Residue Data to Support UAS for Crop Applications

Sheila Flack, PhD
Dietary Safety
August 18, 2024

Why conduct an experiment with drones?

- Regulatory data gaps in Canada:
  - Pesticide application to food & feed via drones is currently not permitted in Canada.
  - Lack of drone-specific efficacy, spray drift, operator exposure and crop residue data.
  - Canada requires comparative data on pesticide residues.

- High innovation potential:
  - Costs for drone use is competitive with other application types.
  - Potential for productivity gains, reduced pesticide use, sustainability, increased safety.

- Complements existing work:
  - Collaborative work at international and North American levels is focused on generating data to address major data gaps (e.g., UAPASTF).

Current Regulatory Framework

- Crop residue studies are used to support new pesticide registrations:
  - Follow the most current regulatory (EPA, PMRA) trial requirements.
  - For dietary risk assessments to evaluate consumer safety.
  - To establish MRLs for trade and enforcement.
  - At critical GAP following label use (e.g., max use rate).
  - Additional data may be needed (ULV applications, formulation changes).
  - Using conventional spray equipment.
    - Assumes equivalency with other spray equipment types
    - **Can we assume equivalency of residues for drone use compared to conventional use?**

Study Timeline Overview

In Spring 2022, in collaboration with the AAFC Policy Branch, a broad range of experts were brought together to pursue an experiment to address the spray drone data gap in Canada.

As a result of consultations and weekly meeting, a multidisciplinary working group (WG) including the PMC, PMRA, Transport Canada, pesticide registrants, and drone operators was formed to identify data gaps and how to address these.

The WG agreed on studies led by the PMC on four different crop types to allow regulators to determine the level of equivalency of crop residues via side-by-side trials comparing drone models to traditional ground application equipment.

In 2023, 12 trials were conducted under GLP (Good Laboratory Practices), and samples collected for analysis of pesticide residue levels. The data will be used by PMRA to evaluate whether drones can be added on-label within the current regulatory structure.

Drone-Based Pesticide Application Working Group

- **Question**:

  Are crop residues resulting from drone/UAS application equivalent to conventional application methods?

- A side-by-side GLP comparative study of chemical residues levels from drone vs. conventional (ground) applications:
  - Multiple drone platforms
  - 4 crop types – large field, small field, orchard, trellis crop
  - Include 2 Bayer active ingredients
  - Increased application rates above labeled rates and reduced PHI to ensure quantifiable residues
  - PMC conducted field trials at 7 locations in Canada
  - Bayer provided analysis of collected samples

Working Group Membership	
AAFC – Strategic Policy Branch	Bayer
AAFC – Pest Management Center	Syngenta
HC – Pest Management Regulatory Agency	Strongfield Environmental Solutions
Transport Canada	Precision AI
TBS – Center for Regulatory Innovation	Protein Industries Canada
OMAFRA	Aerial Evolution Canada

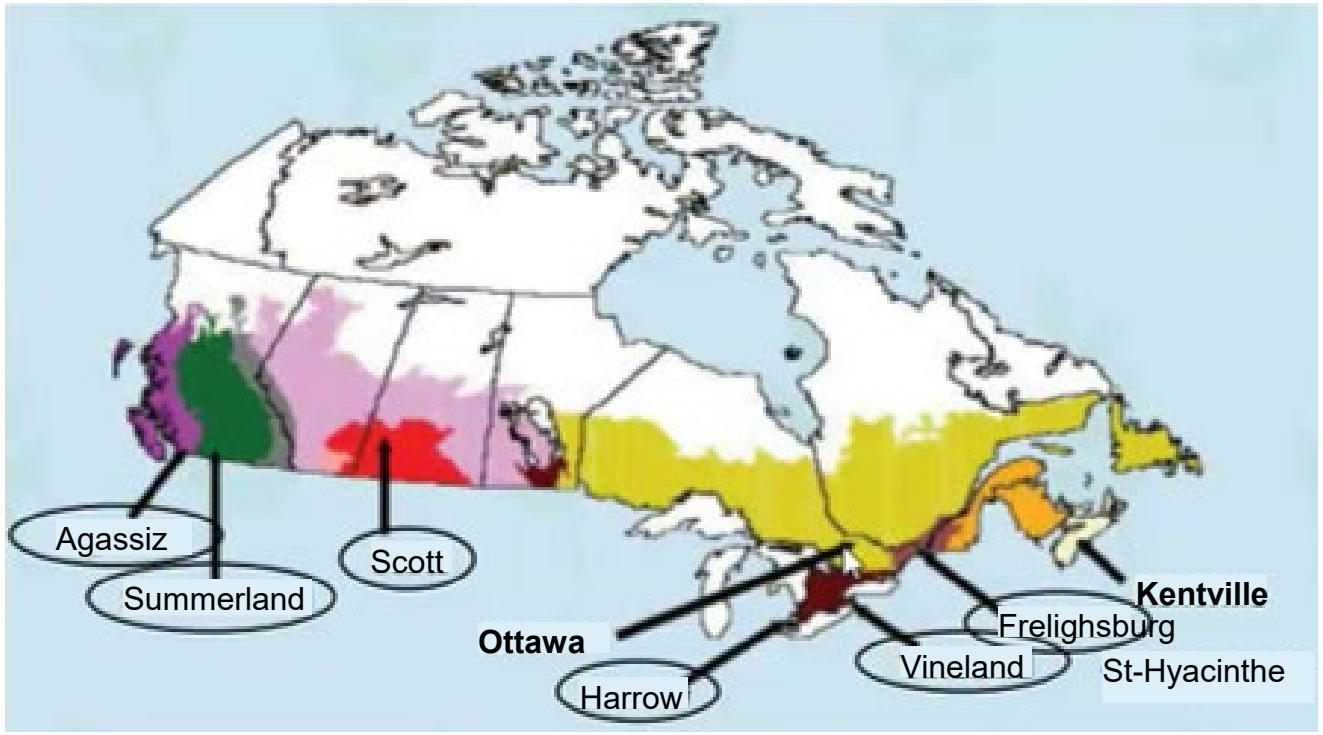
Comparative Residue Study

- Bayer offered two active ingredients:
  - Product 1: Active 1
  - Product 2: Active 1 + Active 2
- Application on representative crops:
  - Large Field Crop: Edible-podded pea
  - Small Field Crop: Broccoli
  - Orchard Crop: Apple
  - Trellis Crop: Grape

Crop	Active Ingredient(s)	Target Application Rate	Crop Fraction Sampled*
Pea	Active 1	250 g a.i./ha	Pea with pod
Broccoli	Active 1 + Active 2	250 & 250 g a.i./ha	Flower head (florets, stalk, stem)
Apple	Active 1 + Active 2	250 & 250 g a.i./ha	Fruit
Grape	Active 1 + Active 2	250 & 250 g a.i./ha	Bunch

Trial Locations

- Six AAFC sites and 1 contracted site for the 12 trials (3 treatment plots per trial, 2 applications per plot):
  - Frelighsburg, QC (broccoli, apple, grape)
  - Vineland, ON (apple, grape)
  - Summerland, BC (apple, grape)
  - Agassiz, BC (broccoli, pea)
  - St-Hyacinthe, QC (broccoli)
  - Harrow, ON (pea)
  - Scott, SK (pea)



Trial Protocol

- Each trial was conducted with 4 treatments:
  - Untreated Control
  - **Two** different drone models
  - Conventional method (Boom or Airblast)
- Each trial was replicated at 3 different locations across Canada (total of 12 trials).
- Four samples of mature crop were harvested per treatment.
- Water-sensitive paper was also collected to evaluate spray deposition.

Treatment No.	Target rate of product	Application Type	No. of applications*	Target Spray Volume**
01 (untreated)	Not applicable	Not applicable	Not applicable	Not applicable
02	0.5-1 L/ha	Foliar, Drone model 1	2	30-80 L/ha
03	0.5-1 L/ha	Foliar, Drone model 2	2	30-80 L/ha
04	0.5-1 L/ha	Foliar, conventional (Boom or Airblast)	2	200-500 L/ha (Boom) 500-800 L/ha (Airblast)

* 2 applications at 7-day intervals with last application 0-day PHI (pea, broccoli), 3-day PHI (apple, grape)
** dependent on crop type; drone spray volume for apple and grape was 60-80 L/ha; lower volume in range was targeted

Spray Application Equipment

- Trials compared boom or airblast applications to the following drone platforms:
  - TTA M6E (for broccoli, apples, peas and grapes)
  - TTA M4E (for peas)
  - Hylio AG 110 (for broccoli, peas)
  - DJI T-10 (for broccoli, apples, and grapes)
  - DJI T-30 (for apples, and grapes)
  - XAG V40 (for apples and grapes)

TTA M6E

Hylio AG-110

XAG V40

DJI T-30

TTA M4E

DJI T-10

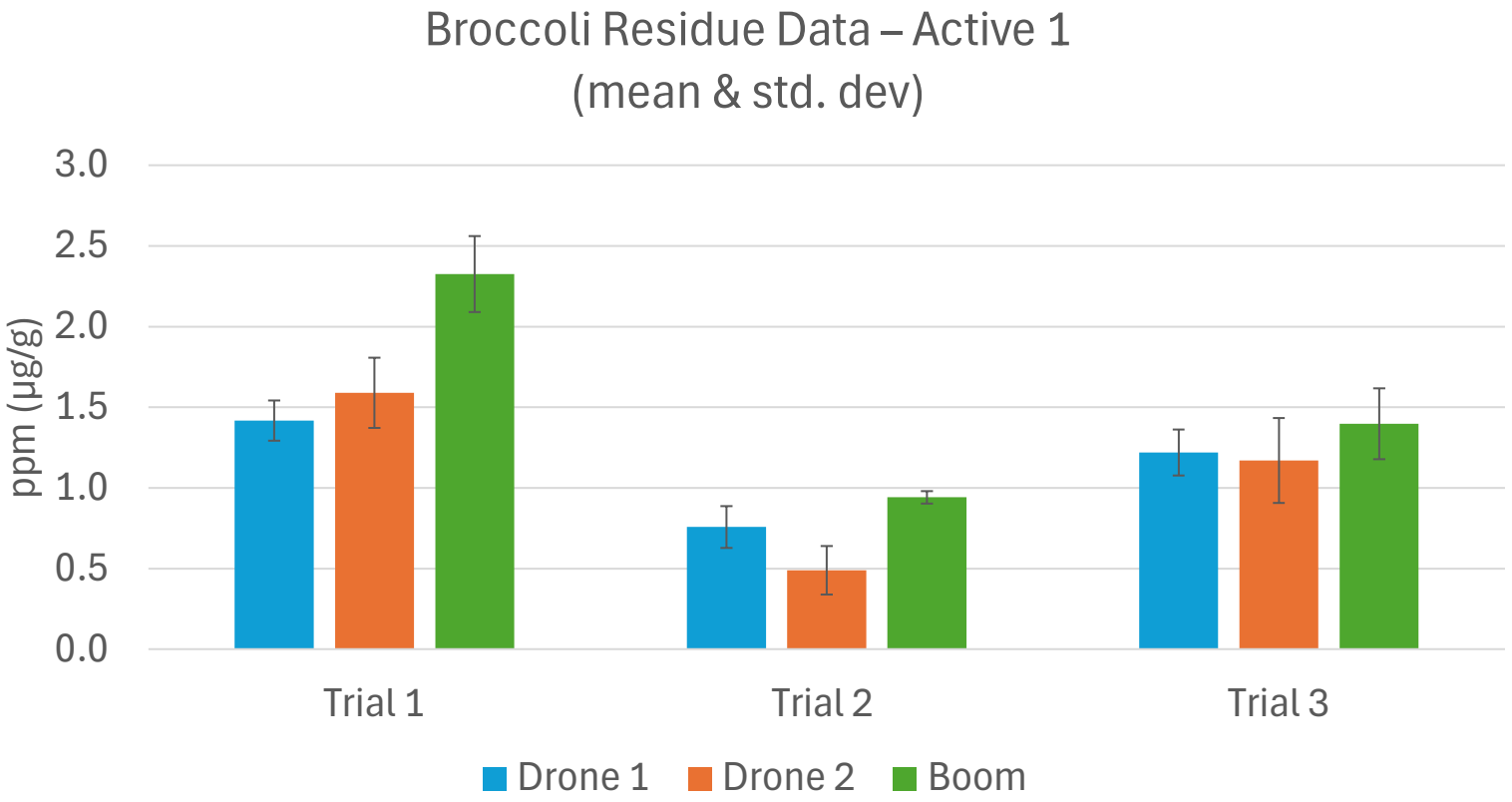
Airblast application

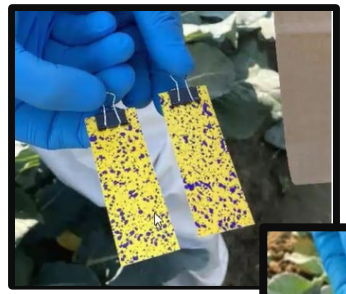
Boom application

Residue Data Analysis

- Sample collection and analysis followed Good Laboratory Practices (GLP)
  - Analyzed for Active 1, Active 2, Active 2 metabolite
- Statistical methods used:
  - Means and standard deviations
  - Box plots for visualizing distribution and spread of data
  - Mixed-effects linear regression model in SAS
- All samples from treated fields were above limits of detection (LOD) for parent.
- All untreated control samples were below LOD.

Residue Results for Broccoli



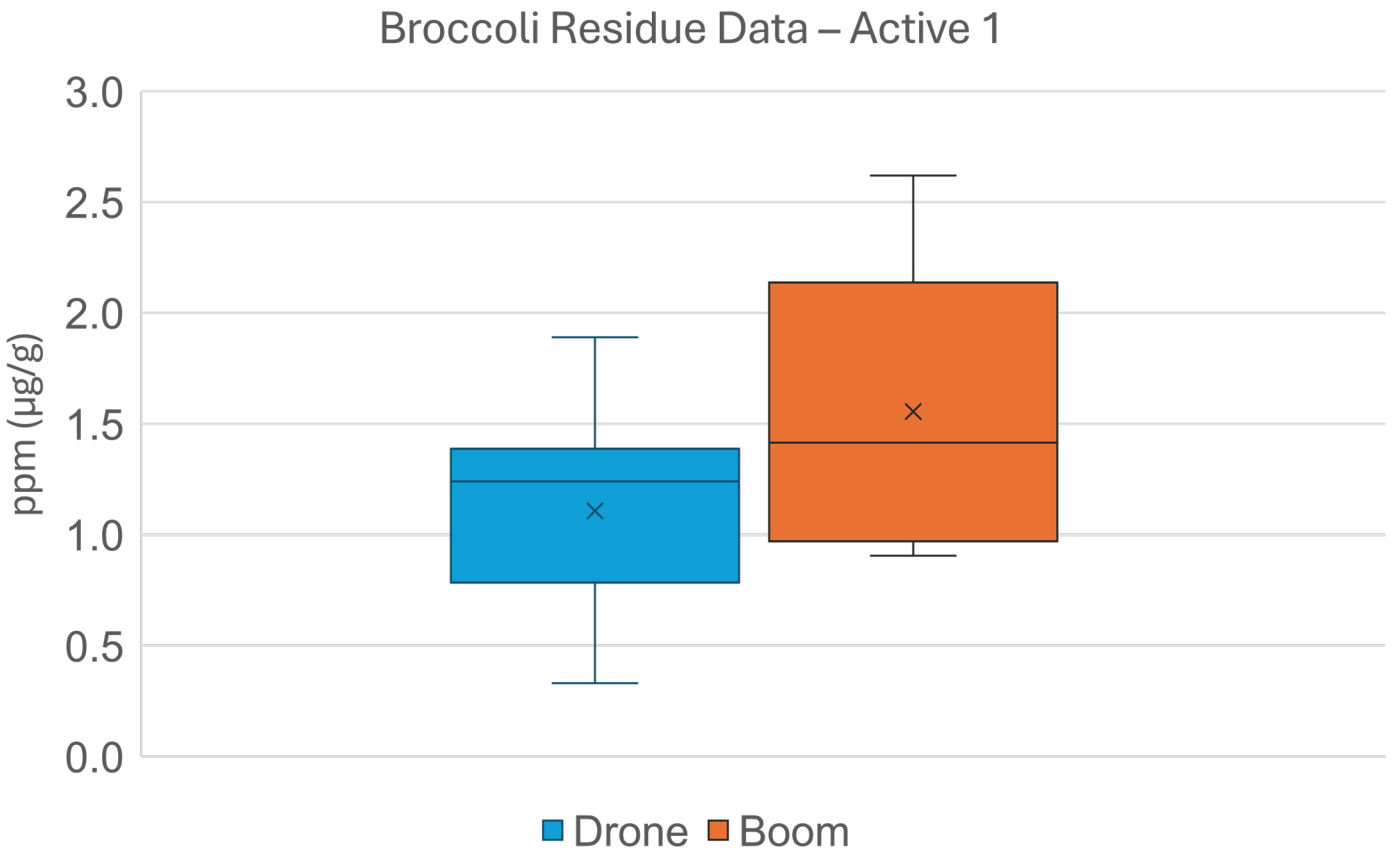


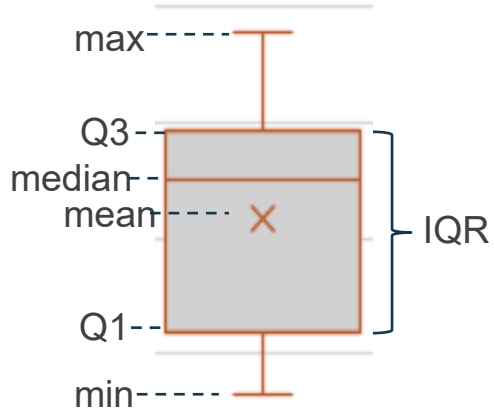
Drone application

Boom application

- Mean residues varied across trials; drone had similar or slightly lower residues compared to boom.
- Variability in residues were similar across treatment types.

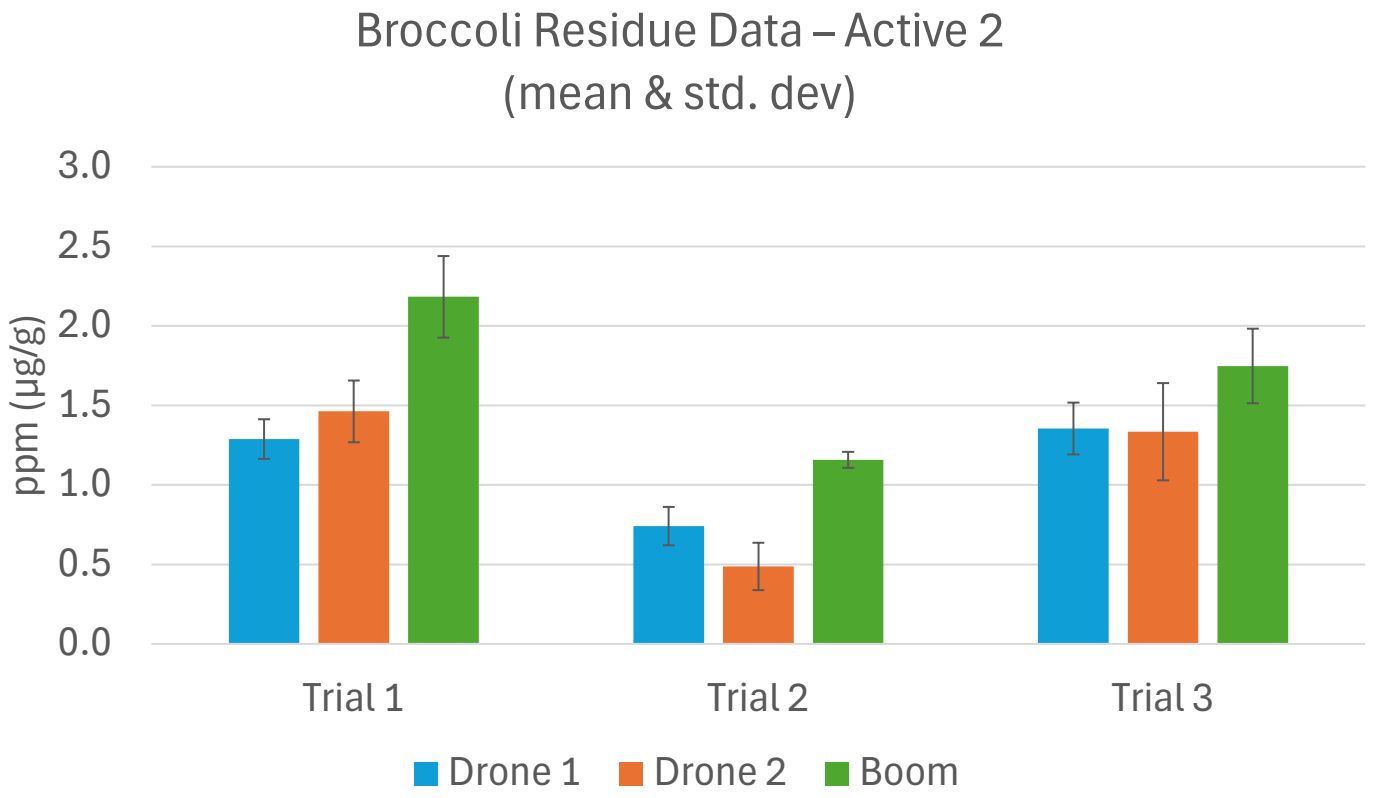
Residue Analysis for Broccoli





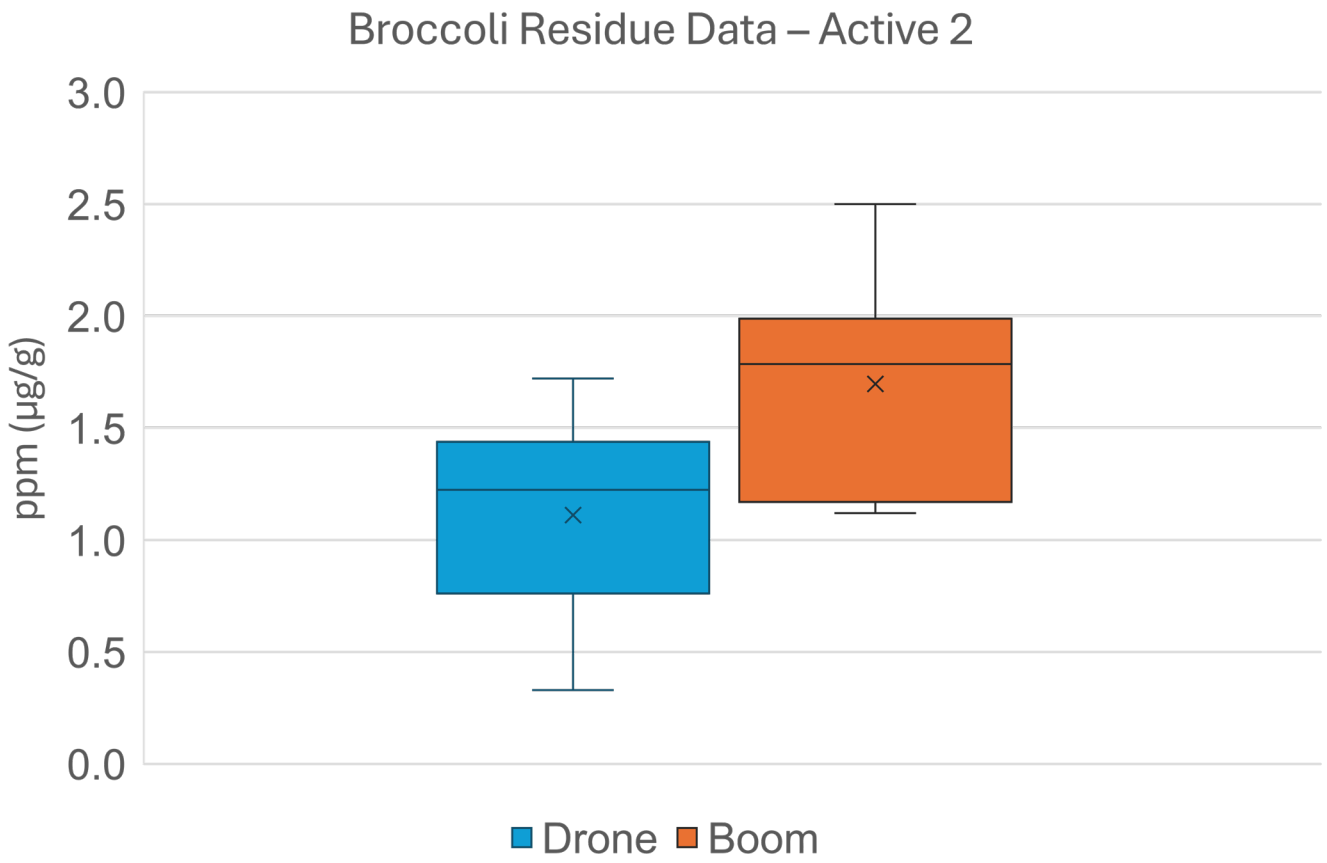
- Residues were slightly elevated for boom application compared to drone application.
- Less variability in residues for drone compared to boom.
- Results were not statistically different across treatments.

Residue Results for Broccoli



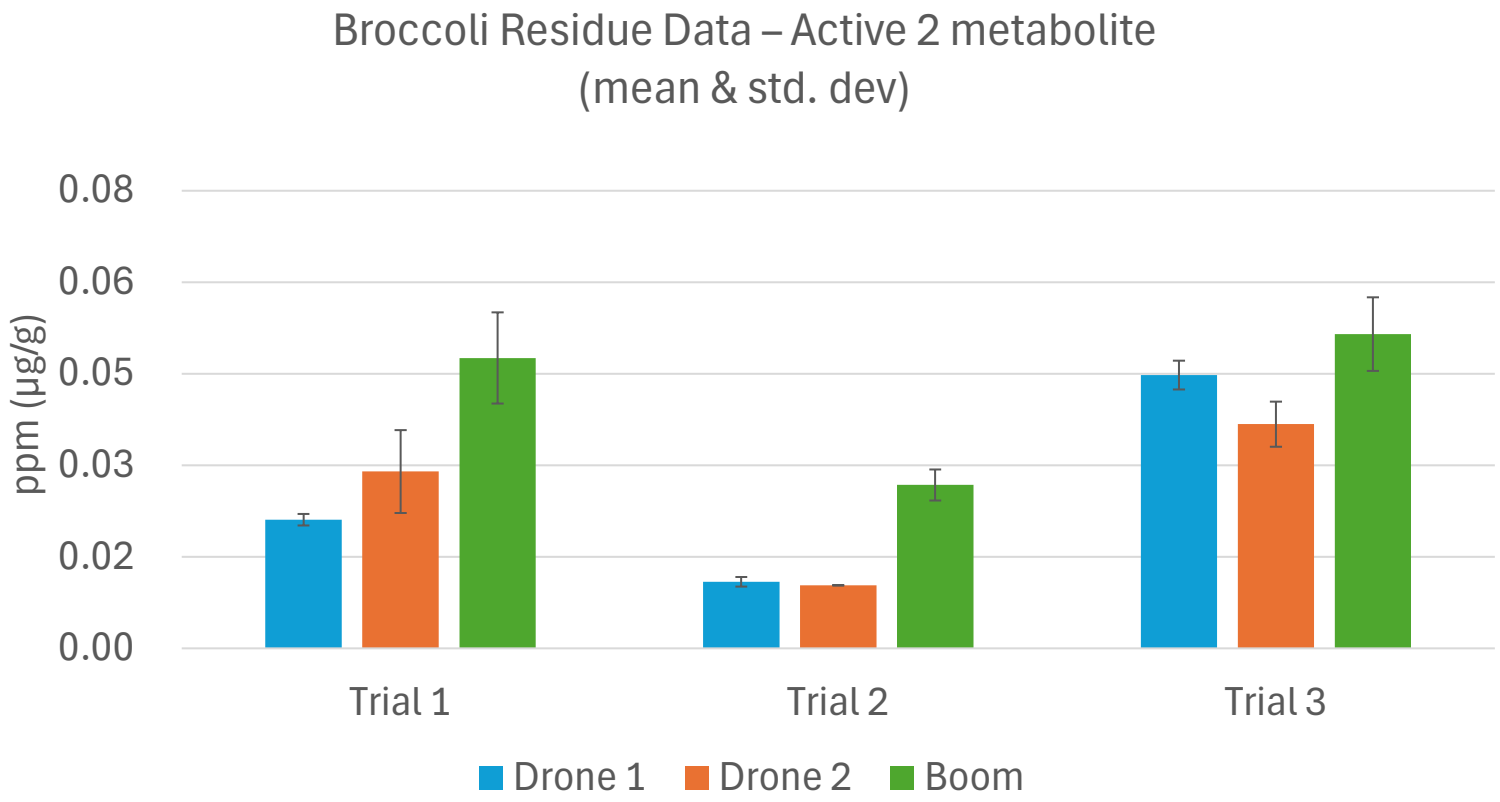
- Mean residues varied across trials; drone had slightly lower residues compared to boom.
- Variability in residues were similar across treatment types.

Residue Analysis for Broccoli



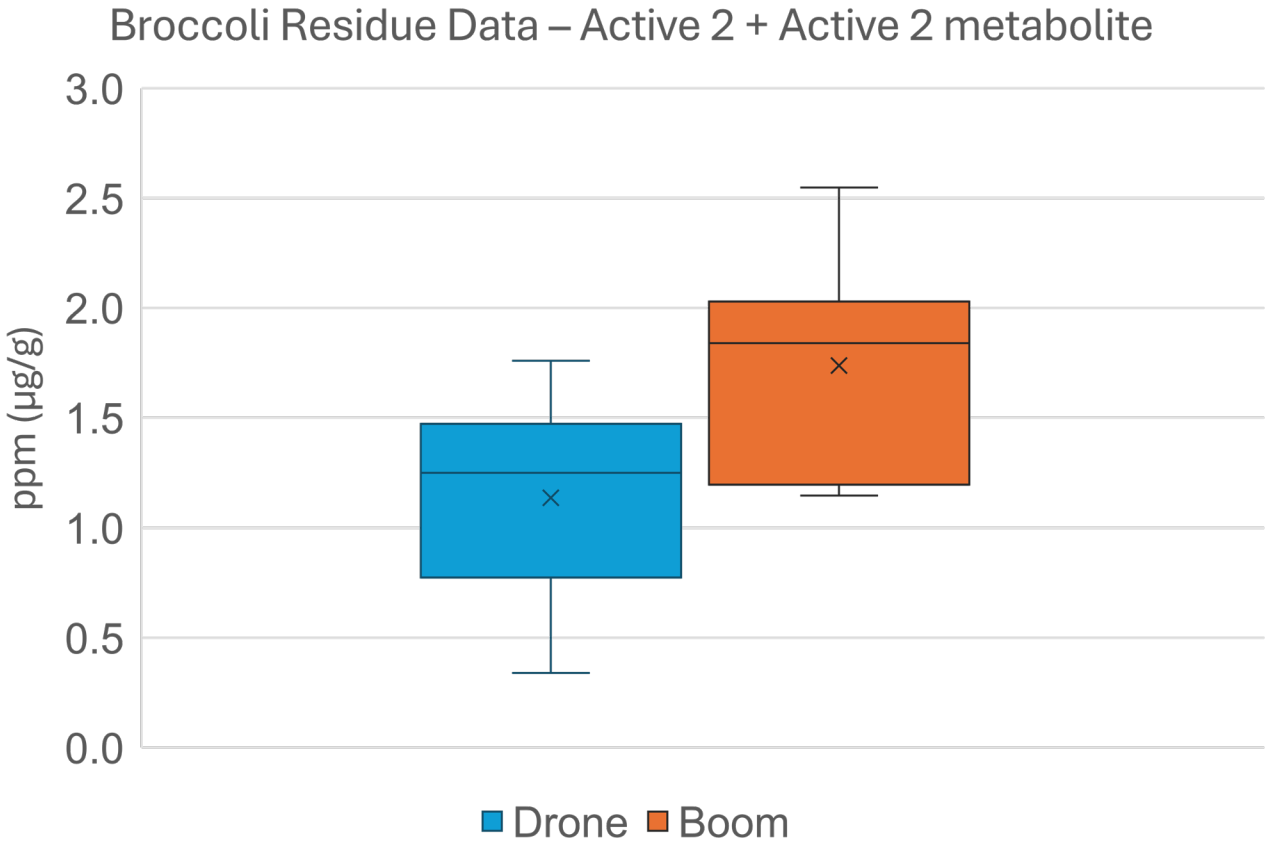
- Boom residues were elevated compared to drone applications and were significantly different.
- Variability in residues for drone and boom were comparable.

Residue Results for Broccoli



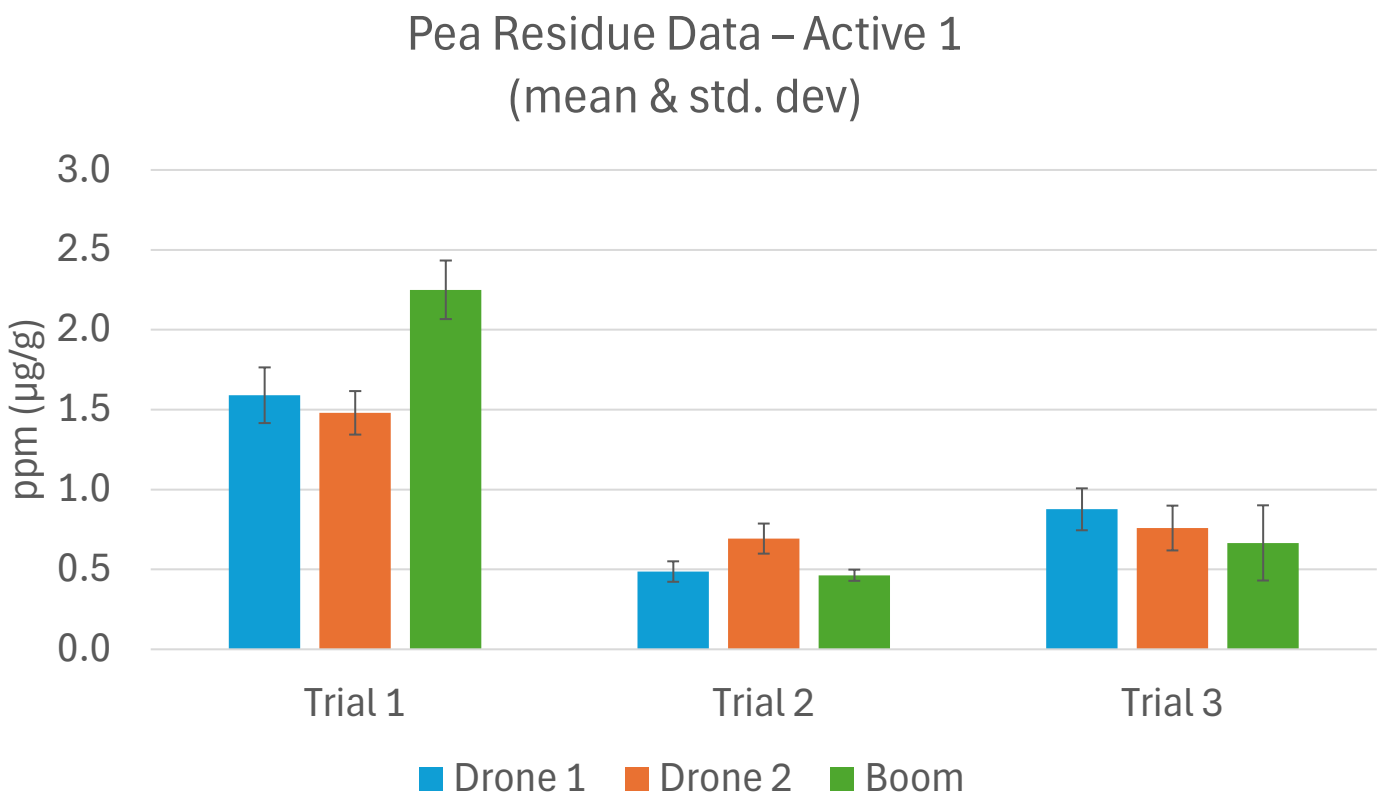
- >50% of samples from drone applications in Trial 2 were <LOD for metabolite.
- Mean residues varied across trials; drone had similar or slightly lower residues compared to boom.

Residue Analysis for Broccoli



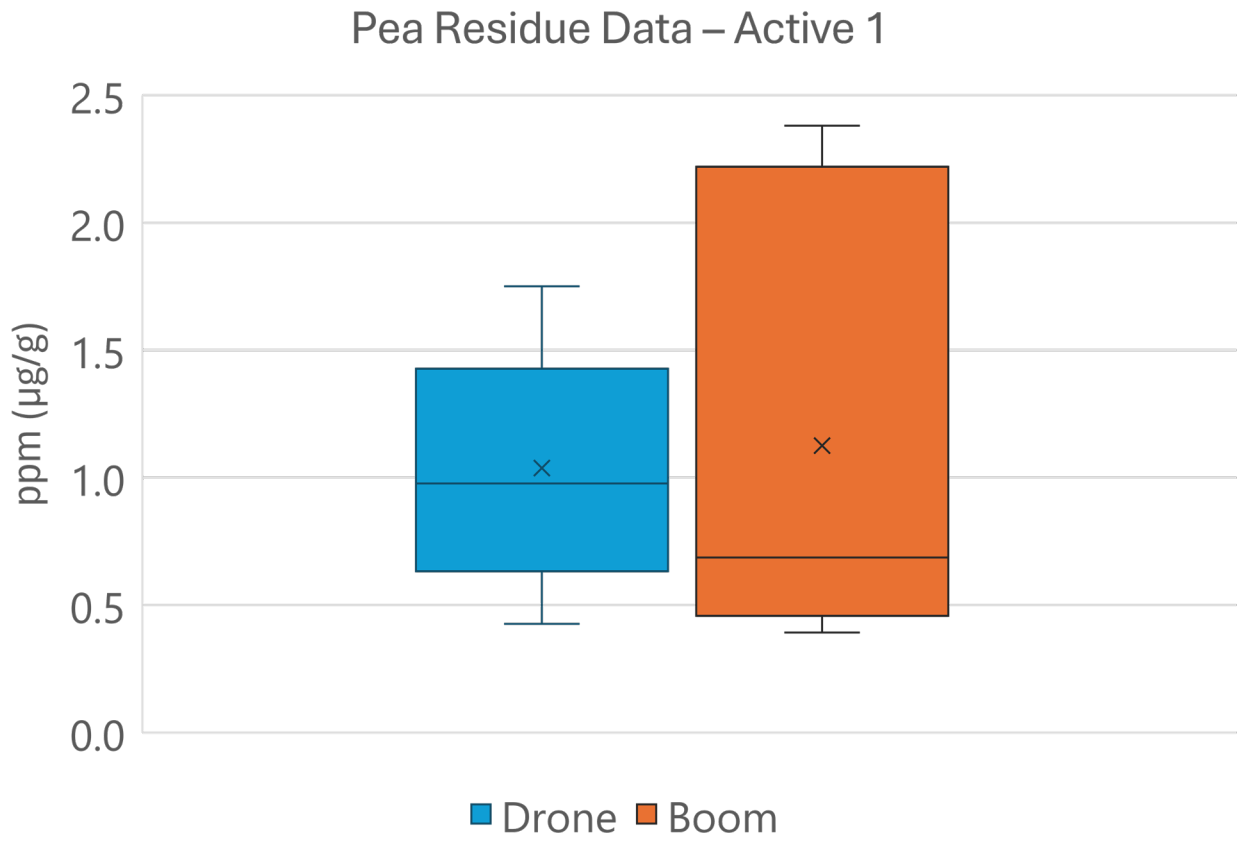
- Boom residues were elevated compared to drone application and were significantly different.
- Variability in residues for drone and boom were comparable.

Residue Results for Pea



- Mean residues varied across trials; drone had similar or slightly lower residues compared to boom.

Residue Analysis for Pea



- Boom application had higher variability in residues compared to the drone application.
- Residues were similar across the application types and not statistically different.

Mixed-Effects Model Results

- Comparing Residues from Drone and Boom Applications (alpha=0.05):

Test	Crop	Active Ingredient	Estimate	Std Error	P-value	Lower (95% CI)	Upper (95% CI)
1	Broccoli	A1	0.447	0.212	0.829	-0.282	1.176
2	Broccoli	A2	0.585	0.142	0.045	0.0314	1.138
3	Broccoli	A2 metabolite*	0.0165	0.0053	0.042	0.00099	0.0319
4	Broccoli		0.207	0.089	0.072	-0.0281	0.441
5	Pea	A1	0.088	0.378	0.829	-1.062	1.239
6			0.110	0.107	0.329	-0.133	0.353

* Estimates on logarithmic scale

- Modeling across active ingredient (and crop) indicated results were similar across treatments

Conclusions and Next Steps

- Residues from drone application are equivalent (or no worse) than boom applications.
  - Higher ground boom residues may be due to differences in:
    - Spray drift potential – height, speed, nozzle type, spray quality
    - Volume of spray application and coverage
- Residues for side-by-side drone applications were not statistically different.
- Broccoli and pea residue data is currently under review by AAFC.
- Completing residue analysis of apple and grape samples (drone vs. airblast).

Acknowledgements

Agriculture & Agri-Food Canada

- Martin Trudeau, AAFC
- Jessica Stoeckli, AAFC

Agriculture and Agri-Food Canada

Analytical Team:

- Lee Huber, Bayer Crop Science
- Heather Henderson, Bayer Crop Science
- Mikayla Mayer, Bayer Crop Science

Statistical Analysis:

- Luke Settles, Bayer Crop Science

Thank You