

# **Analysis of Multipesticide Residues** in Tobacco

The Agilent Triple Quadrupole GC/MS/MS Analyzer for Pesticides in Tobacco

# **Application Note**

Food Testing & Agriculture

# Abstract

A multiple reaction monitoring (MRM) method was developed and evaluated on an Agilent 7000C Triple Quadrupole GC/MS for the analysis of 162 multiclass pesticides in tobacco. This system was equipped with a Multimode Inlet, and injections of 1 µL were made in the splitless mode. The midcolumn backflushing technique was applied for time-effective elimination of less volatile matrix components from the GC column. This reduced the cycle time and prevented contamination of the MS ion source. A modified QuEChERS sample preparation technique was used. Numerous tobacco samples were analyzed for method validation. Key performance parameters investigated were linearity, recovery, %RSD, limit of detection (LOD), and limit of quantitation (LOQ).

Assuming the water content in all tobacco samples was zero, this study showed excellent recoveries (70 to 120%) for 95% of all test pesticides at 0.05 and 0.5 mg/kg (pesticide:tobacco, w:w), and LOQs of 0.01 mg/kg or lower for most pesticides. We obtained excellent linearity from 0.01 to 2 mg/kg (pesticide:tobacco, w:w), and repeatability over seven injections at concentration levels near LOQ, and at 0.1 mg/kg in a tobacco matrix.



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## Introduction

Tobacco, one of the world's leading high-value crops, is prone to pest attack, so farmers apply various pesticides as control measures. Pesticide residues on tobacco during cultivation can remain in the leaves at harvest and even survive postharvest processing treatments, eventually appearing in the final products. Concerns regarding threats to human health from the use of pesticides have prompted the tobacco industry worldwide to put more emphasis on the risks of pesticide residues in tobacco. To protect consumers and control pesticide residue levels, Guidance Residue Levels (GRLs) for 118 pesticides have been issued [1].

Multipesticide residue analysis in tobacco is a challenge in both sample preparation and analytical detection. Tandem mass spectrometry (MS/MS) on a triple quadrupole platform is very useful for screening, confirming, and quantitating trace-level target compounds in these complex matrices because it can minimize interferences. GC/MS/MS techniques provide much better sensitivity and, thus, significantly lower system detection limits. For target pesticide analysis in tobacco matrices, the Agilent 7000C Triple Quadrupole GC/MS/MS Analyzer for Pesticides in Tobacco comes with a turnkey method for 162 pesticides. It also includes an Agilent Pesticides and Environmental Pollutants MRM database (p/n G9250AA) of over 1,000 compounds, which makes the analytical task easy and productive.

The QuEChERS sample preparation technique [2,3,4] has been rapidly accepted worldwide for multipesticide residue analysis due to its attractive features, referred to as Quick, Easy, Cheap, Effective, Rugged, and Safe. QuEChERS extracts can be analyzed by GC combined with MS to determine a wide range of pesticide residues. Agilent Bond Elut QuEChERS Extraction Kits have demonstrated excellent recoveries for frequently used pesticides in different matrices [5]. However, tobacco extracts processed by QuEChERS are still very complex, containing various matrix residues such as high-boiling indigenous compounds.

QuEChERS extracts used in GC/MS/MS analysis can cause contamination and deterioration of the GC analytical column and MS ion source. This results in poor data quality due to poor peak shape, retention time shifting, and loss of responses for active analytes. These extracts also lead to shorter lifetime of GC analytical columns and frequent MS maintenance. To achieve low quantitation limits for pesticide analysis, it is necessary to use the best techniques and supplies to achieve reliable results, and to protect the analytical column and MS ion source. Backflushing the GC column ensures that high-boiling compounds in the matrix do not pass through it, reducing column bleed, eliminating ghost peaks, and minimizing contamination of the mass spectrometer. Therefore, column backflushing can be beneficial for the analysis of tobacco extracts because it significantly reduces analysis time, and reduces both column head trimming and the frequency of MS ion source cleaning. Agilent capillary flow technology (CFT) makes column backflushing routine [6].

The Agilent Ultra Inert deactivation process significantly improves the inertness and robustness of wool liners. The wool surface is deactivated thoroughly. Ultra Inert splitless liners with wool have demonstrated excellent inertness in quantitative analysis of active and difficult pesticides in many matrices. Ultra Inert liners with wool also protect the sample flow path better, resulting in extended column lifetime and less frequent MS source maintenance [7].

This application note describes a study using midcolumn backflushing and the 7000C Triple Quadrupole GC/MS to measure 162 pesticide residues in tobacco. The pesticides were selected because of their presence in the CORESTA GRL list [1], and in the list of pesticides banned or recommended for tobacco cultivation in China.

# **Experimental**

Tobacco matrix blanks, extracted using the QuEChERS method, were spiked with pesticide working solutions. The matrix-matched working calibration standards were then analyzed by GC/MS/MS using multiple reaction monitoring (MRM). A calibration curve from 0.01 to 2 mg/kg was used to evaluate linearity. Pesticide-free tobacco samples spiked with known concentrations of pesticide solutions were extracted by QuEChERS for recovery, repeatability, limit of detection (LOD), and limit of quantitation (LOQ) studies. In all studies, the unit of mg/kg was based on pesticide:tobacco (w:w), assuming the water content in the tobacco samples was zero.

#### **Chemicals and reagents**

All reagents and solvents were HPLC or analytical grade. Acetonitrile (ACN) was from J&K Scientific (Beijing, China). Toluene was from ANPEL Scientific Instrument (Shanghai, China). Water was from J. T. Baker. A set of pesticide stock solutions in acetonitrile (100  $\mu$ g/mL) and the internal standard stock solution in acetonitrile (triphenyl phosphate, TPP), 1,000  $\mu$ g/mL) were purchased from Ultra Scientific (North Kingstown, RI, USA).

#### **Reagent solution preparation**

The pesticide composite intermediate solution (2  $\mu$ g/mL) was prepared by mixing and diluting the pesticide stock solutions with acetonitrile:toluene (2:1, v:v). The Internal Standard (ISTD) intermediate solution (20  $\mu$ g/mL) was prepared by diluting the internal standard stock solution with acetonitrile:toluene (2:1, v/v).

Pesticide working solutions were used for preparation of matrix-matched standards. The working solutions contained ISTD at a constant concentration and pesticide analytes at appropriate concentration levels. Pesticide composite intermediate solution (2  $\mu$ g/mL), ISTD intermediate solution (20  $\mu$ g/mL), and acetonitrile:toluene (2:1, v:v) were used to prepare the working solutions.

Matrix-matched working calibration standards were derived from blank tobacco extracts as described in the sample preparation procedure. Appropriate pesticide working solutions were added to achieve matrix-matched working calibration standards from 0.01 to 2 mg/kg (pesticide:tobacco, w:w), assuming the water content in blank tobacco samples was zero.

#### **Sample preparation**

Preparation of tobacco extracts was based on the modified EN version of the QuEChERS method. Two grams of tobacco were extracted with 10 mL acetonitrile, diluted with 5 mL toluene, extracted with an Agilent Bond Elut QuEChERS Extraction Kit (p/n 5982-5650), and cleaned up using an Agilent Bond Elut QuEChERS Dispersive Kit (p/n 5982-5022). ISTD was added to the sample before extraction to control the entire analytical process. The QuEChERS procedure is shown below.

Blank tobacco extracts were prepared in the same way as the sample treatment procedure, except there was no addition of the ISTD solution, and 1 mL final supernatant was blown to near dryness under a nitrogen stream.



#### Instrumentation

This study was performed on an Agilent 7890A GC coupled to an Agilent 7000C Triple Quadrupole GC/MS with an electron ionization (EI) source. The GC system was equipped with an Electronic Pneumatics Control (EPC), a Multimode Inlet (MMI), an Agilent 7693A Automatic Liquid Sampler, and a backflushing system based on a Purged Ultimate Union controlled by an AUX EPC module. Two Agilent J&W DB-5ms Ultra Inert GC 15 m columns were used to provide analyte separation and a highly inert flow path into the detector. Agilent MassHunter Software was used for instrument control and for qualitative and quantitative data analysis. Retention time locking eliminated the need to adjust time segment windows of MRM groups [8]. The run time was 40.5 minutes with an extra 5 minutes for backflushing.

The Agilent MRM Database was used to help build the MS acquisition method for the target analytes by selecting the MRM transitions with minimum matrix interferences and maximum responses. For each pesticide, two MRM transitions were selected for quantitation and qualification, and the collision energy was optimized. However, different transitions might be used for quantitation in different tobacco matrices to minimize matrix effects. Therefore, it is critical to review the data in matrix before setting up a quantitation method.

Table 1 lists the instrument parameters used in this study. Table 2 shows the consumable supplies, and Table 3 the pesticides in alphabetical order with their quant and qual transitions, and the collision energies for each. Table 1. Instrumentation and analytical conditions.

Column 1	Agilent J&W DB-5ms UI, 15 m × 0.25 mm, 0.25 μm (p/n 122-5512UI), configured from MMI to AUX EPC
Column 2	Agilent J&W DB-5ms UI, 15 m $\times$ 0.25 mm, 0.25 $\mu$ m (p/n 122-5512UI), configured from AUX EPC to vacuum
Carrier gas	Helium
Injection mode	Splitless
Injection volume	1 μL
Solvent washes	Pre-injection         2 × solvent A, acetonitrile, max volume         2 × solvent B, toluene, max volume         Post-injection         5 × solvent A, acetonitrile, max volume         5 × solvent B, toluene, max volume
Sample wash	1 × 3 μL
Sample pumps	3
Injection speed	Fast
MMI temperature program	70 °C for 0 min, then 240 °C/min to 280 °C until the end of the analysis
Purge flow to split vent	50 mL/min at 1.25 min
Gas saver	On 20 mL/min after 10 min
Septum purge flow	3 mL/min
Oven temperature program	60 °C for 1 min, then 40 °C/min to 120 °C, then 5 °C/min to 310 °C
Column 1 flow	1 mL/min
Column 2 flow	1.2 mL/min
Retention time locking	Chlorpyrifos-methyl locked at 18.700 min
Run time	40.5 min
Post run	5 min at 310 °C, AUX EPC pressure 50 psi, inlet pressure 2 psi
MS conditions	
MS source	EI, –70 eV
Source temperature	300 °C
Quadrupole temperature	180 °C
Transfer line temperature	280 °C
Solvent delay	3.75 min
Helium quench gas	2.25 mL/min
Nitrogen collision gas	1.5 mL/min
Acquisition mode	Multiple reaction monitoring
MS1/MS2 resolution	Wide
Time segments	Refer to Table 3

Table 2. Consumable supplies.

Acquisition parameters

Vials	Amber, write-on spot, 100/pk (p/n 5182-0716)
Vial caps	Blue, screw cap, 100/pk (p/n 5182-0717)
Vial inserts	150 µL glass with polymer feet, 100/pk (p/n 5183-2088)
Septa	Advanced green, 50/pk (p/n 5183-4759)
Inlet liners	4 mm id liner, UI, splitless, single taper, glass wool (p/n 5190-2293)
Agilent Bond Elut QuEChERS Extraction Kits EN	p/n 5982-5650
Agilent Bond Elut QuEChERS Dispersive Kits	p/n 5982-5022

Refer to Table 3

CompoundFrancisionCETrancisionCETrancisionCETrancisionCEAlpdraycachofuran18.013.01517.017.010.015.017.010.015.017.010.015.017.010.015.017.010.015.017.010.015.017.010.015.017.010.015.017.010.015.017.010.010.017.010.017.010.010.017.010.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.010.017.0		Quantifier		Qualifier			Quantifier		Qualifier	
3 Hyderogradofuran         180.0 + 1370         15         137.0 + 107.0         15         Diamon         304.0 + 176.0         15         17.1 + 84.0         16         187.1 + 84.0         16         187.1 + 84.0         16         187.1 + 84.0         16         187.1 + 84.0         10         185.0 + 100.0         15         17.1 + 84.0         10         185.0 + 100.0         15         126.0 + 718.0         10         285.0 + 118.0         10         285.0 + 118.0         10         285.0 + 118.0         10         285.0 + 118.0         10         285.0 + 118.0         10         285.0 + 118.0         10         285.0 + 110.0         10           Alchin         223.0 + 118.1         10         214.0 + 108.0         35         215.0 + 110.0         30         Dithenconzoic         222.4 - 214.8         10         245.0 + 110.0         30           Alchin         220.0 + 177.1         20         100 - 77.0         20         Dimethonerph (z)         301.0 + 138.0         15         30.0 + 165.0         10           Accaystochin         243.0 - 142.0         10         100.0 - 77.0         20         Diseutoron         88.0 + 45.0         15         32.0 + 85.0         10           Accaystochin         243.0 - 248.0         10         100.0 + 77.0	Compound	Transition	CE	Transition	CE	Compound	Transition	CE	Transition	CE
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Actampini         152.0 - 116.1         15         126.0 - 120.1         15         126.0 - 120.1         15         Dickarna         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.1 - 120.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8         160.0 - 170.8	Acephate	136.0 → 42.0	5	142.0 → 96.0	5	Dichlorvos	184.9 → 93.0	10	185.0 → 109.0	15
Acheronory         156. 9         63. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182. 9         182.	Acetamiprid	152.0 → 116.1	15	126.0 → 73.0	25	Dicloran	160.1 → 124.1	10	206.1 → 176.0	10
Alachion         227.0 - 100.1         5         268.0 - 168.0         5         Difanconazola         322.8 - 228.0         15         263.0 - 125.0         15         263.0 - 125.0         15         263.0 - 125.0         15         263.0 - 110.0         10           Aldrin         228.3 - 128.0         30         195.0 - 160.0         10         Dimetox         110.0 - 47.0         5         133.0 - 110.0         10           Atrazine         214.3 - 56.1         10         214.9 - 56.1         10         Dimetox         110.0 - 47.0         5         243.0 - 110.0         10           Azinphosemethy         160.0 - 77.1         20         132.0 - 51.0         30         Dimetonomph (2)         301.0 - 138.0         15         300.9 - 165.0         10           Azonyotsobin         344.1 - 171.0         40         243.1 - 245.0         10         Disultoton sulfoxin         167.1 - 151.0         10         125.9 - 97.0         10         125.9 - 97.0         10         125.9 - 97.0         10         125.9 - 97.0         10         125.9 - 97.0         10         170.1 - 151.0         100         Disulfoton sulfoxin         127.0 - 97.0         10         170.1 - 151.0         100         140.0 - 77.1         15         170.9 - 97.0         10         170.9	Acibenzolar-S-methyl	135.0 → 63.1	20	182.0 → 181.1	5	Dieldrin	262.9 → 193.0	35	262.9 → 191.0	35
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Aradan214 9 + 68.110214 9 - 70.25Dimechone17.0 + 70.5524.0 + 67.010Azinphos-entryi16.0 + 77.120160.0 + 77.020Dimethonarpi (E)31.0 - 139.01530.0 - 16.010Azonystorin344.1 + 717.940344.1 - 82.015Dimethonarpi (E)31.0 - 139.01530.0 - 16.017.1Azonystorin26.0 - 72.00523.2 - 94.60523.2 - 94.601017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 165.12017.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.11517.1 - 17.115	alpha-Endosulfan	262.8 → 192.9	30	195.0 → 160.0	10	Dimefox	110.0 → 47.0	35	153.0 → 110.0	10
Azinphos-ethyl         160.0 - 77.1         20         132.0 - 75.0         20         Dimethoate         86.9 - 46.0         15         92.9 - 63.0         10           Azinphos-ethyl         160.0 - 77.1         20         132.0 - 51.0         30         Dimethoaroph (E)         301.0 - 138.0         15         300.9 - 116.0         10           Azonystrobin         244.0 - 77.1         20         234.0 - 52.0         15         Dimethoaroph (E)         301.0 - 138.0         15         107.1 - 152.1         15           Benfluxalin         240.0 - 206.0         2         226.0 - 172.0         15         Disulfoton sulfone         213.0 - 96.0         20         212.0 - 97.0         10           Benfuracarb         190.0 - 102.0         15         190.0 - 170.0         15         Disulfoton sulfone         210.0 - 96.0         20         212.0 - 97.0         15         152.9 - 97.0         15         152.9 - 97.0         15         150.9 - 97.0         15         152.9 - 97.0         15         152.9 - 97.0         15         150.9 - 97.0         15         150.9 - 97.0         15         150.9 - 97.0         15         150.9 - 97.0         15         157.9 - 97.0         15         157.9 - 97.0         15         157.9 - 97.0         15         157.9 - 97.0	Atrazine	214.9 → 58.1	10	214.9 → 200.2	5	Dimetachlone	187.0 → 152.0	5	243.0 → 187.0	10
Azinphos-methyl         1600 - 77.1         20         32.0 + 51.0         30         Dimethomorph (E)         30.1 - 138.0         15         300.9 - 165.0         10           Azoxystobin         260.0 + 148.1         5         233.0 + 146.0         20         Dimethomorph (Z)         30.1 - 138.0         15         300.9 - 165.0         10           Benflarval         292.0 - 254.0         5         232.0 - 206.0         10         Disulfoton         86.0 + 00.0         5         142.0 - 81.0         10           Benflarval         210.0 - 206.0         25         206.9 - 174.0         15         Disulfoton sulfoxide         97.0 - 65.0         27.2 - 9.7.0         15         152.9 - 9.7.0         15           Brienthrin         181.2 - 1165.2         170.1 - 115.0         170.1 - 115.0         15         Erhor         29.8 - 193.0         5         141.0 - 77.1         15           Bromacil         205.0 - 188.0         15         27.0 - 190.0         15         Erhor         29.9 - 92.3.0         15         141.0 - 77.1         15           Bromacil         205.0 - 188.0         15         27.0 - 190.0         15         Famo:sdone         29.2 - 22.0         10         29.1 - 14.0         10           Cathardon         18.8 - 70.0	Azinphos-ethyl	160.0 → 77.1	20	160.0 → 77.0	20	Dimethoate	86.9 → 46.0	15	92.9 → 63.0	10
Azaxystrobin         344.1 - 171.9         40         344.1 - 329.0         15         Dimethomorph (Z)         301.0 - 139.0         15         300.9 - 165.0         10           Benalkav/1         266.0 - 146.1         5         23.9 - 146.0         20         Diphenamid         167.1 - 165.1         20         17.1 - 152.1         15           Benfurcareh         191.0 - 206.0         10         190.0 - 74.0         20         Disulfoton sulfone         21.3 - 94.0         15         12.2 - 97.0         15         27.3 - 23.8 - 23.8         15           Brientanin         181.2 - 165.2         25         181.2 - 165.2         10         Endosuffan sulprize         271.9 - 237.0         15         27.3 - 23.8 - 23.8         15           Bromacil         205.0 - 188.0         15         27.0 - 150.0         15         161.0 - 77.1         15         157.9 - 110.0         15         161.0 - 77.1         15         157.9 - 110.0         10         30.0 - 22.40         15         23.0 - 22.40         10         23.0 - 22.40         15         Edmary 0         15         Famoyabos (Breamiphos 30.150.0         15         30.0 - 22.40         15         23.0 - 22.40         15         23.0 - 22.40         10         23.0 - 22.40         15         23.0 - 22.40         10 <td>Azinphos-methyl</td> <td>160.0 → 77.1</td> <td>20</td> <td>132.0 → 51.0</td> <td>30</td> <td>Dimethomorph (E)</td> <td>301.0 → 139.0</td> <td>15</td> <td>300.9 → 165.0</td> <td>10</td>	Azinphos-methyl	160.0 → 77.1	20	132.0 → 51.0	30	Dimethomorph (E)	301.0 → 139.0	15	300.9 → 165.0	10
Benalaxyl266.0 + 148.15233.9 + 146.020Diphenamia167.1 + 165.120167.1 + 162.115Benfuracarh190.0 - 740.0190.0 - 740.0190.0 - 740.0190.0 - 740.0213.0 - 96.515142.0 + 310.010beta-Endosulfan241.0 - 206.025266.9 + 172.015Disulfons sulfoxide97.0 + 65.020212.0 + 97.030beta-Endosulfan170.1 + 141.1207.0 + 162.2170.1 + 161.540Endosulfan-sulptate271.9 + 237.015273.8 + 238.915Bromachi205.0 + 188.015270.0 - 190.015EPN170.0 + 110.015141.0 + 77.115Bromachi266.0 + 220.210266.0 + 174.220Ethoirn230.9 + 120.0213.0 + 175.010Burtalin266.0 + 220.210266.0 + 174.220Ethoirn230.9 + 120.015157.9 + 91.015Caduafos158.8 + 97.015150.0 + 77.05Fenanaiphos (phenamiphos)303.0 + 154.015303.0 + 180.020Captal116.9 + 82.030149.0 + 70.015Fenaniphos sulfone319.8 - 220.010291.8 + 214.010Carbaryl144.0 + 116.11016.0 + 10.025277.0 + 109.015277.0 + 109.015Carbaryl116.9 + 220.020277.9 + 261.15277.0 + 109.015277.0 + 109.015Carbaryl124.0 + 40.01516.0 + 02.0277.0 + 26.0 <t< td=""><td>Azoxystrobin</td><td>344.1 → 171.9</td><td>40</td><td>344.1 → 329.0</td><td>15</td><td>Dimethomorph (Z)</td><td>301.0 → 139.0</td><td>15</td><td>300.9 → 165.0</td><td>10</td></t<>	Azoxystrobin	344.1 → 171.9	40	344.1 → 329.0	15	Dimethomorph (Z)	301.0 → 139.0	15	300.9 → 165.0	10
Benfurslin $292.0 \rightarrow 264.0$ 5 $292.0 \rightarrow 206.0$ 10Disulfoton $80.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 81.0$ 10Benfurscarb $100.0 \rightarrow 102.0$ 10 $100.0 \rightarrow 74.0$ 20Disulfoton sulfone $81.0 \rightarrow 69.0$ 5 $122.0 \rightarrow 97.0$ 10Benfurscarb $211.0 \rightarrow 206.0$ 25 $220.6 \Rightarrow 17.2$ 15Disulfoton sulfone $271.0 \rightarrow 97.0$ 15 $273.8 \rightarrow 238.9$ 15Bifertanol $170.1 \rightarrow 114.1$ 20 $170.1 \rightarrow 115.0$ 40Endrin $282.8 \rightarrow 133.0$ 35 $263.0 \rightarrow 223.0$ 15 $273.8 \rightarrow 238.9$ 15Bromacil $266.0 \rightarrow 220.2$ 10 $266.0 \rightarrow 174.2$ 20Ethor $230.9 \rightarrow 120.0$ 20 $231.0 \rightarrow 175.0$ 10Burtalin $266.0 \rightarrow 220.2$ 10 $266.0 \rightarrow 174.2$ 20Ethorpohos $157.9 \rightarrow 97.0$ 15 $330.0 \rightarrow 224.0$ 5Cadusafos $158.8 \rightarrow 97.0$ $15$ $157.9 \rightarrow 96.9$ 15Fenamiphos $303.0 \rightarrow 154.0$ 15 $303.0 \rightarrow 224.0$ 10Catharl $116.9 \rightarrow 28.0$ $30$ $149.0 \rightarrow 70.0$ 15Fenamiphos sulfoxid $304.0 \rightarrow 160.0$ 5 $303.0 \rightarrow 224.0$ 10Catharl $116.9 \rightarrow 28.0$ $30$ $149.0 \rightarrow 70.0$ 15Fenamiphos sulfoxid $304.0 \rightarrow 160.0$ 15 $286.9 \rightarrow 272.0$ 15Catharl $221.0 \rightarrow 115.0$ $140.0 \rightarrow 116.1$ 10Fenamiphos sulfoxid $304.0 \rightarrow 160.0$ 15 $286.9 \rightarrow 272.0$ 15Catharl $221.0 \rightarrow 246.0$ $25$ $78.0 \rightarrow 245.0$ $25$ $77.0 \rightarrow 1080.0$ 15 $277$	Benalaxvl	266.0 → 148.1	5	233.9 → 146.0	20	Diphenamid	167.1 → 165.1	20	167.1 → 152.1	15
Benfuracarb190. $0 \rightarrow 102.0$ 10190. $0 \rightarrow 74.0$ 20Disulfaton sulfore213. $0 \rightarrow 96.9$ 15152. $9 \rightarrow 97.0$ 10beta-fuctosulfan241.0 $2 + 165.2$ 2520.8 $> 172.0$ 15Disulfaton sulforide $271.9 \rightarrow 23.0$ 15 $212.0 \rightarrow 97.0$ 30Bitertanol170.1 $\rightarrow 141.1$ 20170.1 $\rightarrow 115.0$ 40Endrin262.8 $\rightarrow 133.0$ 35263.0 $\rightarrow 228.0$ 20Bromophos30.8 $\rightarrow 158.0$ 15270.0 $\rightarrow 100.0$ 15EPN270.9 $\rightarrow 25.0$ 20210.0 $\rightarrow 77.0$ 10Burtanin266.0 $\rightarrow 220.2$ 10266.0 $\rightarrow 174.2$ 20Ethoprophos157.9 $\rightarrow 97.0$ 15157.9 $\rightarrow 91.40$ 5Cadusatos158.8 $\rightarrow 97.0$ 15150.0 $\rightarrow 77.0$ 15Framsudone393.0 $\rightarrow 128.00$ 200201.0 $\rightarrow 175.0$ 10Captalol310.8 $\rightarrow 78.0$ 15150.0 $\rightarrow 77.0$ 15Framsuhos sulfone318.8 $\rightarrow 292.0$ 10291.8 $\rightarrow 214.0$ 10Carbary144.0 $\rightarrow 116.1$ 10160.0 $\rightarrow 62.0$ 20Fenntiphos-sulfoxide304.0 $\rightarrow 156.0$ 5304.0 $\rightarrow 120.0$ 15Carbouran118.0 $\rightarrow 76.0$ 5160.0 $\rightarrow 62.0$ 20Fenchlorphos (Ronnel)286.0 $\rightarrow 220.0$ 15277.0 $\rightarrow 109.0$ 15Chordmer (rars.)271.7 $\rightarrow 236.0$ 15278.0 $\rightarrow 109.0$ 15278.0 $\rightarrow 109.0$ 15278.0 $\rightarrow 109.0$ 15Chordmer (rars.)271.7 $\rightarrow 236.9$ 10278.0 $\rightarrow 109.0$ 15278.0 $\rightarrow 109.0$ 15<	Benfluralin	292.0 → 264.0	5	292.0 → 206.0	10	Disulfoton	88.0 → 60.0	5	142.0 → 81.0	10
beta-Endosulfan241.0206.025206.9172.015Disulforn sulfoxide97.0 $\sim 65.0$ 20212.0 $97.0$ 30Bifenthin181.2 $\sim 165.2$ 25181.2 $\sim 166.2$ 10Endosulfan-sulphate $271.9$ $\sim 230.9$ 15 $273.8$ $\sim 23.9.9$ 15Biromacil205.0 $\sim 188.0$ 15 $270.0$ $\sim 190.0$ 15EPN $157.0$ $\sim 110.0$ 15 $141.0$ $\sim 77.1$ 15Bromacil205.0 $\sim 188.0$ 15 $220.2$ $\sim 20.0$ $\sim 20.0$ $\sim 10.0$ $\sim 157.9$ $\sim 10.0$ $\sim 157.9$ $\sim 10.0$ $\sim 157.9$ $\sim 10.0$ $\sim 157.9$ $\sim 10.0$ $\sim 157.9$ $\sim 20.2$ $\sim 10.0$ $\sim 18.8$ $\sim 20.2$ $\sim 10.0$ $\sim 21.0$ $\sim 21.0$ $\sim 10.0$ <td< td=""><td>Benfuracarb</td><td>190.0 → 102.0</td><td>10</td><td>190.0 → 74.0</td><td>20</td><td>Disulfoton sulfone</td><td>213.0 → 96.9</td><td>15</td><td>152.9 → 97.0</td><td>10</td></td<>	Benfuracarb	190.0 → 102.0	10	190.0 → 74.0	20	Disulfoton sulfone	213.0 → 96.9	15	152.9 → 97.0	10
Biferthrin181.2 $\rightarrow$ 165.225181.2 $\rightarrow$ 166.210Endosulfar-sulphate271.9 $\rightarrow$ 237.015273.8 $\rightarrow$ 238.915Bireranol170.1 $\rightarrow$ 141.120170.1 $\rightarrow$ 115.040Endrin262.8 $\rightarrow$ 193.055263.0 $\rightarrow$ 228.020Bireranol205.0 $\rightarrow$ 188.015207.0 $\rightarrow$ 110.015EFN157.0 $\rightarrow$ 110.015141.0 $\rightarrow$ 77.010Burtalin266.0 $\rightarrow$ 220.210266.0 $\rightarrow$ 174.220Ethorophos157.9 $\rightarrow$ 97.015157.9 $\rightarrow$ 114.05Caduadros158.8 $\rightarrow$ 97.015157.9 $\rightarrow$ 949.015157.9 $\rightarrow$ 97.015157.9 $\rightarrow$ 114.05Caduadros158.8 $\rightarrow$ 97.015157.9 $\rightarrow$ 949.015157.9 $\rightarrow$ 97.015330.0 $\rightarrow$ 224.05Caduadros116.9 $\rightarrow$ 82.030149.0 $\rightarrow$ 70.015Fenamiphos sulfoxide308.0 $\rightarrow$ 154.015308.0 $\rightarrow$ 224.05Carbaryl144.0 $\rightarrow$ 116.110164.0 $\rightarrow$ 100.220Fenitriknin218.0 $\rightarrow$ 166.05304.0 $\rightarrow$ 122.015Carborylan210.0 $\rightarrow$ 164.010164.0 $\rightarrow$ 103.025Fensulfothion218.0 $\rightarrow$ 266.015228.8 $\rightarrow$ 165.015228.8 $\rightarrow$ 96.820Chrosulfan118.0 $\rightarrow$ 76.05270.0 $\rightarrow$ 215.030Fentilonion278.0 $\rightarrow$ 108.015278.0 $\rightarrow$ 108.015Chrosulfan270.0 $\rightarrow$ 248.015278.0 $\rightarrow$ 125.015Fensulfothion218.0 $\rightarrow$ 156.015278.0 $\rightarrow$ 109.015 </td <td><i>beta</i>-Endosulfan</td> <td>241.0 → 206.0</td> <td>25</td> <td>206.9 → 172.0</td> <td>15</td> <td>Disulfoton sulfoxide</td> <td>97.0 → 65.0</td> <td>20</td> <td>212.0 → 97.0</td> <td>30</td>	<i>beta</i> -Endosulfan	241.0 → 206.0	25	206.9 → 172.0	15	Disulfoton sulfoxide	97.0 → 65.0	20	212.0 → 97.0	30
Bitratanol $170.1 \rightarrow 141.1$ $20$ $170.1 \rightarrow 115.0$ $40$ Endrin $262.8 \rightarrow 193.0$ $35$ $263.0 \rightarrow 228.0$ $20$ Bromaphos $330.8 \rightarrow 315.8$ $15$ $207.0 \rightarrow 190.0$ $15$ $ENN$ $157.0 \rightarrow 110.0$ $15$ $141.0 \rightarrow 77.1$ $15$ Bromophos $330.8 \rightarrow 315.8$ $15$ $228.8 \rightarrow 313.8$ $15$ Ethion $230.9 \rightarrow 129.0$ $20$ $231.0 \rightarrow 175.0$ $10$ Cadusafos $158.8 \rightarrow 97.0$ $15$ $157.9 \rightarrow 96.9$ $15$ Famaiphos (phenamiphos) $303.0 \rightarrow 154.0$ $15$ $330.0 \rightarrow 224.0$ $5$ Captarl $16.9 \rightarrow 82.0$ $150.0 \rightarrow 71.9$ $5$ Fenamiphos sulfonce $319.8 \rightarrow 232.0$ $202.0$ $231.8 \rightarrow 714.0$ $15$ Carbaryl $144.0 \rightarrow 115.1$ $20$ $144.0 \rightarrow 115.1$ $10$ Fenamiphos sulfonce $304.0 \rightarrow 196.0$ $5$ $304.0 \rightarrow 122.0$ $15$ Carboulfan $184.0 \rightarrow 76.0$ $5$ $100.0 \rightarrow 72.0$ $15$ Fenamiphos sulfonce $394.0 \Rightarrow 270.0$ $15$ $277.0 \rightarrow 100.0$ $15$ Carboulfan $184.0 \rightarrow 76.0$ $10$ $233.9 \rightarrow 148.1$ $25$ Fenchlorphos (Ronnel) $286.0 \rightarrow 470.0$ $10$ $246.9 \rightarrow 49.0$ $10$ Chioraturalipole $278.0 \rightarrow 249.0$ $25$ $278.0 \rightarrow 215.0$ $372.8 \rightarrow 265.9$ $20$ $271.9 \rightarrow 236.9$ $15$ Fenchlorphos (Ronnel) $266.0 \rightarrow 47.0$ $10$ $124.9 \rightarrow 47.0$ $10$ Chioraturalipolo $271.7 \rightarrow 236.9$ $15$ $278.0 \rightarrow 105.0$ $15$ $157.0 \rightarrow 100.0$ $15$ $157.0 \rightarrow 100.0$ $157.0 \rightarrow 100.0$ $157.0 \rightarrow$	Bifenthrin	181.2 → 165.2	25	181.2 → 166.2	10	Endosulfan-sulphate	271.9 → 237.0	15	$273.8 \rightarrow 238.9$	15
Bromacil $205.0 \rightarrow 188.0$ $15$ $207.0 \rightarrow 190.0$ $15$ EPN $157.0 \rightarrow 110.0$ $15$ $141.0 \rightarrow 77.1$ $15$ Bromophos $330.8 \rightarrow 315.8$ $15$ $228.8 \rightarrow 313.8$ $15$ Ethoiron $230.9 \rightarrow 129.0$ $20$ $231.0 \rightarrow 175.0$ $10$ Butralin $266.0 \rightarrow 220.2$ $10$ $2260.0 \rightarrow 174.2$ $20$ Ethoprophos $57.9 \rightarrow 97.0$ $15$ $157.9 \rightarrow 114.0$ $5$ Captarlo $116.9 \rightarrow 82.0$ $30$ $149.0 \rightarrow 71.0$ $15$ Fanamiphos (phenamiphos) $303.0 + 154.0$ $15$ $291.8 \rightarrow 214.0$ $10$ Carbaryl $144.0 \rightarrow 115.1$ $100$ $144.0 \rightarrow 115.1$ $100$ Fanamiphos sulfoxic $319.8 \rightarrow 292.0$ $10$ $291.8 \rightarrow 214.0$ $10$ Carbaryl $144.0 \rightarrow 115.1$ $20$ $144.0 \rightarrow 115.1$ $10$ Fanamiphos sulfoxic $319.8 \rightarrow 292.0$ $15$ $286.9 \rightarrow 272.0$ $15$ Carbaryl $144.0 \rightarrow 115.1$ $100$ $146.0 \rightarrow 103.0$ $25$ Fenchlorphos (Ronnel) $285.0 \rightarrow 269.9$ $15$ $228.0 \rightarrow 91.0$ $15$ Carbaryl $141.0 \rightarrow 76.0$ $5$ $277.0 \rightarrow 106.0$ $15$ $227.0 \rightarrow 109.0$ $15$ $277.0 \rightarrow 108.0$ $15$ Carbaryl $140.0 \rightarrow 171.1$ $10$ $149.0 \rightarrow 71.0$ $25$ Fenchlorphos (Ronnel) $285.0 \rightarrow 269.9$ $15$ $277.0 \rightarrow 108.0$ $15$ Carbaryl $140.0 \rightarrow 172.0$ $278.0 \rightarrow 126.0$ $15$ $277.0 \rightarrow 108.0$ $15$ $277.0 \rightarrow 108.0$ $15$ $277.0 \rightarrow 108.0$ $15$ Carbaryl $277.0 \rightarrow 266.9$ $279.0 \rightarrow 275.0$ $278.0 $	Bitertanol	170.1 → 141.1	20	170.1 → 115.0	40	Endrin	262.8 → 193.0	35	263.0 → 228.0	20
Bromophos330.8 $\rightarrow$ 315.815228.8 $\rightarrow$ 313.815Ethion230.9 $\rightarrow$ 129.020231.0 $\rightarrow$ 175.010Buttalin266.0 $\rightarrow$ 220.210266.0 $\rightarrow$ 174.220Ethoprophos157.9 $\rightarrow$ 97.015157.9 $\rightarrow$ 114.05Cadusafos158.8 $\rightarrow$ 97.015157.9 $\rightarrow$ 116157.9 $\rightarrow$ 116.915157.9 $\rightarrow$ 116.0230.0 $\rightarrow$ 223.910330.0 $\rightarrow$ 224.05Captafol310.8 $\rightarrow$ 78.016157.9 $\rightarrow$ 71.95Fenamiphos (phenamiphos)303.0 $\rightarrow$ 128.010291.8 $\rightarrow$ 214.010Captan116.9 $\rightarrow$ 82.030149.0 $\rightarrow$ 71.015Fenamiphos sulfonide303.0 $\rightarrow$ 128.020218.8 $\rightarrow$ 217.015Carbor21.0 $\rightarrow$ 164.010164.0 $\rightarrow$ 116.015Fenamiphos sulfonide304.0 $\rightarrow$ 122.015204.0 $\rightarrow$ 122.015Carbor21.0 $\rightarrow$ 164.010164.0 $\rightarrow$ 103.025Fenchiorphos (Ronnie)285.0 $\rightarrow$ 269.015228.8 $\rightarrow$ 86.820Carbor23.9 $\rightarrow$ 206.110124.9 $\rightarrow$ 215.030Fenthion sulfonie29.9 $\rightarrow$ 47.010154.9 $\rightarrow$ 47.010Chorantraniliprole278.0 $\rightarrow$ 249.025278.0 $\rightarrow$ 215.030Fenthion sulfonie125.0 $\rightarrow$ 47.010124.9 $\rightarrow$ 47.015Chordmer (ars)271.7 $\rightarrow$ 226.9 1515278.0 $\rightarrow$ 109.015157.0 $\rightarrow$ 109.025Fondinia sulfonie150.9 $\rightarrow$ 115.0157.0 $\rightarrow$ 125.15Chordmar (aris)271.7 $\rightarrow$ 226.9 15268.9 1515<	Bromacil	205.0 → 188.0	15	207.0 → 190.0	15	FPN	$157.0 \rightarrow 110.0$	15	$141.0 \rightarrow 77.1$	15
Burtalin $266.0 - 220.2$ 10 $266.0 - 174.2$ 20Ethorophos $157.9 - 97.0$ 15 $157.9 - 114.0$ 5Cadusafos $158.8 - 97.0$ 15 $157.9 - 96.9$ 15 $Famoxadone$ $329.9 - 223.9$ 10 $330.0 - 1224.0$ 5Captafol $310.8 - 78.8$ 15 $150.0 - 71.9$ 5Fenamiphos sulfone $319.8 - 224.0$ 10 $330.0 - 1284.0$ 10Captan $116.9 - 82.0$ $144.0 - 710.0$ 15Fenamiphos sulfone $319.8 - 224.0$ 10 $238.0 - 122.0$ 15Carbaryl $144.0 - 115.1$ 20 $144.0 - 110.3$ 25Fenchlorphos (Ronnel) $285.0 - 269.9$ 15 $286.9 - 272.0$ 15Carbouran $221.0 - 164.0$ 10 $164.0 - 103.0$ 25Fenchlorphos (Ronnel) $285.0 - 269.9$ 15 $278.0 - 249.0$ 25Carbouran $21.0 - 164.0$ 10 $160.0 - 62.0$ 20Fenitrothion $271.0 - 260.1$ 5 $277.0 - 109.0$ 15Chorometionate $233.9 - 206.1$ 10 $233.9 - 215.0$ 30Fenthion sulforine $399.9 - 105.0$ 10 $124.9 - 47.0$ 10Chordane (trans-) $271.7 - 236.9$ 15 $372.8 - 265.8$ 15Fenthion sulforine $399.9 - 105.0$ 10 $124.9 - 47.0$ 10Chlordane (trans-) $271.7 - 236.9$ 15 $372.8 + 265.8$ 15Fenthion sulforine $156.0 + 70.0$ 15 $288.0 + 010.0$ 15Chlordane (trans-) $271.7 - 236.9$ 15 $316.6 + 195.6$ 5Folpet	Bromophos	330.8 → 315.8	15	328.8 → 313.8	15	Ethion	230.9 → 129.0	20	231.0 → 175.0	10
Cadusafos158.8 $+$ 97.015157.9 $+$ 96.915Famoxadone329.9 $+$ 223.910330.0 $+$ 224.05Captarol310.8 $+$ 78.815150.0 $+$ 71.95Fenamiphos (henamiphos)303.0 $+$ 154.015303.0 $+$ 124.010Captarol116.9 $+$ 82.030149.0 $+$ 70.015Fenamiphos sulfoxic319.8 $+$ 292.010291.8 $+$ 214.010Carbaryl144.0 $+$ 115.120144.0 $+$ 116.116Fenamiphos sulfoxic304.0 $+$ 122.015Carbaryl144.0 $+$ 115.120144.0 $+$ 116.116Fenamiphos sulfoxic304.0 $+$ 122.015Carbaryl144.0 $+$ 116.110164.0 $+$ 103.025Fenchlorphos (Ronnel)285.0 $+$ 269.915286.9 $+$ 272.015Carbaryl118.0 $+$ 76.05160.0 $+$ 62.020Fentitorhion271.0 $+$ 260.15277.0 $-$ 109.015Chiorattraniliprole278.0 $+$ 249.025278.0 $+$ 215.030Fenthion sulfoxide125.0 $+$ 47.010124.9 $+$ 47.010Chordane ( <i>cias</i> -)372.8 $+$ 265.915372.8 $+$ 265.815Fenthion sulfoxide125.0 $+$ 47.010278.0 $+$ 109.015Chordineform15.19 $+$ 17.110180.9 $+$ 140.015Fluerytrinate156.9 $+$ 107.115198.9 $+$ 107.025Chordineform15.19 $+$ 17.110180.9 $+$ 140.015Fluerytrinate156.9 $+$ 107.115198.9 $+$ 107.0	Butralin	$266.0 \rightarrow 220.2$	10	$266.0 \rightarrow 174.2$	20	Ethoprophos	$157.9 \rightarrow 97.0$	15	$157.9 \rightarrow 114.0$	5
Captafol310.8 $\rightarrow$ 78.815150.0 $\rightarrow$ 71.95Fenamiphos (phenamiphos)303.0 $\rightarrow$ 15.0150303.0 $\rightarrow$ 18.020Captan116.9 $\rightarrow$ 82.030149.0 $\rightarrow$ 70.015Fenamiphos sulfone319.8 $\rightarrow$ 292.010291.8 $\rightarrow$ 214.010Carboruran21.0 $\rightarrow$ 164.010164.0 $\rightarrow$ 113.025Fenamiphos sulfone319.8 $\rightarrow$ 292.010291.8 $\rightarrow$ 214.015Carboruran21.0 $\rightarrow$ 164.010164.0 $\rightarrow$ 103.025Fenchlorphos (Ronnel)285.0 $\rightarrow$ 269.915286.9 $\rightarrow$ 272.015Carborufan23.3 $\rightarrow$ 206.110233.9 $\rightarrow$ 148.125Fenchlorphos (Ronnel)291.8 $\rightarrow$ 166.015292.8 $\rightarrow$ 96.820Chiromethionate233.9 $\rightarrow$ 206.110233.9 $\rightarrow$ 148.125Fenchlorphos (Ronnel)291.8 $\rightarrow$ 156.015292.8 $\rightarrow$ 96.820Chordmane ( <i>cis</i> -)372.9 $\rightarrow$ 265.920271.9 $\rightarrow$ 236.915Fenchlorn sulfone309.9 $\rightarrow$ 100.015124.9 $\rightarrow$ 47.010Chlordma ( <i>cis</i> -)372.9 $\rightarrow$ 265.920271.9 $\rightarrow$ 236.915Fenchlorn sulfone150.0 $\rightarrow$ 100.015167.0 $\rightarrow$ 102.15Chlordma ( <i>cis</i> -)372.9 $\rightarrow$ 266.915372.8 $\rightarrow$ 265.815Fenchlorn sulfone150.0 $\rightarrow$ 10.0157.0 $\rightarrow$ 109.015Chlordmaeform151.9 $\rightarrow$ 171.110180.9 $\rightarrow$ 140.015Fluexthirate156.9 $\rightarrow$ 107.115167.0 $\rightarrow$ 125.15Chlordmaeform316.6 $\rightarrow$ 286.615316.6 $\rightarrow$ 185.0 <td>Cadusafos</td> <td><math>158.8 \rightarrow 97.0</math></td> <td>15</td> <td><math>157.9 \rightarrow 96.9</math></td> <td>15</td> <td>Famoxadone</td> <td><math>329.9 \rightarrow 223.9</math></td> <td>10</td> <td>330 0 → 224 0</td> <td>5</td>	Cadusafos	$158.8 \rightarrow 97.0$	15	$157.9 \rightarrow 96.9$	15	Famoxadone	$329.9 \rightarrow 223.9$	10	330 0 → 224 0	5
Captan116.9 $42.0$ $30$ 149.0 $70.0$ 15Foramiphos sulfoxide $319.8$ $229.0$ $10$ $291.8$ $214.0$ $10$ Carbaryl144.0 $115.1$ $20$ $144.0$ $116.1$ $10$ Foramiphos sulfoxide $304.0$ $196.0$ $5$ $304.0$ $122.0$ $15$ Carboruran $221.0$ $164.0$ $10$ $164.0$ $103.0$ $25$ Forchlorphos (Ronnel) $285.0$ $208.9$ $15$ $286.9$ $272.0$ $15$ Carboruran $118.0$ $76.0$ $5$ $160.0$ $62.0$ $20$ Fornitrohion $277.0$ $260.1$ $5$ $277.0$ $109.0$ $15$ Chiornethionate $233.9$ $233.9$ $248.1$ $25$ Fornulariani (Science (Sc	Captafol	$310.8 \rightarrow 78.8$	15	$150.0 \rightarrow 71.9$	5	Fenaminhos (nhenaminhos)	$303.0 \rightarrow 154.0$	15	$303.0 \rightarrow 180.0$	20
Carbary144.0115.120144.0116.110Feaniphos-suffoxide304.0196.05304.0122.015Carbary221.0 $164.0$ 10164.0103.025Fenchlorphos (Ronnel)285.0269.915286.9272.015Carbosuffan118.0 $76.0$ 5160.062.020Fentirothion277.0260.15277.0109.015Chiomethionate233.9230.9233.9216.0215.077.0280.015278.0109.015Chiorathionate278.0278.0226.2278.0215.030Fenthion278.0169.015278.0109.015Chloradne ( <i>cis</i> -)372.9265.920271.9236.915Fenthion sulfone309.9105.010124.947.010Chlordne ( <i>cis</i> -)372.9265.920271.9236.915Fenthion sulforine125.047.010278.0109.015Chlordner( <i>trans</i> -)217.772.8265.81571.6249.9117.015169.0107.025Chlordner( <i>trans</i> -)216.915.115268.9161.015Fluerytrinate166.9107.115198.9107.025Chlordner( <i>trans</i> -)216.9183.05181.0145.01570.015261.8130.015Chlordner( <i>tr</i>	Cantan	$116.9 \rightarrow 82.0$	30	149 0 → 70 0	15	Fenaminhos sulfone	$319.8 \rightarrow 292.0$	10	$291.8 \rightarrow 214.0$	10
Carbofuran221.0164.010164.0103.025Fonchlorphos (Ronnel)285.0260.015266.9272.015Carbofuran118.0 $76.0$ 5160.0 $62.0$ 20Fenchlorphos (Ronnel)285.0 $280.0$ 266.9 $277.0$ $70.0$ $298.0$ $228.0$ $98.0$ $208.0$ $228.0$ $98.0$ $208.0$ $228.0$ $98.0$ $208.0$ $228.0$ $98.0$ $208.0$ $208.0$ $228.0$ $98.0$ $208.0$ $228.0$ $98.0$ $208.0$ $228.0$ $98.0$ $208.0$ $228.0$ $98.0$ $208.0$ $228.0$ $928.0$ $228.0$ $98.0$ $208.0$ $228.0$ $98.0$ $208.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $98.0$ $208.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $928.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$ $228.0$	Carbaryl	$144.0 \rightarrow 115.1$	20	$144.0 \rightarrow 116.1$	10	Fenaminhos-sulfoxide	$304.0 \rightarrow 196.0$	5	$304.0 \rightarrow 122.0$	15
$ \begin{array}{c} \mbox relation & \mbox relation $	Carbofuran	221 0 → 164 0	10	164 0 → 103 0	25	Fenchlornhos (Bonnel)	285 0 → 269 9	15	286 9 → 272 0	15
$ \begin{array}{c} 233.9 \rightarrow 206.1 & 10 & 233.9 \rightarrow 148.1 & 25 \\ (axythioquinox) \\ Chiorantraniliprole & 278.0 \rightarrow 249.0 & 25 & 278.0 \rightarrow 215.0 & 30 \\ Chorant (ars.) & 372.9 \rightarrow 265.9 & 20 & 271.9 \rightarrow 236.9 & 15 \\ Chorane (crs.) & 372.9 \rightarrow 265.9 & 20 & 271.9 \rightarrow 236.9 & 15 \\ Chorane (crs.) & 372.9 \rightarrow 265.9 & 15 & 372.8 \rightarrow 265.8 & 15 \\ Chorane (ras.) & 271.7 \rightarrow 236.9 & 15 & 372.8 \rightarrow 265.8 & 15 \\ Chordmieform & 151.9 \rightarrow 117.1 & 10 & 180.9 \rightarrow 140.0 & 15 \\ Chorane (ras.) & 266.9 \rightarrow 159.1 & 15 & 268.9 \rightarrow 161.0 & 15 \\ Choronentrofen & 316.6 \rightarrow 286.6 & 15 & 316.6 \rightarrow 195.6 & 25 \\ Choronhalonil & 263.8 \rightarrow 133.0 & 40 & 264.0 \rightarrow 168.0 & 25 \\ Choronhalonil & 263.8 \rightarrow 133.0 & 40 & 264.0 \rightarrow 168.0 & 25 \\ Choronhalonil & 263.8 \rightarrow 133.0 & 40 & 264.0 \rightarrow 168.0 & 25 \\ Choronhalonil & 263.8 \rightarrow 133.0 & 40 & 264.0 \rightarrow 168.0 & 25 \\ Choronhalonil & 265.9 \rightarrow 92.9 & 20 & 124.9 \rightarrow 47.0 & 15 \\ Choronhalonil & 265.9 \rightarrow 92.9 & 20 & 124.9 \rightarrow 47.0 & 15 \\ Choronhalonil & 265.0 \rightarrow 206.0 & 15 & 198.9 \rightarrow 171.0 & 15 \\ Choronhalonil & 265.0 \rightarrow 206.0 & 15 & 162.9 \rightarrow 127.0 & 5 \\ Choronhalonil & 265.0 \rightarrow 206.0 & 15 & 162.9 \rightarrow 127.0 & 5 \\ Cyhalothrin & 266.0 \rightarrow 181.0 & 5 & 181.1 \rightarrow 152.0 & 25 \\ Cyhalothrin & 266.0 \rightarrow 181.0 & 5 & 181.1 \rightarrow 152.0 & 25 \\ Cyhalothrin & 165.1 \rightarrow 127.1 & 5 & 163.1 \rightarrow 127.1 & 5 \\ Choronhalonil & 266.0 \rightarrow 180.0 & 5 & 181.1 \rightarrow 152.0 & 25 \\ Cyhalothrin & 165.1 \rightarrow 127.1 & 5 & 163.1 \rightarrow 127.0 & 5 \\ Cyhalothrin & 165.1 \rightarrow 127.1 & 5 & 163.1 \rightarrow 127.0 & 5 \\ Cyhalothrin & 165.1 \rightarrow 127.1 & 5 & 163.1 \rightarrow 127.0 & 5 \\ Decromethrin & 165.1 \rightarrow 127.1 & 5 & 163.1 \rightarrow 127.0 & 5 \\ Decromethrin & 165.1 \rightarrow 127.1 & 5 & 165.0 \rightarrow 75.0 & 5 \\ Decromethrin & 252.9 \rightarrow 30.0 & 15 & 253.0 \rightarrow 740.0 & 15 \\ Decromethrin & 252.9 \rightarrow 30.0 & 5 & 171.0 \rightarrow 115.0 & 170.0 \rightarrow 118.0 & 5 \\ Demeton-0 & 88.0 \rightarrow 60.0 & 5 & 171.0 \rightarrow 115.0 & 10 \\ Demeton-S & 88.0 \rightarrow 60.0 & 5 & 171.0 \rightarrow 115.0 & 10 \\ Demeton-S & 88.0 \rightarrow 60.0 & 5 & 171.0 \rightarrow 174.0 & 5 \\ Drodione & 313.8 \rightarrow 55.9 & 20 & 313.8 \rightarrow 244.9 & 10 \\ Sazophos & 257.0 \rightarrow 118.0 & 15 & 257.0 \rightarrow 118.0 & 5 \\ Drodione & 313.8 \rightarrow 55.9 & 20 & 313.8 \rightarrow 244.9 & 10 \\ Sazophos & 257.0 \rightarrow 118.0 & 15 & 257.0 \rightarrow 118.0 & 5 \\ Drodione $	Carbosulfan	$118.0 \rightarrow 76.0$	5	$160.0 \rightarrow 62.0$	20	Fenitrothion	$200.0 \rightarrow 200.0$ $277.0 \rightarrow 260.1$	5	$200.0 \div 272.0$ $277.0 \rightarrow 109.0$	15
(arythioquinox)2101101200110120101012010101101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010101010 <td>Chinomethionate</td> <td><math>233.9 \rightarrow 206.1</math></td> <td>10</td> <td><math>233.9 \rightarrow 148.1</math></td> <td>25</td> <td>Fensulfothion</td> <td>291.8 → 156.0</td> <td>15</td> <td><math>297.8 \rightarrow 96.8</math></td> <td>20</td>	Chinomethionate	$233.9 \rightarrow 206.1$	10	$233.9 \rightarrow 148.1$	25	Fensulfothion	291.8 → 156.0	15	$297.8 \rightarrow 96.8$	20
Chlorantraniliprole $278.0 \rightarrow 249.0$ $25$ $278.0 \rightarrow 215.0$ $30$ Fenthion sulfone $39.9 \rightarrow 105.0$ $100.5$ $100.5 \rightarrow 47.0$ $100.5$ Chlordane $(cis \cdot)$ $372.9 \rightarrow 265.9$ $20$ $271.9 \rightarrow 236.9$ $15$ Fenthion sulfonie $39.9 \rightarrow 105.0$ $10$ $278.0 \rightarrow 47.0$ $10$ Chlordane $(trans.)$ $271.7 \rightarrow 236.9$ $15$ $372.8 \rightarrow 265.8$ $15$ Fenthion sulfoxide $125.0 \rightarrow 47.0$ $10$ $278.0 \rightarrow 109.0$ $15$ Chlordane $(trans.)$ $271.7 \rightarrow 236.9$ $15$ $372.8 \rightarrow 265.8$ $15$ Fenthion sulfoxide $125.0 \rightarrow 47.0$ $10$ $278.0 \rightarrow 109.0$ $15$ Chlordimeform $151.9 \rightarrow 117.1$ $10$ $180.9 \rightarrow 140.0$ $15$ Fenthion sulfoxide $125.0 \rightarrow 47.0$ $10$ $278.0 \rightarrow 109.0$ $15$ Chlordimeform $151.9 \rightarrow 117.1$ $10$ $180.9 \rightarrow 140.0$ $15$ Fenthion sulfoxide $125.0 \rightarrow 47.0$ $10$ $278.0 \rightarrow 109.0$ $25$ Chlordimeform $316.6 \rightarrow 286.6$ $15$ $316.6 \rightarrow 195.6$ $25$ Fourderian $143.0 \rightarrow 107.1$ $20$ $157.0 \rightarrow 109.0$ $25$ Chlordintofen $316.8 \rightarrow 286.6$ $15$ $316.6 \rightarrow 195.6$ $25$ Folget $260.0 \rightarrow 130.0$ $15$ $261.8 \rightarrow 130.0$ $15$ Chlordintalonil $263.8 \rightarrow 133.0$ $40$ $264.0 \rightarrow 168.0$ $25$ Formothion $124.9 \rightarrow 47.0$ $15$ $170.0 \rightarrow 93.0$ $5$ Chlorpyrifos $196.9 \rightarrow 169.0$ $15$ $189.9 \rightarrow 171.0$ $15$ $gamma$ -HCH (lindane) $219.0 \rightarrow 183.0$ $5$ $181.0 \rightarrow 145.0$ <t< td=""><td>(oxythioquinox)</td><td>20010 20011</td><td></td><td>20010 11011</td><td>20</td><td>Fenthion</td><td>278 0 → 169 0</td><td>15</td><td><math>278.0 \rightarrow 109.0</math></td><td>15</td></t<>	(oxythioquinox)	20010 20011		20010 11011	20	Fenthion	278 0 → 169 0	15	$278.0 \rightarrow 109.0$	15
Chlordane (cis-) $372.9 \rightarrow 265.9$ $20$ $271.9 \rightarrow 236.9$ $15$ Fentions suffore $200.8 \rightarrow 47.0$ $10$ $278.0 \rightarrow 10.0$ $15$ Chlordane (trans-) $271.7 \rightarrow 236.9$ $15$ $372.8 \rightarrow 265.8$ $15$ $572.8 \rightarrow 265.8$ $15$ Fentions suffore $125.0 \rightarrow 47.0$ $10$ $278.0 \rightarrow 10.0$ $15$ Chlordimeform $151.9 \rightarrow 117.1$ $10$ $180.9 \rightarrow 140.0$ $15$ Fentions suffore $224.9 \rightarrow 119.0$ $15$ $167.0 \rightarrow 125.1$ $5$ Chlordimeform $316.6 \rightarrow 286.6$ $15$ $316.6 \rightarrow 195.6$ $25$ Folget $260.0 \rightarrow 130.0$ $15$ $261.8 \rightarrow 130.1$ $15$ Chlordinitof $263.8 \rightarrow 133.0$ $40$ $264.0 \rightarrow 168.0$ $25$ Folget $260.0 \rightarrow 130.0$ $15$ $261.8 \rightarrow 130.1$ $15$ Chlordinitof $263.8 \rightarrow 133.0$ $40$ $264.0 \rightarrow 168.0$ $25$ Formothion $124.9 \rightarrow 47.0$ $15$ $170.0 \rightarrow 93.0$ $5$ Chlordyrifos $198.9 \rightarrow 169.0$ $15$ $198.9 \rightarrow 171.0$ $15$ $970.0 \rightarrow 183.0$ $5$ $181.0 \rightarrow 145.0$ $15$ Chlordyrifos $196.9 \rightarrow 189.0$ $15$ $204.0 \rightarrow 78.0$ $30$ $HCH$ ( $apha$ -) $216.9 \rightarrow 181.0$ $5$ $190.0 \rightarrow 183.0$ $5$ Chlordhrin $226.0 \rightarrow 206.0$ $15$ $182.9 \rightarrow 127.0$ $5$ $HCH$ ( $beta$ -) $218.9 \rightarrow 188.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyluthrin $226.0 \rightarrow 206.0$ $15$ $182.0 \rightarrow 75.0$ $5$ $163.1 \rightarrow 127.1$ $5$ $163.1 \rightarrow 127.1$ $5$ $163.1 \rightarrow 127.1$ $5$ Cyluthrin <t< td=""><td>Chlorantraniliprole</td><td>278.0 → 249.0</td><td>25</td><td>278.0 → 215.0</td><td>30</td><td>Fenthion sulfone</td><td><math>309.9 \rightarrow 105.0</math></td><td>10</td><td><math>124.9 \rightarrow 47.0</math></td><td>10</td></t<>	Chlorantraniliprole	278.0 → 249.0	25	278.0 → 215.0	30	Fenthion sulfone	$309.9 \rightarrow 105.0$	10	$124.9 \rightarrow 47.0$	10
Chlordane $(trans-)$ $271.7 \rightarrow 236.9$ 15 $372.8 \rightarrow 265.8$ 15Fernvalerate $224.9 \rightarrow 119.0$ 15 $167.0 \rightarrow 120.5$ 167.0 \rightarrow 120.5167.0 $\rightarrow 120.5$ 167.0 $\rightarrow 120.5$ 167	Chlordane ( <i>cis</i> -)	372.9 → 265.9	20	271.9 → 236.9	15	Fenthion sulfoxide	$125.0 \rightarrow 47.0$	10	$278.0 \rightarrow 109.0$	15
Chlordimeform $151.9 \rightarrow 117.1$ $10$ $180.9 \rightarrow 140.0$ $15$ Function $126.9 \rightarrow 107.1$ $15$ $198.9 \rightarrow 107.0$ $25$ Chlordineron $316.6 \rightarrow 286.6$ $15$ $316.6 \rightarrow 195.6$ $25$ Fluertalin $143.0 \rightarrow 107.1$ $20$ $157.0 \rightarrow 109.0$ $25$ Chlorobenzilate $251.1 \rightarrow 139.1$ $15$ $139.1 \rightarrow 75.1$ $30$ Folder $260.0 \rightarrow 130.0$ $15$ $261.8 \rightarrow 107.0$ $25$ Chlorobenzilate $251.1 \rightarrow 139.1$ $15$ $139.1 \rightarrow 75.1$ $30$ Folder $260.0 \rightarrow 130.0$ $15$ $261.8 \rightarrow 109.0$ $15$ Chlorobenzilate $251.1 \rightarrow 139.1$ $15$ $139.1 \rightarrow 75.1$ $30$ Fondos $245.9 \rightarrow 137.0$ $5$ $245.9 \rightarrow 109.0$ $15$ Chlorobenzilate $251.1 \rightarrow 139.1$ $15$ $198.9 \rightarrow 171.0$ $15$ Fondos $245.9 \rightarrow 137.0$ $5$ $245.9 \rightarrow 109.0$ $15$ Chlorobenzilate $255.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ Fondos $245.9 \rightarrow 137.0$ $5$ $181.0 \rightarrow 145.0$ $15$ Chlorobenzilate $225.0 \rightarrow 223.0$ $25$ $298.9 \rightarrow 221.0$ $25$ HCH ( $dalpa-$ ) $216.9 \rightarrow 181.0$ $5$ $181.0 \rightarrow 145.0$ $15$ Chlorobenzilate $225.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ HCH ( $delta-$ ) $218.9 \rightarrow 181.0$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyfluthrin $226.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ HCH ( $delta-$ ) $217.0 \rightarrow 181.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyharbir (lambda) $208.0 \rightarrow 181.0$ $5$ $1$	Chlordane (trans-)	271.7 → 236.9	15	372.8 → 265.8	15	Fenvalerate	$224.9 \rightarrow 119.0$	15	$167.0 \rightarrow 125.1$	5
Chlorfenvinphos $266.9 \rightarrow 159.1$ 15 $268.9 \rightarrow 161.0$ 15Hardynnatic $143.0 \rightarrow 107.1$ 15 $103.0 \rightarrow 107.1$ 15 $103.0 \rightarrow 107.1$ 20 $157.0 \rightarrow 109.0$ 25Chlornitrofen $316.6 \rightarrow 286.6$ 15 $316.6 \rightarrow 195.6$ 25Flumetralin $143.0 \rightarrow 107.1$ 20 $157.0 \rightarrow 109.0$ 25Chlorobenzilate $251.1 \rightarrow 139.1$ 15 $139.1 \rightarrow 75.1$ 30Fonofos $245.9 \rightarrow 137.0$ 5 $245.9 \rightarrow 109.0$ 15Chlorobhalonil $263.8 \rightarrow 133.0$ 40 $264.0 \rightarrow 168.0$ 25Formothion $124.9 \rightarrow 47.0$ 15 $170.0 \rightarrow 93.0$ 5Chloropyrifos $196.9 \rightarrow 169.0$ 15 $198.9 \rightarrow 171.0$ 15 $garma-HCH$ (lindane) $219.0 \rightarrow 183.0$ 5 $181.0 \rightarrow 145.0$ 15Chlorpyrifos-methyl $285.9 \rightarrow 92.9$ 20 $124.9 \rightarrow 47.0$ 15 $HCH$ ( $alpha$ -) $216.9 \rightarrow 181.0$ 5 $219.0 \rightarrow 183.0$ 5Chlorphal-dimethyl (DCPA) $300.9 \rightarrow 223.0$ 25 $298.9 \rightarrow 221.0$ 25 $HCH$ ( $beta$ -) $218.9 \rightarrow 183.1$ 5 $219.0 \rightarrow 183.0$ 5Cylautrin $226.0 \rightarrow 206.0$ 15 $162.9 \rightarrow 127.0$ 5 $Heptachlor$ $271.7 \rightarrow 238.9$ 15 $273.7 \rightarrow 238.9$ 15Cylautrin $265.0 \rightarrow 75.0$ 5 $181.0 \rightarrow 152.0$ $25$ $Heptachlor$ $271.7 \rightarrow 238.9$ 15 $238.9 \rightarrow 219.0$ $30$ Dezomet $161.9 \rightarrow 88.0$ 5 $89.0 \rightarrow 46.0$ 15 $Heptachlor epoxides$ $ia2.9 \rightarrow 118.9$ $25$ $289.0 \rightarrow 219.0$ $30$ Deltamethrin $252$	Chlordimeform	151.9 → 117.1	10	180.9 → 140.0	15	Flucythrinate	$156.9 \rightarrow 107.1$	15	107.0 × 120.1	25
Chlornitrofen $316.6 \rightarrow 286.6$ $15$ $316.6 \rightarrow 195.6$ $25$ Folget $260.0 \rightarrow 130.0$ $150.3 \rightarrow 103.3$ <t< td=""><td>Chlorfenvinphos</td><td>266.9 → 159.1</td><td>15</td><td>268.9 → 161.0</td><td>15</td><td>Flumetralin</td><td><math>130.0 \neq 107.1</math> 143 0 <math>\rightarrow 107.1</math></td><td>20</td><td><math>150.0 \neq 107.0</math> <math>157.0 \rightarrow 109.0</math></td><td>25</td></t<>	Chlorfenvinphos	266.9 → 159.1	15	268.9 → 161.0	15	Flumetralin	$130.0 \neq 107.1$ 143 0 $\rightarrow 107.1$	20	$150.0 \neq 107.0$ $157.0 \rightarrow 109.0$	25
Chlorobenzilate $251.1 \rightarrow 139.1$ $15$ $139.1 \rightarrow 75.1$ $30$ Fondors $245.9 \rightarrow 103.0$ $15$ $201.3 \rightarrow 103.1$ $15$ Chlorothalonil $263.8 \rightarrow 133.0$ $40$ $264.0 \rightarrow 168.0$ $25$ Fondors $245.9 \rightarrow 137.0$ $5$ $245.9 \rightarrow 109.0$ $15$ Chlorothalonil $263.8 \rightarrow 133.0$ $40$ $264.0 \rightarrow 168.0$ $25$ Fondors $245.9 \rightarrow 137.0$ $5$ $245.9 \rightarrow 109.0$ $15$ Chlorothalonil $263.8 \rightarrow 133.0$ $40$ $264.0 \rightarrow 168.0$ $25$ Fondors $245.9 \rightarrow 137.0$ $5$ $245.9 \rightarrow 109.0$ $15$ Chlorothalonil $285.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ Fondors $219.0 \rightarrow 183.0$ $5$ $181.0 \rightarrow 145.0$ $15$ Chlorothal-dimethyl (DCPA) $300.9 \rightarrow 223.0$ $25$ $298.9 \rightarrow 221.0$ $25$ HCH ( $alpha$ -) $216.9 \rightarrow 181.0$ $5$ $219.0 \rightarrow 183.0$ $5$ Clomazone $125.0 \rightarrow 89.0$ $15$ $204.0 \rightarrow 78.0$ $30$ HCH ( $delta$ -) $217.0 \rightarrow 181.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyfluthrin $226.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ Heptachlor $271.7 \rightarrow 236.9$ $15$ $273.7 \rightarrow 238.9$ $15$ Cyhaothrin (lambda) $208.0 \rightarrow 181.0$ $5$ $181.1 \rightarrow 152.0$ $25$ Heptachlor epoxides ( $cis$ -) $352.8 \rightarrow 262.9$ $15$ $354.8 \rightarrow 264.9$ $15$ Opermethrin $165.1 \rightarrow 127.1$ $5$ $163.1 \rightarrow 127.1$ $5$ Heptachlor epoxides ( $cis$ -) $352.8 \rightarrow 219.0$ $30$ Dazomet $161.9 \rightarrow 89.0$ $5$ $89.0 \rightarrow$	Chlornitrofen	316.6 → 286.6	15	316.6 → 195.6	25	Folnet	260 0 -> 130 0	15	$261.8 \rightarrow 130.1$	15
Chlorothalonil $263.8 \rightarrow 133.0$ $40$ $264.0 \rightarrow 168.0$ $25$ Formothion $124.9 \rightarrow 47.0$ $15$ $170.0 \rightarrow 93.0$ $5$ Chloropyrifos $196.9 \rightarrow 169.0$ $15$ $198.9 \rightarrow 171.0$ $15$ $198.9 \rightarrow 47.0$ $15$ $170.0 \rightarrow 93.0$ $5$ Chloropyrifos $196.9 \rightarrow 169.0$ $15$ $198.9 \rightarrow 171.0$ $15$ $198.9 \rightarrow 47.0$ $15$ $170.0 \rightarrow 93.0$ $5$ Chloropyrifos $285.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ $170.0 \rightarrow 93.0$ $5$ $181.0 \rightarrow 145.0$ $15$ Chloropharine $285.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ $181.0 \rightarrow 145.0$ $15$ Chloropharine $250.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ $181.0 \rightarrow 145.0$ $15$ Chloropharine $250.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ $181.0 \rightarrow 145.0$ $15$ Chloropharine $125.0 \rightarrow 89.0$ $15$ $204.0 \rightarrow 78.0$ $30$ $HCH$ $(alpha-)$ $216.9 \rightarrow 181.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyfluthrin $226.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ $Heptachlor$ $271.7 \rightarrow 236.9$ $15$ $273.7 \rightarrow 238.9$ $15$ Cyhaothrin (lambda) $208.0 \rightarrow 181.0$ $5$ $181.1 \rightarrow 152.0$ $25$ $Heptachlor epoxides$ $182.9 \rightarrow 118.9$ $25$ $289.0 \rightarrow 219.0$ $30$ Dazomet $161.9 \rightarrow 89.0$ $5$ $89.0 \rightarrow 46.0$ $15$ $Heptachlor epoxides$ $124.0 \rightarrow 89.0$ $10$ $124.0 \rightarrow 63.0$ $35$ Deltamethrin $252.9 \rightarrow 93.0$ $15$ $253.0 \rightarrow 174.0$	Chlorobenzilate	251.1 → 139.1	15	139.1 → 75.1	30	Fonofos	$200.0 \neq 130.0$ $245.9 \rightarrow 137.0$	5	201.0 > 100.1 $245.9 \rightarrow 109.0$	15
Chlorpyrifos $196.9 \rightarrow 169.0$ $15$ $198.9 \rightarrow 171.0$ $15$ $198.9 \rightarrow 171.0$ $15$ $198.9 \rightarrow 171.0$ $15$ $198.0 \rightarrow 171.0$ $160.5 \rightarrow 181.0$ $160.5 \rightarrow 181.0$ $160.5 \rightarrow 181.0$ $160.5 \rightarrow 181.0$ $15$ Chlorpyrifos-methyl $285.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ $160.4 \rightarrow 183.0$ $5$ $181.0 \rightarrow 145.0$ $15$ Chlorthal-dimethyl (DCPA) $300.9 \rightarrow 223.0$ $25$ $298.9 \rightarrow 221.0$ $25$ $160.4 \rightarrow 78.0$ $30$ $5$ $181.0 \rightarrow 183.0$ $5$ Clomazone $125.0 \rightarrow 89.0$ $15$ $204.0 \rightarrow 78.0$ $30$ $160.4 \rightarrow 183.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyfluthrin $226.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ $HCH$ ( $delta$ -) $217.0 \rightarrow 181.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyhalothrin (lambda) $208.0 \rightarrow 181.0$ $5$ $181.1 \rightarrow 152.0$ $25$ Heptachlor $271.7 \rightarrow 236.9$ $15$ $273.7 \rightarrow 238.9$ $15$ Cypermethrin $165.1 \rightarrow 127.1$ $5$ $163.1 \rightarrow 127.1$ $5$ Heptachlor epoxides ( $cis$ -) $352.8 \rightarrow 262.9$ $15$ $354.8 \rightarrow 264.9$ $15$ Dazomet $161.9 \rightarrow 89.0$ $5$ $89.0 \rightarrow 46.0$ $15$ Heptachlor epoxides ( $trans$ -) $182.9 \rightarrow 118.9$ $25$ $289.0 \rightarrow 219.0$ $30$ Deltamethrin $252.9 \rightarrow 93.0$ $15$ $253.0 \rightarrow 75.0$ $5$ Hexachlorobenzene $283.8 \rightarrow 213.9$ $30$ $281.8 \rightarrow 211.9$ $30$ Denteon-O $88.0 \rightarrow 60.0$ $5$ $126.0 \rightarrow 65.0$ $10$ Indoxacarb $202.9 \rightarrow 134.0$ $15$	Chlorothalonil	263.8 → 133.0	40	264.0 → 168.0	25	Formothion	$174.9 \rightarrow 47.0$	15	$2+0.0 \rightarrow 100.0$ $170.0 \rightarrow 93.0$	5
Chlorpyrifos-methyl $285.9 \rightarrow 92.9$ $20$ $124.9 \rightarrow 47.0$ $15$ $gamma-hor (minute)$ $216.9 \rightarrow 160.0$ $5$ $101.0 \rightarrow 143.0$ $15$ Chlorphal-dimethyl (DCPA) $300.9 \rightarrow 223.0$ $25$ $298.9 \rightarrow 221.0$ $25$ $HCH$ ( $alpha$ -) $216.9 \rightarrow 181.0$ $5$ $219.0 \rightarrow 183.0$ $5$ Clomazone $125.0 \rightarrow 89.0$ $15$ $204.0 \rightarrow 78.0$ $30$ $HCH$ ( $alpha$ -) $218.9 \rightarrow 183.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyfluthrin $226.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ $HCH$ ( $delta$ -) $217.0 \rightarrow 181.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyhalothrin (lambda) $208.0 \rightarrow 181.0$ $5$ $181.1 \rightarrow 152.0$ $25$ $Heptachlor$ $271.7 \rightarrow 236.9$ $15$ $273.7 \rightarrow 238.9$ $15$ Cypermethrin $165.1 \rightarrow 127.1$ $5$ $163.1 \rightarrow 127.1$ $5$ $Heptachlor$ epoxides ( $ris$ -) $352.8 \rightarrow 262.9$ $15$ $354.8 \rightarrow 264.9$ $15$ Dazomet $161.9 \rightarrow 89.0$ $5$ $89.0 \rightarrow 46.0$ $15$ $Heptachlor$ epoxides ( $rias$ -) $182.9 \rightarrow 118.9$ $25$ $289.0 \rightarrow 219.0$ $30$ Deltamethrin $252.9 \rightarrow 93.0$ $15$ $253.0 \rightarrow 174.0$ $5$ $Hexachlorobenzene$ $283.8 \rightarrow 213.9$ $30$ $281.8 \rightarrow 211.9$ $30$ Demeton-O $88.0 \rightarrow 60.0$ $5$ $171.0 \rightarrow 115.0$ $10$ $Indoxacarb$ $202.9 \rightarrow 134.0$ $15$ $203.0 \rightarrow 78.0$ $30$ Demeton-S $88.0 \rightarrow 60.0$ $5$ $126.0 \rightarrow 65.0$ $10$ $Iprobinos$ $245.9 \rightarrow 91.0$ $15$ $203.0 \rightarrow 78.0$ $30$ <tr< td=""><td>Chlorpyrifos</td><td>196.9 → 169.0</td><td>15</td><td>198.9 → 171.0</td><td>15</td><td>aamma-HCH (lindana)</td><td>219 0 -&gt; 183 0</td><td>5</td><td>170.0 + 00.0 <math>181.0 \rightarrow 145.0</math></td><td>15</td></tr<>	Chlorpyrifos	196.9 → 169.0	15	198.9 → 171.0	15	aamma-HCH (lindana)	219 0 -> 183 0	5	170.0 + 00.0 $181.0 \rightarrow 145.0$	15
Chlorthal-dimethyl (DCPA) $300.9 \rightarrow 223.0$ $25$ $298.9 \rightarrow 221.0$ $25$ $161.0 \rightarrow 161.0$ $30.3 \rightarrow 161.0$ $5$ $216.3 \rightarrow 161.0$ $5$ $216.3 \rightarrow 161.0$ $5$ Clomazone $125.0 \rightarrow 89.0$ $15$ $204.0 \rightarrow 78.0$ $30$ $4CH$ (beta-) $218.9 \rightarrow 183.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyfluthrin $226.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ $HCH$ (delta-) $217.0 \rightarrow 181.1$ $5$ $219.0 \rightarrow 183.0$ $5$ Cyhalothrin (lambda) $208.0 \rightarrow 181.0$ $5$ $181.1 \rightarrow 152.0$ $25$ $Heptachlor$ $271.7 \rightarrow 236.9$ $15$ $273.7 \rightarrow 238.9$ $15$ Cypermethrin $165.1 \rightarrow 127.1$ $5$ $163.1 \rightarrow 127.1$ $5$ $Heptachlor$ epoxides (cis-) $352.8 \rightarrow 262.9$ $15$ $354.8 \rightarrow 264.9$ $15$ Dazomet $161.9 \rightarrow 89.0$ $5$ $89.0 \rightarrow 46.0$ $15$ $Heptachlor$ epoxides (trans-) $182.9 \rightarrow 118.9$ $25$ $289.0 \rightarrow 219.0$ $30$ Deltamethrin $252.9 \rightarrow 93.0$ $15$ $253.0 \rightarrow 174.0$ $5$ $Hexachlorobenzene$ $283.8 \rightarrow 213.9$ $30$ $281.8 \rightarrow 211.9$ $30$ Deltamethrin $252.9 \rightarrow 93.0$ $15$ $253.0 \rightarrow 174.0$ $5$ $Indoxacarb$ $202.9 \rightarrow 134.0$ $15$ $203.0 \rightarrow 78.0$ $30$ Demeton-O $88.0 \rightarrow 60.0$ $5$ $126.0 \rightarrow 65.0$ $10$ $Iprobenfos$ $245.9 \rightarrow 91.0$ $15$ $203.9 \rightarrow 91.0$ $5$ Demeton-S $88.0 \rightarrow 60.0$ $5$ $124.0 \rightarrow 78.9$ $10$ $Isazophos$ $257.0 \rightarrow 119.0$ $15$ $257.0 \rightarrow 162.0$ $5$ <td>Chlorpyrifos-methyl</td> <td>285.9 → 92.9</td> <td>20</td> <td>124.9 → 47.0</td> <td>15</td> <td>HCH (alpha_)</td> <td>216.0 - 100.0</td> <td>5</td> <td>219 0 → 183 0</td> <td>5</td>	Chlorpyrifos-methyl	285.9 → 92.9	20	124.9 → 47.0	15	HCH (alpha_)	216.0 - 100.0	5	219 0 → 183 0	5
Clomazone $125.0 \rightarrow 89.0$ $15$ $204.0 \rightarrow 78.0$ $30$ Hor (beta ) $216.0 \rightarrow 160.1$ $0$ $216.0 \rightarrow 160.1$ $0$ Cynalothrin $226.0 \rightarrow 206.0$ $15$ $162.9 \rightarrow 127.0$ $5$ $HCH$ (delta-) $217.0 \rightarrow 181.1$ $5$ $219.0 \rightarrow 183.1$ $5$ Cyhalothrin (lambda) $208.0 \rightarrow 181.0$ $5$ $181.1 \rightarrow 152.0$ $25$ $Heptachlor$ $271.7 \rightarrow 236.9$ $15$ $273.7 \rightarrow 238.9$ $15$ Cypermethrin $165.1 \rightarrow 127.1$ $5$ $163.1 \rightarrow 127.1$ $5$ $Heptachlor epoxides$ ( <i>cis-</i> ) $352.8 \rightarrow 262.9$ $15$ $354.8 \rightarrow 264.9$ $15$ Dazomet $161.9 \rightarrow 89.0$ $5$ $89.0 \rightarrow 46.0$ $15$ $Heptachlor epoxides$ ( <i>trans-</i> ) $182.9 \rightarrow 118.9$ $25$ $289.0 \rightarrow 219.0$ $30$ DBCP $157.0 \rightarrow 75.0$ $5$ $155.0 \rightarrow 75.0$ $5$ $Hexachlorobenzene$ $283.8 \rightarrow 213.9$ $30$ $281.8 \rightarrow 211.9$ $30$ Deltamethrin $252.9 \rightarrow 93.0$ $15$ $253.0 \rightarrow 174.0$ $5$ $Indoxacarb$ $202.9 \rightarrow 134.0$ $15$ $203.0 \rightarrow 78.0$ $30$ Demeton-O $88.0 \rightarrow 60.0$ $5$ $126.0 \rightarrow 65.0$ $10$ $Iprobenfos$ $245.9 \rightarrow 91.0$ $15$ $203.9 \rightarrow 91.0$ $5$ Demeton-S-methyl $88.0 \rightarrow 60.0$ $5$ $142.0 \rightarrow 78.9$ $10$ $Isazophos$ $257.0 \rightarrow 119.0$ $15$ $257.0 \rightarrow 162.0$ $5$	Chlorthal-dimethyl (DCPA)	300.9 → 223.0	25	298.9 → 221.0	25	HCH (beta-)	$210.0 \Rightarrow 101.0$ $218.9 \Rightarrow 183.1$	5	$219.0 \Rightarrow 103.0$ $219.0 \Rightarrow 183.0$	5
Cyfluthrin $226.0 \rightarrow 206.0$ 15 $162.9 \rightarrow 127.0$ 5Interfection $271.0 \rightarrow 101.1$ 5 $212.0 \rightarrow 103.1$ 5Cyhalothrin (lambda) $208.0 \rightarrow 181.0$ 5 $181.1 \rightarrow 152.0$ 25Heptachlor $271.7 \rightarrow 236.9$ 15 $273.7 \rightarrow 238.9$ 15Cypermethrin $165.1 \rightarrow 127.1$ 5 $163.1 \rightarrow 127.1$ 5Heptachlor epoxides ( <i>cis.</i> -) $352.8 \rightarrow 262.9$ 15 $354.8 \rightarrow 264.9$ 15Dazomet $161.9 \rightarrow 89.0$ 5 $89.0 \rightarrow 46.0$ 15Heptachlor epoxides ( <i>trans.</i> -) $182.9 \rightarrow 118.9$ 25 $289.0 \rightarrow 219.0$ 30DBCP $157.0 \rightarrow 75.0$ 5 $155.0 \rightarrow 75.0$ 5Hexachlorobenzene $283.8 \rightarrow 213.9$ 30 $281.8 \rightarrow 211.9$ 30Deltamethrin $252.9 \rightarrow 93.0$ 15 $253.0 \rightarrow 174.0$ 5Indoxacarb $202.9 \rightarrow 134.0$ 15 $203.0 \rightarrow 78.0$ 30Demeton-O $88.0 \rightarrow 60.0$ 5 $126.0 \rightarrow 65.0$ 10Iprobenfos $245.9 \rightarrow 91.0$ 15 $203.0 \rightarrow 78.0$ 30Demeton-S $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ 10Isazophos $257.0 \rightarrow 119.0$ 15 $257.0 \rightarrow 162.0$ 5	Clomazone	125.0 → 89.0	15	204.0 → 78.0	30		217.0 -> 181.1	5	$210.0 \rightarrow 100.0$ $219.0 \rightarrow 183.1$	5
Cyhalothrin (lambda) $208.0 \rightarrow 181.0$ 5 $181.1 \rightarrow 152.0$ $25$ Heptachlor $271.7 \rightarrow 230.3$ $13$ $270.7 \rightarrow 230.3$ $13$ $270.7 \rightarrow 230.3$ $13$ Cypermethrin $165.1 \rightarrow 127.1$ 5 $163.1 \rightarrow 127.1$ 5Heptachlor epoxides ( <i>cis</i> -) $352.8 \rightarrow 262.9$ $15$ $354.8 \rightarrow 264.9$ $15$ Dazomet $161.9 \rightarrow 89.0$ 5 $89.0 \rightarrow 46.0$ $15$ Heptachlor epoxides ( <i>trans</i> -) $182.9 \rightarrow 118.9$ $25$ $289.0 \rightarrow 219.0$ $30$ DBCP $157.0 \rightarrow 75.0$ 5 $155.0 \rightarrow 75.0$ 5Heptachlor benzene $283.8 \rightarrow 213.9$ $30$ $281.8 \rightarrow 211.9$ $30$ Deltamethrin $252.9 \rightarrow 93.0$ 15 $253.0 \rightarrow 174.0$ 5Indoxacarb $202.9 \rightarrow 134.0$ $15$ $203.0 \rightarrow 78.0$ $30$ Demeton-0 $88.0 \rightarrow 60.0$ 5 $171.0 \rightarrow 115.0$ $10$ Iprobenfos $245.9 \rightarrow 91.0$ $15$ $203.9 \rightarrow 91.0$ $5$ Demeton-S $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ $10$ Isazophos $257.0 \rightarrow 119.0$ $15$ $257.0 \rightarrow 162.0$ $5$	Cyfluthrin	226.0 → 206.0	15	162.9 → 127.0	5	Hontachlor	271.0 > 101.1	15	213.0 > 103.1 $273.7 \rightarrow 238.0$	15
Cypermethrin $165.1 \rightarrow 127.1$ 5 $163.1 \rightarrow 127.1$ 5 $163.1 \rightarrow 127.1$ 5 $163.1 \rightarrow 127.1$ 5 $163.1 \rightarrow 127.1$ 5Dazomet $161.9 \rightarrow 89.0$ 5 $89.0 \rightarrow 46.0$ 15 $157.0 \rightarrow 75.0$ 5 $155.0 \rightarrow 75.0$ 5 $124.0 \rightarrow 89.0$ 10 $124.0 \rightarrow 63.0$ 35Deltamethrin $252.9 \rightarrow 93.0$ 15 $253.0 \rightarrow 174.0$ 5 $160.0 \rightarrow 65.0$ 10 $124.0 \rightarrow 63.0$ 35Demeton-O $88.0 \rightarrow 60.0$ 5 $171.0 \rightarrow 115.0$ 10 $100.0 \rightarrow 119.0$ $15$ $203.0 \rightarrow 78.0$ 30Demeton-S $88.0 \rightarrow 60.0$ 5 $126.0 \rightarrow 65.0$ 10 $100.0 \rightarrow 119.0$ $15$ $203.0 \rightarrow 78.0$ 30Demeton-S-methyl $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ 10 $128.0 \rightarrow 119.0$ 15 $257.0 \rightarrow 162.0$ 5	Cyhalothrin (lambda)	208.0 → 181.0	5	181.1 → 152.0	25	Hentachlor enovides (cis-)	$352.8 \rightarrow 262.9$	15	$275.7 \neq 250.5$ $354.8 \rightarrow 264.9$	15
Dazomet $161.9 \rightarrow 89.0$ 5 $89.0 \rightarrow 46.0$ 15Heptenohos (nars) 102.3 $\rightarrow 110.3$ $23$ $203.0 \rightarrow 210.0$ $35$ DBCP $157.0 \rightarrow 75.0$ 5 $155.0 \rightarrow 75.0$ 5Heptenohos $124.0 \rightarrow 89.0$ 10 $124.0 \rightarrow 63.0$ $35$ Deltamethrin $252.9 \rightarrow 93.0$ 15 $253.0 \rightarrow 174.0$ 5Hexachlorobenzene $283.8 \rightarrow 213.9$ $30$ $281.8 \rightarrow 211.9$ $30$ Demeton-0 $88.0 \rightarrow 60.0$ 5 $171.0 \rightarrow 115.0$ 10Indoxacarb $202.9 \rightarrow 134.0$ 15 $203.0 \rightarrow 78.0$ $30$ Demeton-S $88.0 \rightarrow 60.0$ 5 $126.0 \rightarrow 65.0$ 10Iprobenfos $245.9 \rightarrow 91.0$ 15 $203.9 \rightarrow 91.0$ 5Demeton-S-methyl $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ 10Isazophos $257.0 \rightarrow 119.0$ 15 $257.0 \rightarrow 162.0$ 5	Cypermethrin	165.1 → 127.1	5	163.1 → 127.1	5	Hentachlor enovides (trans.)	$182.0 \rightarrow 118.0$	25	$289.0 \rightarrow 219.0$	30
DBCP $157.0 \rightarrow 75.0$ 5 $155.0 \rightarrow 75.0$ 5 $155.0 \rightarrow 75.0$ 5Heperhopitos $124.0 \Rightarrow 03.0$ $10$ $124.0 \Rightarrow 03.0$ $33$ Deltamethrin $252.9 \rightarrow 93.0$ $15$ $253.0 \rightarrow 174.0$ 5Hexachlorobenzene $283.8 \Rightarrow 213.9$ $30$ $281.8 \Rightarrow 211.9$ $30$ Demeton-0 $88.0 \rightarrow 60.0$ 5 $171.0 \rightarrow 115.0$ 10Indoxacarb $202.9 \rightarrow 134.0$ $15$ $203.0 \rightarrow 78.0$ $30$ Demeton-S $88.0 \rightarrow 60.0$ 5 $126.0 \rightarrow 65.0$ 10Iprobenfos $245.9 \rightarrow 91.0$ $15$ $203.9 \rightarrow 91.0$ 5Demeton-S-methyl $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ $10$ Isazophos $257.0 \rightarrow 119.0$ $15$ $257.0 \rightarrow 162.0$ $5$	Dazomet	161.9 → 89.0	5	89.0 → 46.0	15	Hontononhos	124.0 -> 89.0	10	$12/10 \rightarrow 63/0$	35
Deltamethrin $252.9 \rightarrow 93.0$ 15 $253.0 \rightarrow 174.0$ 5Intext introduction operation $202.9 \rightarrow 134.0$ 15 $203.0 \rightarrow 78.0$ 30Demeton-0 $88.0 \rightarrow 60.0$ 5 $171.0 \rightarrow 115.0$ 10Indoxa carb $202.9 \rightarrow 134.0$ 15 $203.0 \rightarrow 78.0$ 30Demeton-S $88.0 \rightarrow 60.0$ 5 $126.0 \rightarrow 65.0$ 10Iprobenfos $245.9 \rightarrow 91.0$ 15 $203.9 \rightarrow 91.0$ 5Demeton-S-methyl $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ 10Isazophos $257.0 \rightarrow 119.0$ 15 $257.0 \rightarrow 162.0$ 5	DBCP	157.0 → 75.0	5	155.0 → 75.0	5	Hevechlorobenzene	$124.0 \rightarrow 03.0$ 283.8 $\rightarrow 213.9$	30	$124.0 \Rightarrow 03.0$ 281.8 $\Rightarrow 211.9$	30
Demeton-0 $88.0 \rightarrow 60.0$ 5 $171.0 \rightarrow 115.0$ 10Indoxacian $202.9 \rightarrow 93.0$ 15 $203.0 \rightarrow 78.0$ 30Demeton-S $88.0 \rightarrow 60.0$ 5 $126.0 \rightarrow 65.0$ 10Iprobenfos $245.9 \rightarrow 91.0$ 15 $203.9 \rightarrow 91.0$ 5Demeton-S-methyl $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ 10Iprodione $313.8 \rightarrow 55.9$ 20 $313.8 \rightarrow 244.9$ 10IndoxacianIndoxacianIprobenfosIprodione $257.0 \rightarrow 119.0$ 15 $257.0 \rightarrow 162.0$ 5	Deltamethrin	252.9 → 93.0	15	253.0 → 174.0	5	Indoxacarh	$200.0 \times 210.9$ 202 9 $\rightarrow 12/10$	15	201.0 -> 79.0	30
Demeton-S         88.0 $\rightarrow$ 60.0         5         126.0 $\rightarrow$ 65.0         10         Iproteines         243.3 $\rightarrow$ 51.0         13         203.3 $\rightarrow$ 51.0         5           Demeton-S-methyl         88.0 $\rightarrow$ 60.0         5         142.0 $\rightarrow$ 78.9         10         Iproteines         313.8 $\rightarrow$ 55.9         20         313.8 $\rightarrow$ 244.9         10           Isazophos         257.0 $\rightarrow$ 119.0         15         257.0 $\rightarrow$ 162.0         5	Demeton-0	88.0 → 60.0	5	171.0 → 115.0	10	Inrohenfos	$232.0 \neq 104.0$ $245.9 \Rightarrow 01.0$	15	$203.0 \Rightarrow 70.0$ 203.9 $\Rightarrow$ 91.0	5
Demeton-S-methyl $88.0 \rightarrow 60.0$ 5 $142.0 \rightarrow 78.9$ 10Isazophos $257.0 \rightarrow 119.0$ 15 $257.0 \rightarrow 162.0$ 5	Demeton-S	88.0 → 60.0	5	126.0 → 65.0	10	Inrodione	$213.8 \rightarrow 55.9$	20	$200.0 \Rightarrow 01.0$ 313.8 $\rightarrow 244.0$	10
isazupilus 207.0 - 119.0 10 207.0 - 102.0 0	Demeton-S-methyl	88.0 → 60.0	5	142.0 → 78.9	10	leazonhoe	257 0 → 110 0	20 15	257 0 → 162 0	5
Demeton-S-methyl sulfone $169.1 \rightarrow 109.0$ 15 $169.1 \rightarrow 125.1$ 5 Isonronalin $264.0 \rightarrow 222.2$ 5 $238.0 \rightarrow 165.2$ 10	Demeton-S-methyl sulfone	169.1 → 109.0	15	169.1 → 125.1	5	Isopropalin	264.0 → 222.2	5	$238.0 \rightarrow 165.0$	10

Table 3. Quantifier and qualifier MRM transitions for target pesticides\*.

\*Note: for analytes with multiple artifacts, the one with the highest response was analyzed and quantified.

	Quantifier	Quantifier				Quantifier		Qualifier	
Compound	Transition	CE	Transition	CE	Compound	Transition	CE	Transition	CE
Isoprothiolane	162.1 → 85.0	20	189.1 → 89.0	20	Pendimethalin (penoxaline)	251.8 → 162.2	10	251.8 → 161.1	15
Leptophos	377.0 → 362.0	20	376.8 → 361.8	20	Permethrin	163.0 → 127.0	5	183.1 → 165.1	10
Malathion	172.9 → 99.0	15	126.9 → 99.0	5	Phorate	121.0 → 47.0	30	260.0 → 75.0	10
Metalaxyl	234.0 → 146.1	20	234.0 → 174.1	10	Phosalone	182.0 → 75.1	30	182.0 → 111.0	15
Methamidophos	141.0 → 64.0	20	141.0 → 95.0	5	Phosphamidon (E)	264.0 → 127.0	15	264.0 → 72.0	10
Methidathion	144.9 → 85.0	5	144.9 → 58.1	15	Phosphamidon (Z)	264.0 → 127.0	15	192.9 → 127.0	5
Methiocarb	168.0 → 109.1	15	168.0 → 91.0	30	Piperonyl butoxide	176.1 → 103.1	25	176.1 → 131.1	15
Methiocarb sulfone	200.0 → 121.0	15	185.0 → 121.0	5	Pirimicarb	238.0 → 166.2	10	166.0 → 55.1	20
Methomyl	105.0 → 88.0	5	105.0 → 58.0	10	Pirimiphos-methyl	290.0 → 125.0	20	232.9 → 151.0	5
Methoprene	153.0 → 111.1	5	153.0 → 83.0	20	Profenofos	338.8 → 268.7	15	207.9 → 63.0	30
Methoxychlor	227.0 → 169.1	25	227.0 → 141.1	40	Propoxur	110.0 → 63.0	25	110.0 → 64.0	15
Metolachlor	238.0 → 162.2	10	162.2 → 133.2	15	Prothiofos	308.9 → 238.9	15	266.9 → 239.0	5
Mevinphos	127.0 → 95.0	15	192.0 → 127.0	10	Pyrazophos	221.0 → 193.1	10	232.0 → 204.1	10
Mexacarbate	165.1 → 134.0	10	165.1 → 150.0	15	Quinalphos	298.0 → 156.0	20	157.0 → 102.0	30
Mirex	271.8 → 236.8	15	273.8 → 238.8	15	Quizalofop-p-ethyl	371.8 → 298.9	10	163.0 → 136.0	10
Monocrotophos	192.0 → 127.1	10	127.1 → 95.0	15	Schradan	153.1 → 46.1	15	199.0 → 92.0	5
Myclobutanil	179.0 → 125.1	10	150.0 → 123.0	15	Tefluthrin	177.1 → 87.0	30	177.1 → 127.1	15
Naled	144.9 → 109.0	15	184.9 → 93.0	15	Teflubenzuron	197.0 → 135.0	30	197.0 → 142.0	25
Napropamide	271.0 → 72.1	15	128.0 → 72.1	5	Terbufos	230.9 → 129.0	20	230.9 → 175.0	10
Nitrofen	202.0 → 139.1	20	282.9 → 253.0	10	Terbufos sulfone	264.0 → 97.0	25	199.0 → 97.0	20
<i>o,p'</i> -DDD	235.0 → 165.2	20	237.0 → 165.2	20	Tetrachlorvinphos	330.8 → 108.9	15	328.8 → 108.9	15
<i>o,p'</i> -DDE	246.0 → 176.2	30	248.0 → 176.2	30	Tetradifon	158.9 → 111.0	20	353.8 → 226.8	10
<i>o,p'</i> -DDT	235.0 → 165.0	20	237.0 → 165.0	20	Thiamethoxam	212.0 → 139.0	15	212.0 → 125.0	10
Omethoate	155.9 → 110.0	5	155.9 → 79.0	20	Thionazin	143.0 → 79.0	10	175.0 → 79.0	10
Oxadixyl	163.0 → 132.1	5	232.9 → 146.1	10	Triadimefon	208.0 → 181.1	5	208.0 → 111.0	20
Oxamyl	98.0 → 58.0	10	145.0 → 71.9	20	Triadimenol	168.0 → 70.0	10	128.0 → 65.0	25
p,p'-DDD	235.0 → 165.0	20	237.0 → 165.0	20	Triazophos	257.0 → 162.1	5	161.2 → 134.2	5
<i>p,p'</i> -DDE	315.8 → 246.0	15	246.1 → 176.2	30	Trichlorfon	145.0 → 109.0	12	109.0 → 79.0	10
<i>p,p'</i> -DDT	235.0 → 165.0	20	237.0 → 165.0	20	Triflumuron	139.0 → 75.0	30	139.0 → 111.0	15
Parathion	290.9 → 109.0	10	138.9 → 109.0	5	Trifluralin	305.9 → 264.0	5	290.0 → 248.0	5
Parathion-methyl	262.9 → 109.0	10	232.9 → 109.0	10	Uniconazole	234.1 → 137.0	15	234.1 → 165.1	10
Penconazole	248.0 → 192.1	15	248.0 → 157.1	25	Vamidothion	141.9 → 78.9	10	145.0 → 87.0	5

Table 3. Quantifier and qualifier MRM transitions for target pesticides\*.

Note: for analytes with multiple artifacts, the one with the highest response was analyzed and quantified.

## **Results and Discussion**

#### Recovery

Table 4 shows the mean recoveries of three repetitive tobacco samples at 0.05 and 0.5 mg/kg, respectively. For both concentration levels, 95% of the pesticides were in the range of 70 to 120%, showing excellent recoveries. The mean recoveries of 70 to 120% and RSD  $\leq$  20% represent widely acceptable validation criteria in pesticide residue analysis, but other criteria could be used and justified depending on the purpose of the analysis. For example, the Pesticide Data Program (PDP) requires mean recoveries of 50 to 150% for methods used for analysis of PDP samples [9], because the main aim of PDP is to provide exposure data, and ideally include as many pesticides as possible in multiresidue methods.

If they are consistent (RSD  $\leq$  20%), some compounds with recoveries outside 70 to 120% can still be analyzed by QuEChERS, but may require special consideration. Compounds such as captan, chlorothalonil, diflubenzuron, and folpet are base-sensitive and unstable even in acetonitrile. They tend to degrade in the presence of basic compounds (at higher pH), and often present issues in terms of recovery from the matrix and precision during analysis. Although not used in this study, the evaluation of their corresponding internal standards such as captan-d6 and folpet-d4 are recommended [10] to control recovery and ensure reliable results, especially for longer batches in which the number of injections exceeds 40. Compounds such as benfuracarb and carbosulfan are acid-sensitive and degrade at lower pH.

				Recove				
	Linearity		0.05 m	g/kg				
Pesticide	Linear range (mg/kg)	R <sup>2</sup>	Recovery (%)	%RSD	Recovery (%)	%RSD	LOD (mg/kg)	LOQ (mg/kg)
3-Hydroxycarbofuran	0.01-2	0.9958	95.26	11.98	106.21	6.17	0.0416	0.1388
Acephate	0.01-2	0.9973	78.95	9.89	76.12	4.11	0.0036	0.0121
Acetamiprid	0.01-2	0.9985	101.3	2.34	107.03	2.11	0.0074	0.0246
Acibenzolar-S-methyl	0.01-2	0.9976	88.61	0.48	98.16	1.65	0.0014	0.0045
Alachlor	0.01-2	0.9984	99.29	3.2	100.68	1.86	0.0015	0.0052
Aldrin	0.01-2	0.9997	92.71	0.93	105.2	0.86	0.002	0.0068
<i>alpha</i> -Endosulfan	0.01-2	0.9993	101.24	4.88	108.07	2.46	0.0026	0.0088
Azinphos-ethyl	0.01-2	0.9925	92.8	2.32	94.73	2.32	0.0018	0.0059
Azinphos-methyl	0.01-2	0.9942	103.94	5.11	88.6	0.57	0.0213	0.0711
Azoxystrobin	0.01-2	0.9977	104.3	6.05	108.05	1.68	0.0037	0.0125
Benalaxyl	0.01-2	0.9996	104.12	2.07	106.13	2.77	0.001	0.0034
Benfluralin	0.01-2	0.9796	86.6	3.81	85.13	2.57	0.0023	0.0077
Benfuracarb	0.01-2	0.9990	78.45	2.82	78.57	3.09	0.0023	0.0077
<i>beta</i> -Endosulfan	0.01-2	0.9993	103.62	5.35	105.88	1.83	0.0067	0.0223
Bifenthrin	0.01-2	0.9999	103.37	1.28	108.8	1.61	0.0026	0.0088
Bitertanol	0.01-2	0.9994	103.58	2.89	106.16	1.45	0.0027	0.0089
Bromacil	0.01-2	0.9992	96.42	1.63	101.98	1.86	0.0013	0.0044
Bromophos	0.01-2	0.9990	95.63	1.96	102.49	1.6	0.0012	0.0041
Butralin	0.01-2	0.9764	86.01	2.22	84.08	2.05	0.0025	0.0083
Cadusafos	0.01-2	0.9990	94.92	5.19	100.05	2.46	0.0026	0.0086
Captafol	0.01-2	0.9991	94.37	22.53	74.16	10.38	0.0222	0.0739
Captan	0.01-2	0.9954	77.23	3.74	79.66	9.92	0.0061	0.0204
Carbarvl	0.01-2	0.9991	98.84	0.78	102.09	2.79	0.0032	0.0107
Carbofuran	0.01-2	0.9967	113.25	13.81	107.89	1.65	0.0134	0.0446
Carbosulfan	0.01-2	0.9980	83.01	5.14	98.27	0.6	0.0018	0.0059
Chinomethionate (oxythioguinox)	0.01-2	0.9989	63.97	5.88	58.37	2.49	0.0017	0.0056
Chlorantraniliprole	0.01-2	0.9982	129.44	2.96	123.13	3.23	0.004	0.0132
Chlordane ( <i>cis</i> -)	0.01-2	0.9994	94.74	7.3	105.68	2.6	0.0031	0.0103
Chlordane (trans-)	0.01-2	0.9995	97.11	2.41	105.74	1.86	0.0027	0.0091
Chlordimeform	0.01-2	0.9996	92 57	2.85	93.24	1.97	0.0026	0.0086
Chlorfenvinphos	0.01-2	0.9989	101.32	3.62	104.28	1.26	0.0011	0.0037
Chlornitrofen	0.01-2	0.9886	92.29	1.41	93.14	3.44	0.0039	0.0129
Chlorobenzilate	0.01-2	0.9996	101.61	1.95	107.34	1.65	0.0011	0.0037
Chlorothalonil	0.01-2	0.9958	31.84	15.52	46.19	3.11	0.0019	0.0065
Chlorpyrifos	0.01-2	0.9992	95.06	6.73	105.14	1.95	0.0025	0.0085
Chlorpyrifos-methyl	0.01-2	0.9982	94 51	3.18	100.01	1.85	0.0023	0.0076
Chlorthal-dimethyl (DCPA)	0.01-2	0.9996	99.72	3.62	106.3	1.58	0.0008	0.0027
Clomazone	0.01-2	0.9995	97.78	2.71	100.83	3.97	0.0014	0.0045
Cyfluthrin	0.01-2	0.9940	99.34	4.3	99 79	2.14	0.0014	0.0047
Cyhalothrin ( <i>lamhda</i> )	0.01-2	0.9931	96.48	3 61	95.36	0.57	0.0012	0.004
Cypermethrin	0.01-2	0.9927	103.83	5.85	101.93	1.04	0.0025	0.0083
Dazomet	0.01-2	0.9971	78 53	7.59	88.67	2.76	0.003	0.0099
DBCP	0.01-2	0,9999	86 41	0.64	93.17	6.56	0.0019	0,0062
Deltamethrin	0.01-2	0.9864	95.48	6.67	91.64	2.23	0.003	0.0101
Demeton-0	0.01-2	0,9991	107.06	10.43	101.67	2.54	0.0017	0.0057
Demeton-S	0.01-2	0.9980	94 01	6 4 6	98 75	2.04	0.007	0.0065
Demeton-S-methyl	0.01-2	0.9979	93 46	6.69	99.2	2.36	0.004	0.0133
Demeton-S-methyl sulfone	0.01-2	0 9945	90.44	4 22	86.32	3.97	0.0031	0.0103
Diazinon	0.01-2	0 9992	95 75	3.04	100 53	3.04	0.003	0 0000
Dichlorvos	0.01-2	0 9999	112.03	5.74	122.71	3.44	0.0037	0.0122

Table 4. Method validation data: linearity, recovery (n = 3), RSD (n = 3), LOD, and LOQ of 162 pesticides.

	Recovery and %RSD							
	Linearity		0.05 m	g/kg	0.5 m	g/kg		
	Linear range		Recovery		Recovery		LOD	L00.
Pesticide	(mg/kg)	R <sup>2</sup>	(%)	%RSD	(%)	%RSD	(mg/kg)	(mg/kg)
Dicloran	0.01-2	0.9950	93.75	2.11	95.61	4.68	0.0028	0.0092
Dieldrin	0.01-2	0.9998	105.82	5.78	108.27	2.73	0.0043	0.0142
Difenoconazole	0.01-2	0.9985	105.12	2.14	108.8	1.27	0.0034	0.0115
Dimefox	0.01-2	0.9997	90.95	8.55	94.64	5.17	0.0036	0.0121
Dimetachlone	0.01-2	0.9998	99.98	5.29	105.32	1.69	0.003	0.01
Dimethoate	0.01-2	0.9960	97.04	5.59	98.46	0.61	0.003	0.0101
Dimethomorph (E)	0.01-2	0.9990	104.55	4.02	109.43	1.11	0.0017	0.0055
Dimethomorph (Z)	0.01-2	0.9997	105.95	3.4	113.19	2.29	0.0028	0.0093
Diphenamid	0.01-2	0.9996	101.55	4.29	105.3	1.21	0.0011	0.0036
Disulfoton	0.01-2	0.9984	92.8	1.86	99.38	2.75	0.0023	0.0075
Disulfoton sulfone	0.01-2	0.9965	94.79	5.19	99.66	0.95	0.0026	0.0088
Disulfoton sulfoxide	0.01-2	0.9976	105.45	8.03	104.96	8.06	0.003	0.01
Endosulfan-sulphate	0.01-2	0.9995	102.74	2.37	106.35	1.13	0.0009	0.0031
Endrin	0.01-2	0.9994	94.83	3.33	105.86	1.11	0.0039	0.0129
EPN	0.01-2	0.9946	96.29	3.99	97.99	2.26	0.0014	0.0048
Ethion	0.01-2	0.9959	97.75	4.41	101.84	2.27	0.0016	0.0052
Ethoprophos	0.01-2	0.9989	93.44	5.69	100.76	1.57	0.0033	0.0108
Famoxadone	0.01-2	0.9845	96.3	7.56	94.2	1.15	0.0039	0.0131
Fenaminhos (nhenaminhos)	0.01-2	0.9991	99.23	3.11	102.83	1.86	0.0023	0.0075
Fenamiphos sulfone	0.01-2	0.9979	101.7	3.25	102.54	1.47	0.0013	0.0045
Fenamiphos-sulfoxide	0.01-2	0.9840	97.96	6.87	86.91	0.81	0.002	0.0067
Fenchlorphos (Bonnel)	0.01-2	0.9990	97.07	4.74	104.12	0.96	0.002	0.0065
Fenitrothion	0.01-2	0.9804	86.01	3.82	86.01	0.74	0.0026	0.0085
Fensulfothion	0.01-2	0.9874	113 76	2 77	120.81	3.12	0.0028	0 0094
Fenthion	0.01-2	0.9994	97.7	5.98	103.19	0.1	0.0024	0.0078
Fenthion sulfone	0.01-2	0.9979	93 67	6.96	97.65	2.82	0.0031	0.0102
Fenthion sulfoxide	0.01-2	0.9976	95.04	4 15	96.24	1.56	0.002	0.0066
Fenvalerate	0.01-2	0.9878	112.17	1.57	95.4	2.55	0.0072	0.0241
Flucythrinate	0.01-2	0.9959	106.16	2.37	106.38	2.89	0.0009	0.0031
Flumetralin	0.01-2	0.9904	90.29	5.57	93.81	1.97	0.0023	0.0076
Folpet	0.01-2	0.9906	75.72	5.77	71.03	8.01	0.0025	0.0082
Fonofos	0.01-2	0.9985	93 59	3 4 4	98 78	2.8	0.0017	0.0056
Formothion	0.01-2	0.9971	86 49	2 55	87.42	3.52	0.0029	0.0098
gamma-HCH (lindane)	0.01-2	0.9988	93.99	1 46	96.48	4.32	0.0013	0.0043
HCH (alpha-)	0.01-2	0.9991	94 48	2 64	100.32	3.89	0.0015	0.0049
HCH (heta-)	0.01-2	0.9981	97.69	3.91	98 73	3.95	0.0012	0.0039
HCH (delta-)	0.01-2	0.9990	96.07	3.67	97.4	4 18	0.0012	0.0043
Hentachlor	0.01-2	0.9967	89.21	3 27	98.28	2 77	0.0013	0.0043
Hentachlor enoxides ( <i>cis</i> -)	0.01-2	0.9993	95.93	3 73	105 75	2.06	0.002	0.0066
Hentachlor epoxides (trans-)	0.01-2	0.9996	104 44	6 65	106.73	2.00	0.002	0.0125
Hentenonhos	0.01-2	0.9989	93 56	5.38	99.32	2.22	0.0029	0.0098
Hexachlorobenzene	0.01-2	0.9997	83 24	2 29	95 74	3.13	0.0015	0.0051
Indoxacarb	0.01-2	0.9998	106 45	3 22	115 42	1 11	0.0010	0.0001
Inrobentos	0.01_2	0.0000	96.43	3.84	100.83	1 52	0.0035	0.0117
Inrodione	0.01_2	0.0000	99.45	5 51	105.60	2.37	0.0025	0.0085
Isazonhos	0.01-2	0.0000	97 65	2 4 2	98 61	5.92	0.0020	0.0000
Isonronalin	0.01-2	0.0000	87.05	1 75	87.92	1 55	0.0023	0.0000
Isopropulli	0.01-2	0.0022	101 5	1 29	106.6	1.00	0.0024	0.0001
Lentonhos	0.01-2	0.0000 N QQQ1	96 11	3.87	104	1 77	0.0003	0.0023
Malathion	0.01-2	0.0001	96 68	4 77	100 62	1 21	0.0010	0.0032
Metalaxvl	0.01-2	0.0070	99.00	4.16	105.66	1.52	0.0021	0.007
motulunyi	0.01-2	0.0001	00.20	-T. T.U	100.00	1.02	0.0020	0.0007

				Recove	ry and %RSD			
	Linearity		0.05 m	g/kg	0.5 m	g/kg		
	Linear range		Recovery		Recovery		LOD	L00.
Pesticide	(mg/kg)	R <sup>2</sup>	(%)	%RSD	(%)	%RSD	(mg/kg)	(mg/kg)
Methamidophos	0.01-2	0.9985	64.8	9.05	72.27	3.05	0.004	0.0134
Methidathion	0.01-2	0.9980	94.26	2.82	98.29	1.07	0.0023	0.0075
Methiocarb	0.01-2	0.9993	97.78	4.25	102.84	1.89	0.0017	0.0057
Methiocarb sulfone	0.01-2	0.9973	92.5	2.96	100.65	1.07	0.0035	0.0118
Methomyl	0.01-2	0.9970	120.17	10.64	106.37	10.74	0.006	0.0201
Methoprene	0.01-2	0.9988	107.7	10.08	104.43	3.23	0.0179	0.0595
Methoxychlor	0.01-2	0.9970	93.03	1.39	94.25	5.39	0.0022	0.0072
Metolachlor	0.01-2	0.9991	97.92	2.1	103.27	1.29	0.0009	0.003
Mevinphos	0.01-2	0.9992	95.16	4.22	97.9	1.37	0.0058	0.0195
Mexacarbate	0.01-2	0.9991	99.65	4 4 2	101.16	3.76	0.0021	0.007
Mirex	0.01-2	0.9995	88.83	1.75	103.68	1.92	0.001	0.0032
Monocrotophos	0.01-2	0.9946	88	10.24	90.02	2.7	0.0052	0.0172
Myclobutanil	0.01-2	0.9997	103.08	1	106.29	1.24	0.0013	0.0044
Naled	0.01-2	0.9872	27.35	2.48	15.82	18.06	0.0019	0.0062
Napropamide	0.01-2	0.9995	101.99	1.08	105.75	1.08	0.0025	0.0083
Nitrofen	0.01-2	0.9924	93.4	2 75	94 42	1 19	0.0028	0 0095
a n'-DDD	0.01-2	0.9997	101 75	0.8	110 48	1.03	0.001	0.0034
o,p' 200	0.01-2	0.0007	95.92	1.07	107.07	0.81	0.0015	0.0051
a n'-DDT	0.01-2	0.0007	95.75	1.07	107.07	1 Q1	0.0010	0.0001
Omethoate	0.01-2	0.0070	83 31	11 12	82.39	4.61	0.0021	0.007
	0.01-2	0.0001	106.24	3.18	106 29	1 77	0.0007	0.0120
Oxamyl	0.01-2	0.0000	100.24	8.43	96.25	5.86	0.0013	0.0001
	0.01-2	0.0071	107.10	0.4J 2.1	100.25	1.4	0.0207	0.0003
<i>p,p</i> • 000	0.01-2	0.0001	158 52	6.65	111 0/	1. <del>4</del> 2.2	0.001	0.0052
<i>p,p</i> • 002	0.01-2	0.0067	100.52	3.45	05.5	6 70	0.0103	0.000
Parathion	0.01-2	0.03507	88.20	3.45	86.33	1.52	0.0030	
Parathion mothyl	0.01-2	0.0754	87 10	J.30	88.47	3.18	0.003	0.0033
Ponconazolo	0.01-2	0.0000	100.13	3.0/	103 //	0.47	0.0020	0.0034
Pendimethalin (nenovaline)	0.01-2	0.5554	100.03 02.07	2.16	02.0	1.0	0.0010	0.0000
Permethrin	0.01-2	0.0700	02.07	0.07	107.26	1.0	0.003	0.0033
Phorato	0.01-2	0.0070	0/ /2	2.07	0011	2 02	0.002	0.0000
Phasalana	0.01-2	0.3370	06 62	2.37	100 12	2.02	0.0023	0.0030
Phoenhamidon (E)	0.01-2	0.5500	02 1	2.4 12.20	09 59	2.90	0.0012	0.0039
Phoenhamidon (Z)	0.01-2	0.3371	07.0/	15.55	00.00	2.05	0.0012	0.0041
Pinospilaliluoli (2)	0.01-2	0.9972	97.94 110.20	4.04	90.44 106 /	2.40	0.0010	0.005
Piperollyi butoxide	0.01-2	0.9990	101.20	1.09	100.4	2.00	0.0023	0.0075
Piriminhaa mathul	0.01-2	0.0001	05 16	1.37	103.44	1.41	0.0014	0.0047
Profession	0.01-2	0.9901	90.10 00.EC	4.70	101.20	1.21	0.0017	0.0000
Protenoios	0.01-2	0.9900	90.00	2.31	104.9	1.00	0.0024	0.0002
Protoco	0.01-2	0.9993	97.23	4.97	103.02	1.55	0.0020	0.0007
Protiniolos	0.01-2	0.9989	97.90	1.00	103.32	1.17	0.0015	0.0052
Pyrazophos	0.01-2	0.9970	99.03 00.05	1.98	100.77	1.4	0.0015	0.005
Quinalphos	0.01-2	0.9984	99.95	3.3 4.00	101.18	3.7	0.0041	0.0138
Quizalotop- <i>p</i> -etnyl	0.01-2	0.9988	102.40	4.23	107.90	1.99	0.0014	0.0048
Schradan Taflada in	0.01-2	0.9939	94.01	1.1	85.95 105.00	3.14	0.0023	0.0070
	0.01-2	0.9996	101.33	1.27	105.38	3.87	0.0014	0.0048
Terrubenzuron	0.01-2	0.9996	95.89	0.04	99.8/	5.37	0.0004	0.0052
Terbufos aultara	0.01.2	0.9965	92.01	5.1J	97.UJ	3.U5 2.52	0.0024	0.00/9
Terputos suitone	0.01.2	0.9972	91.00	4.51	100.41	2.53		0.0042
ietrachiorvinphos	0.01-2	0.9989	97.53	1.72	99.85	1.16	0.0025	0.0082
letraditon	0.01-2	0.9997	103.63	2.25	106.68	2.12	0.0008	0.0028
Ihiamethoxam	0.01-2	0.9986	101.04	3.29	100.03	1.66	0.0018	0.006

	Recovery and %RSD							
Pesticide	Linearity	0.05 mg/kg		0.5 mg/kg				
	Linear range (mg/kg)	R <sup>2</sup>	Recovery (%)	%RSD	Recovery (%)	%RSD	LOD (mg/kg)	LOQ (mg/kg)
Thionazin	0.01-2	0.9988	94.57	5.34	100.92	2.39	0.0028	0.0094
Triadimefon	0.01-2	0.9994	97.77	3.36	103.18	2.13	0.002	0.0066
Triadimenol	0.01-2	0.9998	96.31	4.96	104.37	0.66	0.0017	0.0058
Triazophos	0.01-2	0.9976	101.33	1.78	101.32	2.38	0.0022	0.0073
Trichlorfon	0.01-2	0.9970	86.41	12	84.19	5.46	0.0042	0.0138
Triflumuron	0.01-2	0.9993	96.79	4.56	103.99	1.55	0.0031	0.0103
Trifluralin	0.01-2	0.9887	91.83	6.06	92.37	2.27	0.0034	0.0113
Uniconazole	0.01-2	0.9995	102.08	2.6	104.09	0.82	0.0025	0.0084
Vamidothion	0.01-2	0.9944	86.29	11.05	85.34	2.68	0.0024	0.0081

#### **Backflushing the column**

The GC/MS/MS system used a Purged Ultimate Union (PUU), and its configuration is shown in Figure 1. Backflushing was done for 5 minutes after the run by raising the pressure at the PUU and lowering the inlet pressure. This reversed the flow through the column and purged high-boiling matrix components from the head of the column, out through the inlet's split vent. With the PUU installed, inlet and GC column maintenance is possible without venting the mass spectrometer. Figure 2 shows that 5 minutes of backflushing cleaned the analytical columns and reduced the cycle time for target analytes in tobacco extracts.

During the course of this study, approximately 200+ 1  $\mu$ L injections of concentrated tobacco extracts were made into the GC/MS/MS system with no evidence of column or MS performance problems, as shown in Figure 3.



RT locking compound – chlorpyrifos-methyl at 18.700 minutes

Figure 1. Hardware diagram of the Agilent Tobacco Analyzer. The GC/MS/MS system used for MRM analysis was configured with A) Multimode Inlet, B) Purged Ultimate Union, and C) two Agilent J&W DB-5ms UI, 15 m  $\times$  0.25 mm, 0.25 µm, GC columns.



Figure 2. Backflushing cleaned the analytical columns and reduced the cycle time for target analytes in tobacco extracts.



Figure 3. Chromatograms of clomazone, triadimefon, myclobutanil, and permethrin at 0.01 mg/kg after 200+ 1 µL injections of concentrated tobacco extracts.

#### Accurate calibration

A set of eight calibration matrix standards were injected consecutively, and yielded coefficient of correlation values ( $R^2$ ) that were > 0.99 in over 92% of the cases. Naled, trifluralin, benfluralin, parathion-methyl, fenitrothion, isopropalin, pendimethalin, fensulfothion, chlornitrofen, fenamiphos-sulfoxide, fenvalerate, deltamethrin, and famoxadone yielded  $R^2$  values from 0.98 to 0.99. Parathion and butralin yielded  $R^2$  values from 0.97 to 0.98. Figure 4 shows calibration curves obtained in the tobacco matrix for six commonly detected pesticides in tobacco, namely triadimefon, metalaxyl, isoprothiolane, clomazone, acetamiprid, and cyfluthrin.

Some pesticides, especially organophosphates, degrade in solvents. For these pesticides, pure solid phase standards are suggested for storage. They need to be diluted and analyzed in a timely manner to achieve better linearity. The current MS gain factor setting in this study was 10. This may be lowered to achieve a larger linear range, if necessary.

#### LOOs well below MRLs

The LOD and LOQ calculations follow the EPA model, which is approached with replicates using a t-value at 99% confidence [11]. In this study, seven repetitive injections of tobacco matrix blanks with known low concentration levels of spiked pesticides were analyzed to calculate LOD and LOQ. LOQs of all 162 pesticides were well below the GRLs issued by ACAC [1].

Although all 162 pesticides can be analyzed with GC/MS, to achieve even lower LOQs, the preferred technique for some pesticides is LC/MS. These include some benzoylurea insecticides such as diflubenzuron, teflubenzuron, and triflumuron; some carbamates such as benfuracarb, carbaryl, carbofuran, 3-hydroxycarbofuran, carbosulfan, methiocarb, methomyl, oxamyl, and pirimicarb; more polar or otherwise problematic organophosphates such as acephate, azinphos-Et/Me, dimethoate, methamidophos, monocrotophos, naled, and omethoate; some neonicotinoids such as acetamipirid and thiamethoxam; and nonhalogenated pyrethroids.



Figure 4. Calibration curves in a tobacco matrix for representative pesticides triadimefon, metalaxyl, isoprothiolane, clomazone, acetamiprid, and cyfluthrin.

Other features that can affect LOQs include pesticide stability and the lack of characteristic precursor ions using electron ionization. When using electron ionization, pesticides such as captafol and methoprene have fragmented El spectra and lack characteristic precursors, product ions, or MRM transitions, that affect their LOQs. Degradation of pesticides is also a common reason why some pesticides do not have good LOQs. Because naled and trichlorfon degrade to dichlorvos even at room temperature, these three pesticides are sometimes analyzed together and quantified using dichlorvos, only. Teflubenzuron degrades to three main artifacts, and only the artifact with the highest response was analyzed in this study. Captan not only has a fragmented El spectrum, but also tends to degrade to 1,2,3,6-tetrahydrophthalimide, which affect its LOD and LOQ.

#### **Excellent RSDs**

Figure 5A shows seven consecutive injections of each sample at concentration levels near LOQ and 0.1 mg/kg, respectively. Of 162 pesticides tested, 159 were at the concentration level near LOQ, and 161 at 0.1 mg/kg yielded %RSDs less than 15%.

Figure 5B shows the number of pesticides in tobacco with given %RSD values based on calculated amounts at two concentrations, 0.05 and 0.5 mg/kg. Percentage RSD values were obtained from three repetitive recovery study samples, and each was injected once on the GC/MS/MS. Of 162 pesticides tested, 160 at 0.05 mg/kg (98.8%), and 161 at 0.5 mg/kg (99.4%) yielded %RSD less than 15%.

In both studies, repeatability was excellent, showing less than 15% RSD for over 95% of the pesticides, even for the most challenging compounds omethoate, acephate, and DDT. Some pesticides, such as p,p'-DDT and methoxychlor, have similar structures and are known to degrade in the GC inlet, causing signal variability. In such cases, a suitable, compound-specific ISTD can be added to the final extract before instrumental analysis for signal normalization. For p,p'-DDT, the postextraction addition of a labeled ISTD ( $^{13}C_{12}$ -p,p'-DDT) can be a cost-effective way to address degradation and other potential GC-related issues.



Figure 5. Distribution of %RSD of 162 pesticides in tobacco matrices: (A) seven consecutive injections of one sample at the concentration level near LOQ and at 0.1 mg/kg, (B) three repetitive recovery study samples at two different concentration levels of 0.05 and 0.5 mg/kg.

#### **Matrix effects**

Some pesticides showed consistent responses in different matrices, but some pesticides had different responses in different matrices due to either matrix enhancement or matrix suppression, and sometimes even slightly different retention time. Disulfoton sulfoxide, formothion, heptenophos, and tefluthrin spiked at 0.1 mg/kg were used as probes. Figure 6 shows the matrix effect of three different tobacco matrices from two different countries. The matrix enhancement of disulfoton sulfoxide and formothion in tobacco matrix 3 was stronger than the one in tobacco matrices 1 and 2. The retention time of disulfoton sulfoxide was also affected by different matrices. Heptenophos and tefluthrin showed consistent results in all three matrices. Therefore, matrix effect was compound dependent and it is important to use matrix-matched calibrations to achieve accurate quantitation results.



Figure 6. Chromatograms of disulfoton sulfoxide, formothion, heptenophos, and tefluthrin in three different tobacco matrices: (A-C) matrix blanks of three different tobacco matrices, (D-F) spiked at 0.1 mg/kg in three different matrix blanks.

## Conclusions

The Agilent 7000C Triple Quadrupole GC/MS/MS Analyzer for Pesticides in Tobacco is a sensitive and rugged tool for target pesticide analysis in this complex matrix. The design of the system enables lower detection limits for pesticides when combined with an inert sample path and GC column backflushing. The high sensitivity EI Extractor Ion Source with improved thermal characteristics delivers confident trace analysis even in tobacco matrices, and the Triple-Axis HED-EM Detector reduces neutral noise by the doubly off-axis position of the HED-EM. These features enabled LOQs well below the GRLs issued by ACAC. Excellent linearity  $(R^2 > 0.99)$  for over 92% of 162 pesticides and excellent analysis repeatability (%RSD < 15%) for over 95% of 162 pesticides in tobacco matrices were achieved. The modified QuEChERS method using Agilent Bond Elut **QuEChERS** Extraction and Dispersive kits yielded excellent recoveries from 70 to 120% for 95% of all test pesticides.

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