

一站式流程化农残检测解决方案：TSQ Endura LC-MS/MS 与 TraceFinder 软件用于蔬菜基质中 440 种农残同时定量的高通量分析

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1. 前言

近些年来, 此起彼伏的食品安全事件引起了人们强烈的关注, 持续不断地严格加强食品安全监管已经成为全社会最大的共识, 这直接刺激了限量标准更严格、体系架构更严谨完备的食品安全标准的诞生与升级。在中国, 新版 GB2763-2014《食品中农药最大残留限量》国家标准已正式颁布实施, 它连同日本的肯定列表制度(positive list system)、欧盟的 EU/EC 指令条例 No.752/2014 等一道, 共同构成了各国严格的食品安全监管法规标准体系。相较于上一版, 新国标 2763-2014 收录的农残种类与最大残留量指标(MRLs)都有了较大的扩容增项, 这无疑对相应的农残检测手段提出了更高更严格的技术要求。时至今日, 食品安全领域中的工作常态已然转变为对复杂基质中数百计的多农残项目同时进行高灵敏度、高特异性的高通量检测, 这种业态转变需要质谱技术的革新, 也需要测试解决方案的完善。

TSQ Endura LC-MS/MS 是基于主动离子管控技术(Active Ion Management, AIM™)开发的全新一代液质联用系统, 它通过 S-lens 射频透镜组、中性粒子挡杆、HyperQuad 四极杆、主动离子碰撞池、双模式离散打拿极检测器等集成创新(图 1), 使得仪器对离子聚焦、传输、隔离、碰撞与检测等离子操控环节得以实现了全新突破, 赋予了其领先的灵敏度、高达 500 SRM/s 的扫描速度与出色的稳健性, 从而能全面满足复杂基质中多农残高通量检测的各种技术挑战, 在食品安全领域中具有广阔的应用空间与使用价值。

本文展示了一种以 TSQ Endura MS 为平台、以 TraceFinder™ 软件为流程化驱动引擎的一站式农残检测解决方案, 并将其用于辣椒基质中 440 种农残同时定量的高通量检测分析。

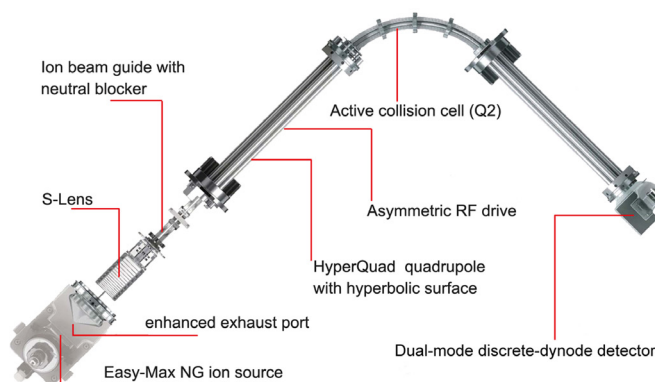


图 1. 创新的 TSQ Endura MS 质谱仪硬件构造示意图

2. 实验条件

2.1 样品制备

实验使用的农残标样由 Ultra Scientific 公司提供 (Rhode Island, USA), 440 种农残混标乙腈溶液的母液浓度为 2.5 µg/mL。

辣椒 (bell pepper) 空白基质由美国 California Department of Food and Agriculture 提供, 基质由 15 g 辣椒匀浆物使用 15 mL 乙腈, 经 QuEChERS 方法提取获得。配置基质加标样时, 先取适量基质加入 1.5 倍体积超纯水用以改善溶剂效应。再取农残混标, 使用乙腈/水 (v/v, 4/6) 逐级稀释, 最后将加水后的空白基质与对应浓度点的标样溶液混合, 充分涡旋混匀后, 得浓度为 0.001、0.002、0.005、0.01、0.02、0.05、0.1、0.2、0.5...~200 pg/µL (ppb) 的一系列溶液。由低至高, 每个浓度点重复进样三针, 用以测试农残在辣椒基质中的最低检测限 (LOD) 与定量限 (LOQ), 每个农药的标准曲线在 LOQ 到 200 pg/µL 浓度区间内绘制。

2.2 色谱分离

反相色谱分离使用 Thermo Dionex Ultimate 3000 超高效液相色谱仪完成，配备 HPG3400-RS 二元高压梯度泵（35 μ L 小体积静态混合器）、WPS-3000TRS 自动进样器与 TCC-3000RS 柱温箱，色谱条件见下表。

| | | |
|------|---|------------------|
| 色谱柱: | Thermo Scientific Accucore aQ (100 \times 2.1 mm, 2.6 μ m) | |
| 流动相: | 水相: H ₂ O+5 mM 甲酸铵 +0.1% 甲酸 有机相: MeOH+5 mM 甲酸铵 +0.1% 甲酸 | |
| 流速: | 300 μ L/min | |
| 柱温: | 30 $^{\circ}$ C | |
| 梯度: | 时间 /min | 水相 % 有机相 % |
| | 0.0 | 98 2 |
| | 0.5 | 98 2 |
| | 2.0 | 60 40 |
| | 20.0 | 5 95 |
| | 22.0 | 5 95 |
| | 22.1 | 98 2 |
| | 25.0 | 98 2 |

2.3 质谱检测

质谱检测使用 TSQ Endura MS 串联三重四极杆质谱仪的 tSRM 定时选择反应监测功能 (timed Selected Reaction Monitor) 进行，配备 Easy-Max NGTM HESI 加热电喷雾离子源。包括保留时间、SRM 离子对、RF 电压与碰撞能量等在内的 tSRM 条件，直接从 TraceFinder 软件 pQuan 化学数据库 (version 1.0, pesticides Quantitation chemical database) 调用 (图 2)，TSQ Endura MS 仪器方法编辑为拖拽 - 释放式设计，且支持各种方法模板的灵活定制 (图 3)。根据农残不同的电离属性，方法中正负电离模式来回切换。依据不同化学属性的农药因色谱行为而造成的峰宽不同，设定 tSRM 时间窗口为 1~5 min。除十三吗啉、丙环唑等少数物质外，其余绝大多数设定为 1 min。Q1 与 Q3 分辨率设定为 0.7 FWHM，Q2 碰撞池氦气压力为 1.5 mTorr。tSRM 扫描循环时间 (cycle time) 为 1.2 s。其余质谱条件见下表。

| | |
|----------------------------------|-------------------------------|
| 气化温度 vaporizer temp.: | 450 $^{\circ}$ C |
| 离子传输管温度 ion transfer tube temp.: | 200 $^{\circ}$ C |
| 喷雾电压 spray voltage: | 3500 V(ESI+), 2500V (ESI-) |
| 鞘气流速 sheath gas: | 60 arb |
| 辅助气流速 Aux gas: | 5 arb |
| 吹扫挡锥气流速 sweep gas: | 1 arb |

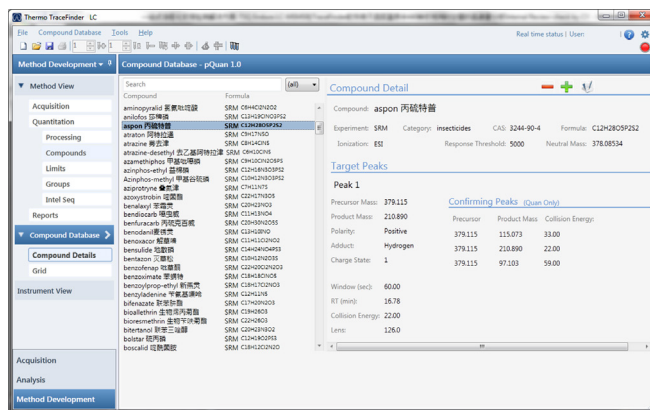


图 2 农残检测方法 TraceFinder pQuan 化学数据库

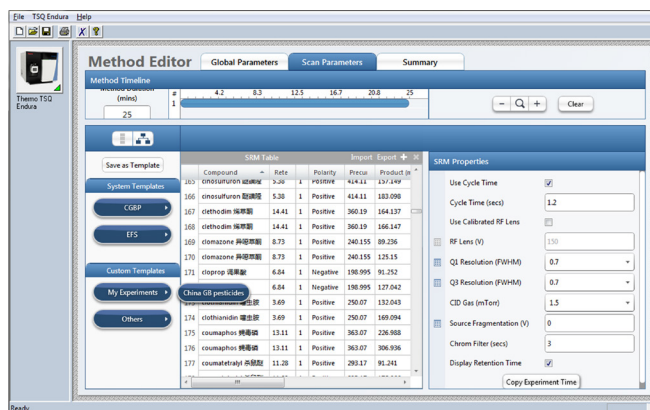


图 3 实验使用的质谱 tSRM 仪器方法模板界面

2.4 数据处理

实验使用 TraceFinder 3.2 软件进行数据库管理、序列采集、数据处理以及报告模板自定义与输出，其灵活强大的功能可为农残检测的流程化提供一站式服务。尤其，作为面向食品安全常见农残的检测方法数据库，TraceFinder 中 pQuan 数据库包含了完备的农残定量与确证信息，以及保留时间、CAS、基本用途等其他相关信息 (图 2)。利用 pQuan 数据库，实验无需再使用标样进行繁琐的方法优化与开发，而是从数据库中调取相关的条件，直接进行样品测定。如图 4 展示的步骤，TraceFinder 软件使得同时进行数百种农残检测的繁复工作大大清晰地流程化了。

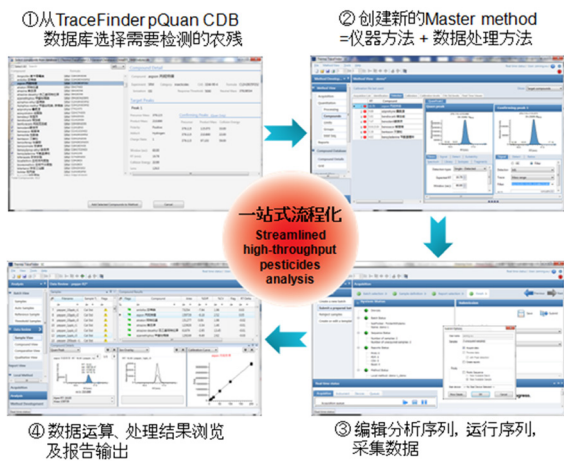


图 4 TraceFinder 软件用于农残检测的流程化工作步骤

3. 结果与讨论

TSQ Endura MS 具有业界领先的 SRM 扫描速度, 使用简便的 tSRM 功能, 质谱只在给定的时间窗口内进行特定离子对的扫描。一方面, 这大大提高了质谱扫描离子驻留时间 (dwell time) 的利用率; 另一方面, 也唯有此才使得在短至 20 min 的快速梯度内同时对数百种农残进行高灵敏度检测成为可能 (图 5)。通过对色谱条件的系统优化, 从图 6 散点图与频次图可知, 实验实现了对 440 种农残良好的色谱分离, 它们均匀地分布在 20 min 有效分离时间窗口内, 这确保了质谱 tSRM 扫描循环时间可以较为均衡地分配到每个 transition 上, 改善定量效果。

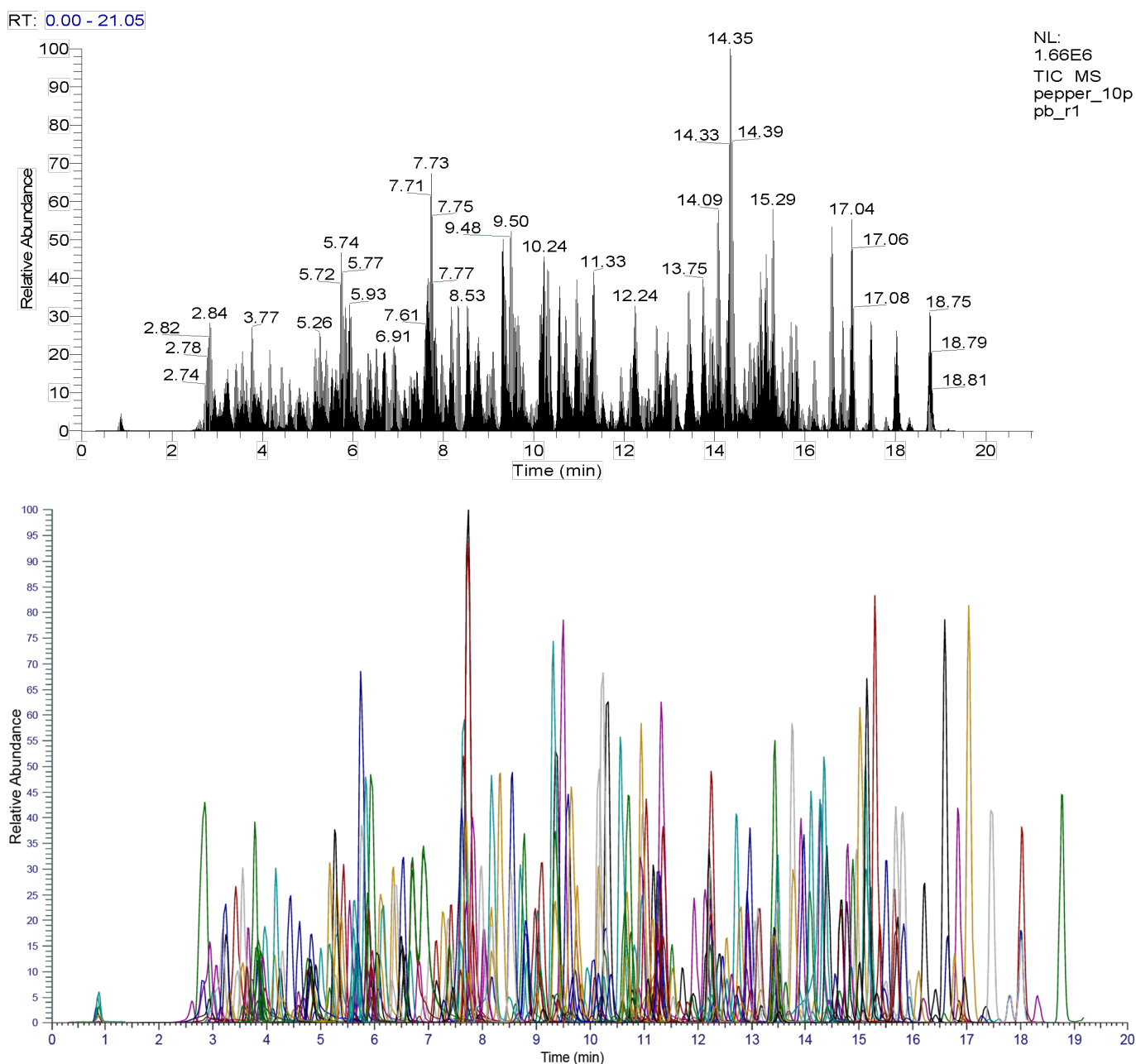


图 5 上图: 菜椒基质中 440 种农残同时检测的总离子流图, 下图: 440 种农残的提取离子色谱图 (10 pg/ μ L)

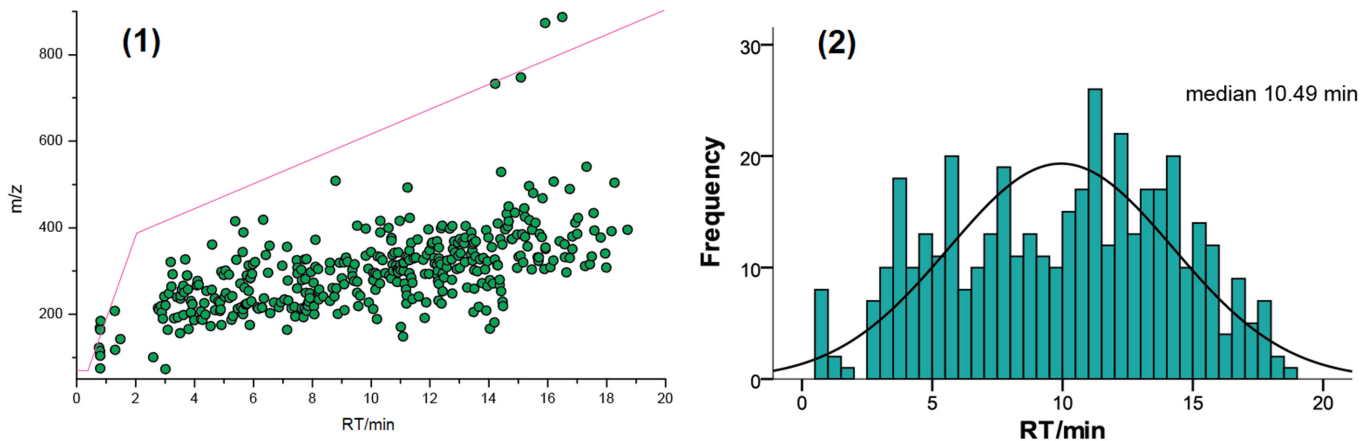


图 6 (1) 农残精确 m/z vs. 保留时间散点图, (2) 保留时间的频次分布图

TraceFinder 具有丰富强大的数据浏览、编辑与再处理等功能, 能为高通量农残检测数据处理提供全方位的功能支持。图 7 为 TraceFinder 数据结果的一种典型界面, 这中间 LC-MS/MS 农残分析的各种信息得以高度凝练地图形化展示, 统全局于一眼, 大大有助于提高实际检测工作中的信息处理效率。同时, 这一界面可模板化编辑, 具有出色的可扩展性, 能满足不同实验室的个性化需求。

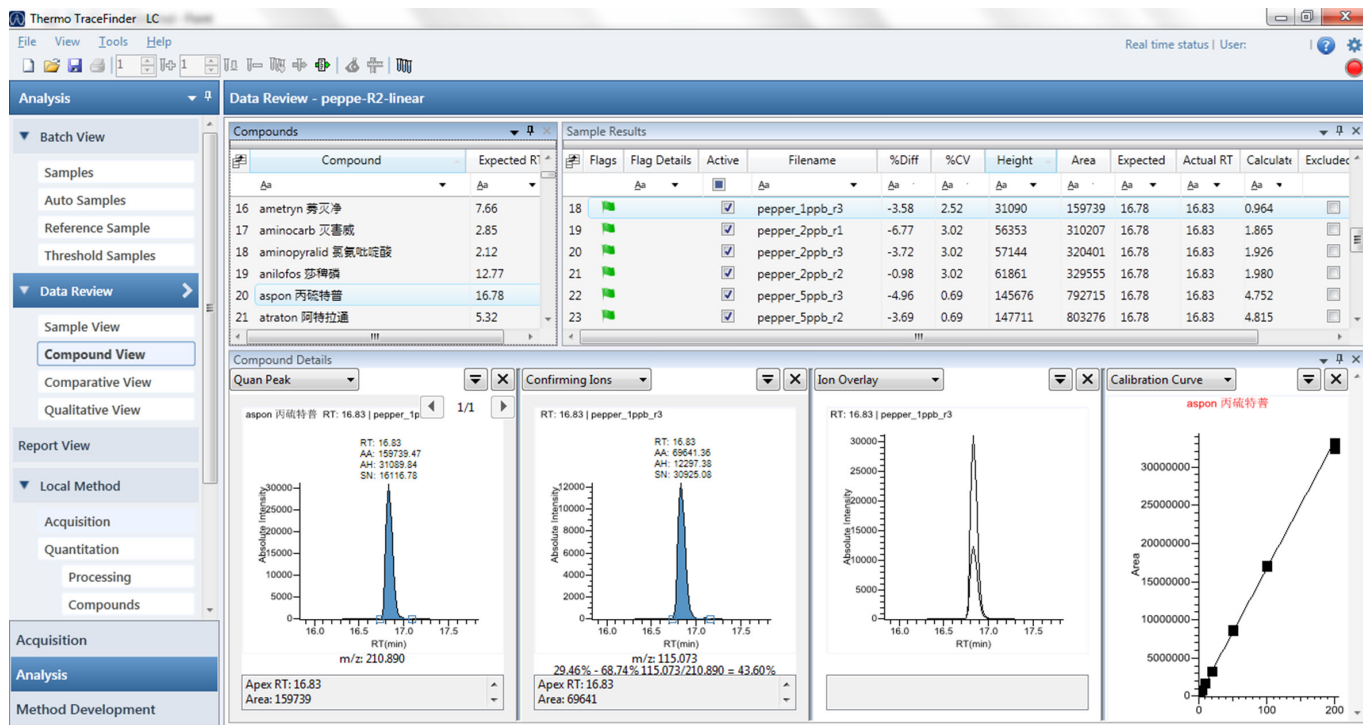


图 7 TraceFinder 农残检测数据处理结果的典型界面 (Compound View)

实验严格综合考虑峰面积的变异系数 CV % (LOD 浓度点处三次重复进样的 CV% 开始稳定重现地小于 30%, LOQ 浓度点处小于 20%)、色谱峰形与信噪比等三种因素, 确定了 TSQ Endura MS 对辣椒基质中 440 种农残进行同时检测的 LOD 与 LOQ 值, 结果见表 1。根据农药化学属性导致的响应水平不同, LOD 在 0.005 $\mu\text{g}/\mu\text{L}$ (5 ppt) 到 20 $\mu\text{g}/\mu\text{L}$ (20 ppb) 之间, LOQ 分布在 0.01 $\mu\text{g}/\mu\text{L}$ (10 ppt) 到 50 $\mu\text{g}/\mu\text{L}$ (50 ppb) 范围内, 对应的峰面积 CV% 分别为 0.34~29.95% 与 0.43~19.94%。并且, 有 430 种农残的标准曲线相关系数大于 0.99, 显示 TSQ Endura MS 具有出色的线性。

表 1 菜椒基质中 440 种农药的定量结果

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|-----------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 矮壮素 | 0.20 | 0.50 | 0.81 | 122.195->58.413, 122.195->63.318 | + | 24 | 0.9963 |
| 丙烯酰胺 | 1.00 | 2.00 | 0.82 | 72.300->55.433, 72.300->45.450 | + | 41 | 0.9972 |
| 亚乙基硫脲 | 0.05 | 0.50 | 0.84 | 103.205->44.497, 103.205->60.324 | + | 40 | 0.9983 |
| 烟碱 | 0.50 | 1.00 | 0.85 | 163.220->130.156, 163.220->117.173 | + | 29 | 0.9974 |
| 甲胺磷 | 0.05 | 0.10 | 0.85 | 142.135->94.176, 142.135->125.049 | + | 16 | 0.9989 |
| 盐酸甲哌 | 0.05 | 0.10 | 0.85 | 114.180->98.269, 114.180->58.426 | + | 28 | 0.9995 |
| 灭蝇胺 | 0.50 | 1.00 | 0.86 | 167.200->85.266, 167.200->68.324 | + | 35 | 0.9868 |
| 叔丁胺 | 0.05 | 0.10 | 0.86 | 74.325->41.515, 74.325->58.418 | + | 32 | 0.9960 |
| 丙烯硫脲 | 2.00 | 5.00 | 0.87 | 117.200->60.340, 117.200->72.273 | + | 26 | 0.9970 |
| 氯氨吡啶酸 | 5.00 | 10.00 | 1.95 | 206.970->161.033, 206.970->134.082 | + | 35 | 0.9934 |
| 吡蚜酮 | 2.00 | 5.00 | 2.42 | 218.175->105.192, 218.175->78.286 | + | 41 | 0.9972 |
| 乙酰甲胺磷 | 0.05 | 0.10 | 2.59 | 184.045->143.046, 184.045->95.174 | + | 26 | 0.9988 |
| 氧乐果 | 0.05 | 0.10 | 2.67 | 214.105->125.072, 214.105->155.072 | + | 25 | 0.9985 |
| 霜霉威 | 0.05 | 0.10 | 2.71 | 189.260->102.220, 189.260->74.300 | + | 28 | 0.9994 |
| 呋虫胺 | 0.20 | 0.50 | 2.73 | 203.085->129.186, 203.085->112.238 | + | 21 | 0.9968 |
| 灭害威 | 0.02 | 0.05 | 2.84 | 209.205->152.164, 209.205->137.181 | + | 26 | 0.9993 |
| 氨氯吡啶酸 | 20.00 | 50.00 | 2.89 | 238.895->194.888, 238.895->158.908 | - | 20 | 0.9936 |
| 丁酮砒威 | 0.20 | 0.50 | 2.97 | 223.145->63.315, 223.145->86.269 | + | 19 | 0.9984 |
| 棉隆 | 0.20 | 0.50 | 2.98 | 163.140->120.088, 163.140->44.518 | + | 21 | 0.9692 |
| 亚砒磷 | 0.05 | 0.10 | 2.99 | 247.095->169.027, 247.095->109.123 | + | 29 | 0.9919 |
| 烯啶虫胺 | 0.20 | 0.50 | 2.99 | 271.150->237.098, 271.150->224.099 | + | 18 | 0.9994 |
| 涕灭威砒 † | 0.05 | 0.10 | 2.99 | 240.175->86.273, 240.175->63.325 | + | 31 | 0.9997 |
| 杀线威 † | 0.05 | 0.10 | 3.05 | 237.075->72.304, 237.075->90.267 | + | 11 | 0.9990 |
| 噻虫嗪 | 0.10 | 0.20 | 3.16 | 292.105->181.099, 292.105->132.041 | + | 21 | 0.9990 |
| 甲基-S-内吸砒砒 | 0.05 | 0.10 | 3.16 | 263.070->169.166, 263.070->109.140 | + | 31 | 0.9995 |
| 灭多威 | 0.20 | 0.50 | 3.21 | 163.125->73.296, 163.125->117.183 | + | 29 | 0.9993 |
| 百治砒 | 0.10 | 0.20 | 3.22 | 238.055->112.235, 238.055->127.141 | + | 20 | 0.9992 |
| 蚜灭多砒 | 0.02 | 0.10 | 3.23 | 319.990->178.093, 319.990->169.058 | + | 23 | 0.9995 |
| 二氯苯甲酰胺 | 0.20 | 0.50 | 3.25 | 190.080->145.060, 190.080->109.154 | + | 41 | 0.9989 |
| 吡虫啉 | 0.10 | 0.20 | 3.39 | 256.135->209.101, 256.135->175.136 | + | 21 | 0.9987 |
| 多菌灵 | 0.10 | 0.20 | 3.40 | 192.155->160.130, 192.155->132.151 | + | 33 | 0.9991 |
| 非草隆 | 1.00 | 2.00 | 3.42 | 165.200->77.287, 165.200->72.311 | + | 19 | 0.9981 |
| 亚胺唑-脱苯甲基 | 5.00 | 20.00 | 3.45 | 287.990->176.125, 287.990->134.150 | + | 25 | 0.9925 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|---------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 甲氟磷 | 0.05 | 0.10 | 3.52 | 155.195->110.140, 155.195->135.124 | + | 19 | 0.9996 |
| 杀虫丹亚砷 | 0.05 | 0.10 | 3.53 | 242.155->107.204, 242.155->77.286 | + | 49 | 0.9992 |
| 久效威亚砷 | 0.10 | 0.50 | 3.53 | 235.185->104.185, 235.185->57.444 | + | 17 | 0.9992 |
| 乐果 | 0.05 | 0.10 | 3.55 | 230.060->125.085, 230.060->79.240 | + | 33 | 0.9997 |
| 啶虫脒 | 0.10 | 0.20 | 3.57 | 223.145->126.134, 223.145->90.226 | + | 37 | 0.9993 |
| 敌百虫 | 0.20 | 0.50 | 3.60 | 256.905->109.146, 256.905->79.260 | + | 32 | 0.9990 |
| 唑啉磺草胺 | 0.10 | 0.20 | 3.60 | 326.075->129.129, 326.075->262.071 | + | 21 | 0.9996 |
| 杀虫脒 | 0.20 | 0.50 | 3.61 | 197.180->117.183, 197.180->46.513 | + | 23 | 0.9990 |
| 磺噻隆 | 0.05 | 0.10 | 3.64 | 265.090->208.017, 265.090->162.023 | + | 26 | 0.9990 |
| 噻虫胺 | 0.10 | 0.20 | 3.66 | 250.070->169.094, 250.070->132.043 | + | 19 | 0.9991 |
| 二氧威 | 0.02 | 0.10 | 3.74 | 224.165->123.172, 224.165->95.242 | + | 29 | 0.9995 |
| 氯草敏 | 0.20 | 0.50 | 3.76 | 222.140->104.210, 222.140->92.241 | + | 29 | 0.9992 |
| 蚜灭磷 | 0.01 | 0.05 | 3.77 | 288.100->146.118, 288.100->118.142 | + | 25 | 0.9994 |
| 噻菌灵 | 0.20 | 0.50 | 3.78 | 202.115->175.052, 202.115->131.158 | + | 36 | 0.9990 |
| 速灭磷 | 0.20 | 0.50 | 3.80 | 225.125->127.093, 225.125->109.140 | + | 34 | 0.9954 |
| 苯噻草酮 | 0.20 | 0.50 | 3.86 | 203.065->175.165, 203.065->174.160 | + | 19 | 0.9994 |
| 麦穗宁 | 0.10 | 0.20 | 3.90 | 185.170->157.144, 185.170->130.184 | + | 32 | 0.9990 |
| 溴莠敏 | 0.20 | 1.00 | 3.91 | 265.940->92.237, 265.940->104.205 | + | 28 | 0.9993 |
| 西玛通 | 0.20 | 0.50 | 4.05 | 198.130->124.216, 198.130->128.184 | + | 23 | 0.9990 |
| 噻虫啉 | 0.05 | 0.10 | 4.10 | 253.105->126.109, 253.105->90.203 | + | 38 | 0.9996 |
| 丁咪酰胺 | 0.05 | 0.10 | 4.11 | 186.195->87.262, 186.195->44.505 | + | 32 | 0.9997 |
| 甲咪唑烟酸 | 0.05 | 0.10 | 4.12 | 276.180->231.113, 276.180->216.085 | + | 26 | 0.9996 |
| 去乙基阿特拉津 | 0.05 | 0.10 | 4.13 | 188.170->146.095, 188.170->104.155 | + | 28 | 0.9994 |
| 氧化萎锈灵 | 0.10 | 0.20 | 4.16 | 268.135->175.060, 268.135->147.064 | + | 27 | 0.9991 |
| 鼠立死 | 0.20 | 0.50 | 4.30 | 172.160->136.152, 172.160->107.196 | + | 28 | 0.9992 |
| 硫环磷 | 0.02 | 0.05 | 4.31 | 256.095->140.039, 256.095->61.343 | + | 26 | 0.9996 |
| 野燕枯 | 0.50 | 1.00 | 4.33 | 249.215->193.119, 249.215->130.190 | + | 41 | 0.9966 |
| 苄氨基嘌呤 | 0.20 | 0.50 | 4.41 | 226.210->91.214, 226.210->142.137 | + | 26 | 0.9995 |
| 二甲嘧酚 | 0.05 | 0.20 | 4.45 | 210.235->140.183, 210.235->71.357 | + | 33 | 0.9991 |
| 双氟磺草胺 | 0.05 | 0.50 | 4.48 | 360.065->129.146, 360.065->109.152 | + | 59 | 0.9988 |
| 乙嘧酚 | 0.05 | 0.10 | 4.49 | 210.235->140.198, 210.235->98.236 | + | 30 | 0.9990 |
| 丁酮威 † | 0.05 | 0.20 | 4.57 | 208.085->75.301, 208.085->47.427 | + | 31 | 0.9967 |
| 吡草特代谢物 | 0.20 | 0.50 | 4.63 | 207.105->77.280, 207.105->68.319 | + | 32 | 0.9997 |
| 二丙烯草胺 | 0.20 | 0.50 | 4.65 | 174.170->98.266, 174.170->41.532 | + | 25 | 0.9993 |
| 甲氧隆 | 0.05 | 0.10 | 4.68 | 229.145->72.326, 229.145->156.063 | + | 28 | 0.9997 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|--------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 涕灭威 † | 0.02 | 0.10 | 4.68 | 208.085->89.255, 208.085->49.423 | + | 34 | 0.9993 |
| 抗蚜威 | 0.05 | 0.10 | 4.81 | 239.225->182.157, 239.225->72.307 | + | 23 | 0.9992 |
| 畜磷磷 | 0.05 | 0.20 | 4.90 | 298.050->217.040, 298.050->125.112 | + | 25 | 0.9990 |
| 氯氟吡氧乙酸 | 5.00 | 10.00 | 4.94 | 252.910->194.955, 252.910->232.641 | - | 6.5 | 0.9925 |
| 咪唑乙烟酸 | 0.05 | 0.20 | 4.96 | 290.225->245.121, 290.225->177.108 | + | 30 | 0.9991 |
| 萘乙酰胺 | 0.02 | 0.05 | 4.99 | 186.165->141.134, 186.165->115.177 | + | 42 | 0.9996 |
| 双酰草胺 | 0.05 | 0.10 | 5.06 | 237.195->120.168, 237.195->77.285 | + | 45 | 0.9995 |
| 磷胺 | 0.50 | 1.00 | 5.06 | 300.030->127.126, 300.030->109.182 | + | 44 | 0.9992 |
| 速灭威 | 0.05 | 0.10 | 5.11 | 166.165->109.183, 166.165->94.219 | + | 34 | 0.9997 |
| 氰草津 | 0.05 | 0.10 | 5.12 | 241.150->214.103, 241.150->104.135 | + | 32 | 0.9992 |
| 特普 | 0.01 | 0.05 | 5.17 | 291.155->179.010, 291.155->235.042 | + | 15 | 0.9995 |
| 阿特拉通 | 0.05 | 0.10 | 5.20 | 212.250->170.137, 212.250->100.199 | + | 30 | 0.9990 |
| 避蚊酯 | 0.10 | 0.20 | 5.30 | 195.120->163.072, 195.120->77.277 | + | 35 | 0.9990 |
| 地胺磷 | 0.05 | 0.10 | 5.31 | 270.115->140.070, 270.115->168.050 | + | 20 | 0.9997 |
| 醚磺隆 | 0.02 | 0.05 | 5.34 | 414.110->183.098, 414.110->157.149 | + | 24 | 0.9987 |
| 灭草松 | 1.00 | 2.00 | 5.34 | 239.025->132.080, 239.025->197.000 | - | 21 | 0.9977 |
| 甲基吡啶磷 | 0.02 | 0.05 | 5.38 | 325.055->183.026, 325.055->139.077 | + | 28 | 0.9996 |
| 甲基硫菌灵 | 0.02 | 0.05 | 5.40 | 343.025->151.135, 343.025->160.124 | + | 32 | 0.9994 |
| 噻草酮 | 0.10 | 0.20 | 5.43 | 215.075->187.131, 215.075->171.115 | + | 24 | 0.9997 |
| 灭草隆 | 0.05 | 0.20 | 5.51 | 199.160->72.299, 199.160->126.093 | + | 28 | 0.9997 |
| 灭藻醌 | 0.50 | 1.00 | 5.55 | 208.120->172.082, 208.120->77.302 | + | 38 | 0.9979 |
| 除草定 | 0.10 | 0.20 | 5.56 | 261.095->204.989, 261.095->187.872 | + | 30 | 0.9997 |
| 咪草酸 | 0.05 | 0.10 | 5.56 | 289.225->229.146, 289.225->144.123 | + | 38 | 0.9995 |
| 环噻酮 | 0.02 | 0.05 | 5.62 | 253.245->171.118, 253.245->71.332 | + | 32 | 0.9995 |
| 残杀威 | 0.05 | 0.10 | 5.62 | 210.185->111.177, 210.185->93.215 | + | 27 | 0.9997 |
| 噻吩磺隆 | 0.05 | 0.10 | 5.65 | 388.065->167.117, 388.065->205.005 | + | 29 | 0.9973 |
| 敌敌畏 | 0.10 | 0.20 | 5.66 | 221.025->109.150, 221.025->79.254 | + | 29 | 0.9994 |
| 克百威 | 0.02 | 0.05 | 5.70 | 222.185->165.129, 222.185->123.160 | + | 25 | 0.9997 |
| 咪酰胺 | 0.05 | 0.10 | 5.73 | 282.165->254.096, 282.165->160.174 | + | 27 | 0.9997 |
| 咯嗉酮 | 0.10 | 0.20 | 5.74 | 174.190->132.156, 174.190->117.171 | + | 36 | 0.9996 |
| 噁虫威 | 0.02 | 0.05 | 5.75 | 224.175->167.126, 224.175->109.174 | + | 21 | 0.9996 |
| 马拉氧磷 | 0.02 | 0.05 | 5.75 | 315.120->99.157, 315.120->71.280 | + | 47 | 0.9991 |
| 咪唑啉啉酸 | 0.05 | 0.10 | 5.83 | 312.205->267.115, 312.205->199.067 | + | 31 | 0.9993 |
| 丁噻隆 | 0.01 | 0.02 | 5.91 | 229.185->172.136, 229.185->116.136 | + | 30 | 0.9998 |
| 萘草胺 | 0.05 | 0.10 | 5.92 | 292.150->144.132, 292.150->149.076 | + | 21 | 0.9981 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|--------------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 甲基内吸磷 O | 0.05 | 0.10 | 5.93 | 230.980->89.256, 89.150->61.369 | + | 14 | 0.9995 |
| 特草定 | 1.00 | 5.00 | 5.94 | 215.035->159.023, 215.035->73.236 | - | 35 | 0.9976 |
| 西草净 | 0.10 | 0.20 | 5.95 | 214.085->96.240, 214.085->68.356 | + | 36 | 0.9992 |
| 苯线磷亚砷 | 0.05 | 0.10 | 5.96 | 320.160->233.025, 320.160->292.091 | + | 17 | 0.9993 |
| 二甲基 - 甲苯磺酰二胺 | 0.05 | 0.10 | 5.99 | 215.055->106.230, 215.055->79.299 | + | 30 | 0.9994 |
| 甲磺草胺 | 5.00 | 10.00 | 6.03 | 384.945->306.967, 384.945->198.954 | - | 40 | 0.9906 |
| 敌草净 | 0.05 | 0.10 | 6.05 | 214.185->172.103, 214.185->82.273 | + | 32 | 0.9995 |
| 异噁隆 | 0.05 | 0.10 | 6.10 | 212.115->167.150, 212.115->72.336 | + | 26 | 0.9997 |
| 苯胺磷砷 | 0.02 | 1.00 | 6.17 | 336.175->308.029, 336.175->266.016 | + | 22 | 0.9993 |
| 磺草唑胺 | 0.05 | 0.20 | 6.30 | 418.035->175.019, 418.035->140.100 | + | 53 | 0.9995 |
| 萎锈灵 | 0.02 | 0.05 | 6.31 | 236.145->143.095, 236.145->87.224 | + | 28 | 0.9997 |
| 磺胺硝苯 | 10.00 | 20.00 | 6.34 | 334.000->270.068, 334.000->136.073 | - | 31 | 0.9892 |
| 甲萘威 | 0.01 | 0.10 | 6.39 | 202.165->145.110, 202.165->127.152 | + | 31 | 0.9996 |
| 倍硫磷亚砷 | 0.02 | 0.05 | 6.40 | 295.095->280.003, 295.095->264.035 | + | 18 | 0.9995 |
| 甲呋酰胺 | 0.02 | 0.05 | 6.49 | 202.165->109.176, 202.165->43.469 | + | 44 | 0.9998 |
| 氯磺隆 | 0.05 | 0.20 | 6.55 | 358.015->167.122, 358.015->141.175 | + | 21 | 0.9983 |
| 乙硫苯威 | 0.02 | 0.05 | 6.58 | 226.165->107.183, 226.165->77.279 | + | 45 | 0.9998 |
| 调果酸 | 2.00 | 10.00 | 6.63 | 198.995->127.042, 198.995->91.252 | - | 43 | 0.9958 |
| 扑灭通 | 0.02 | 0.05 | 6.66 | 226.245->184.140, 226.245->142.149 | + | 25 | 0.9996 |
| 倍硫磷砷 | 0.10 | 0.20 | 6.69 | 311.070->279.021, 311.070->125.104 | + | 23 | 0.9994 |
| 特丁通 | 0.05 | 0.10 | 6.72 | 226.245->170.153, 226.245->142.137 | + | 27 | 0.9995 |
| 久效威 † | 1.00 | 2.00 | 6.73 | 236.215->57.428, 236.215->76.291 | + | 12 | 0.9946 |
| 绿谷隆 | 0.02 | 0.05 | 6.78 | 215.135->126.110, 215.135->99.160 | + | 36 | 0.9996 |
| 24- 滴 | 2.00 | 10.00 | 6.88 | 218.935->160.990, 218.935->124.997 | - | 26 | 0.9962 |
| 氟草隆 | 0.02 | 0.05 | 6.89 | 233.165->72.322, 233.165->160.076 | + | 30 | 0.9996 |
| 仲丁通 | 0.05 | 0.10 | 6.89 | 226.245->170.127, 226.245->142.127 | + | 26 | 0.9991 |
| 二硝基邻甲酚 | 2.00 | 5.00 | 7.05 | 196.995->179.996, 196.995->122.100 | - | 29 | 0.9950 |
| 甲拌磷亚砷 | 0.02 | 0.05 | 7.06 | 277.095->143.038, 277.095->97.130 | + | 34 | 0.9996 |
| 溴苯腈 | 5.00 | 10.00 | 7.11 | 275.775->81.112, 275.775->79.126 | - | 28 | 0.9958 |
| 硫双威 | 0.01 | 0.05 | 7.13 | 355.110->88.230, 355.110->73.287 | + | 59 | 0.9998 |
| 甲拌磷砷 | 0.05 | 0.20 | 7.17 | 293.075->171.037, 293.075->143.029 | + | 20 | 0.9995 |
| 甲基乙拌磷 | 1.00 | 5.00 | 7.19 | 247.085->89.241, 247.085->61.353 | + | 31 | 0.9957 |
| 绿麦隆 | 0.02 | 0.10 | 7.24 | 213.180->72.310, 213.180->140.094 | + | 27 | 0.9996 |
| 苯胺灵 | 0.05 | 0.20 | 7.24 | 180.175->138.098, 180.175->120.169 | + | 19 | 0.9995 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|-------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 麦锈灵 | 0.02 | 0.05 | 7.26 | 324.065->230.940, 324.065->202.961 | + | 42 | 0.9996 |
| 莠去津 | 0.02 | 0.05 | 7.27 | 216.100->174.063, 216.100->104.164 | + | 31 | 0.9996 |
| 粉唑醇 | 0.10 | 0.20 | 7.30 | 302.160->70.334, 302.160->123.111 | + | 30 | 0.9987 |
| 乙氧喹啉 | 10.00 | 20.00 | 7.33 | 218.225->174.119, 218.225->160.117 | + | 36 | 0.9647 |
| 溴谷隆 | 0.05 | 0.10 | 7.36 | 259.060->169.993, 259.060->170.981 | + | 29 | 0.9994 |
| 异丙威 | 0.01 | 0.02 | 7.37 | 194.195->95.220, 194.195->77.260 | + | 37 | 0.9996 |
| 乙拌磷砷 | 0.05 | 0.20 | 7.38 | 307.080->97.137, 307.080->125.097 | + | 20 | 0.9997 |
| 吡咪唑 | 0.05 | 0.10 | 7.41 | 213.210->172.114, 213.210->118.162 | + | 39 | 0.9997 |
| 毒草胺 | 0.02 | 0.05 | 7.52 | 212.180->170.073, 212.180->94.223 | + | 30 | 0.9998 |
| 虫线磷 | 0.05 | 0.20 | 7.52 | 249.025->113.150, 249.025->193.036 | + | 17 | 0.9991 |
| 吡唑草胺 | 0.01 | 0.05 | 7.55 | 278.185->210.092, 278.185->134.201 | + | 25 | 0.9997 |
| 莠灭净 | 0.01 | 0.05 | 7.56 | 228.180->186.102, 228.180->68.320 | + | 38 | 0.9995 |
| 二甲草胺 | 0.02 | 0.05 | 7.59 | 256.185->224.089, 256.185->148.165 | + | 28 | 0.9993 |
| 甲氧丙净 | 0.10 | 0.20 | 7.61 | 272.125->240.159, 272.125->198.124 | + | 26 | 0.9994 |
| 咪唑嗪 | 1.00 | 2.00 | 7.63 | 248.005->150.085, 248.005->124.114 | + | 34 | 0.9978 |
| 避蚊胺 | 0.02 | 0.05 | 7.64 | 192.240->119.167, 192.240->91.236 | + | 32 | 0.9998 |
| 抑霉唑 | 0.50 | 1.00 | 7.67 | 297.135->159.043, 297.135->255.025 | + | 20 | 0.9978 |
| 伐灭磷 | 0.02 | 0.05 | 7.68 | 326.080->280.944, 326.080->217.003 | + | 22 | 0.9990 |
| 精甲霜灵 | 0.01 | 0.02 | 7.71 | 280.200->220.128, 280.200->160.172 | + | 26 | 0.9995 |
| 甲霜灵 | 0.01 | 0.02 | 7.71 | 280.225->220.150, 280.225->192.175 | + | 21 | 0.9997 |
| 异丙隆 | 0.05 | 0.10 | 7.72 | 207.225->72.312, 207.225->134.182 | + | 26 | 0.9997 |
| 噻草硫醚 | 0.20 | 2.00 | 7.76 | 327.070->139.101, 327.070->203.976 | + | 42 | 0.9992 |
| 炔草隆 | 0.20 | 0.50 | 7.81 | 237.130->126.114, 237.130->222.101 | + | 20 | 0.9995 |
| 甲基苯噻隆 | 0.05 | 0.10 | 7.81 | 222.145->165.105, 222.145->150.104 | + | 36 | 0.9996 |
| 混杀威 | 0.02 | 0.05 | 7.96 | 194.195->137.155, 194.195->122.175 | + | 29 | 0.9996 |
| 丰索磷 | 0.05 | 0.10 | 7.98 | 309.090->252.995, 309.090->235.001 | + | 24 | 0.9991 |
| 环莠隆 | 0.05 | 0.10 | 7.98 | 199.255->89.243, 199.255->72.318 | + | 25 | 0.9995 |
| 蔬果磷 | 0.50 | 1.00 | 8.00 | 217.010->107.198, 217.010->77.295 | + | 45 | 0.9716 |
| 氟草敏 | 0.10 | 0.20 | 8.00 | 304.100->284.039, 304.100->160.084 | + | 34 | 0.9995 |
| 硫菌灵 | 0.01 | 0.05 | 8.02 | 371.055->151.109, 371.055->93.242 | + | 53 | 0.9985 |
| 敌草隆 | 0.02 | 0.05 | 8.07 | 233.095->72.330, 233.095->46.519 | + | 19 | 0.9996 |
| 氯吡脞 | 0.02 | 0.05 | 8.15 | 248.035->129.127, 248.035->93.236 | + | 36 | 0.9993 |
| 庚烯磷 | 0.05 | 0.10 | 8.15 | 251.095->127.126, 251.095->125.012 | + | 17 | 0.9993 |
| 双苯酰草胺 | 0.01 | 0.05 | 8.32 | 240.215->134.160, 240.215->167.134 | + | 25 | 0.9993 |
| 碘苯腈 | 0.50 | 2.00 | 8.48 | 369.745->126.981, 369.745->214.889 | - | 33 | 0.9992 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|------------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 咪菌胺 | 0.01 | 0.02 | 8.52 | 230.195->137.159, 230.195->67.358 | + | 38 | 0.9996 |
| 甜菜安 † | 0.01 | 0.01 | 8.53 | 318.090->182.126, 318.090->136.142 | + | 29 | 0.9996 |
| 解草啉 | 0.10 | 0.20 | 8.55 | 259.995->149.167, 259.995->134.182 | + | 31 | 0.9993 |
| 啉霉胺 | 0.20 | 0.50 | 8.65 | 200.195->168.102, 200.195->181.140 | + | 40 | 0.9995 |
| 甜菜宁 | 1.00 | 2.00 | 8.68 | 301.170->136.097, 301.170->108.181 | + | 34 | 0.9938 |
| 异噁草酮 | 0.01 | 0.02 | 8.69 | 240.155->125.150, 240.155->89.236 | + | 49 | 0.9997 |
| 内吸磷 S | 0.01 | 0.01 | 8.74 | 259.035->89.248, 259.035->61.375 | + | 35 | 0.9997 |
| 甲基磺隆 | 0.01 | 0.02 | 8.79 | 507.980->167.113, 507.980->324.914 | + | 26 | 0.9980 |
| 甲基谷硫磷 | 0.20 | 1.00 | 8.81 | 318.185->125.122, 318.185->77.308 | + | 34 | 0.9984 |
| 十二环吗啉 | 0.10 | 0.20 | 8.82 | 282.355->116.242, 282.355->98.280 | + | 29 | 0.9993 |
| 环酯草醚 | 0.20 | 0.50 | 8.83 | 319.145->139.143, 319.145->301.087 | + | 25 | 0.9990 |
| 2, 4, 5- 涕 | 2.00 | 5.00 | 8.85 | 252.870->194.913, 252.870->158.966 | - | 29 | 0.9956 |
| 另丁津 | 0.02 | 0.05 | 8.94 | 230.170->174.069, 230.170->104.139 | + | 33 | 0.9996 |
| 扑灭津 | 0.02 | 0.10 | 8.96 | 230.195->188.107, 230.195->146.106 | + | 26 | 0.9994 |
| 仲丁威 | 0.01 | 0.05 | 8.98 | 208.230->95.244, 208.230->77.295 | + | 38 | 0.9996 |
| 氟啶草酮 | 0.10 | 0.20 | 8.98 | 330.085->310.117, 330.085->290.126 | + | 34 | 0.9994 |
| 乙霉威 | 0.05 | 0.10 | 8.99 | 268.200->180.143, 268.200->124.163 | + | 35 | 0.9993 |
| 特丁磷砷 | 0.20 | 0.50 | 9.10 | 321.065->143.045, 321.065->115.074 | + | 28 | 0.9990 |
| 氟苯啉醇 | 0.10 | 0.20 | 9.20 | 315.095->252.073, 315.095->243.018 | + | 27 | 0.9992 |
| 乙氧呋草黄 | 0.10 | 0.20 | 9.24 | 287.040->121.200, 287.040->161.123 | + | 23 | 0.9994 |
| 苯锈啶 | 0.10 | 0.20 | 9.26 | 274.325->147.175, 274.325->132.176 | + | 43 | 0.9994 |
| 杀螟硫磷 | 10.00 | 20.00 | 9.28 | 277.995->125.175, 277.995->152.175 | + | 37 | 0.9931 |
| 咪霜灵 | 0.01 | 0.05 | 9.28 | 302.190->242.115, 302.190->270.077 | + | 11 | 0.9998 |
| 啉菌酯 | 0.05 | 0.10 | 9.29 | 404.120->372.067, 404.120->344.076 | + | 27 | 0.9997 |
| 扑草净 | 0.02 | 0.05 | 9.30 | 242.115->158.126, 242.115->200.143 | + | 21 | 0.9993 |
| 敌稗 | 0.05 | 0.10 | 9.31 | 218.085->162.045, 218.085->127.104 | + | 30 | 0.9971 |
| 二甲吩草胺 | 0.02 | 0.05 | 9.34 | 276.130->244.048, 276.130->168.114 | + | 27 | 0.9997 |
| 2 甲 4 氯丙酸 | 5.00 | 10.00 | 9.35 | 212.980->141.050, 212.980->105.148 | - | 33 | 0.9965 |
| 利谷隆 | 0.05 | 0.10 | 9.47 | 249.095->182.077, 249.095->160.041 | + | 21 | 0.9993 |
| 氯炔灵 | 5.00 | 10.00 | 9.50 | 224.050->111.144, 224.050->77.297 | + | 38 | 0.9847 |
| 特丁津 | 0.01 | 0.02 | 9.51 | 230.170->174.091, 230.170->96.243 | + | 29 | 0.9996 |
| 乙虫腈 | 0.05 | 0.10 | 9.60 | 397.015->350.942, 397.015->254.978 | + | 39 | 0.9995 |
| 丁苯吗啉 | 0.05 | 0.10 | 9.60 | 304.310->147.189, 304.310->132.193 | + | 44 | 0.9996 |
| 氟磺胺草醚 | 10.00 | 20.00 | 9.61 | 436.955->194.963, 436.955->285.956 | - | 25 | 0.9843 |
| 特丁净 | 0.01 | 0.02 | 9.63 | 242.215->186.113, 242.215->158.090 | + | 27 | 0.9996 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|--------------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 味草酮 | 0.05 | 0.10 | 9.68 | 334.150->247.094, 334.150->178.127 | + | 48 | 0.9995 |
| 烯酰吗啉 | 0.05 | 0.10 | 9.71 | 388.155->301.105, 388.155->165.118 | + | 34 | 0.9853 |
| 啶酰菌胺 | 0.10 | 0.20 | 9.75 | 343.040->307.065, 343.040->272.091 | + | 34 | 0.9994 |
| 三氟羧草醚 | 2.00 | 10.00 | 9.79 | 359.915->315.943, 359.915->285.795 | - | 17 | 0.9963 |
| 啶斑肟 | 0.05 | 0.10 | 9.81 | 295.090->93.227, 295.090->263.019 | + | 20 | 0.9982 |
| 叠氮津 | 0.20 | 0.50 | 9.82 | 226.065->156.099, 226.065->68.328 | + | 30 | 0.9996 |
| 多效唑 | 0.10 | 0.20 | 9.83 | 294.190->70.324, 294.190->125.114 | + | 36 | 0.9992 |
| 灭锈胺 | 0.02 | 0.05 | 9.86 | 270.225->228.085, 270.225->119.150 | + | 26 | 0.9995 |
| 三唑醇 | 0.50 | 1.00 | 9.89 | 296.170->70.338, 296.170->43.499 | + | 59 | 0.9985 |
| 稻瘟灵 | 0.05 | 0.10 | 9.99 | 291.120->188.993, 291.120->145.039 | + | 36 | 0.9995 |
| 氟酰胺 | 0.02 | 0.05 | 10.02 | 324.170->262.055, 324.170->242.076 | + | 28 | 0.9995 |
| 苯并噻二唑 | 0.50 | 1.00 | 10.03 | 211.100->136.101, 211.100->140.081 | + | 28 | 0.9943 |
| 炔苯酰草胺 | 0.05 | 0.10 | 10.05 | 256.105->189.986, 256.105->172.983 | + | 24 | 0.9986 |
| 禾草敌 | 0.10 | 0.20 | 10.05 | 188.210->126.197, 188.210->55.441 | + | 26 | 0.9996 |
| 马拉硫磷 | 0.10 | 0.20 | 10.12 | 331.090->125.092, 331.090->99.191 | + | 30 | 0.9992 |
| 三唑酮 | 0.50 | 1.00 | 10.14 | 294.125->141.076, 294.125->127.083 | + | 33 | 0.9973 |
| 异噁唑草胺 | 0.01 | 0.02 | 10.14 | 333.255->165.111, 333.255->150.113 | + | 41 | 0.9997 |
| 环丙唑醇 | 0.50 | 1.00 | 10.18 | 292.170->70.326, 292.170->125.121 | + | 30 | 0.9989 |
| 氯噻磺隆 | 0.05 | 0.10 | 10.21 | 415.075->186.013, 415.075->121.133 | + | 41 | 0.9995 |
| 氯唑磷 | 0.05 | 0.10 | 10.33 | 314.125->120.129, 314.125->271.997 | + | 15 | 0.9996 |
| 腈菌唑 | 0.20 | 0.50 | 10.39 | 289.170->70.316, 289.170->125.107 | + | 33 | 0.9987 |
| 二苯胺 | 2.00 | 5.00 | 10.44 | 170.200->93.235, 170.200->66.354 | + | 44 | 0.9948 |
| 糠菌唑 | 0.20 | 0.50 | 10.52 | 377.935->159.015, 377.935->161.018 | + | 31 | 0.9991 |
| 2, 4, 5- 涕丙酸 | 5.00 | 10.00 | 10.52 | 268.900->196.900, 268.900->160.972 | - | 30 | 0.9909 |
| 胺丙畏 | 0.10 | 0.20 | 10.53 | 282.065->138.114, 282.065->110.117 | + | 31 | 0.9993 |
| 乙氧磺隆 | 0.02 | 0.05 | 10.54 | 399.100->261.057, 399.100->218.052 | + | 28 | 0.9993 |
| 麦草伏甲酯 | 0.01 | 0.05 | 10.62 | 336.130->105.171, 336.130->77.279 | + | 55 | 0.9995 |
| 甲氧虫酰肼 | 0.02 | 0.05 | 10.63 | 369.270->149.114, 369.270->133.131 | + | 25 | 0.9996 |
| 环酰菌胺 | 0.10 | 0.20 | 10.64 | 302.120->97.255, 302.120->55.424 | + | 38 | 0.9977 |
| 苯噻唑草胺 | 0.05 | 0.10 | 10.64 | 299.155->148.157, 299.155->120.199 | + | 27 | 0.9994 |
| 哒嗪硫磷 | 0.10 | 0.20 | 10.65 | 341.120->189.089, 341.120->189.089 | + | 24 | 0.9993 |
| 乙环唑 | 0.20 | 0.50 | 10.66 | 328.110->159.023, 328.110->123.151 | + | 59 | 0.9990 |
| 异丙净 | 0.05 | 0.20 | 10.76 | 256.235->214.145, 256.235->144.124 | + | 31 | 0.9994 |
| 氟咯草酮 | 0.20 | 0.50 | 10.77 | 312.070->292.053, 312.070->212.041 | + | 35 | 0.9976 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|--------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 二苯隆 | 0.05 | 0.10 | 10.77 | 303.180->125.128, 303.180->119.222 | + | 23 | 0.9994 |
| 草达津 | 0.05 | 0.20 | 10.78 | 230.170->202.101, 230.170->132.119 | + | 25 | 0.9995 |
| 联苯腈酯 | 0.50 | 1.00 | 10.79 | 301.200->170.140, 301.200->152.138 | + | 43 | 0.9931 |
| 吡嘧磺隆 | 0.02 | 0.05 | 10.82 | 415.100->182.102, 415.100->139.145 | + | 42 | 0.9995 |
| 乙嘧酚磺酸酯 | 0.10 | 0.50 | 10.87 | 317.210->166.143, 317.210->272.096 | + | 21 | 0.9990 |
| 吡喃草酮 | 0.50 | 2.00 | 10.88 | 342.200->166.161, 342.200->98.231 | + | 33 | 0.9969 |
| 三唑磷 | 0.02 | 0.05 | 10.89 | 314.095->162.100, 314.095->119.182 | + | 35 | 0.9995 |
| 苯氟磺胺 | 0.50 | 1.00 | 10.90 | 332.920->223.932, 332.920->123.132 | + | 28 | 0.9993 |
| 环丙酸酰胺 | 1.00 | 2.00 | 10.94 | 271.915->159.971, 271.915->227.961 | - | 13 | 0.9962 |
| 异戊乙净 | 0.02 | 0.05 | 10.95 | 256.235->186.106, 256.235->158.096 | + | 29 | 0.9998 |
| 灭菌磷 | 0.02 | 0.10 | 10.99 | 300.100->148.090, 300.100->130.121 | + | 35 | 0.9996 |
| 灭菌唑 | 0.05 | 0.10 | 11.00 | 318.190->70.333, 318.190->125.116 | + | 30 | 0.9983 |
| 乙草胺 | 0.20 | 0.50 | 11.01 | 270.205->224.068, 270.205->148.182 | + | 23 | 0.9995 |
| 杀鼠醚 | 0.05 | 0.10 | 11.05 | 293.170->175.066, 293.170->91.241 | + | 30 | 0.9989 |
| 益棉磷 | 0.10 | 0.20 | 11.06 | 346.090->132.140, 346.090->137.106 | + | 25 | 0.9982 |
| 甲草胺 | 0.50 | 1.00 | 11.07 | 270.195->238.073, 270.195->162.155 | + | 23 | 0.9996 |
| 氟丙嘧草酯† | 0.05 | 0.10 | 11.09 | 492.110->331.005, 492.110->348.993 | + | 17 | 0.9993 |
| 硅氟唑 | 0.20 | 0.50 | 11.10 | 294.190->70.337, 294.190->135.145 | + | 24 | 0.9976 |
| 灭线磷 | 0.05 | 0.10 | 11.11 | 243.110->131.010, 243.110->97.130 | + | 32 | 0.9996 |
| 啉菌胺 | 0.10 | 0.20 | 11.13 | 224.195->106.194, 224.195->77.278 | + | 39 | 0.9994 |
| 噻吩草胺 | 0.05 | 0.10 | 11.14 | 324.105->127.111, 324.105->59.355 | + | 42 | 0.9995 |
| 灭蚜磷 | 0.20 | 0.50 | 11.14 | 330.010->171.008, 330.010->143.024 | + | 29 | 0.9993 |
| 环丙嘧磺隆 | 0.02 | 0.05 | 11.19 | 422.135->261.028, 422.135->218.021 | + | 29 | 0.9992 |
| 牧草胺 | 0.01 | 0.05 | 11.20 | 234.265->91.262, 234.265->65.358 | + | 59 | 0.9995 |
| 氟环唑 | 0.20 | 0.50 | 11.21 | 330.130->121.163, 330.130->123.136 | + | 21 | 0.9995 |
| 氟噻草胺 | 0.02 | 0.05 | 11.25 | 364.120->152.106, 364.120->124.163 | + | 33 | 0.9993 |
| 异丙草胺 | 2.00 | 5.00 | 11.26 | 284.265->130.241, 284.265->98.267 | + | 30 | 0.9920 |
| 四氟醚唑 | 0.10 | 0.20 | 11.27 | 372.055->159.028, 372.055->70.331 | + | 24 | 0.9995 |
| 敌草胺 | 0.05 | 0.10 | 11.28 | 272.235->171.107, 272.235->128.160 | + | 16 | 0.9996 |
| 异丙甲草胺 | 0.05 | 0.10 | 11.33 | 284.190->252.114, 284.190->176.180 | + | 28 | 0.9996 |
| 氨磺乐灵 | 5.00 | 10.00 | 11.40 | 345.015->280.947, 345.015->240.954 | - | 25 | 0.9966 |
| 鱼藤酮 | 0.05 | 0.10 | 11.53 | 395.150->213.086, 395.150->191.115 | + | 39 | 0.9989 |
| 庚酰草胺 | 0.10 | 0.20 | 11.55 | 240.185->85.325, 240.185->93.217 | + | 35 | 0.9996 |
| 啉菌环胺 | 0.10 | 0.20 | 11.59 | 226.205->93.226, 226.205->118.164 | + | 34 | 0.9994 |
| 烯效唑 | 0.20 | 0.50 | 11.60 | 292.195->70.312, 292.195->125.109 | + | 32 | 0.9989 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|-------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 腈苯唑 | 0.50 | 1.00 | 11.61 | 337.170->125.113, 337.170->70.304 | + | 22 | 0.9991 |
| 茵草敌 | 0.20 | 0.50 | 11.61 | 190.105->86.171, 190.105->43.693 | + | 21 | 0.9991 |
| 噁唑菌酮 | 5.00 | 20.00 | 11.63 | 373.080->327.069, 373.080->282.184 | - | 22 | 0.9935 |
| 氟霜唑 | 0.05 | 0.10 | 11.69 | 325.000->108.169, 325.000->217.067 | + | 21 | 0.9994 |
| 育畜磷 | 0.02 | 0.05 | 11.70 | 292.125->236.034, 292.125->108.159 | + | 30 | 0.9994 |
| 稻瘟酰胺 | 0.05 | 0.10 | 11.71 | 329.130->302.037, 329.130->189.015 | + | 28 | 0.9994 |
| 甲磺乐灵 | 0.50 | 2.00 | 11.77 | 346.135->304.003, 346.135->242.034 | + | 19 | 0.9935 |
| 苯氧威 | 0.10 | 0.20 | 11.85 | 302.165->88.233, 302.165->44.507 | + | 44 | 0.9982 |
| 杀虫畏 | 0.20 | 0.50 | 11.90 | 366.950->240.901, 366.950->205.934 | + | 40 | 0.9994 |
| 醚菌酯 | 0.20 | 0.50 | 11.96 | 314.090->222.122, 314.090->235.099 | + | 18 | 0.9988 |
| 氟硅唑 | 0.10 | 0.20 | 11.98 | 316.060->247.092, 316.060->165.152 | + | 31 | 0.9993 |
| 驱虫特 | 0.02 | 0.05 | 11.99 | 231.235->101.191, 231.235->73.320 | + | 29 | 0.9997 |
| 甲基对氧磷 | 0.10 | 0.20 | 11.99 | 248.155->157.150, 248.155->101.190 | + | 12 | 0.9997 |
| 虫酰肼 | 0.05 | 0.10 | 12.00 | 353.270->133.153, 353.270->105.232 | + | 42 | 0.9995 |
| 异稻瘟净 | 0.01 | 0.02 | 12.08 | 289.100->91.224, 289.100->65.352 | + | 59 | 0.9994 |
| 丙环唑 | 0.20 | 0.50 | 12.11 | 342.130->159.015, 342.130->123.151 | + | 59 | 0.9991 |
| 苄氯三唑醇 | 0.20 | 0.50 | 12.13 | 328.150->70.312, 328.150->159.011 | + | 38 | 0.9986 |
| 喹硫磷 | 0.05 | 0.10 | 12.19 | 299.035->163.082, 299.035->147.130 | + | 25 | 0.9990 |
| 啶菌酯 | 0.01 | 0.02 | 12.19 | 368.160->145.154, 368.160->115.203 | + | 50 | 0.9992 |
| 草不隆 | 0.50 | 2.00 | 12.20 | 275.120->159.998, 275.120->41.533 | + | 31 | 0.9951 |
| 地散磷 | 0.20 | 0.50 | 12.20 | 398.020->158.105, 398.020->141.104 | + | 35 | 0.9992 |
| 丁噻草酮 | 0.02 | 0.05 | 12.20 | 269.215->200.116, 269.215->172.148 | + | 25 | 0.9996 |
| 戊菌唑 | 0.10 | 0.20 | 12.20 | 284.120->70.350, 284.120->159.039 | + | 30 | 0.9997 |
| 苯草醚 | 5.00 | 10.00 | 12.22 | 264.990->248.030, 264.990->182.101 | + | 34 | 0.9957 |
| 乙嘧硫磷 | 0.20 | 0.50 | 12.25 | 293.120->265.067, 293.120->125.093 | + | 28 | 0.9991 |
| 噻草酸甲酯 | 0.20 | 0.50 | 12.26 | 404.030->343.988, 404.030->274.011 | + | 31 | 0.9983 |
| 稻丰散 | 0.05 | 0.10 | 12.27 | 321.065->246.802, 321.065->135.123 | + | 22 | 0.9996 |
| 草克死 | 0.10 | 0.20 | 12.30 | 224.030->116.185, 224.030->88.240 | + | 23 | 0.9994 |
| 拌种胺 | 0.05 | 0.10 | 12.35 | 252.235->110.209, 252.235->123.169 | + | 20 | 0.9996 |
| 戊唑醇 | 0.05 | 0.10 | 12.39 | 308.200->70.338, 308.200->125.106 | + | 35 | 0.9991 |
| 地虫硫磷 | 0.10 | 0.20 | 12.43 | 247.065->109.132, 247.065->125.088 | + | 17 | 0.9988 |
| 异氯磷 | 20.00 | 50.00 | 12.50 | 298.120->265.864, 298.120->172.090 | + | 31 | 0.9904 |
| 苯霜灵 | 0.01 | 0.02 | 12.50 | 326.230->148.174, 326.230->121.197 | + | 32 | 0.9994 |
| 倍硫磷 | 0.10 | 0.20 | 12.52 | 279.055->169.024, 279.055->153.068 | + | 28 | 0.9978 |
| 治螟磷 | 0.01 | 0.10 | 12.52 | 323.080->143.055, 323.080->97.111 | + | 31 | 0.9993 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|--------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 地乐酚 | 0.50 | 1.00 | 12.53 | 239.020->193.024, 239.020->134.086 | - | 48 | 0.9970 |
| 噻唑烟酸 | 0.05 | 0.10 | 12.57 | 397.125->377.096, 397.125->335.039 | + | 32 | 0.9995 |
| 苜草唑 | 0.20 | 0.50 | 12.61 | 403.060->91.248, 403.060->139.113 | + | 29 | 0.9990 |
| 四唑酰草胺 | 0.10 | 0.20 | 12.65 | 350.165->197.127, 350.165->83.298 | + | 24 | 0.9994 |
| 新燕灵 | 0.05 | 0.10 | 12.69 | 366.120->105.174, 366.120->77.261 | + | 59 | 0.9997 |
| 莎稗磷 | 0.05 | 0.10 | 12.71 | 368.080->171.005, 368.080->125.078 | + | 32 | 0.9995 |
| 环丙酰菌胺 | 0.02 | 0.05 | 12.81 | 334.125->139.144, 334.125->103.226 | + | 43 | 0.9997 |
| 特乐酚 | 0.10 | 0.20 | 12.87 | 239.045->206.985, 239.045->197.070 | - | 22 | 0.9944 |
| 甲基嘧啶磷 | 0.02 | 0.10 | 12.89 | 306.150->164.150, 306.150->108.188 | + | 33 | 0.9994 |
| 乙氧苯草胺 | 0.05 | 0.10 | 12.90 | 340.100->149.109, 340.100->121.129 | + | 34 | 0.9983 |
| 麦草氟异丙酯 | 0.01 | 0.05 | 12.90 | 364.160->105.174, 364.160->77.278 | + | 59 | 0.9994 |
| 吡唑解草酯 | 0.01 | 0.05 | 12.92 | 373.095->327.013, 373.095->298.999 | + | 28 | 0.9996 |
| 叶菌唑 | 0.10 | 0.50 | 12.94 | 320.175->70.335, 320.175->125.106 | + | 34 | 0.9988 |
| 咯菌腈 | 0.05 | 0.10 | 12.97 | 249.050->216.959, 249.050->121.133 | + | 28 | 0.9994 |
| 蝇毒磷 | 0.05 | 0.10 | 13.01 | 363.070->226.988, 363.070->306.936 | + | 19 | 0.9991 |
| 咪鲜胺 | 0.05 | 0.10 | 13.03 | 376.090->307.983, 376.090->70.349 | + | 27 | 0.9993 |
| 溴苯烯磷 | 0.50 | 1.00 | 13.07 | 402.955->170.007, 402.955->248.884 | + | 22 | 0.9991 |
| 十三吗啉 | 0.50 | 1.00 | 13.10 | 298.360->130.215, 298.360->98.274 | + | 32 | 0.9974 |
| 吡菌磷 | 0.10 | 0.20 | 13.15 | 374.115->222.080, 374.115->194.065 | + | 35 | 0.9992 |
| 甲基立枯磷 | 0.50 | 1.00 | 13.19 | 300.910->268.916, 300.910->125.111 | + | 20 | 0.9975 |
| 甲拌磷 | 0.10 | 0.20 | 13.20 | 260.970->75.288, 260.970->47.438 | + | 31 | 0.9988 |
| 氨基灵 | 0.50 | 5.00 | 13.23 | 323.150->289.125, 323.150->247.049 | + | 21 | 0.9990 |
| 联苯三唑醇 | 0.20 | 0.50 | 13.25 | 338.190->70.313, 338.190->153.109 | + | 41 | 0.9980 |
| 吡唑醚菌酯 | 0.02 | 0.05 | 13.26 | 388.150->163.107, 388.150->149.093 | + | 31 | 0.9995 |
| 克草敌 | 0.05 | 0.10 | 13.26 | 204.215->128.175, 204.215->57.429 | + | 20 | 0.9996 |
| 灭草敌 | 0.05 | 0.10 | 13.29 | 204.215->128.225, 204.215->86.250 | + | 16 | 0.9994 |
| 苯螨特 | 0.01 | 0.02 | 13.30 | 364.140->199.044, 364.140->105.202 | + | 23 | 0.9996 |
| 伏杀硫磷 | 0.02 | 0.05 | 13.34 | 368.015->182.010, 368.015->111.135 | + | 42 | 0.9993 |
| 辛硫磷 | 0.02 | 0.10 | 13.37 | 299.135->129.154, 299.135->77.307 | + | 29 | 0.9993 |
| 吡唑硫磷 | 0.02 | 0.20 | 13.38 | 361.100->257.001, 361.100->140.087 | + | 36 | 0.9993 |
| 异柳磷 | 0.02 | 0.05 | 13.40 | 346.170->216.984, 346.170->121.144 | + | 41 | 0.9993 |
| 禾草丹 | 0.02 | 0.05 | 13.43 | 258.145->125.128, 258.145->89.223 | + | 50 | 0.9995 |
| 氯辛硫磷 | 0.05 | 0.10 | 13.44 | 332.970->163.077, 332.970->97.125 | + | 23 | 0.9992 |
| 烯唑醇 | 0.05 | 0.20 | 13.46 | 326.155->70.303, 326.155->159.041 | + | 32 | 0.9991 |
| 乙拌磷 | 0.20 | 0.50 | 13.52 | 275.015->89.267, 275.015->61.381 | + | 40 | 0.9984 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions† | Polarity | Confirm / CE | R ² |
|---------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 磺菌胺 | 1.00 | 2.00 | 13.60 | 412.940->171.002, 412.940->348.950 | - | 27 | 0.9962 |
| 环草敌 | 0.20 | 0.50 | 13.62 | 216.215->83.301, 216.215->55.422 | + | 29 | 0.9996 |
| 氯亚胺硫磷 | 0.05 | 0.20 | 13.68 | 393.985->208.066, 393.985->181.068 | + | 34 | 0.9995 |
| 甲基毒死蜱 | 0.50 | 1.00 | 13.69 | 321.950->289.824, 321.950->124.929 | + | 22 | 0.9968 |
| 戊菌隆 | 0.01 | 0.05 | 13.69 | 329.090->125.141, 329.090->89.247 | + | 59 | 0.9994 |
| 硫线磷 | 0.01 | 0.05 | 13.71 | 271.165->158.999, 271.165->131.015 | + | 25 | 0.9996 |
| 氟吡甲禾灵 | 0.02 | 0.05 | 13.72 | 376.110->316.063, 376.110->288.071 | + | 28 | 0.9992 |
| 特草灵 | 0.10 | 0.20 | 13.75 | 278.235->109.193, 278.235->94.213 | + | 54 | 0.9995 |
| 啶草丹 | 0.01 | 0.02 | 13.89 | 264.190->146.114, 264.190->119.200 | + | 19 | 0.9994 |
| 啶草磷 | 0.01 | 0.02 | 13.92 | 354.180->170.985, 354.180->143.035 | + | 34 | 0.9994 |
| 燕麦敌 | 0.50 | 1.00 | 14.08 | 270.125->128.143, 270.125->109.114 | + | 30 | 0.9967 |
| 多杀霉素 A | 2.00 | 5.00 | 14.10 | 732.470->98.267, 732.470->142.214 | + | 26 | 0.9964 |
| 磷酸三异丁酯 | 0.02 | 0.05 | 14.10 | 267.245->99.138, 267.245->81.199 | + | 56 | 0.9994 |
| 噻草酮 | 0.05 | 0.10 | 14.11 | 326.230->280.122, 326.230->180.124 | + | 23 | 0.9954 |
| 丙草胺 | 0.02 | 0.05 | 14.11 | 312.245->252.110, 312.245->176.174 | + | 30 | 0.9978 |
| 多果定 | 0.20 | 0.50 | 14.16 | 228.215->57.445, 228.215->43.514 | + | 29 | 0.9949 |
| 丁草敌 | 0.10 | 0.20 | 14.18 | 218.210->57.428, 218.210->41.518 | + | 27 | 0.9996 |
| 除虫菊素 II | 5.00 | 10.00 | 14.21 | 373.175->105.200, 373.175->128.175 | + | 38 | 0.9870 |
| 苜草丹 | 0.01 | 0.02 | 14.28 | 252.190->91.274, 252.190->65.368 | + | 59 | 0.9996 |
| 肟菌酯 | 0.02 | 0.05 | 14.28 | 409.140->186.086, 409.140->145.085 | + | 44 | 0.9995 |
| 茚虫威 | 0.20 | 0.50 | 14.32 | 528.055->150.060, 528.055->203.023 | + | 38 | 0.9990 |
| 吡氟酰草胺 | 0.10 | 0.20 | 14.32 | 395.105->266.033, 395.105->246.029 | + | 36 | 0.9935 |
| 乙羧氟草醚 † | 0.05 | 0.10 | 14.34 | 464.992->344.006, 464.992->223.001 | + | 35 | 0.9993 |
| 磷酸三丁酯 | 0.05 | 0.10 | 14.34 | 267.220->99.157, 267.220->81.205 | + | 58 | 0.9994 |
| 烯草酮 | 0.10 | 0.20 | 14.35 | 360.190->164.137, 360.190->166.147 | + | 27 | 0.9995 |
| 丙硫克百威 | 0.20 | 0.50 | 14.50 | 411.215->195.085, 411.215->162.117 | + | 38 | 0.9880 |
| 吡草酮 | 0.05 | 0.10 | 14.50 | 431.050->105.222, 431.050->139.144 | + | 29 | 0.9986 |
| 氟铃脲 | 1.00 | 2.00 | 14.57 | 458.920->438.932, 458.920->174.866 | - | 37 | 0.9967 |
| 噻嗪酮 | 0.10 | 0.20 | 14.58 | 306.235->57.448, 306.235->106.219 | + | 28 | 0.9992 |
| 噻恩菊酯 † | 0.02 | 0.05 | 14.61 | 414.145->171.125, 414.145->143.160 | + | 30 | 0.9992 |
| 氟硫草定 | 0.10 | 0.20 | 14.63 | 402.060->354.005, 402.060->271.991 | + | 31 | 0.9976 |
| 吡氟甲禾灵 | 0.02 | 0.05 | 14.63 | 434.100->316.025, 434.100->288.037 | + | 31 | 0.9998 |
| 啶禾灵 | 0.02 | 0.05 | 14.73 | 373.090->299.034, 373.090->271.038 | + | 28 | 0.9995 |
| 丙溴磷 | 0.01 | 0.02 | 14.73 | 374.980->304.843, 374.980->346.925 | + | 15 | 0.9992 |
| 氟酰胺 | 0.50 | 5.00 | 14.76 | 490.985->470.974, 490.985->304.961 | - | 19 | 0.9967 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|------------------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 味线威 | 0.05 | 0.10 | 14.83 | 383.210->195.072, 383.210->167.081 | + | 27 | 0.9994 |
| 特丁硫磷 | 0.10 | 0.50 | 14.89 | 289.000->57.459, 289.000->130.889 | + | 30 | 0.9988 |
| 胺菊酯 | 0.05 | 0.10 | 14.91 | 332.240->164.120, 332.240->135.203 | + | 21 | 0.9993 |
| 多杀霉素 D | 0.50 | 1.00 | 14.97 | 746.455->142.203, 746.455->98.269 | + | 43 | 0.9972 |
| 啉啶磷 | 0.01 | 0.02 | 15.00 | 334.080->198.138, 334.080->182.179 | + | 25 | 0.9996 |
| 乙氧氟草醚 | 10.00 | 20.00 | 15.02 | 361.990->316.051, 361.990->237.077 | + | 27 | 0.9957 |
| 噁草酸 | 0.05 | 0.20 | 15.03 | 444.155->371.071, 444.155->299.080 | + | 25 | 0.9992 |
| 啉螨醚 | 0.02 | 0.05 | 15.04 | 378.250->184.106, 378.250->150.169 | + | 37 | 0.9996 |
| 氟螨嗪 | 0.05 | 0.20 | 15.07 | 417.060->397.046, 417.060->167.057 | + | 28 | 0.9980 |
| 吡氟禾草灵 | 0.01 | 0.05 | 15.08 | 384.165->282.101, 384.165->328.106 | + | 18 | 0.9991 |
| 氟烯草酸 † | 0.02 | 0.05 | 15.09 | 441.180->308.046, 441.180->252.075 | + | 39 | 0.9995 |
| 丁基啉啶磷 | 0.01 | 0.02 | 15.12 | 319.170->277.049, 319.170->153.157 | + | 31 | 0.9997 |
| 乳氟禾草灵 † | 0.05 | 0.10 | 15.13 | 479.105->344.011, 479.105->222.994 | + | 36 | 0.9994 |
| 生物烯丙菊酯 | 0.50 | 1.00 | 15.26 | 303.225->91.223, 303.225->79.296 | + | 25 | 0.9993 |
| 烯丙菊酯 | 0.20 | 0.50 | 15.26 | 303.150->91.242, 303.150->79.306 | + | 27 | 0.9990 |
| 吲哚酮草酯 | 0.20 | 0.50 | 15.27 | 394.035->348.022, 394.035->365.993 | + | 15 | 0.9992 |
| 增效醚 † | 0.01 | 0.02 | 15.27 | 356.315->177.150, 356.315->119.206 | + | 36 | 0.9995 |
| 氟蚁腴 | 0.10 | 0.50 | 15.30 | 495.200->323.151, 495.200->151.075 | + | 56 | 0.9957 |
| 丁草胺 | 0.05 | 0.10 | 15.31 | 312.170->238.136, 312.170->162.195 | + | 26 | 0.9976 |
| 稗草丹 | 0.02 | 0.05 | 15.43 | 331.200->133.190, 331.200->108.207 | + | 30 | 0.9997 |
| 肟草酮 | 0.02 | 0.05 | 15.48 | 330.235->284.141, 330.235->96.217 | + | 30 | 0.9997 |
| 吡丙醚 | 0.02 | 0.05 | 15.48 | 322.190->96.237, 322.190->185.104 | + | 25 | 0.9994 |
| 除线磷 | 1.00 | 2.00 | 15.56 | 314.930->258.925, 314.930->286.950 | + | 13 | 0.9965 |
| 亚胺唑 | 0.10 | 0.50 | 15.57 | 411.035->125.130, 411.035->342.027 | + | 18 | 0.9997 |
| 双硫磷 | 0.05 | 0.10 | 15.67 | 467.005->418.987, 467.005->404.954 | + | 17 | 0.9994 |
| 乙硫磷 | 0.02 | 0.05 | 15.69 | 385.040->143.013, 385.040->171.025 | + | 19 | 0.9996 |
| 噻螨酮 | 0.05 | 0.10 | 15.69 | 353.160->167.973, 353.160->151.068 | + | 32 | 0.9989 |
| 野麦畏 | 0.50 | 1.00 | 15.70 | 304.085->143.035, 304.085->83.161 | + | 46 | 0.9983 |
| 氟啶胺 | 0.20 | 0.50 | 15.70 | 462.890->415.901, 462.890->397.936 | - | 19 | 0.9991 |
| 氟吡酰草胺 | 0.05 | 0.10 | 15.73 | 377.115->238.071, 377.115->359.104 | + | 23 | 0.9994 |
| 甲氨基阿维菌素 B1b 苯甲酸盐 | 0.50 | 2.00 | 15.78 | 872.495->158.178, 872.495->82.279 | + | 46 | 0.9937 |
| 毒死蜱 | 0.02 | 0.05 | 15.92 | 352.010->199.943, 352.010->320.065 | + | 8 | 0.9994 |
| 喹氧灵 | 0.02 | 0.05 | 15.95 | 308.075->197.022, 308.075->272.067 | + | 30 | 0.9992 |
| 啉啶脲 | 0.02 | 0.05 | 16.05 | 506.035->349.008, 506.035->158.114 | + | 23 | 0.9996 |

| 农药名称 | LOD (ppb) | LOQ (ppb) | RT (min) | Parent-> Product m/z SRM transitions‡ | Polarity | Confirm / CE | R ² |
|------------------|-----------|-----------|----------|---------------------------------------|----------|--------------|----------------|
| 硫丙磷 | 0.05 | 0.10 | 16.17 | 323.090->155.061, 323.090->139.117 | + | 33 | 0.9989 |
| 快螨特 † | 0.05 | 0.10 | 16.21 | 368.140->107.198, 368.140->57.440 | + | 23 | 0.9985 |
| 虫螨磷 | 0.10 | 0.50 | 16.29 | 361.020->304.902, 361.020->224.955 | + | 25 | 0.9910 |
| 甲氨基阿维菌素 B1a 苯甲酸盐 | 0.20 | 1.00 | 16.40 | 886.505->158.190, 886.505->82.301 | + | 47 | 0.9985 |
| 氟虫脲 | 0.05 | 0.10 | 16.50 | 489.040->158.090, 489.040->141.090 | + | 43 | 0.9992 |
| 酞酸二环己基酯 | 0.01 | 0.02 | 16.57 | 331.090->149.094, 331.090->121.166 | + | 47 | 0.9992 |
| 甲氧菊酯 | 0.05 | 0.10 | 16.57 | 350.180->125.172, 350.180->55.436 | + | 47 | 0.9993 |
| 仲丁灵 | 0.02 | 0.05 | 16.58 | 296.185->240.110, 296.185->222.110 | + | 24 | 0.9997 |
| 除虫菊素 I | 1.00 | 2.00 | 16.73 | 329.160->105.250, 329.160->128.180 | + | 34 | 0.9988 |
| 氯硫磷 † | 0.20 | 0.50 | 16.80 | 315.000->214.985, 315.000->186.996 | + | 35 | 0.9991 |
| 螺螨酯 | 0.02 | 0.05 | 16.81 | 411.085->313.027, 411.085->71.376 | + | 18 | 0.9995 |
| 丙硫特普 | 0.01 | 0.02 | 16.81 | 379.115->210.890, 379.115->115.073 | + | 33 | 0.9996 |
| 丁醚脲 | 5.00 | 10.00 | 16.89 | 385.255->329.184, 385.255->278.176 | + | 35 | 0.9965 |
| 唑螨酯 | 0.01 | 0.02 | 16.89 | 422.235->366.126, 422.235->214.136 | + | 32 | 0.9990 |
| 氯氧菊酯 † | 0.50 | 1.00 | 17.00 | 433.085->191.064, 433.085->199.160 | + | 15 | 0.9990 |
| 异丙乐灵 | 0.50 | 1.00 | 17.18 | 310.230->222.093, 310.230->264.158 | + | 20 | 0.9995 |
| 氟啶脲 | 0.10 | 0.20 | 17.30 | 539.995->382.974, 539.995->346.999 | + | 46 | 0.9993 |
| 苯醚氰菊酯 | 2.00 | 5.00 | 17.37 | 376.240->181.081, 376.240->153.105 | + | 47 | 0.9988 |
| 脱叶磷 | 0.01 | 0.01 | 17.43 | 315.150->169.018, 315.150->57.423 | + | 25 | 0.9997 |
| 苜蓿菊酯 1 | 0.05 | 0.10 | 17.79 | 339.250->171.147, 339.250->143.173 | + | 27 | 0.9994 |
| 克来范 | 5.00 | 20.00 | 17.86 | 632.675->426.652, 632.675->586.693 | - | 18 | 0.9905 |
| 啉螨醚 | 0.01 | 0.02 | 17.93 | 307.230->161.188, 307.230->57.448 | + | 25 | 0.9995 |
| 苜蓿菊酯 2 | 0.02 | 0.05 | 18.01 | 339.150->171.124, 339.150->143.182 | + | 27 | 0.9997 |
| 氟胺氰菊酯 | 0.05 | 0.10 | 18.04 | 503.155->208.075, 503.155->181.100 | + | 25 | 0.9990 |
| 醚菊酯 † | 0.05 | 0.10 | 18.39 | 394.240->359.174, 394.240->135.156 | + | 26 | 0.9996 |

†: 母离子为 $[M+NH_4]^+$ 峰, 其余均为 $[M+H]^+$ 或 $[M-H]^-$ 峰。

‡: 前一个子离子为定量离子, 后一个为定性确证子离子 1。

进一步的统计分析得知，实验中 440 种农残 LOD 与 LOQ 的中位数值 (median value) 分别为 0.05 pg/ μ L (50 ppt) 与 0.1 pg/ μ L (100 ppt)，显示了基于主动离子管控技术研发的 TSQ Endura MS 具有出色的灵敏度性能。同时，值得注意的是，本实验为确保分析的高通量性与大多数农残的检测效果，使用了单一流动相体系进行快速正负电离切换，一定程度上牺牲了适用于负离子模式的农残的检测灵敏度(使用乙酸铵体系，会有很大改善)。但尽管如此，如图 8 所示，对表 1 中的农残 LOD 与 LOQ 值进行频次分析可知，累计分别有 438 (占总数的 99.5%) 与 430 种 (占总数的 97.7%) 农残的 LOD 与 LOQ 小于 10 pg/ μ L 这一国标最低 MRL 限值，同时这也是欧盟法规与日本肯定列表制度中的通用标准。本方法实现的 LOQ 全部满足 GB2763-2014 强制国家标准中的 MRLs 指标要求。因此，TSQ Endura LC-MS/MS 是食品安全领域中高灵敏度、高特异性与高通量农残检测的优质平台。

4. 结论:

- 利用主动离子管控技术的创新设计，TSQ Endura MS 实现了出色灵敏度、极致耐用性与高度易用性的有机统一。
- TraceFinder 强大灵活的数据处理功能、智能交互式信息管理界面，以及 pQuan 农残检测方法数据库，能够为农残检测提供一站式的全流程服务。
- TSQ Endura LC-MS/MS 与 TraceFinder 软件强强联合，将在农残检测中具有广阔的应用空间。

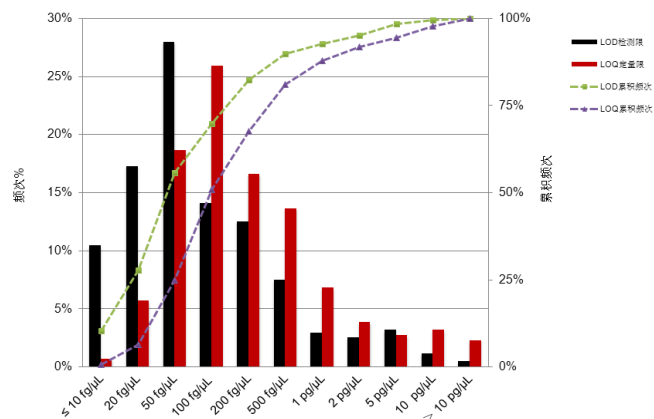


图 8 本实验中 440 种农残同时检测的 LOD 与 LOQ 值频次统计结果

5. 致谢

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