DPR PMAC Meeting:

Dissemination and Training for Citrus Spray Application Expert System Adoption in California: Efforts and Outcomes

Peter Ako Larbi, Ph.D.

Assistant CE Extension Specialist/

Assistant Professor of Cooperative Extension

Agricultural Application Engineering

Kearney Agricultural Research & Extension Center, Parlier, CA

palarbi@ucanr.edu

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Introduction

Need for general pesticide stewardship

Pesticide use remains inevitable in crop production, despite efforts to reduce their use via IPM.

Introduction

Spray Application in Trees and Vines

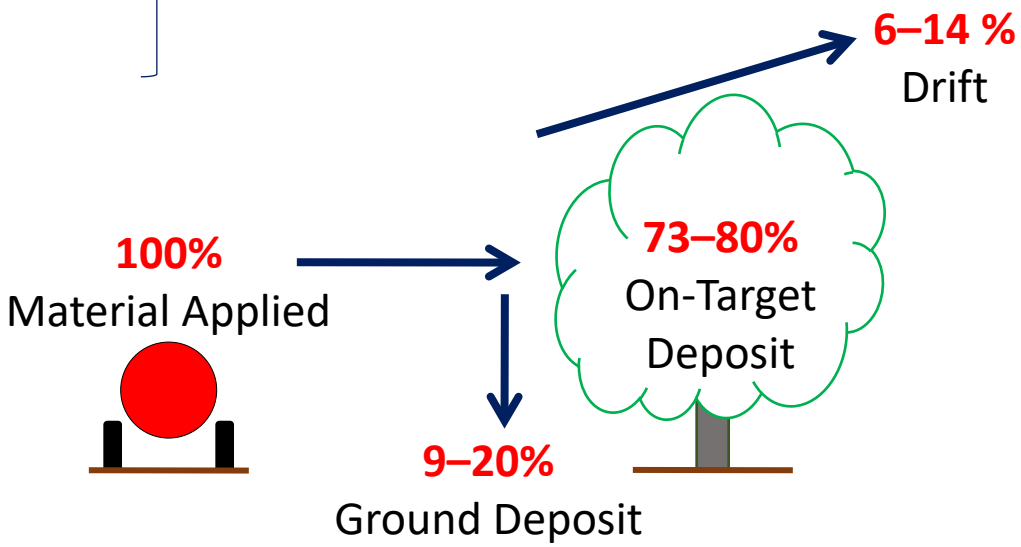
Airblast sprayers are most used sprayers in the San Joaquin Valley.

Introduction

Complex Nature of Spray Application

- Lower than desired on-target spray deposition persistently occurs in citrus spray application due to several interacting factors
  - equipment design
  - application parameters
  - spray physical properties
  - tree characteristics
  - weather condition

Complex interactions influence on-target spray deposition and off-target losses

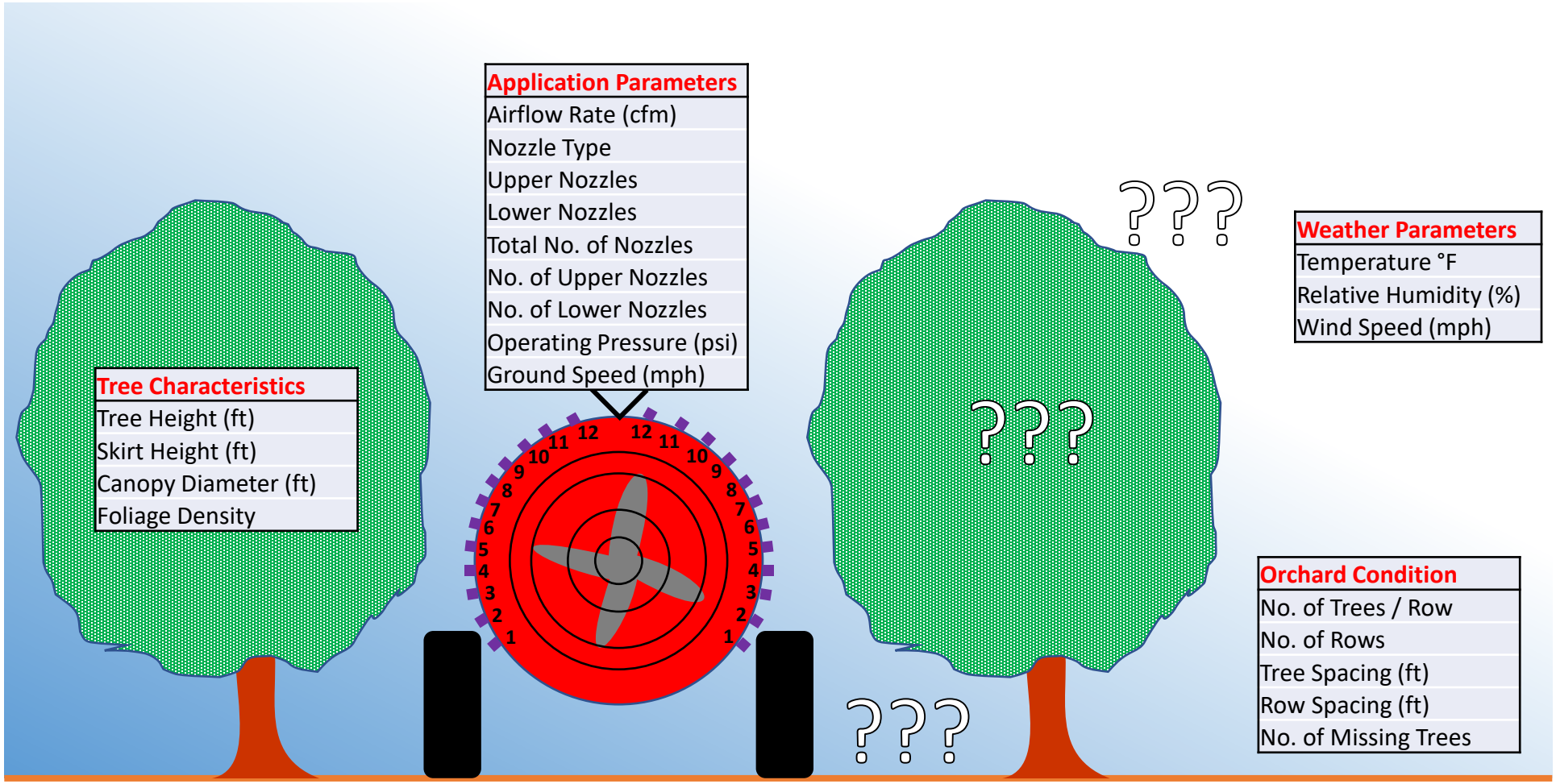


18–26% Total Off-target Losses

(Salyani et al., 2007)

Introduction

Daunting Task

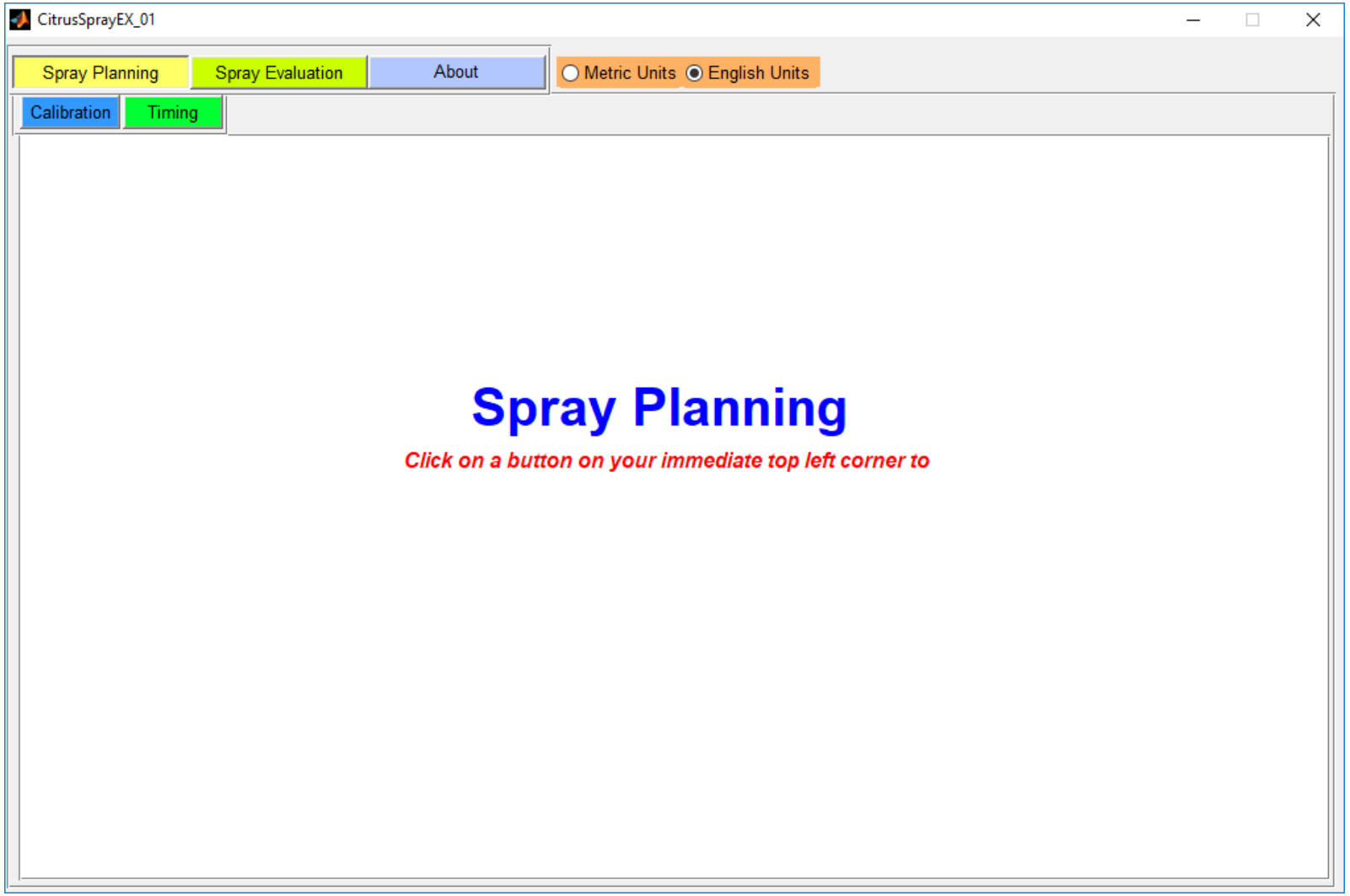


Introduction

Overview of CitrusSprayEx: Welcome Screen

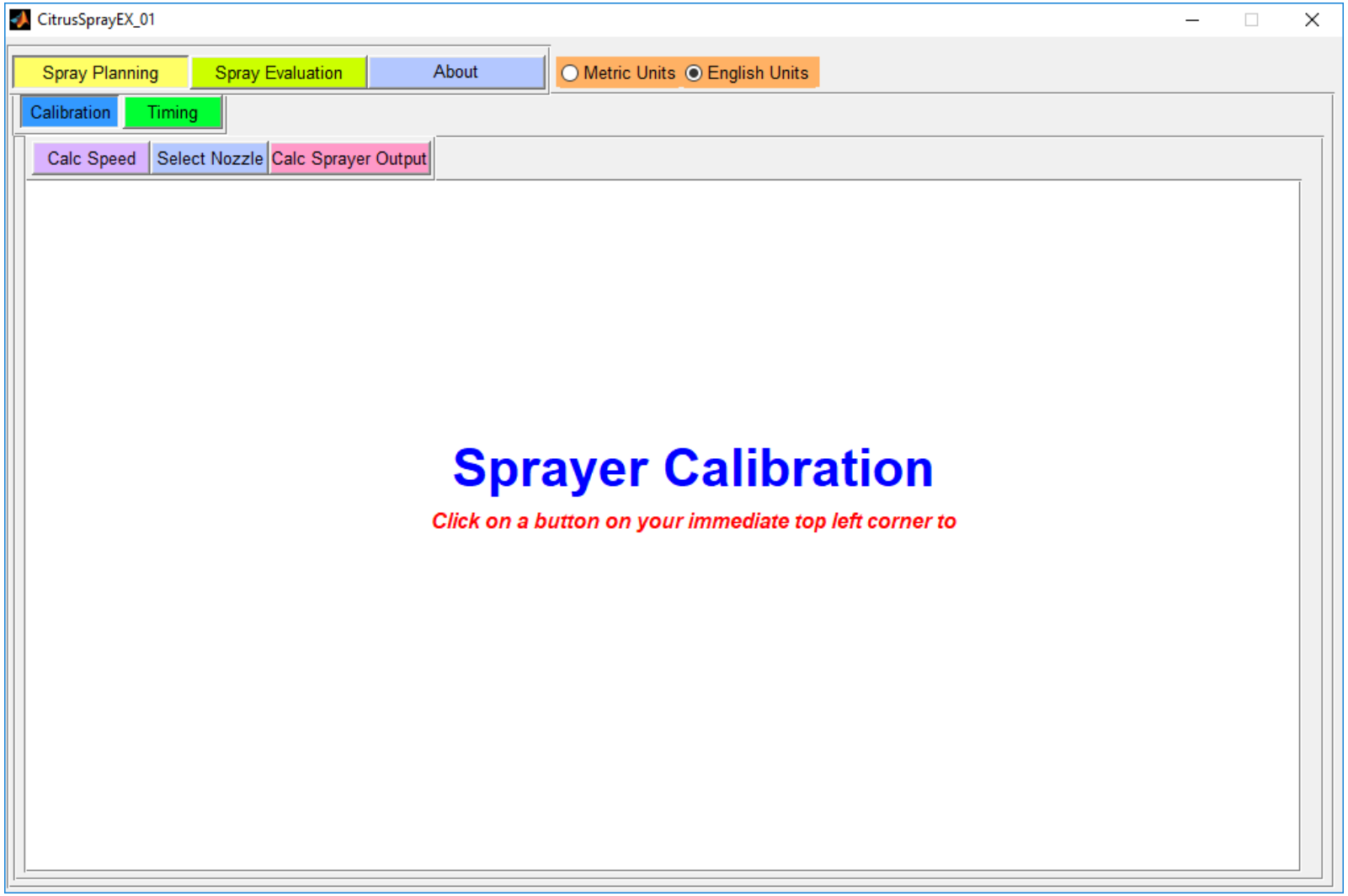
Introduction

Overview of CitrusSprayEx: Spray Planning Front Screen



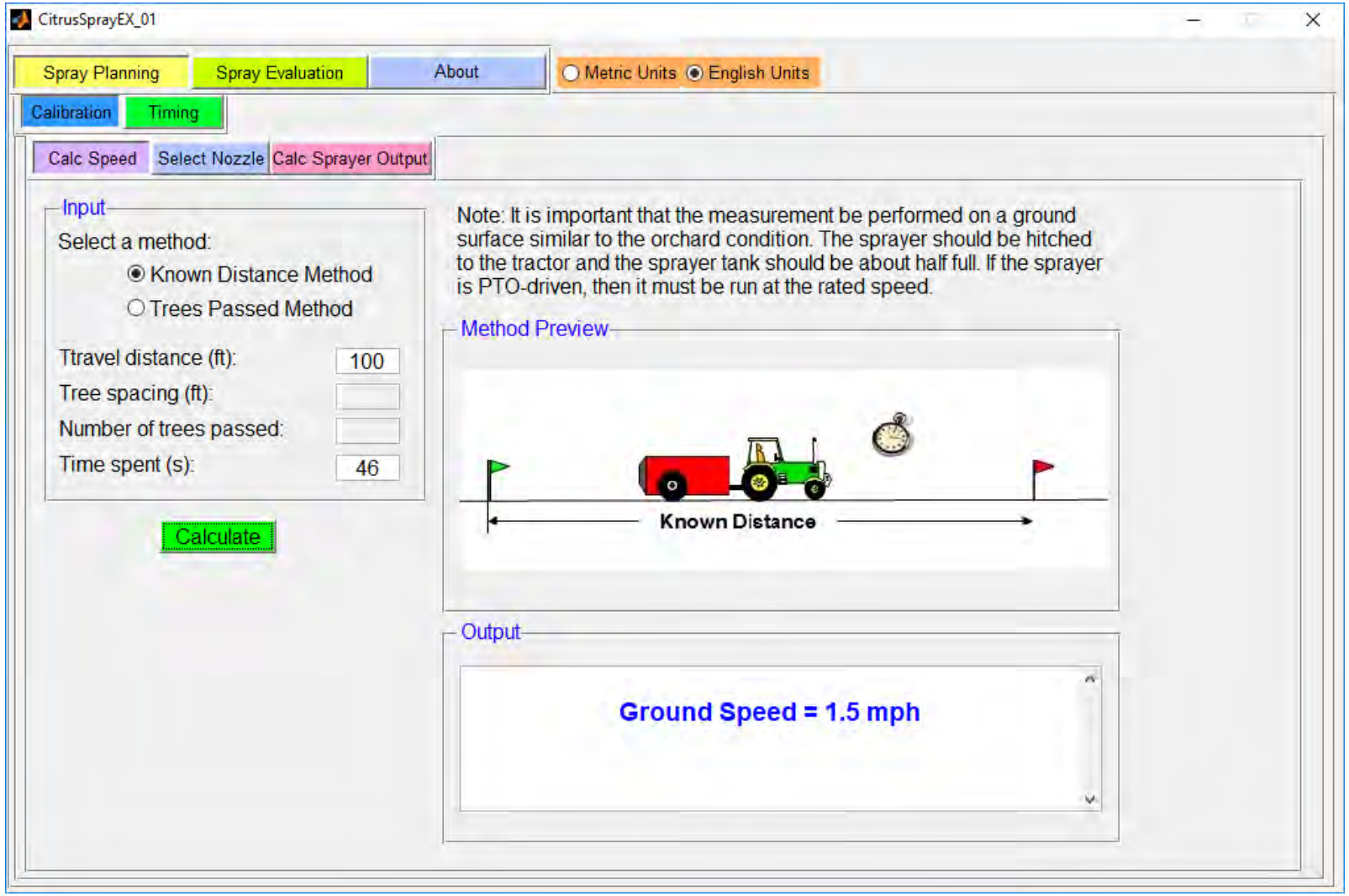
Introduction

Overview of CitrusSprayEx: Sprayer Calibration Front Screen



Introduction

Overview of CitrusSprayEx: Speed Calculation Screen



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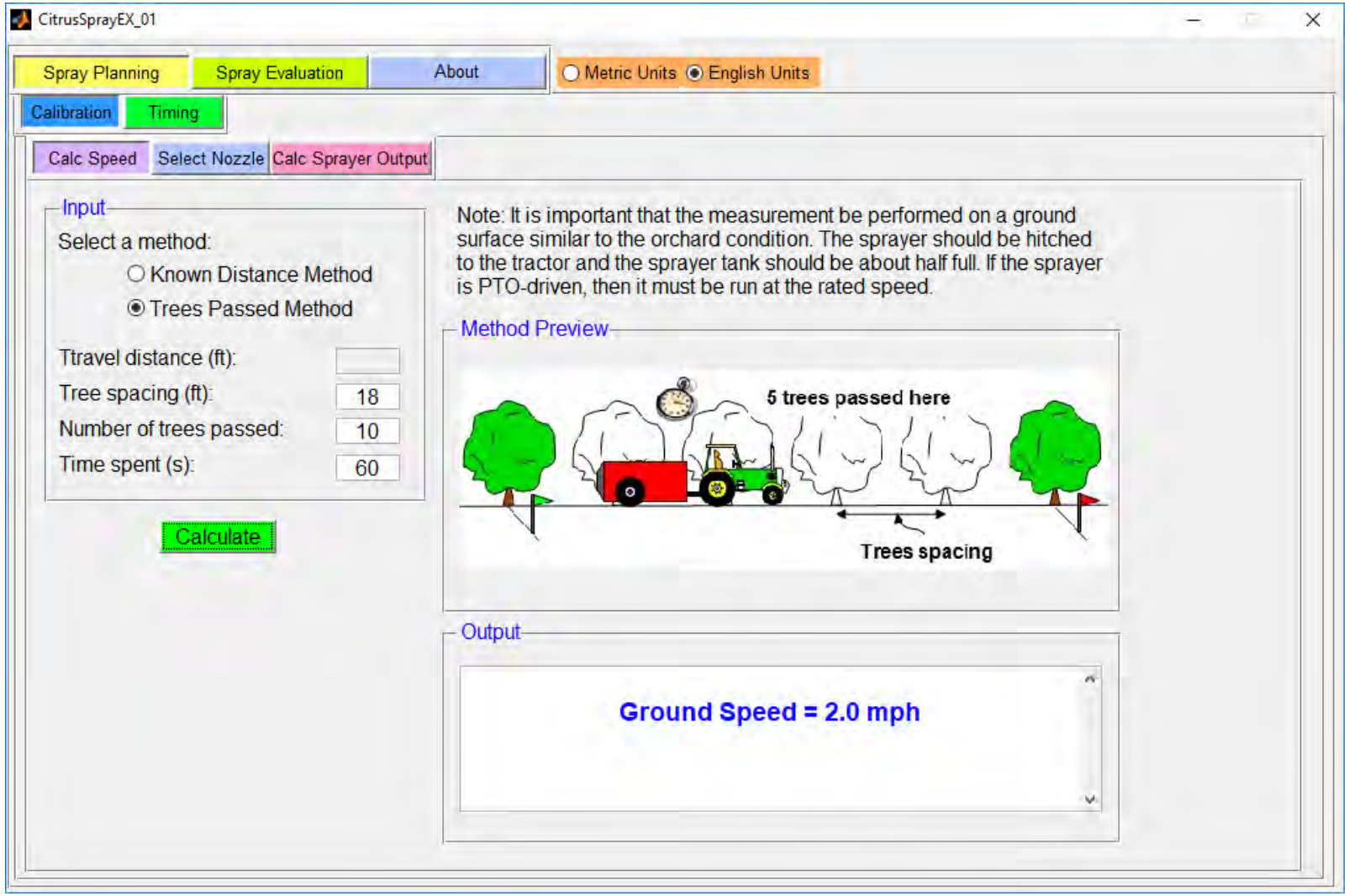
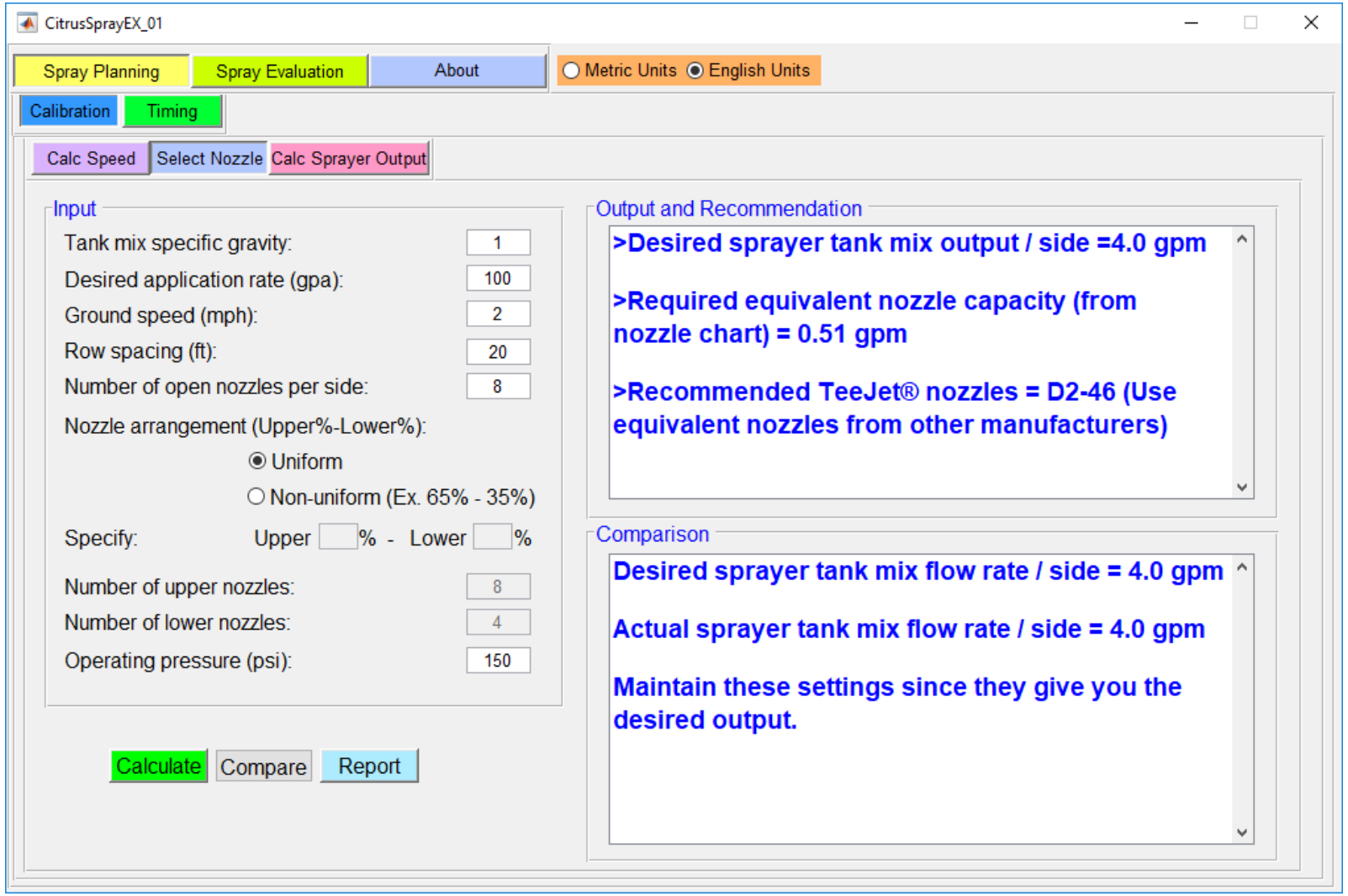


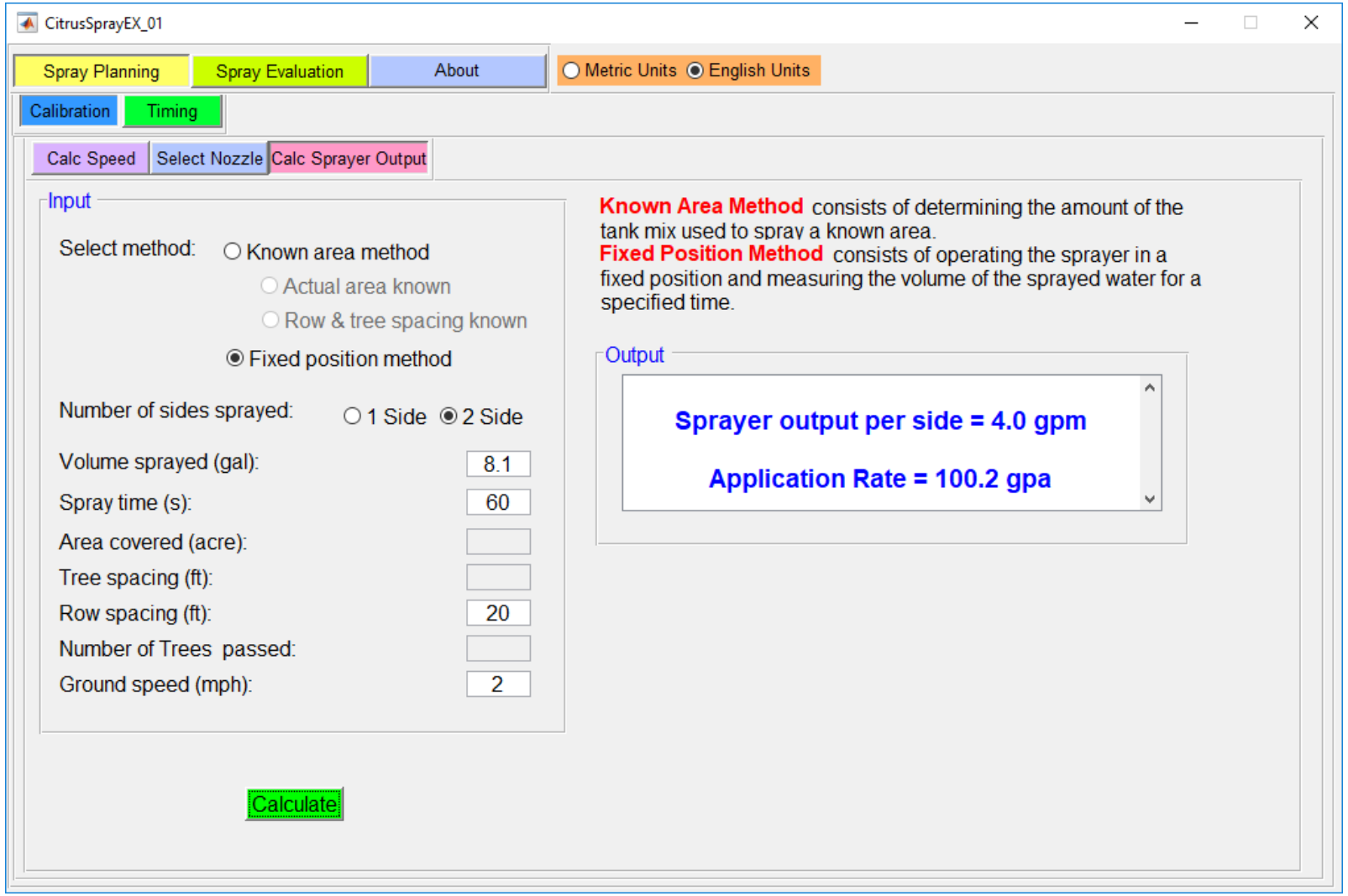
Introduction

Overview of CitrusSprayEx: Nozzle Selection Screen



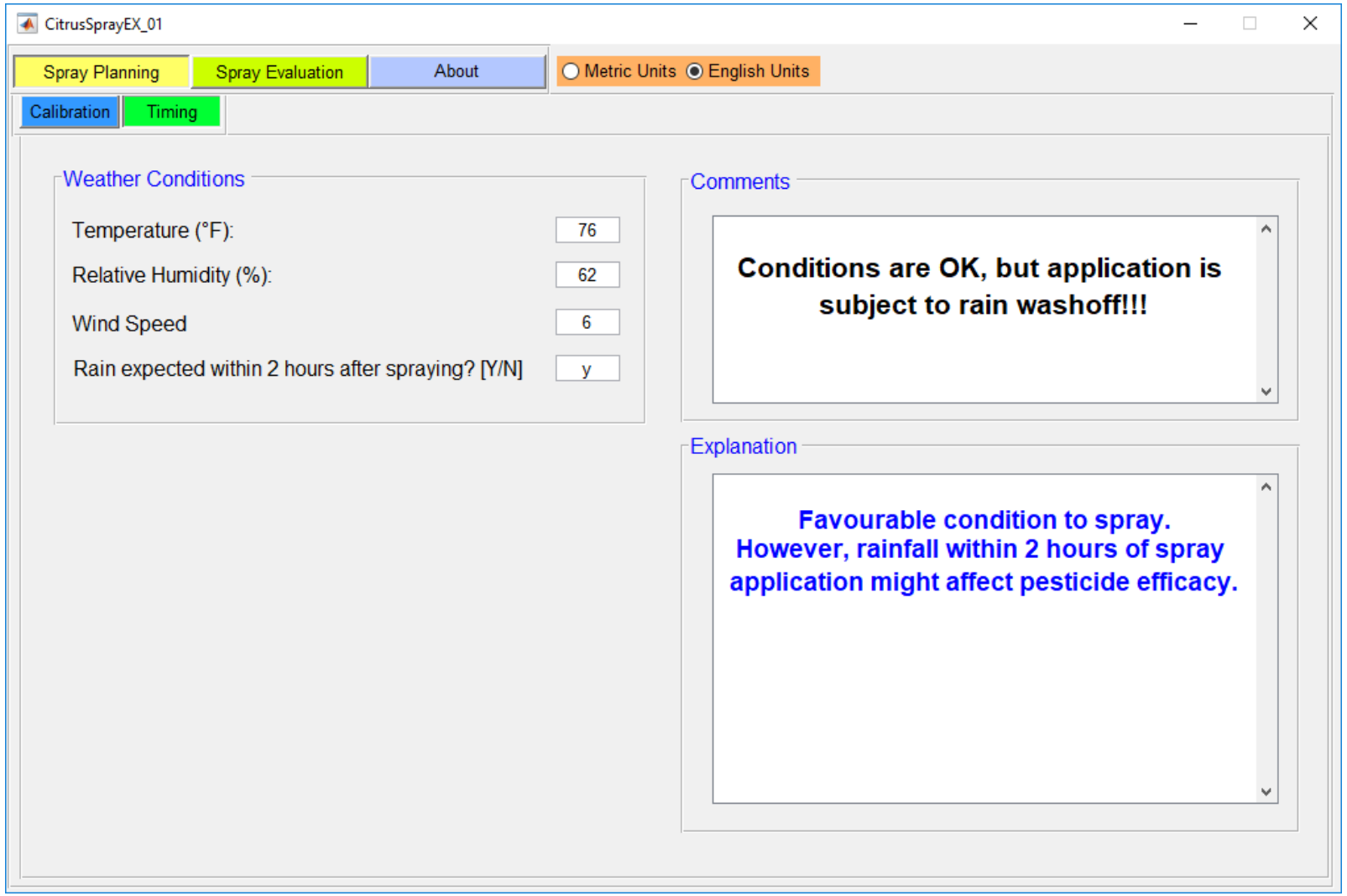
Introduction

Overview of CitrusSprayEx: Sprayer Output Calculation Screen



Introduction

Overview of CitrusSprayEx: Application Timing Screen



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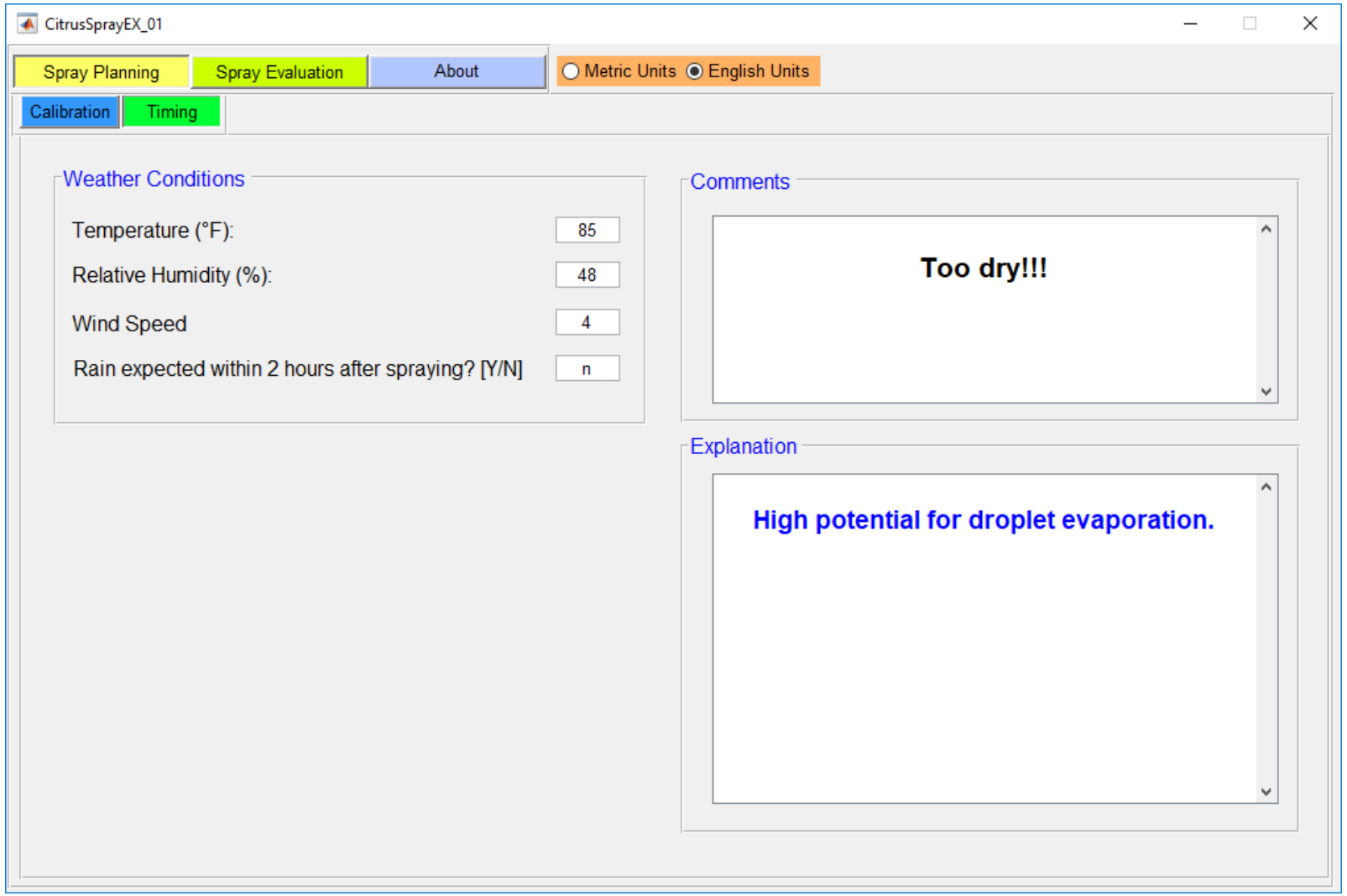

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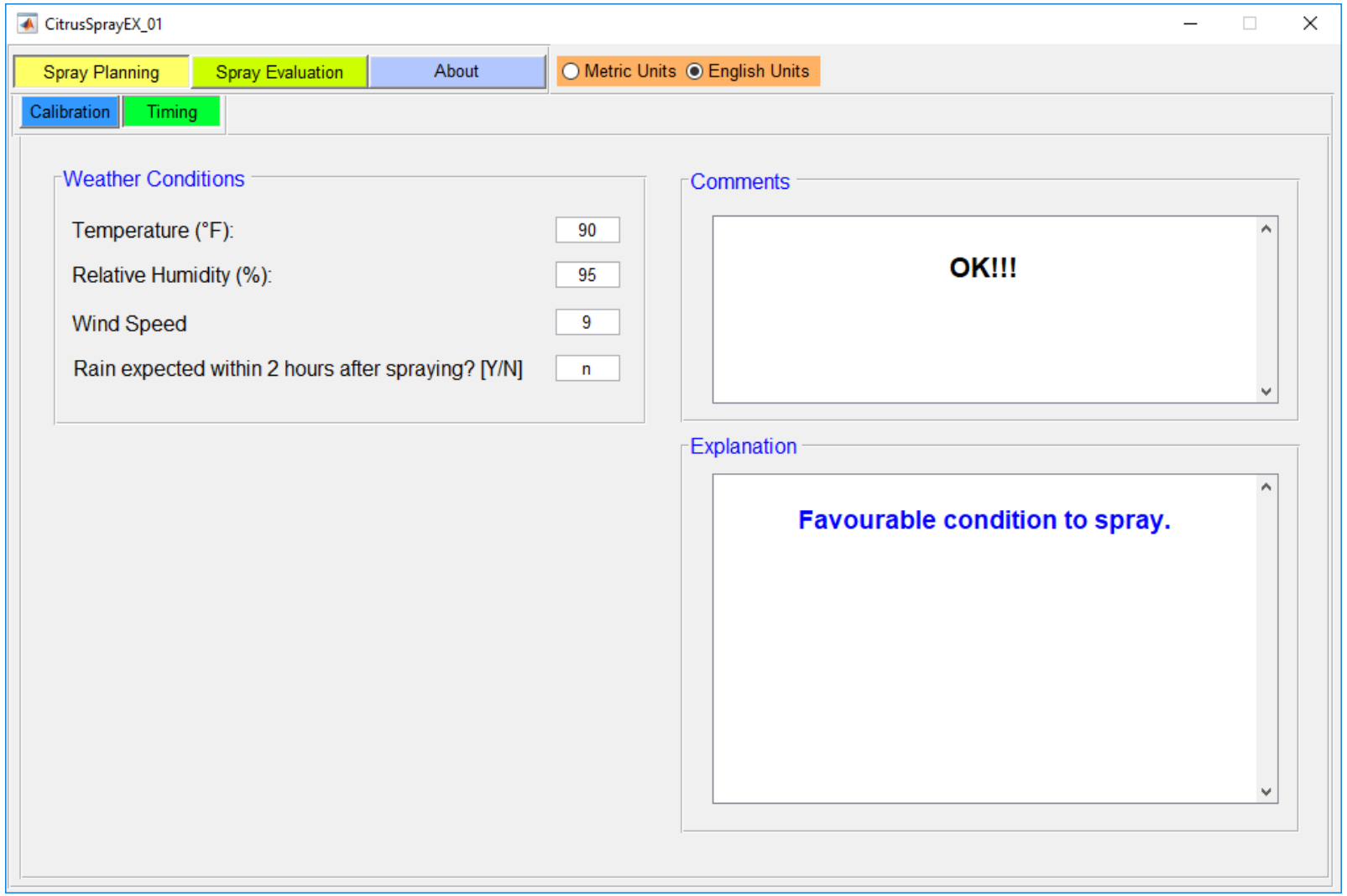
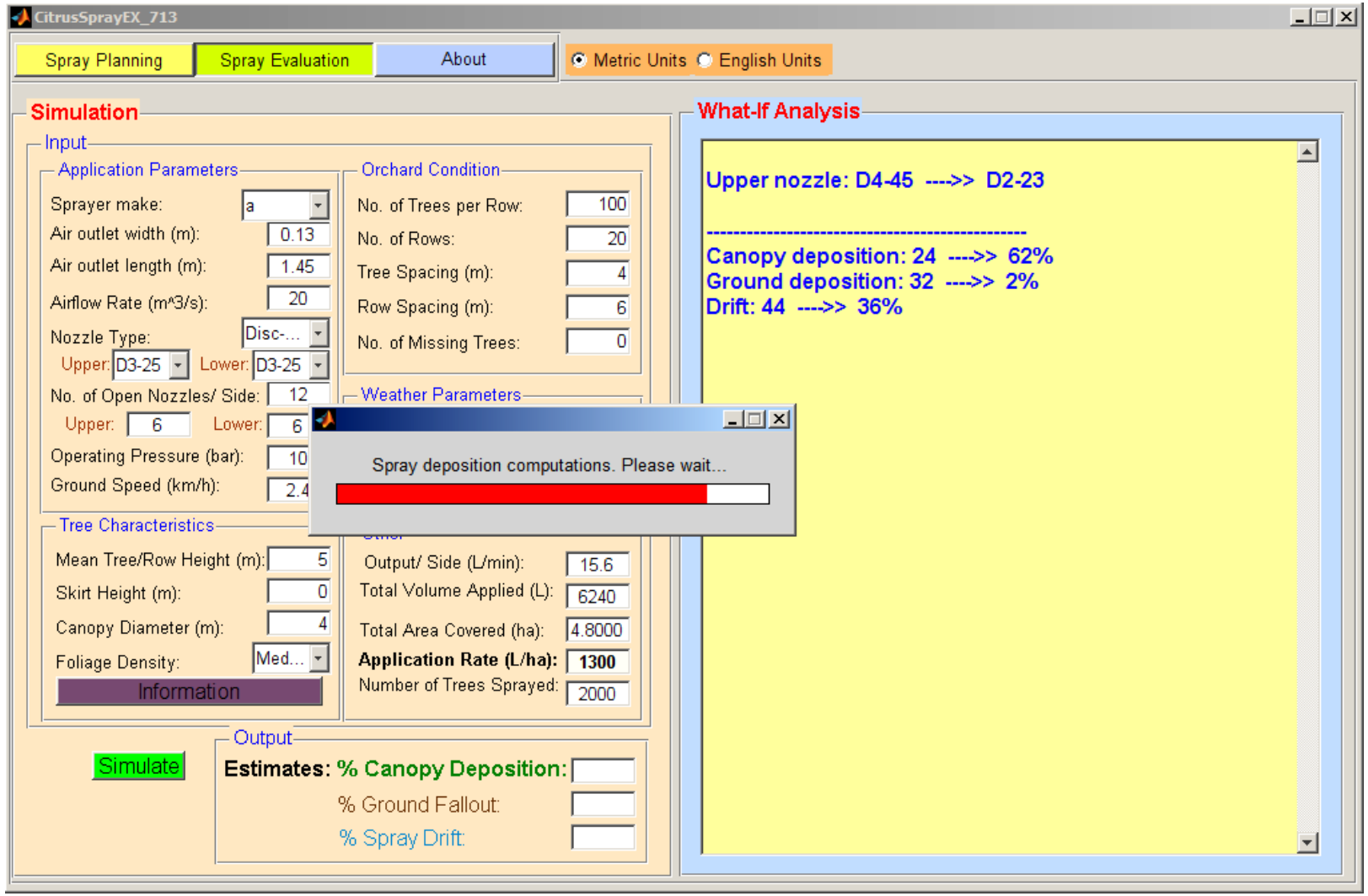


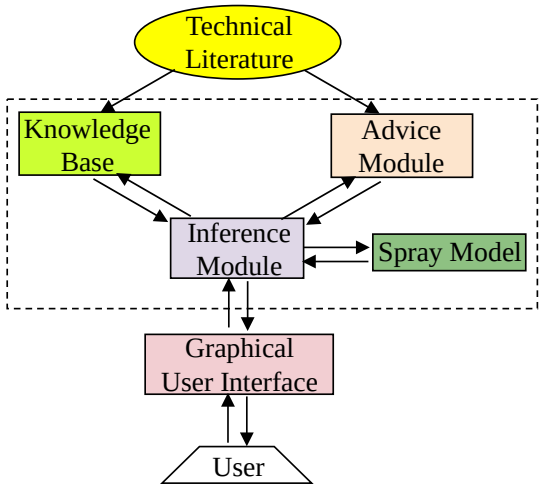
Introduction

Overview of CitrusSprayEx: Spray Evaluation Screen

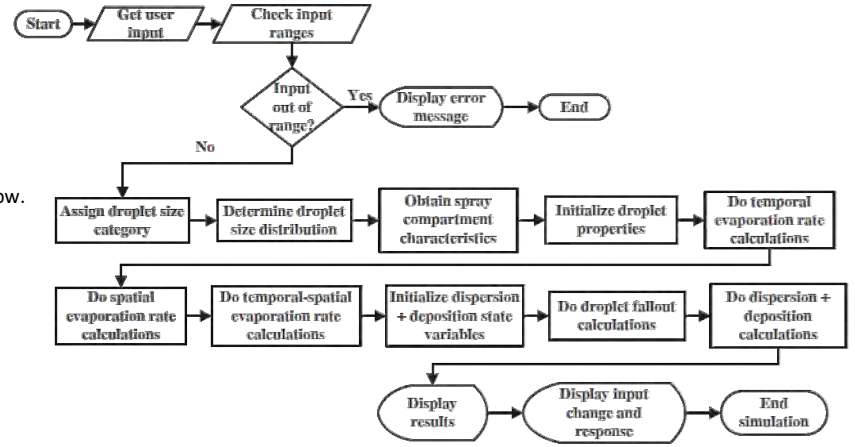


The basis of the spray evaluation section is the Larbi-Salyani airblast spray deposition model originally developed for citrus applications.

Model-based Expert System

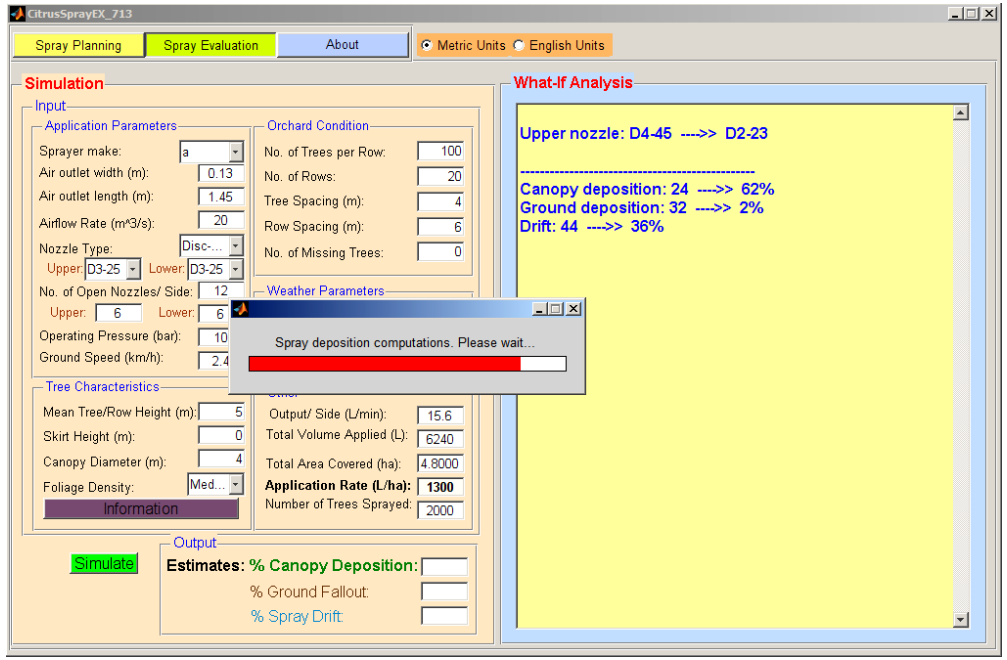


Structure of ES with arrows showing the direction of information flow.



Simplified flowchart for spray evaluation simulation

Source: **Larbi, P.A.** and M. Salyani. 2012c.



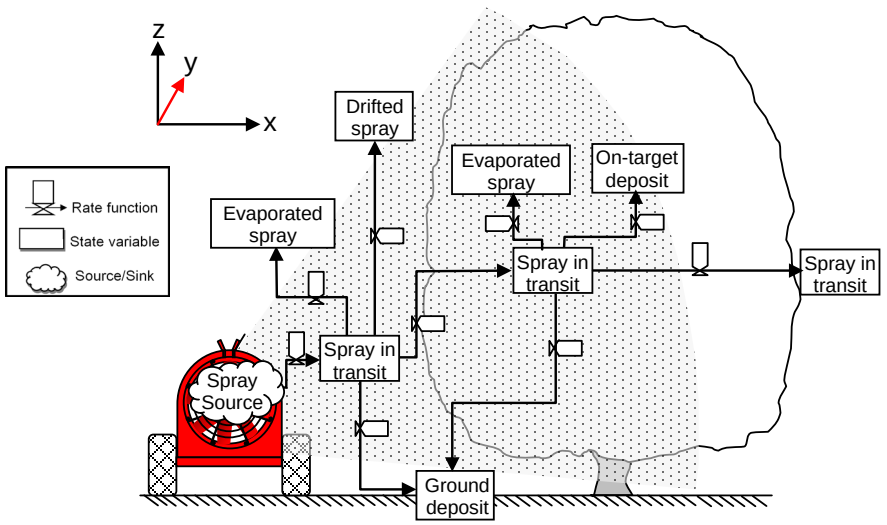
GUI for spray evaluation showing an ongoing simulation.

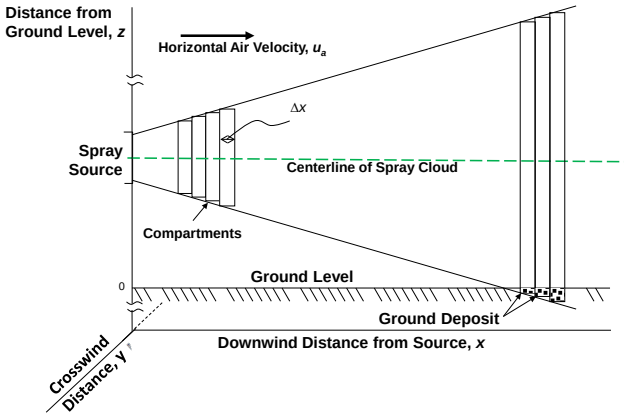
Table 6
Percentage of evaluation response for different ratings.[a]

Category, %	Excellent, %	Very good, %	Good	Fair	Poor
ES content	80	20	0	0	0
Presentation	55	35	10	0	0
Effectiveness	30	70	0	0	0
User appeal & suitability	50	30	15	5	0
ES response	55	35	10	0	0
Ease of use	70	30	0	0	0
User interface and media quality	53	27	7	13	0

[a] Based on all questions under each category.

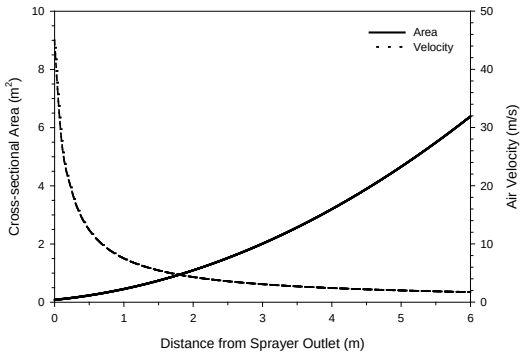
Larbi-Salyani Airblast Spray Deposition Model

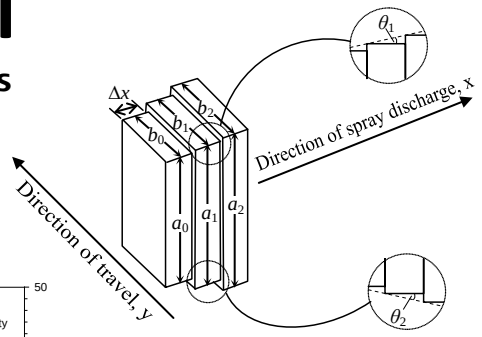


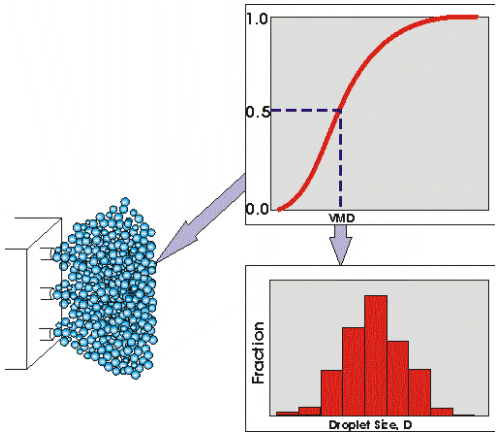


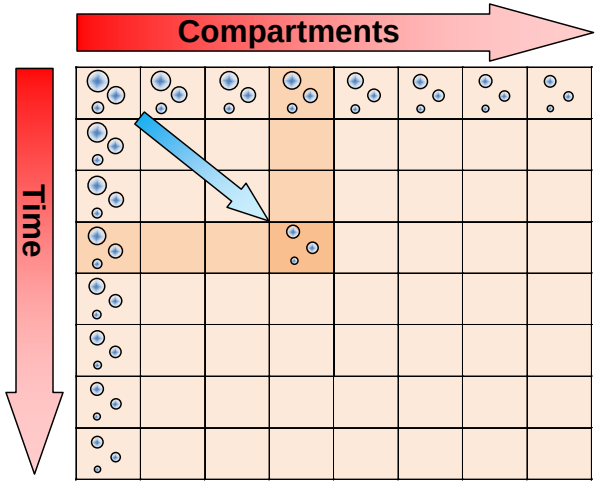
Compartment Characteristics

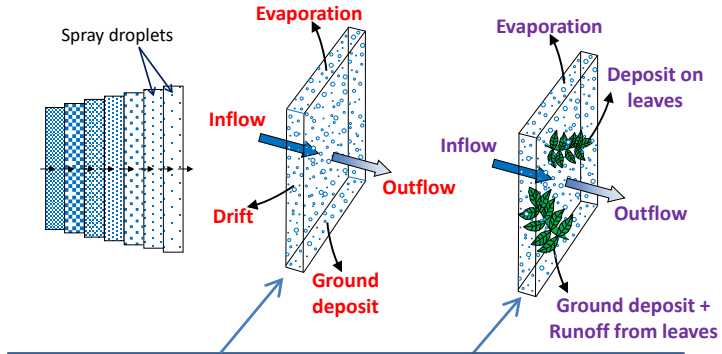
- Cross-sectional area
- Volume
- Air velocity







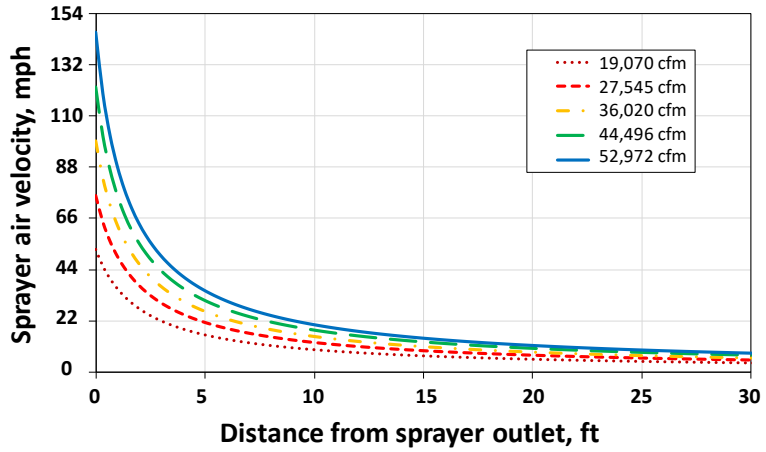


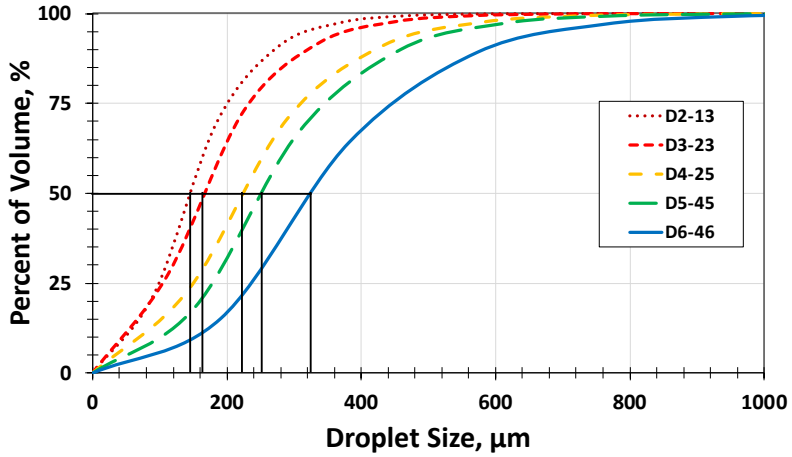


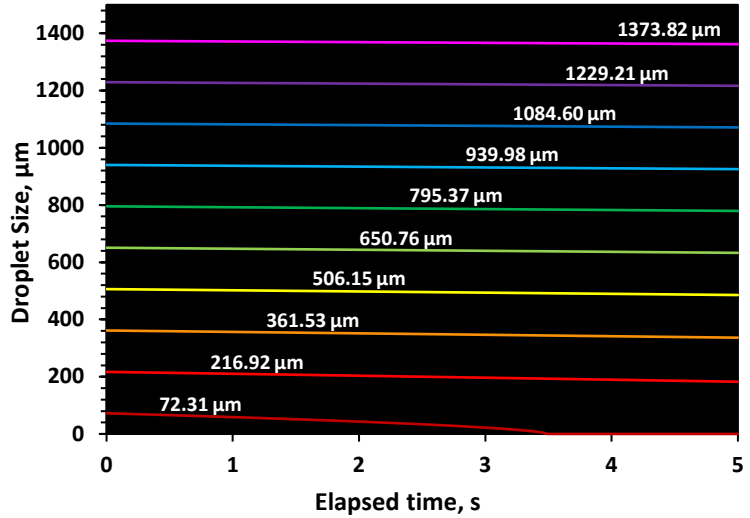
$$\frac{dm_x(t)}{dt} = f_{in,x}(t) - f_{out,x}(t) - f_{vap,x}(t) - f_{drift,x}(t) - f_{ground,x}(t)$$ Outside canopy

$$\frac{dm_{x'}(t)}{dt} = f_{in,x'}(t) - f_{out,x'}(t) - f_{vap,x'}(t) - f_{dep,x'}(t) - f_{runoff,x'}$$ Inside canopy

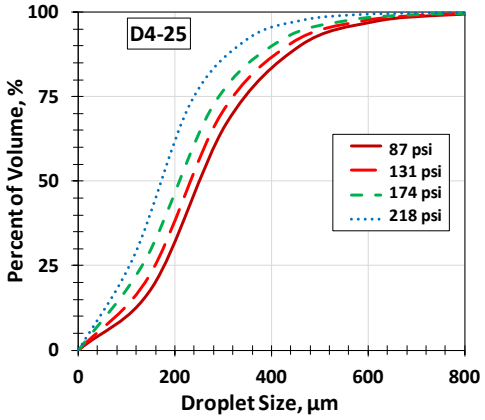
Spray Simulation



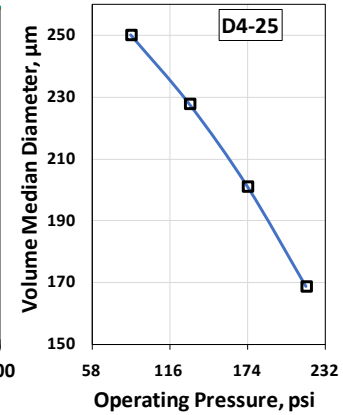




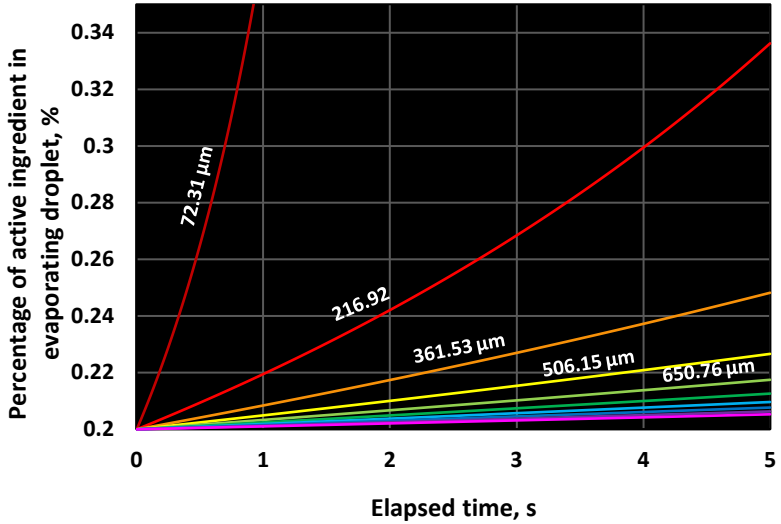
(a)



(b)



Nozzle	VMD (µm)	ASABE Droplet Category
D2-13	148.39	Very Fine to Fine
D3-23	166.33	Fine
D4-25	219.63	Fine to Medium
D5-45	252.32	Fine to Medium
D6-46	330.70	Medium to Coarse

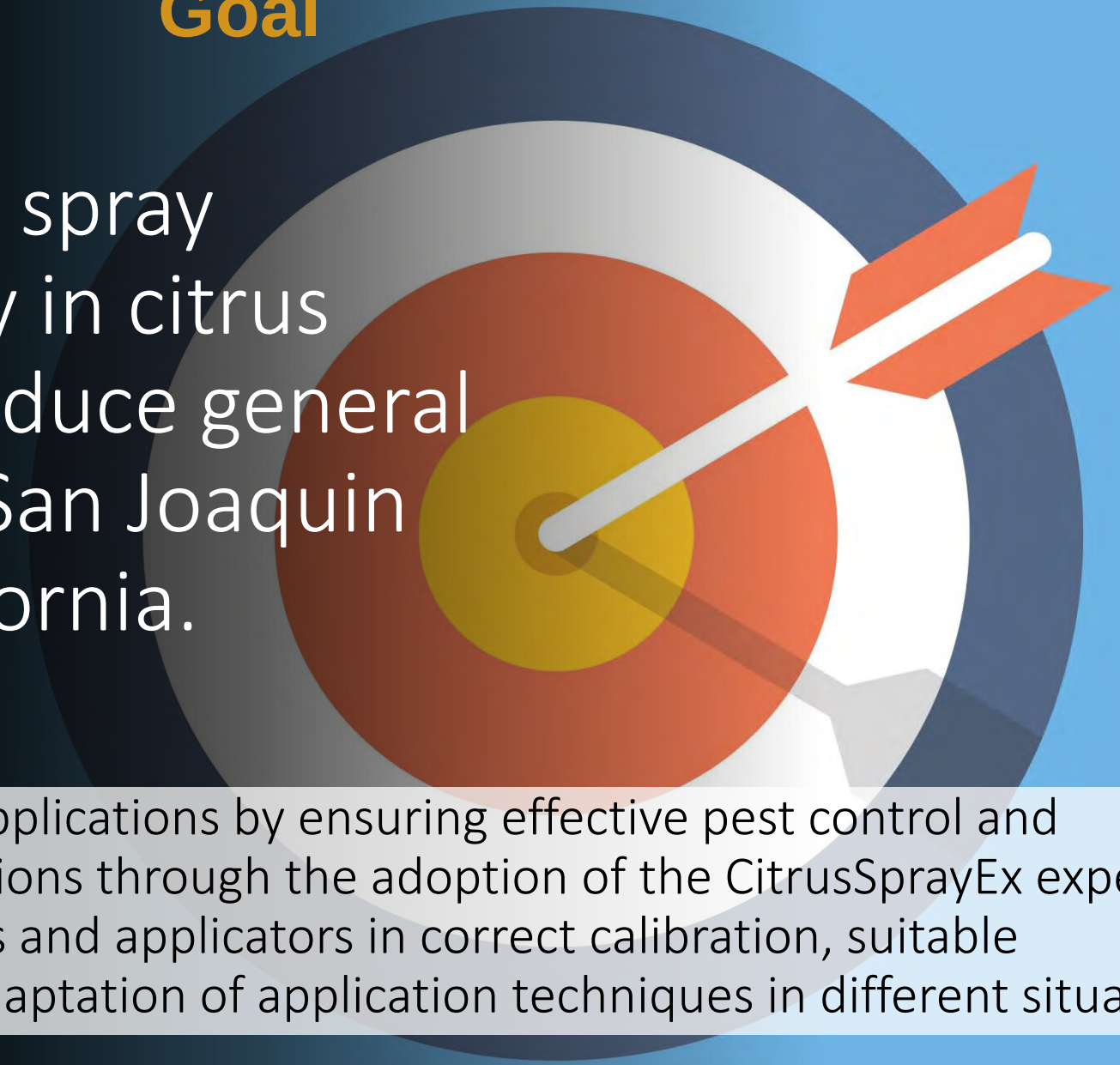


Motivation

Need to increase agricultural sustainability through improved productivity and environmental stewardship.

Opportunity to provide decision support to enable growers and pesticide applicators to recognize/use spray application best practices under normally complex field conditions.

Goal

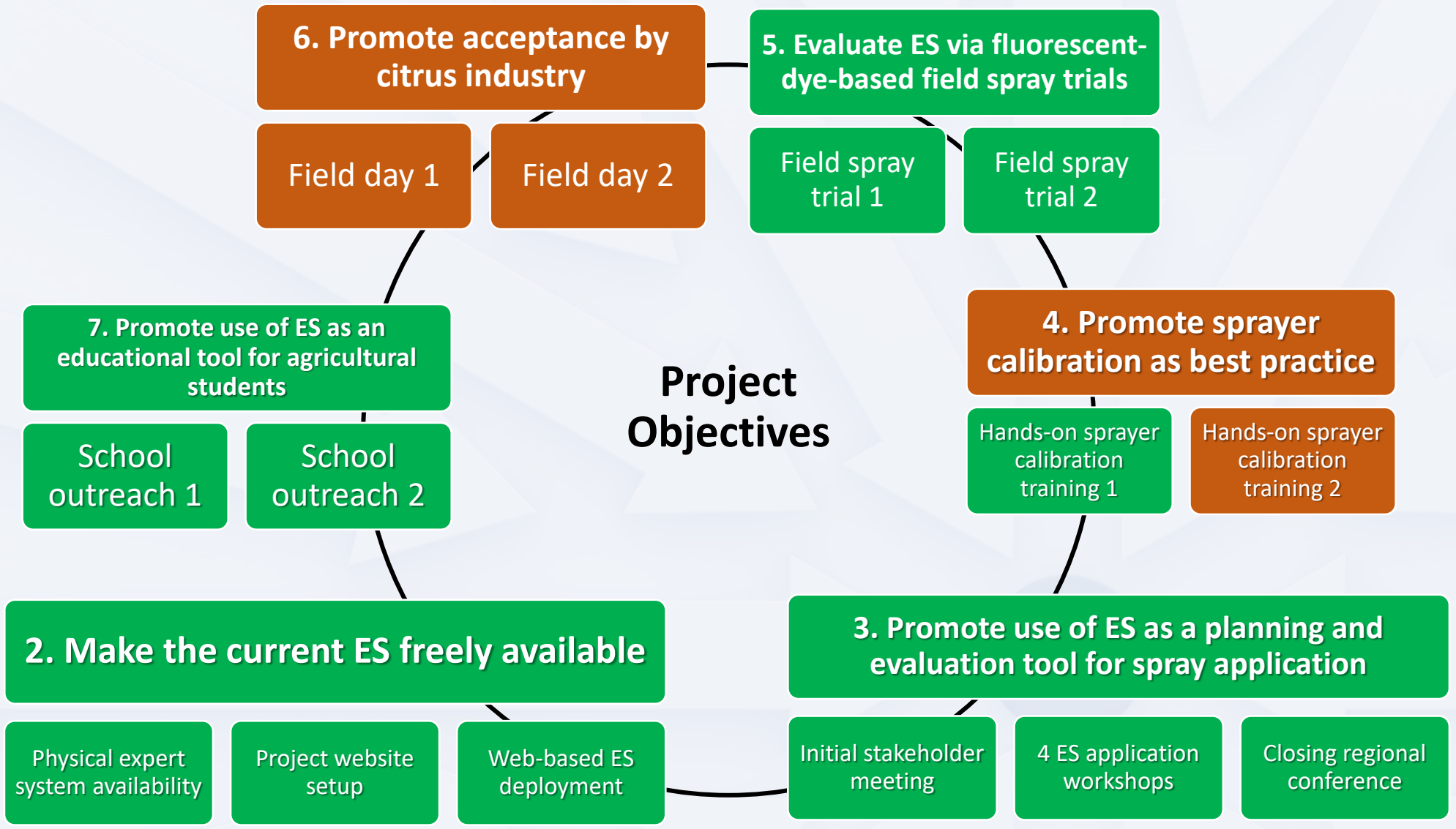


To improve pesticide spray application efficiency in citrus production and to reduce general pesticide use in the San Joaquin Valley region of California.

Specific and long term:

To cut the number of pesticide applications by ensuring effective pest control and reduced need for repeat applications through the adoption of the CitrusSprayEx expert system (ES) which guides growers and applicators in correct calibration, suitable application timing, and proper adaptation of application techniques in different situations.

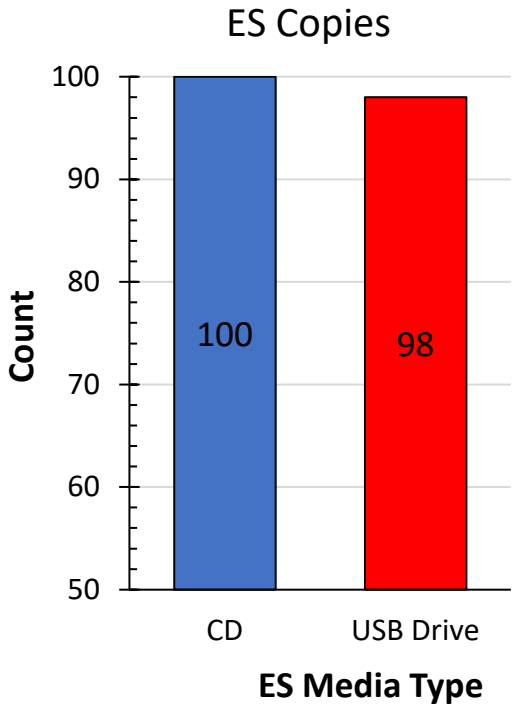
Measurable Project Objectives

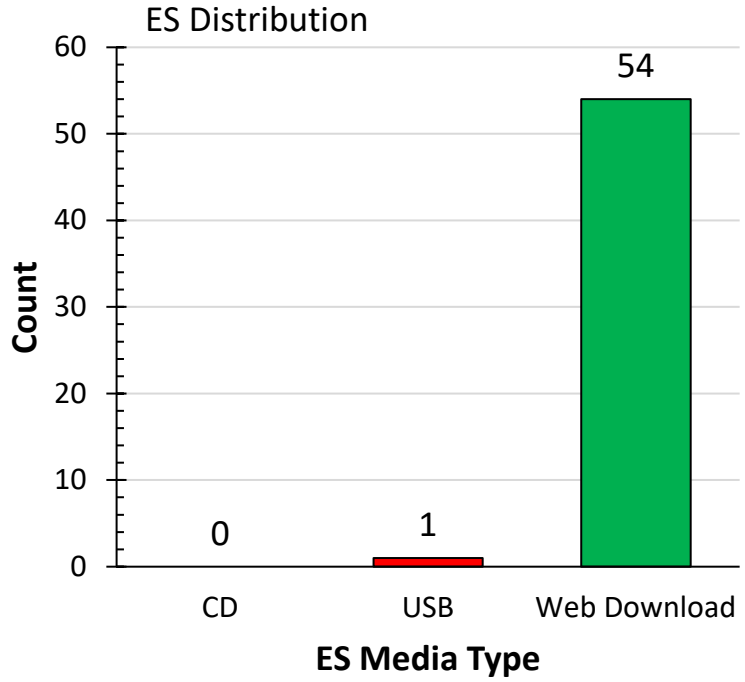


Approach and Outcomes

2. Make the current ES freely available

Physical expert system availability





Approach and Outcomes

2. Make the current ES freely available

Project website setup

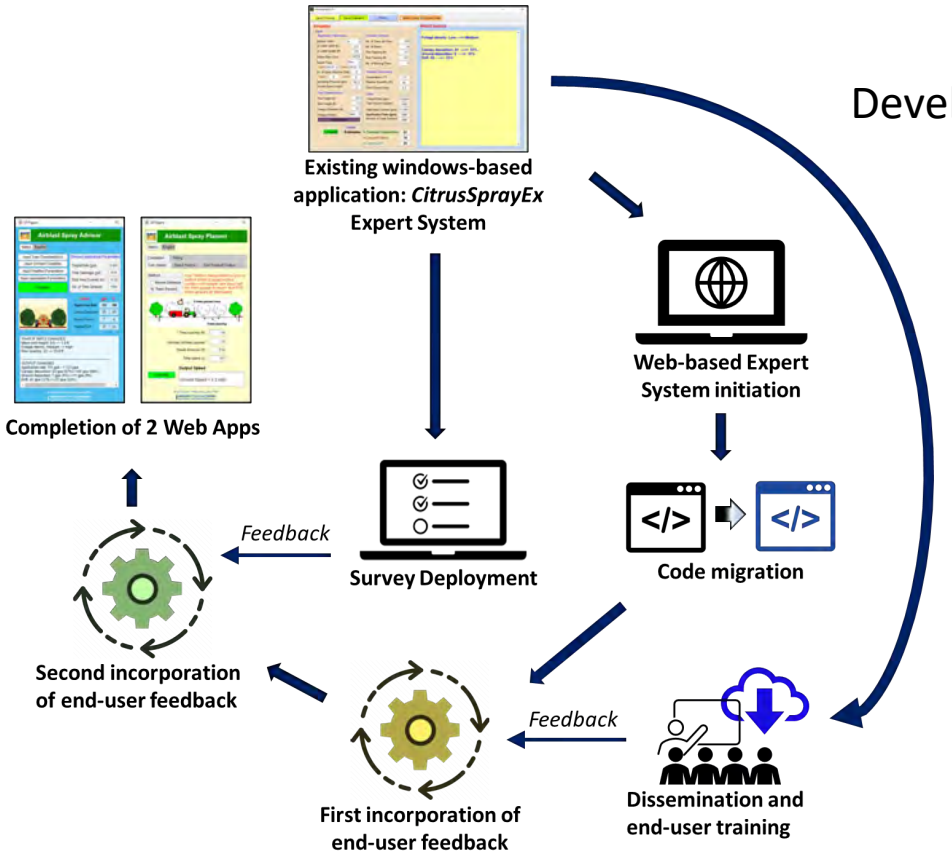
https://ucanr.edu/sites/CSEESDeploy/Project_Info/

Or

https://ucanr.edu/p/71771

Approach and Outcomes

2. Make the current ES freely available



Development in MATLAB

Web-based ES deployment

Web-based ES initiation

ES code migration

1st incorporation of end-user feedback — Multiple versions developed

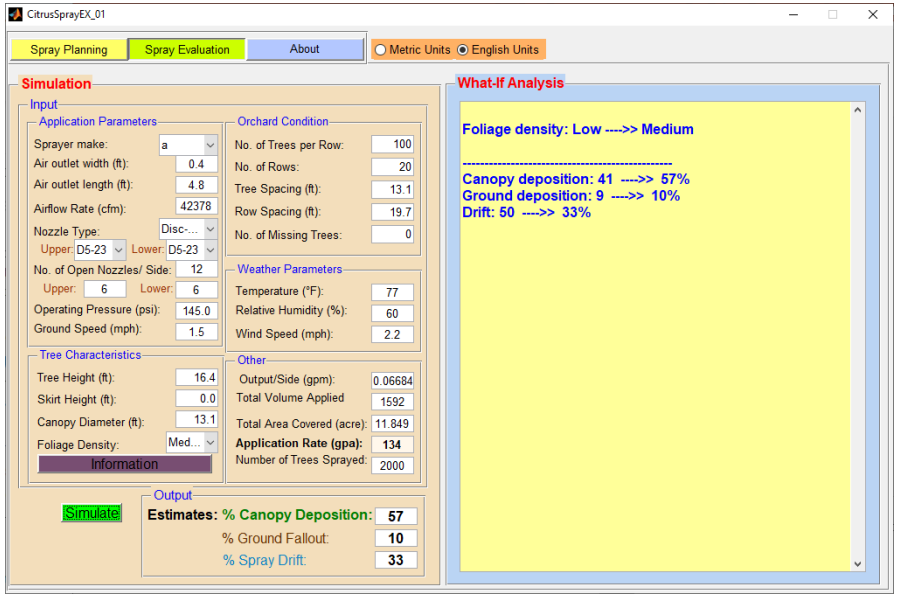
2nd incorporation of end-user feedback — Split into 2 apps

Completion of new ES

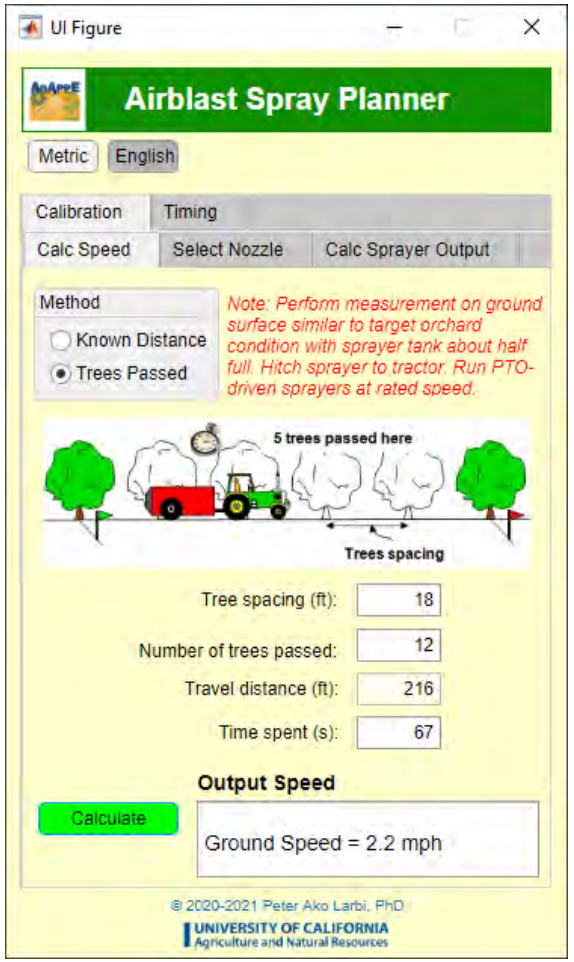
Flow diagram of airblast decision support web app development.

Approach and Outcomes

Web-based ES Deployment



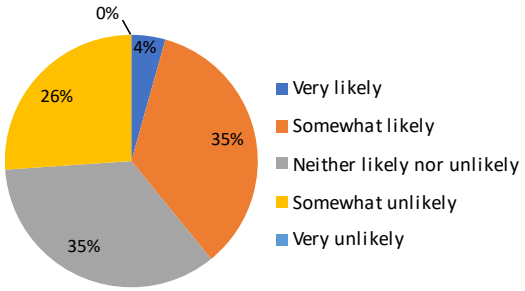
https://matlab.uckare.org/webapps/home/session.html?app=AirblastSprayAdvisor_Basic



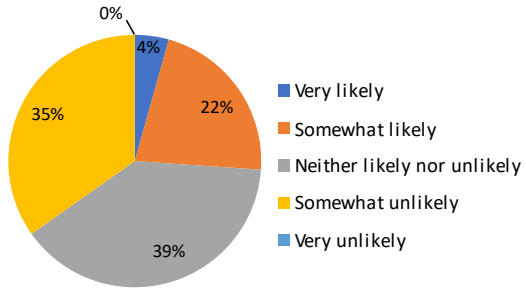
https://matlab.uckare.org/webapps/home/session.html?app=AirblastSprayPlanner

Adoption Consideration

How likely are you to use the expert system (the current (*CitrusSprayEx* or an improved app) in your spray application planning and evaluation? (n=23)



How likely are you to recommend the use of the expert system (the current (*CitrusSprayEx* or an improved app) to others for their spray application planning and evaluation? (n=23)



Approach and Outcomes

Web-based ES Deployment

Compatible with:

- **PC**
- **Mac**
- **iPad**
- **iPhone**
- **Chromebook**

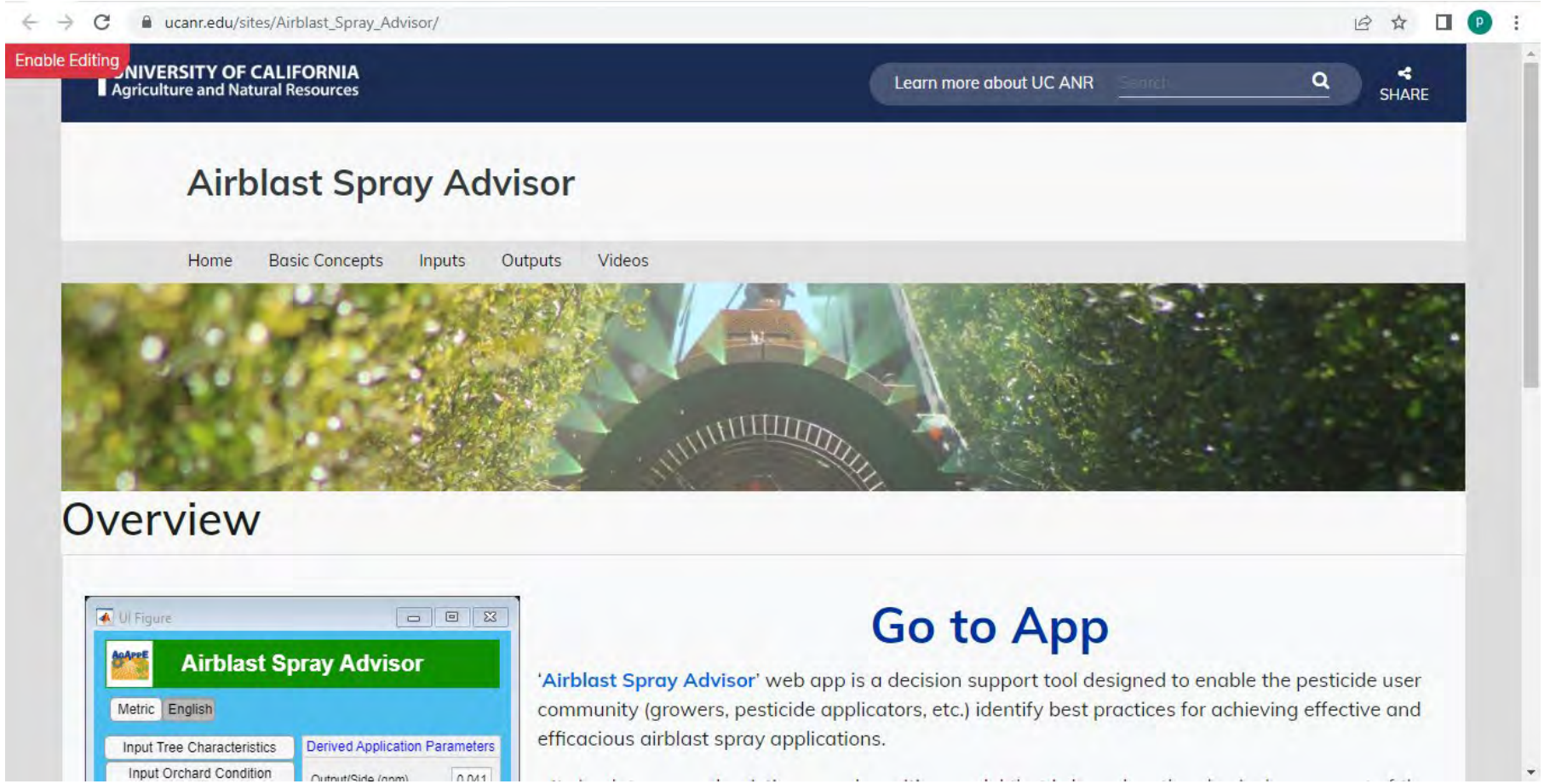
Not Compatible with:

- Android

https://matlab.uckare.org/webapps/home/session.html?app=AirblastSprayAdvisor_Basic

Approach and Outcomes

Web-based ES Deployment



https://ucanr.edu/sites/Airblast_Spray_Advisor/ OR https://ucanr.edu/p/71771

Approach and Outcomes

3. Promote use of ES as a planning and evaluation tool for spray application

Initial stakeholder meeting

A 2-hour information session on CitrusSprayEx Expert System and project overview.

Date: March 13, 2020

Format: Virtual via Zoom

Access: Open to Public

CEU Approved: 1.5 other CEU

Registered: 41

Attended: 19

Received CEU credits: 9

Discussion:

What other aspects do you think the project should have focused on? What other activities/tasks do you think the project should have included? Any other comments on how this project could better serve industry need?

Feedback:

1. Overall, project goals and tasks are reasonable and adequate.
2. Availability and application of the CitrusSprayEx expert system are practical and would be beneficial to the end users.
3. Number of inputs required is overwhelming and could be simplified or the expert system should be presented in a modular format tailored to different audiences. This feedback was considered in further development a new web-based, mobile-friendly expert system.

Approach and Outcomes

3. Promote use of ES as a planning and evaluation tool for spray application

4 ES application workshops

All events were virtual and open to the public.

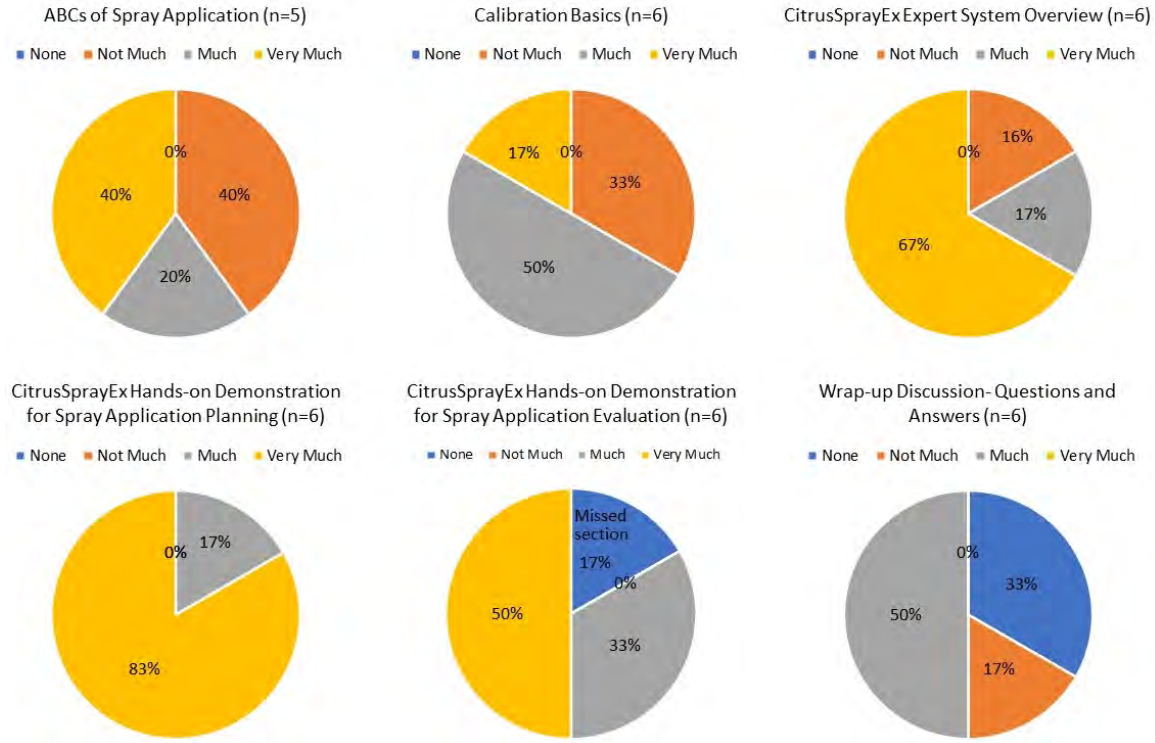
	CitrusSprayEx Application Workshop		Airblast Spray Application Web App Webinar	
Date	4/23-24, 2020	6/18-19, 2020	3/11/2021	3/11/2022
CEU Approved	5.5		2.0	
# Registered		7	77	24
# Attended:	11	3	52	6
# Receiv'g CEUs	12		15	1

Feedback (sample comments):

- "The application needs to be easier to use."
- "It was very educational, simple and user friendly."
- "We have been waiting for a program like this. Maybe one also for ground spraying."
- "Very good coverage of the basics and the new program. Making it web based would be a good improvement"
- "Excellent exercise"

Question	Response		
Marketing (n=7)	Email (14%)	CDPR Website (14%)	Colleague (72%)
Expectations (n=6)	Learn all (33%)	Learn CitrusSprayEx (50%)	CEU (17%)

How much new information did you learn from these topics?



Approach and Outcomes

3. Promote use of ES as a planning and evaluation tool for spray application

Closing regional conference

A 3-day conference; May 16 to 18, 2022; Featured a welcome address by Dr. Glenda Humiston, Vice President, UCANR and Closing Remarks by Dr. Fadi Fathallah, Professor and Chair, Department of Biological and Agricultural Engineering, UC Davis:

- 10 sessions
- 10 moderators
- 3 keynote talks
- 25 technical talks
- 4 panels
- 21 technical speakers
- 15 panel speakers
- 3 concept videos: https://ucanr.edu/sites/ASAM/Resources/
- 17 DPR continuing education units
- 10 countries in participation (including United States)
- 75 registered
- 66 participants
- 20, 23, and 29 took final exam for days 1, 2, and 3, respectively

Approach and Outcomes

4. Promote sprayer calibration as a best practice

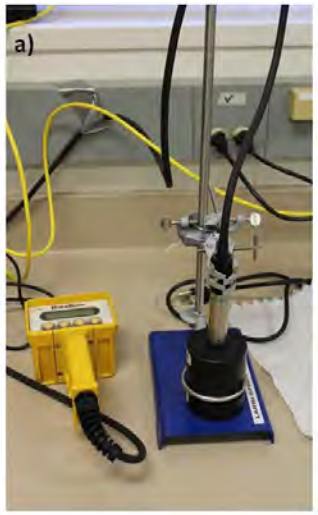
Hands-on sprayer calibration training 1

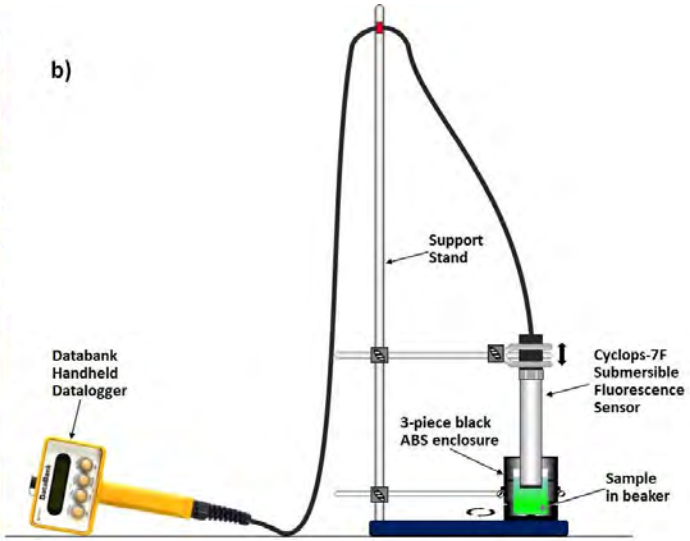
Hands-on sprayer calibration training 2

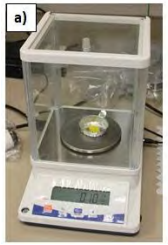
Sprayer calibration as a best practice was promoted in a hands-on calibration exercise that was recorded and presented virtually. A calibration training package is under development.

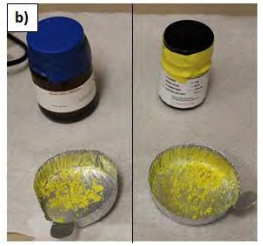
Approach and Outcomes

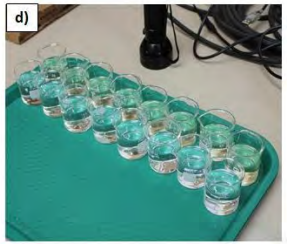
5. Evaluate ES via fluorescent-dye-based field spray trials

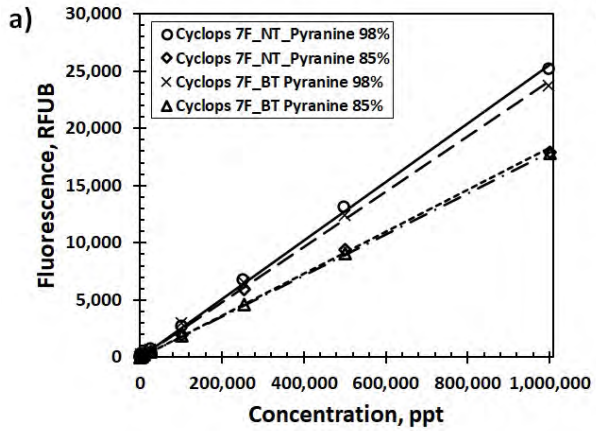


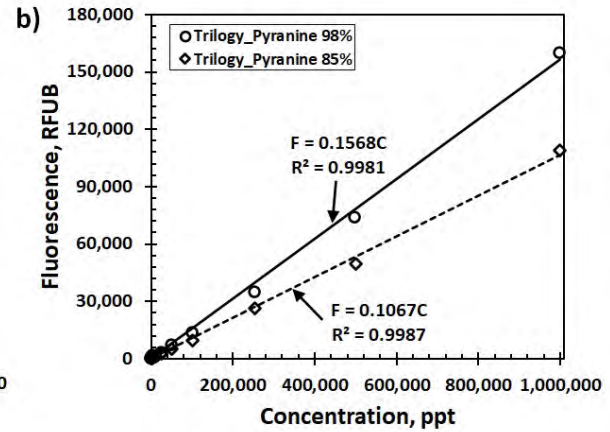


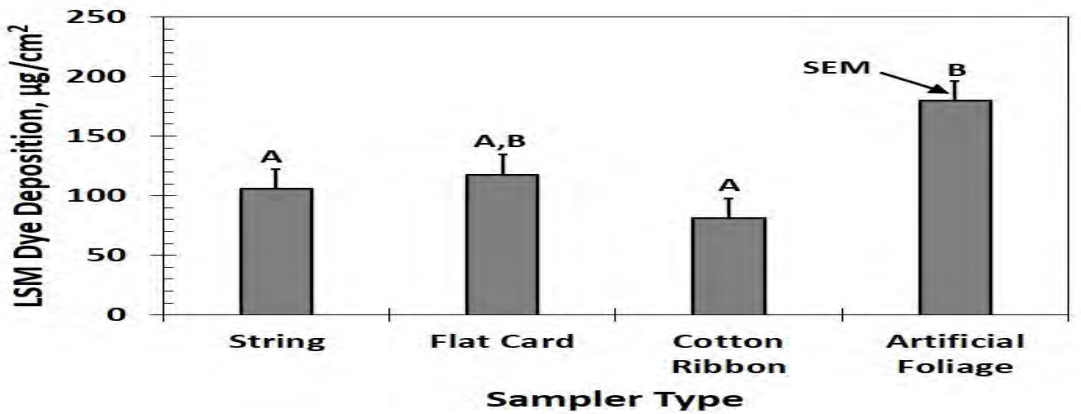












P. A. Larbi, "Configuration and Assessment of a Submersible Fluorometer for Evaluating Fluorescent Dye Deposition," Journal of Testing and Evaluation 50, no. 3 (May/June 2022): 1286–1298. https://doi.org/10.1520/JTE20210617

Approach and Outcomes

5. Evaluate ES via fluorescent-dye-based field spray trials

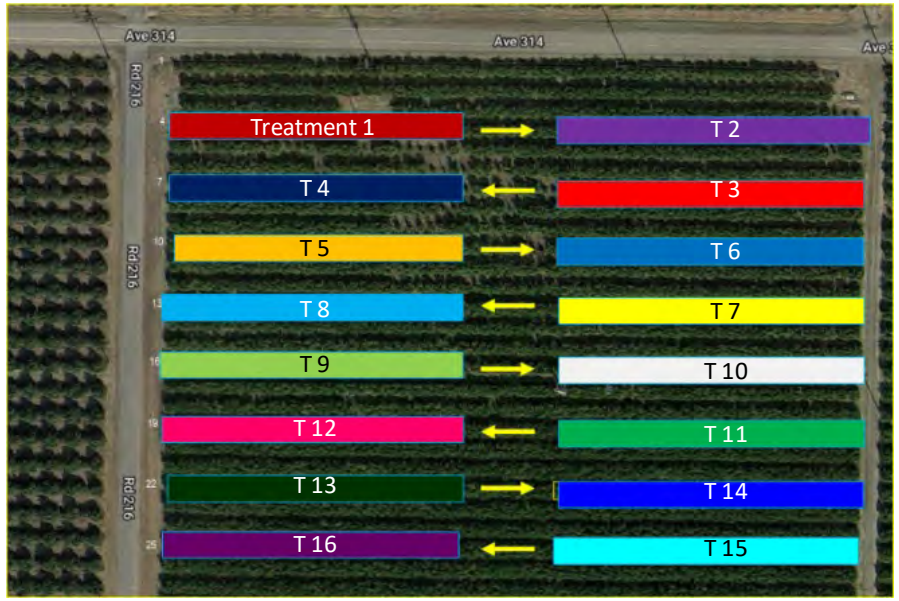
Field spray trial 1

Field spray trial 2

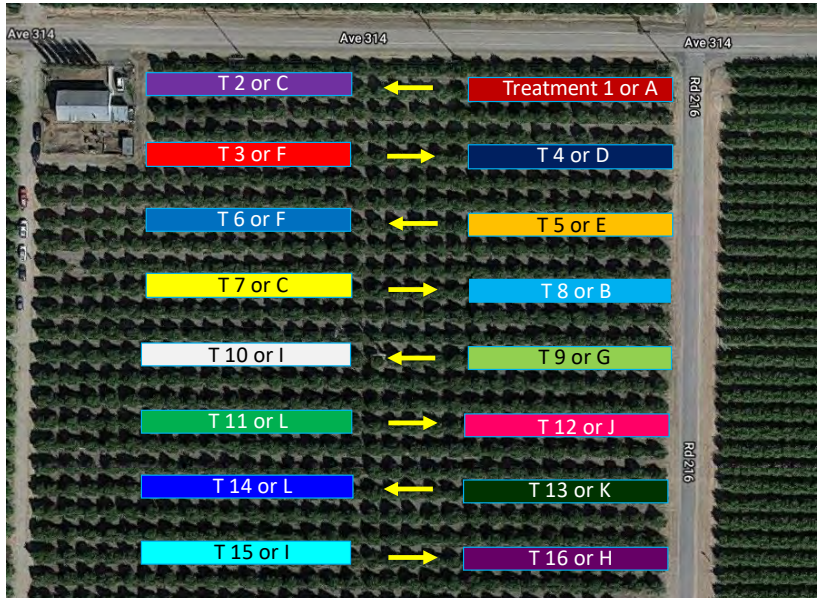
Settings	Fan Speed (F)	Travel Speed (S)	Nozzle Size (N)	Nozzle Row (NR)
Initial settings	1	1	1	1
Change Nozzle Row	1	1	1	2**
Change Travel Speed	1	2**	1	2
Change Nozzle Row	1	2	1	1**
Change Nozzle size	1	2	2**	1
Change Nozzle Row	1	2	2	2**
Change Travel Speed	1	1**	2	2
Change Nozzle Row	1	1	2	1**
Change Fan Speed	2**	1	1	1
Change Nozzle Row	2	1	1	2**
Change Travel Speed	2	2**	1	2
Change Nozzle Row	2	2	1	1**
Change Nozzle size	2	2	2**	1
Change Nozzle Row	2	2	2	2**
Change Travel Speed	2	1**	2	2
Change Nozzle Row	2	1	2	1**

** – Change

16 trials total



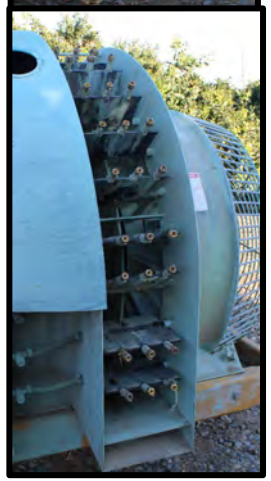
12 trials total



Approach and Outcomes

5. Evaluate ES via fluorescent-dye-based field spray trials

Field spray trial 1 & Field spray trial 2



Approach and Outcomes

5. Evaluate ES via fluorescent-dye-based field spray trials

Field spray trial 1 & Field spray trial 2

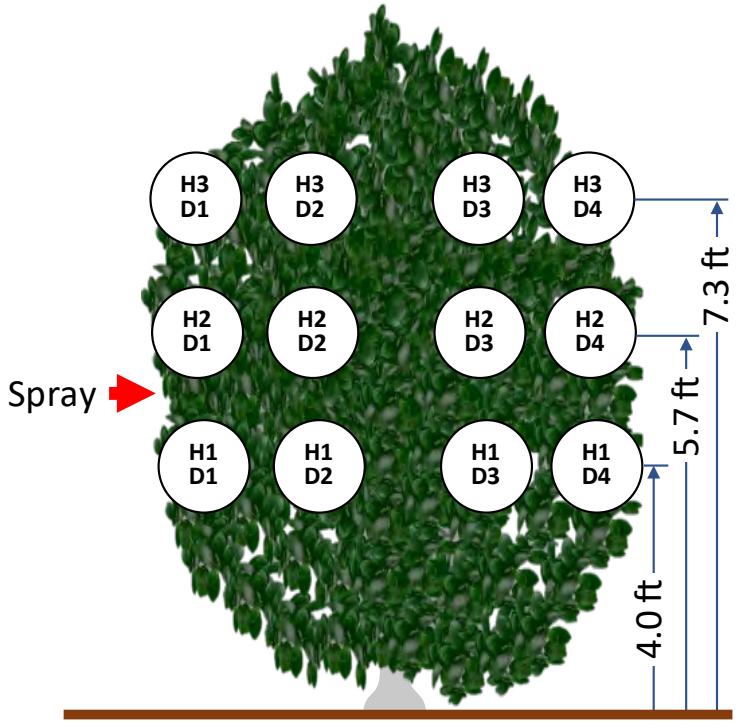


Fig 3. Schematic of sprayed leaf sampling locations (H– height; D – depth) in target canopy.

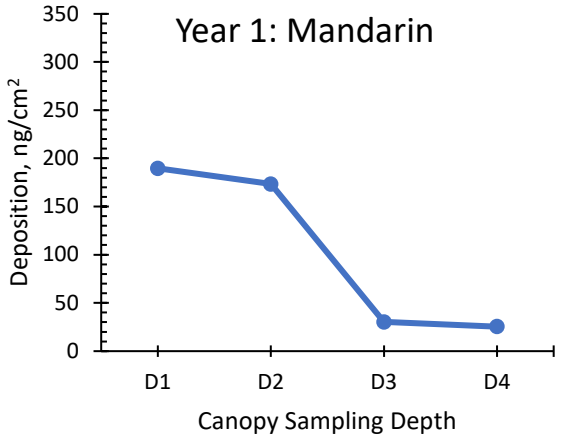
A total of 576 leaf samples (i.e., 3 canopy heights x 4 canopy depths x 16 treatments x 3 replications) were **analyzed by fluorometry** together with sprayer tank samples.

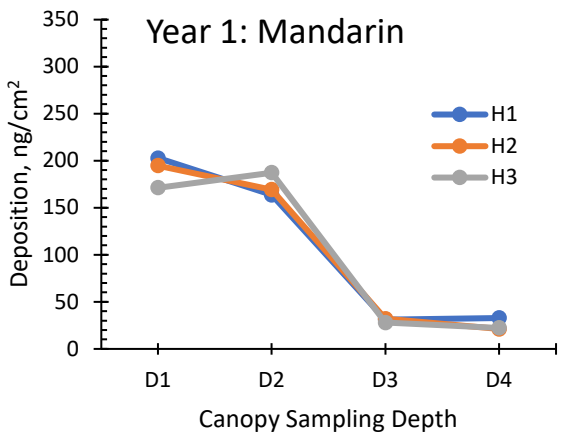
Following the fluorometric analysis, **total area of each leaf sample was also obtained using a leaf area meter** after the leaves were padded dry using paper towels.

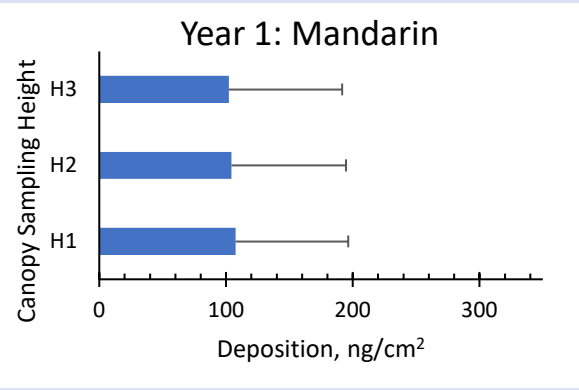
Approach and Outcomes

5. Evaluate ES via fluorescent-dye-based field spray trials

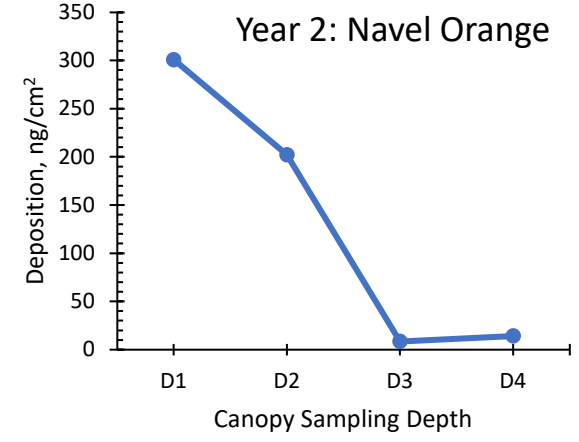
Field spray trial 1

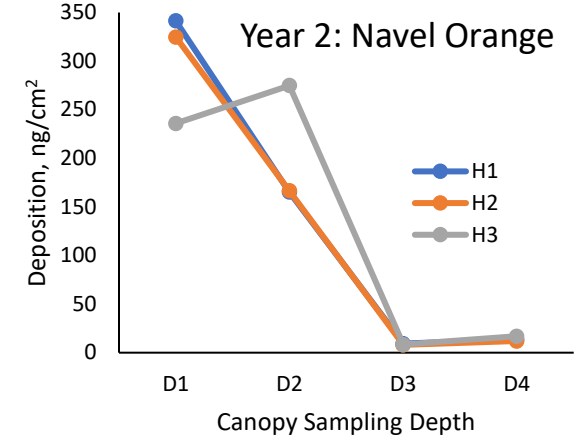


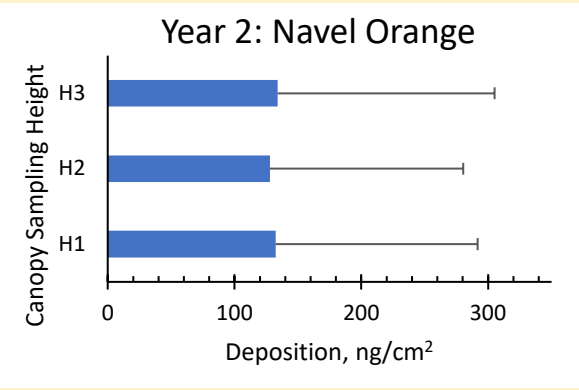




Field spray trial 2





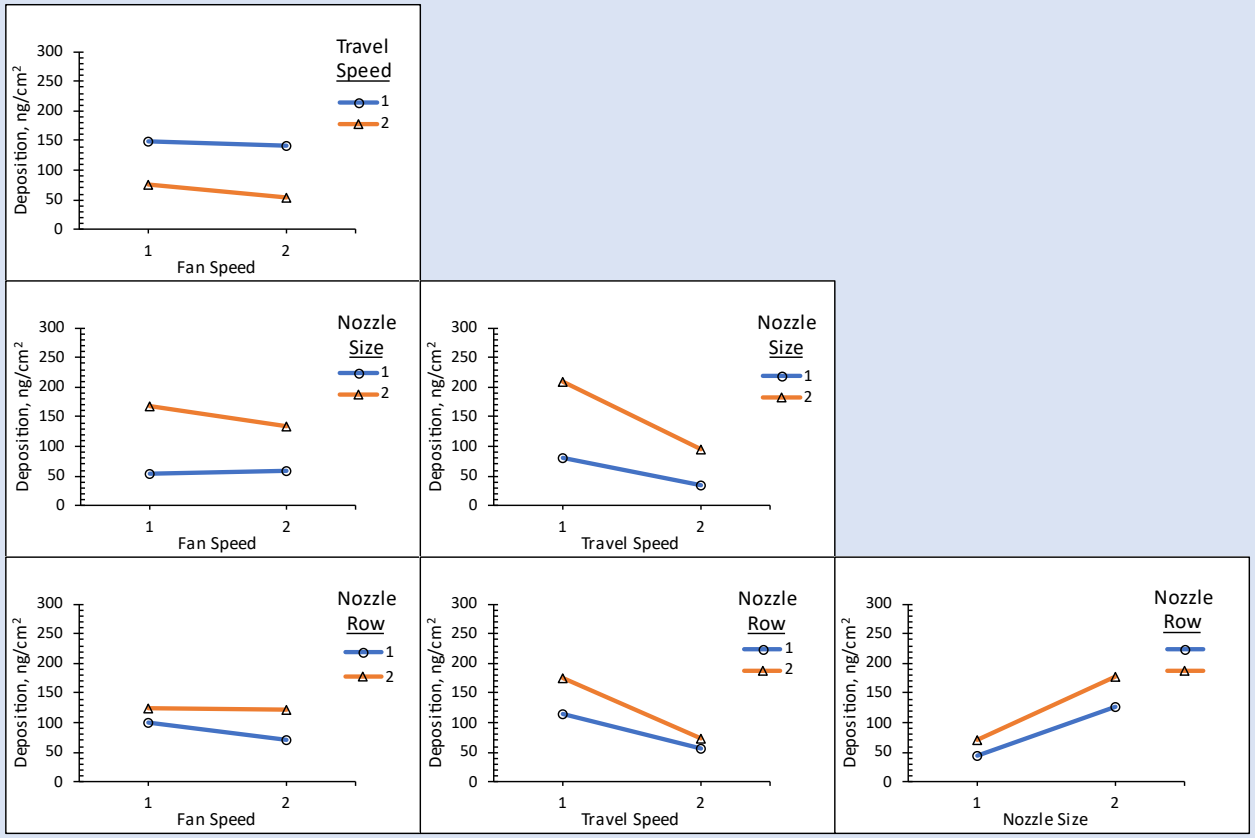


Approach and Outcomes

5. Evaluate ES via fluorescent-dye-based field spray trials

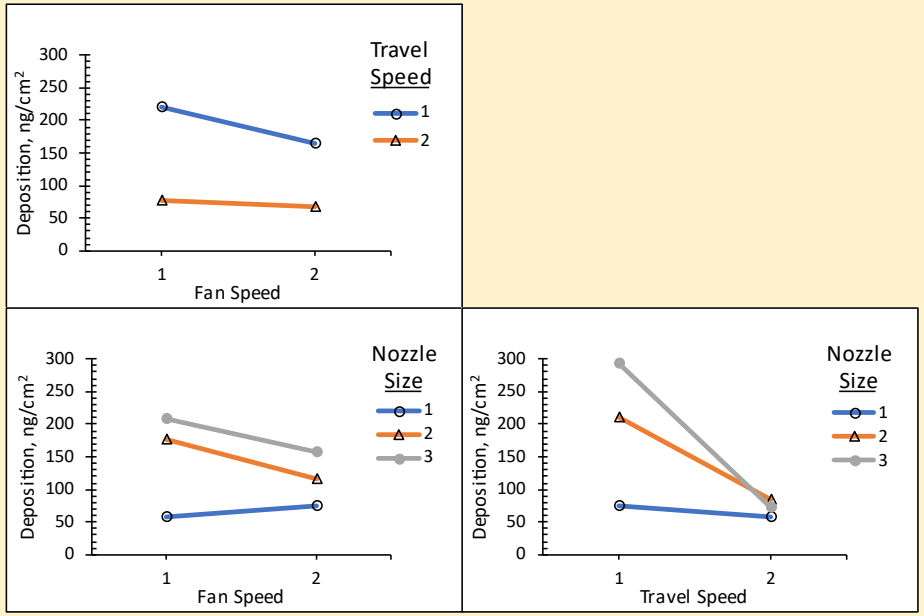
Field spray trial 1

Year 1: Mandarin
Canopy Deposition



Field spray trial 2

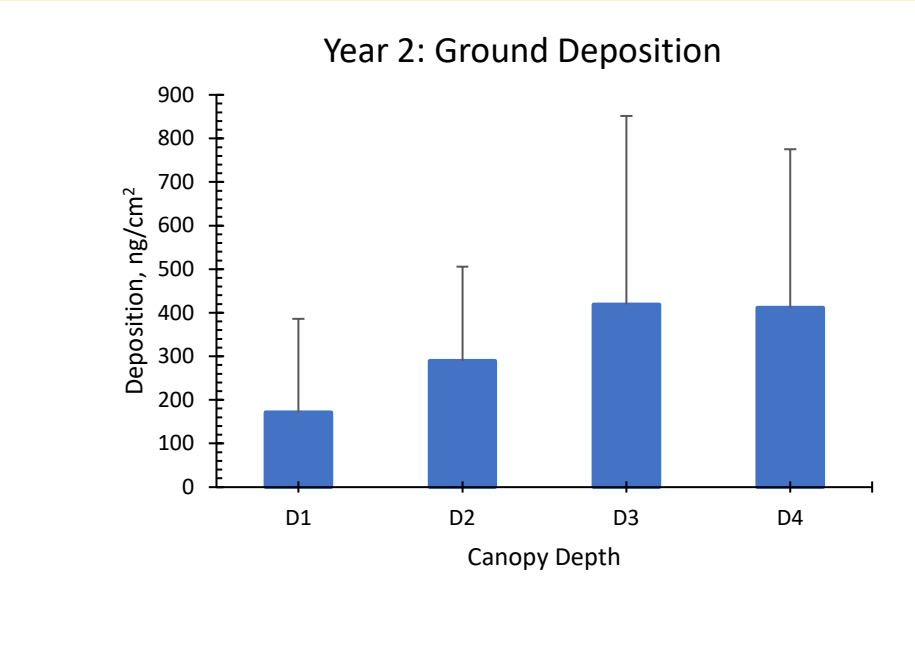
Year 2: Navel Orange
Canopy Deposition

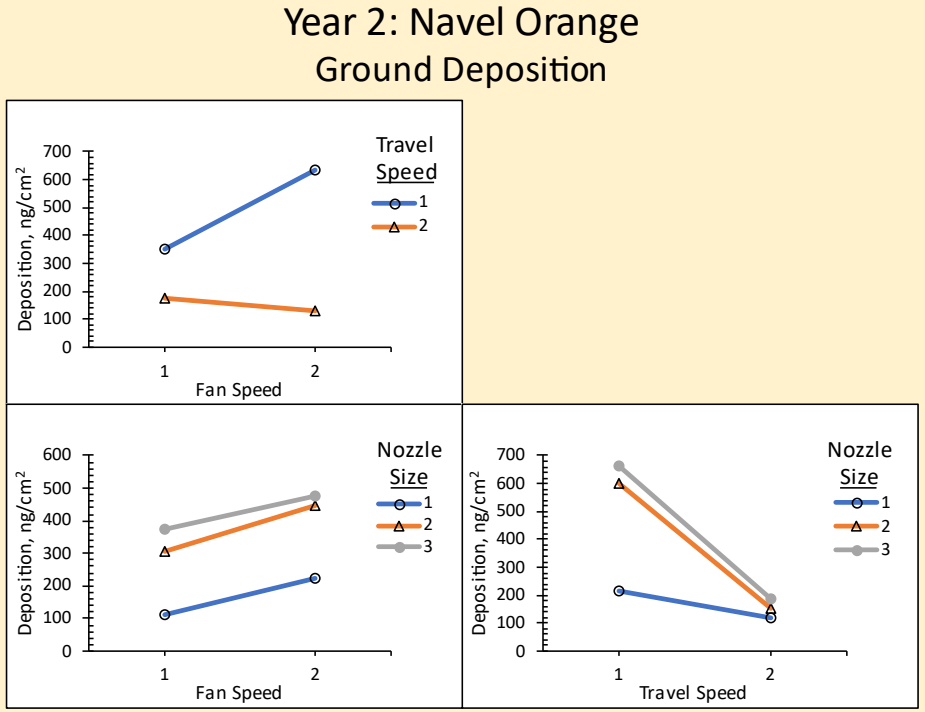


Approach and Outcomes

5. Evaluate ES via fluorescent-dye-based field spray trials

Field spray trial 2

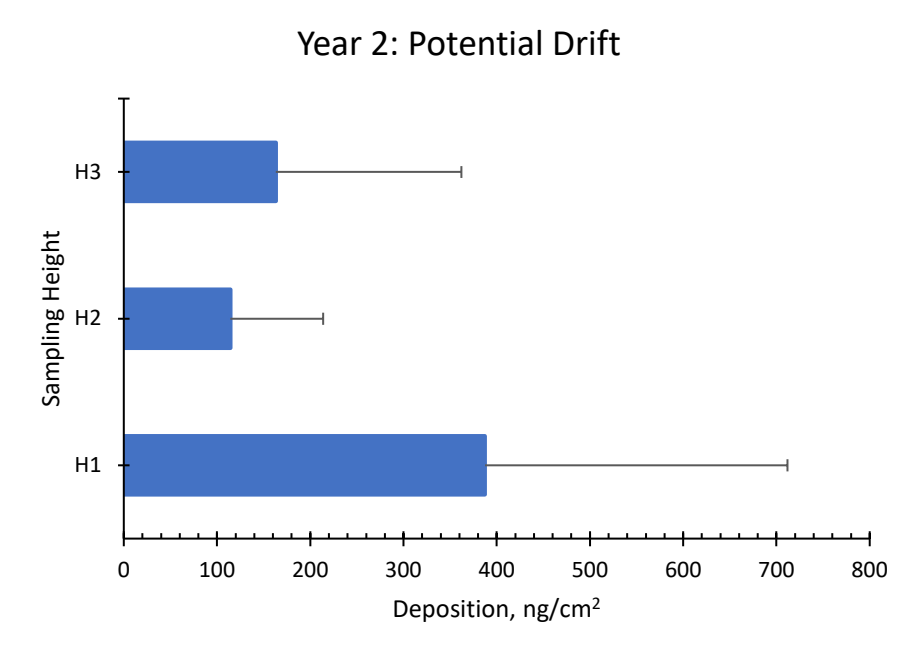


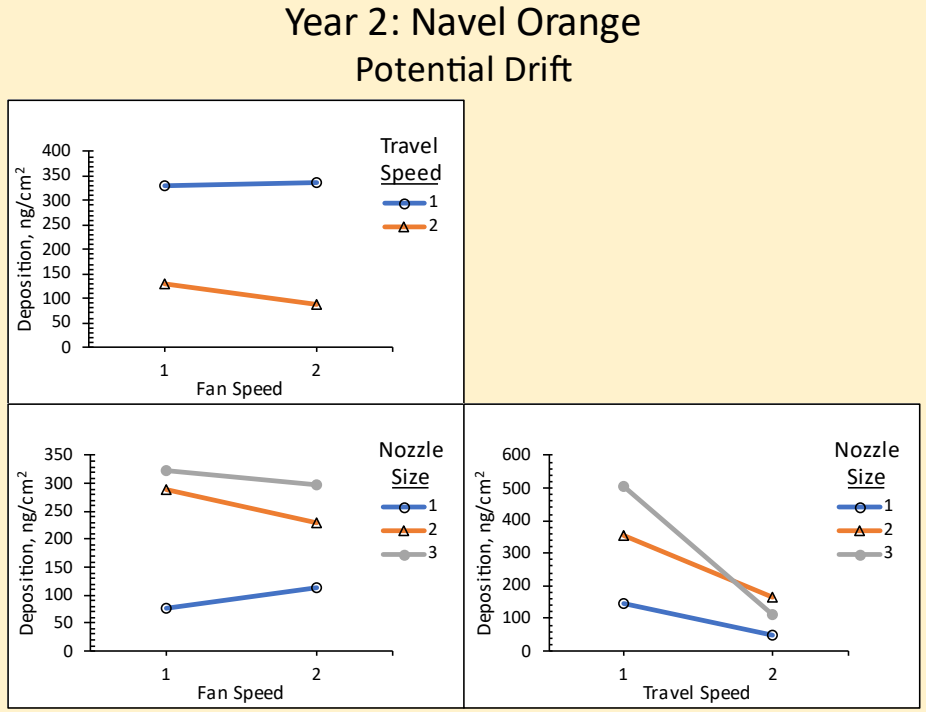


Approach and Outcomes

5. Evaluate ES via fluorescent-dye-based field spray trials

Field spray trial 2





Approach and Outcomes

6. Promote acceptance by citrus industry

Field day 1

Field day 2

Approach and Outcomes

7. Promote use of ES as an educational tool for agricultural students

School outreach 1

School outreach 2

1. **Guest lecture** at California State University Viticulture and Enology class: **22 undergraduate students** and 1 instructor in attendance.

2. **School Outreach Hosting** at the Agricultural Application Engineering (AgAppE) Laboratory at the Kearney Agricultural Research and Extension Center: **14 first-year and transfer undergraduate students, 1 graduate student**, and 2 instructors in attendance

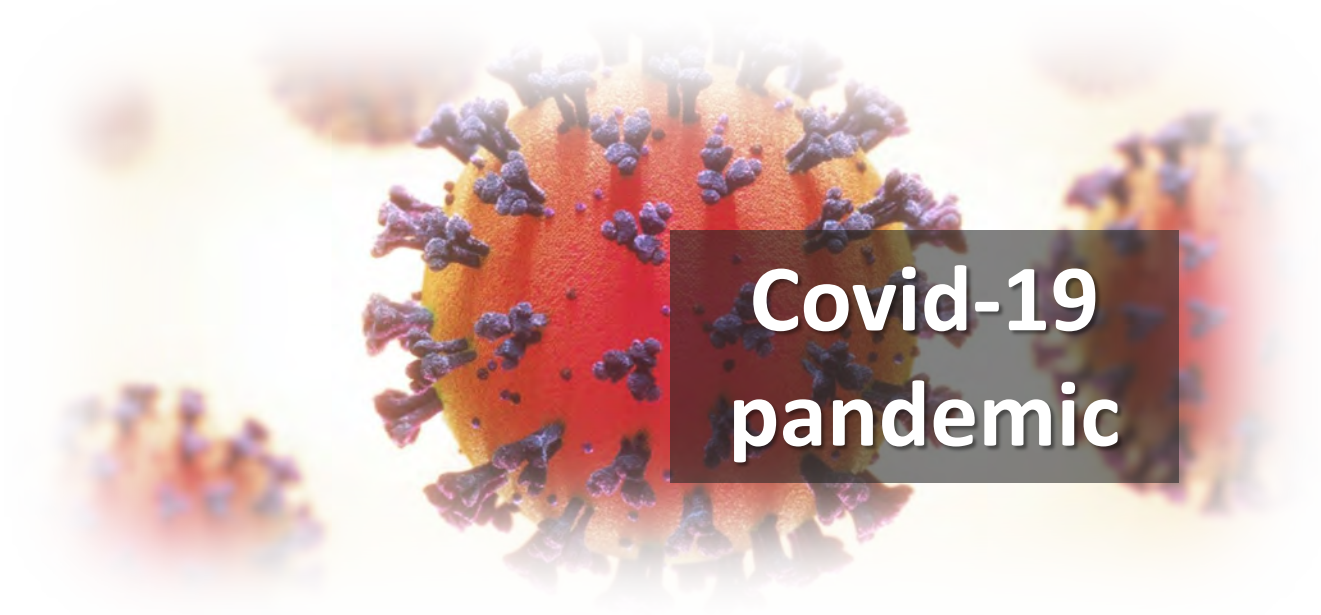
Approach and Outcomes

7. Promote use of ES as an educational tool for agricultural students

School outreach 2

Challenges and Setbacks

- **Major challenge was Covid-19 pandemic**
  - ✓No/limited in-person engagement during project period
  - ✓Uncertainty in webinar participation numbers



Conclusions

1. General grant administration (meetings; quarterly, annual progress, and final reporting; and invoices) have been upheld and is ongoing as required.

2. Learning from and building on an existing expert system application, new airblast spray application decision support web apps were successfully developed and deployed.

3. Use of decision support tools for planning and evaluating spray application in trees and vines was promoted through a citrus industry engagement meeting, four application webinars, and a 3-day conference.

4. Sprayer calibration as a best practice was promoted in a hands-on calibration exercise that was recorded and presented virtually. A calibration training package is under development.

Conclusions

5. Conducted a fluorescent-dye-based spray lab study and two field studies for evaluating spray deposition model and expert system/web app.

6. Acceptance of spray application expert system/web apps by industry was promoted in several invited/organized presentations. A field day training package is under development.

7. The spray application expert system/web app was promoted as an educational tool for undergraduate agricultural students in an indoor guest lecture session and an indoor/outdoor hands-on session.

Thank You!

Peter Ako Larbi, Ph.D.

palarbi@ucanr.edu

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