/kg, in tomato fruit within the first 24 h after application. Following that period,

Table (2): Dissipation of imidacloprid, lambda-cyhalothrin and profenofos residues in/on tomato fruit.

Time (days)	Imidacloprid		Lambda-Cyhalothrin		Profenofos	
	Residue level (mean) mg/kg	% Dissipation**	Residue level (mean) mg/kg	% Dissipation	Residue level (mean) mg/kg	% Dissipation
0*	0.61	0	0.95	0	11.56	0
1	0.51	16.39	0.69	27.36	9.68	16.26
3	0.45	26.22	0.23	75.78	5.4	53.28
5	0.33	45.90	0.14	85.26	3.57	69.11
7	0.19	68.85	N.D	N.D	1.3	88.75
10	0.12	80.32	N.D	N.D	0.6	91.71
15	0.09	98.58	N.D	N.D	0.03	99.74
21	N.D	N.D	N.D	N.D	N.D	N.D
MRL	0.5***		0.1****		10*****	
$T_{0.5}$	5.22		1.7		2.88	
PHI (days)	2		6		1	

*Zero time after one hour of the first treatment; hour of the third treatment;

**Dissipation rate = Initial residue - residue level x100 / initial residue

***Reg. (EC) No 149/2008

****http://ec.europa.eu/sanco_pesticides/public/index.cfm?event=pesticide.residue.Current MRL and language = EN

*****http://www.codexalimentarius.net/pestres/data/pesticides/details.html;jsessionid=E9B7C9BC9B1E553C67F41C10E67236D9?d-16497-o=2&id=206&d-16497-s=3

profenofos residues in/on tomato fruit decreased to 5.4 and 3.57 mg/kg, at 3and 5 days after treatment, respectively. Following that period, profenofos residues in/on tomato fruit decreased to 5.4, 3.57 ,1.3, 0.6 and 0.03 mg/kg, at 3, 5, 7,10 and 15 days after treatment, Samples taken 21 days after treatment contained no detectable amount of in tomato fruit. The dissipation rate of tomato fruit exhibited a first order kinetics. The half-life of profenofos calculated in tomato fruit treated at recommended dose was 2.88 days (Table 2). The dissipation of the pesticide residues in/on crops depends on environmental condition, type of application, plant species, dosage, and interval between application, the relation between the treated surface and its weight and living state of the plant surface, in addition to harvest time. European Union MRL for profenofos in tomato is 0.1 mg/kg. It can thus be concluded that the pre harvest interval (PHI) of profenofos on tomato was 1 days after the last treatment.

These results agree with (**Youn*et al*., 2009**). The data revealed that there is a rapid loss of this pesticide from the first few hours/days after application to the end of the periodic interval, because the pesticide residues are rapidly lost from plant surfaces by volatilization or some other process **(Elkines, 1989).**Many researchers have calculated the half-lives of imidacloprid in different fruits (**Gupta *et al*., 2008**). These studies indicated that residues of imidacloprid on different fruits were rapidly lost in 2 and 4.3 days after application at the recommended and used dosage. Also, (**Sanyal *et al*., 2006**) reported the half-lives of imidacloprid in CTC tea in the range of 0.91–1.16 days. **(Abdellseid and Abdel.Rahman2014)** reported the half-life time of abamectin residues in tomato was 2.4 days.and (PHI) of abamectin on tomato was 8 days after the treatment. (**Nassar *et al*. 2015**). They determine residue amounts of imidacloprid in tomato fruits after different time intervals of application and to evaluate their detrimental effects on white albino rats. Results revealed that the initial deposit (residue amount after 1 h of last spray application) was 0.316 mg kg-1 and decreased to 0.32, 0.23, 0.21, 0.14, 0.12 and 0.11 mg kg-1 after 3, 5, 7, 10, 14 and 21 days of last spray, respectively and the half-life time was 10.16 days. (**Al-kazafy *et al*. 2016**), They showed that imidacloprid has a minimum preharvest interval (PHI) followed by spirotetramat and etofenprox. The Pre- Harvest Interval (PHI) was 3.8, 5.8 and 6.8 days, respectively.

3.4. Correlation between the Residue Levels:

Correlations between the Residue Levels of imidacloprid, lambda-cyhalothrin and profenofos residues in/on tomato fruit were demonstrated at Table 3. The correlations were the most between lambda-cyhalothrin and

Table (3): Pearson Correlations between Residue Levels of imidacloprid, lambda-cyhalothrin and profenofos residues in/on tomato fruit

Pesticide		Imidacloprid	Lambda-Cyhalothrin	Profenofos
Imidacloprid	**Correlation Coefficient**	1	0.886	0.959
	P Value	-	0.00339	0.000165
	Number of Samples	8	8	8
Lambda-Cyhalothrin	**Correlation Coefficient**	0.886	1	0.977
	P Value	0.00339	-	0.0000309
	Number of Samples	8	8	8
Profenofos	**Correlation Coefficient**	0.959	0.977	1
	P Value	0.000165	0.0000309	-
	Number of Samples	8	8	8

Profenofos (0.977), followed by imidacloprid and profenofos (0.959), then the least between lambda-cyhalothrin and imidacloprid (0.886).

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الاتجاهات النسبية لإنهيار كل من مبيدات الايميداكلوبريد واللمبدا-سيهالوثرين والبروفينوفوس في ثمارالطماطم

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2- المعمل المركزى للمبيدات ، مركز البحوث الزراعية ، الدقى ، الجيزة.

الملخص العربى

استهدفت الدراسة دراسة متبقيات مبيدات ايميداكلوبريد و لمبادا سيهالوثرين و بروفينوفوس و تبديدها علي الطماطم تحت ظروف حقلية، و تم استخلاص متبقيات المبيدات الثلاثة من عينات الطماطم وتم النتقية وفقاً لطريقة كيتشروهى طريقة سريعة ، سهلة ، رخيصة ، فعالة وآمنة وتم تقديرها بواسطة (الكروماتوجرافيا السائلة مع كاشف مجموعة الصمام الثنائى و الكروماتوجرافيا الغازية مع كاشف إلتقاط الألكترون و كاشف اللهب و عند مستويات التقوية (0.05 ، 0.01 ، 0.001 مليجرام/كيلوجرم) في الطماطم ، تبين أن نسب الإسترجاع تراوحت بين 94٪ إلى 96.3٪. تم العثور على حد الكشف وحد التحديد الكمي لكل من ايميداكلوبريد و لمبادا سيهالوثرين و بروفينوفوس بالقيم التالية: 0.01 و 0.03 مجم / كجم 0.005 و 0.015 مجم / كجم و0.01 و 0.03 مجم / كجم ، على التوالي . كانت فترة نصف العمر لتبديد ، وبقايا للايميداكلوبريد و لمبادا سيهالوثرين و بروفينوفوس في الطماطم 5.22 و 1.7 و 2.88 يوم ، على التوالي. ووفقاً للحد الأقصى لحدود البقايا كانت 0.5 و 0.1 و 10 مجم / كجم على التوالي. كانت فترة ما قبل الحصاد للايميداكلوبريد و لمبادا سيهالوثرين و بروفينوفوس على الطماطم 2 و 6 و 1 يوم ، على التوالي. كانت الارتباطات بين إنهيارالثلاث مبيدات هي الأكثر بين لمبادا سيهالوثرين و بروفينوفوس ، تليها ايميداكلوبريد و بروفينوفوس ثم الأقل بين لمبادا سيهالوثرين و ايميداكلوبريد.