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Evaluating Performance of Current Spray Technologies for Site-Specific Pesticide Applications

Ravi Kumar Meena
PhD Student
College of Engineering
University of Georgia

UNIVERSITY OF GEORGIA
College of Engineering

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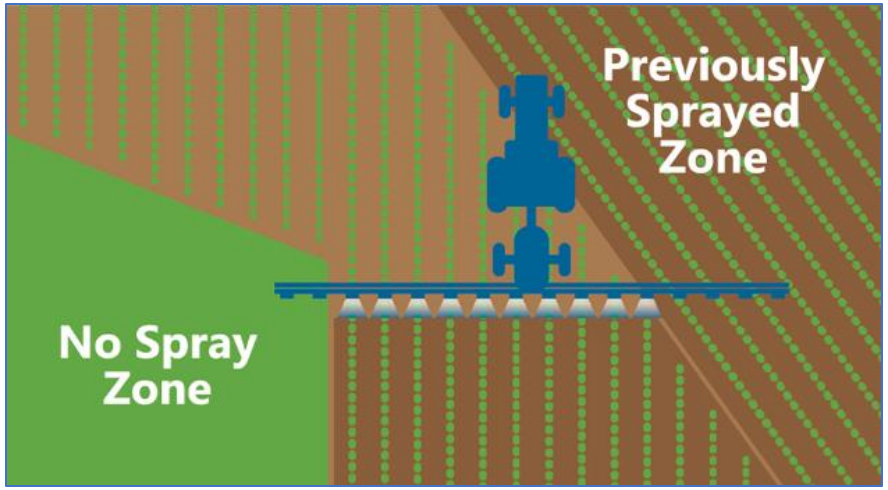
Introduction

- Spray technology on modern agricultural sprayers has advanced tremendously in the last few years.
- Heavy use of pesticides and off-target applications have also raised concerns about their adverse effects on environment.
- Rising interest in site-specific (targeted) pesticide applications recently as a way to be more precise and efficient with pesticide applications.

Source: https://www.dtnpf.com/agriculture/web/ag/news/article/2021/04/01/see-kill

Spray Technologies and In-Field Performance

- Various spray technologies are currently available on modern agricultural sprayers for precision pesticide applications
- Sprayers equipped with both rate control and pulse width modulation (PWM) systems provide capabilities to implement pre-defined rates from Rx maps
- Limited information is available on the performance of these systems (accuracy and rate transitions) when implementing site-specific applications (spray areas only)



Hypothesis

The Pulse Width Modulation (PWM) system will demonstrate improved performance and precision compared to traditional rate control system during site-specific applications.

Objective

To assess and compare the performance of rate control and PWM systems on an agricultural sprayer for single-rate, uniform and variable-rate site-specific pesticide applications.

Application Equipment and Systems

Sprayer:

- 6-row test sprayer (5.9 m boom)
- Individual nozzle control (13 nozzles)
- System flow meter and pressure sensor

Flow Control Systems:

- TeeJet IC35 Rate Controller
- TeeJet DynaJet IC7140 PWM System

Study Treatments

Single-Rate Testing:

Target Rates:

- 93.5 L ha^{-1}
- 116.1 L ha^{-1}
- 140.3 L ha^{-1}

Variable-Rate Testing:

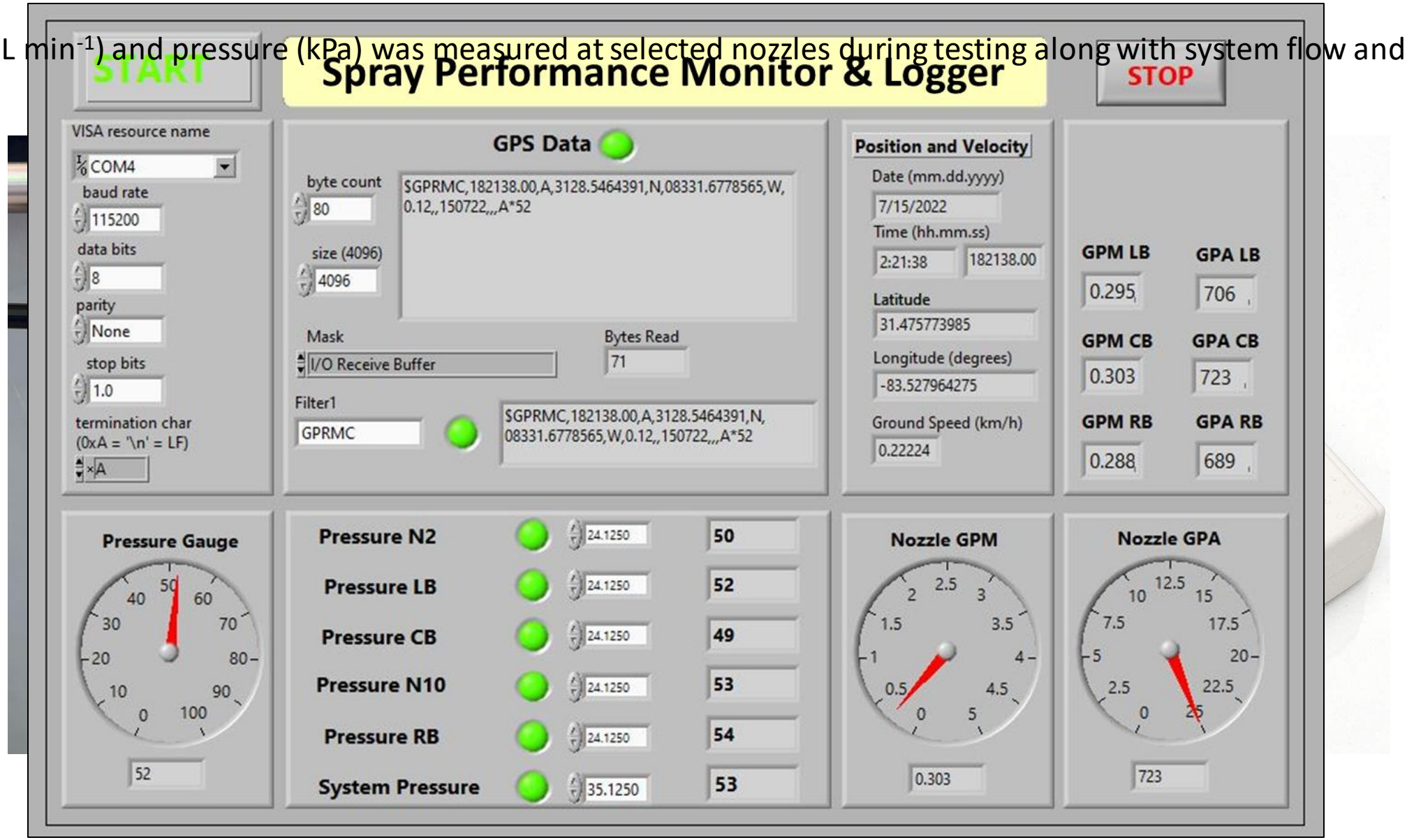
Transitions:

- 93.5 - 116.1 L ha^{-1}
- 93.5 - 140.3 L ha^{-1}
- 116.1 - 93.5 L ha^{-1}
- 116.1 - 140.3 L ha^{-1}
- 140.3 - 93.5 L ha^{-1}
- 140.3 - 116.1 L ha^{-1}

- Both SS and VR tests were conducted at three (simulated) ground speeds: 12.9, 16.1 & 19.3 km h^{-1}.
- All tests were implemented using TeeJet Technologies AEROS 9040 display/controller.

Data Acquisition System

Flow rate (L min^{-1}) and pressure (kPa) was measured at selected nozzles during testing along with system flow and pressure.

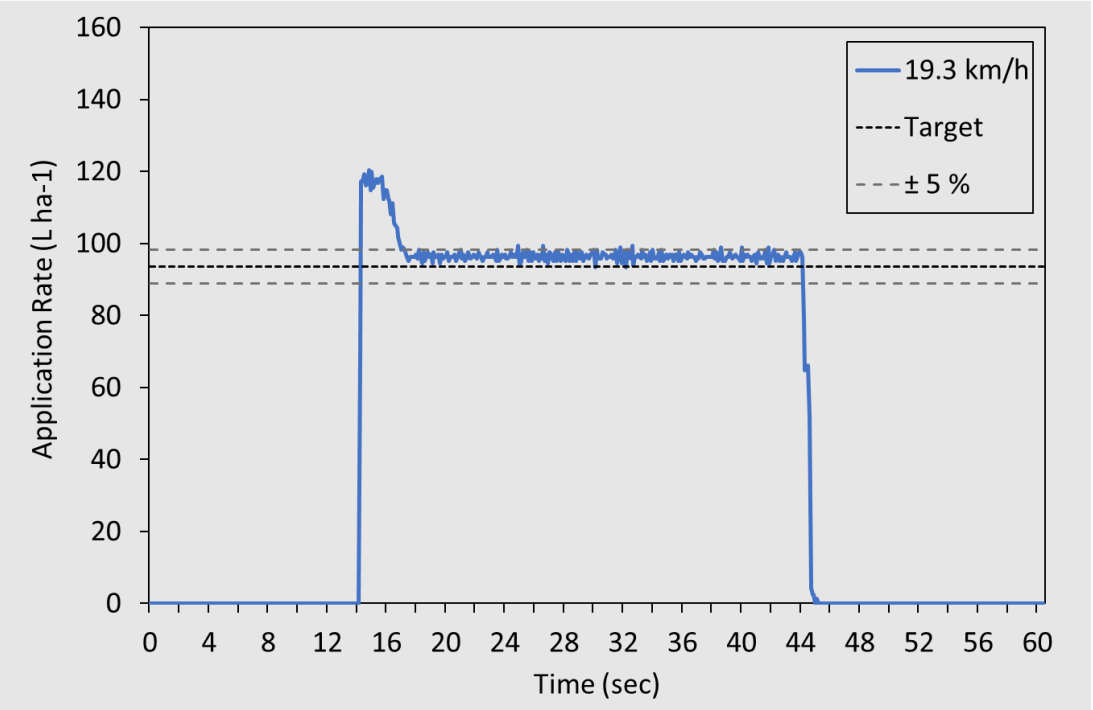


Data Collection and Analysis

Data Collection:

- **Single-Rate Testing**: the time required by each system (rate controller and PWM) to attain and stabilize the target application rate.

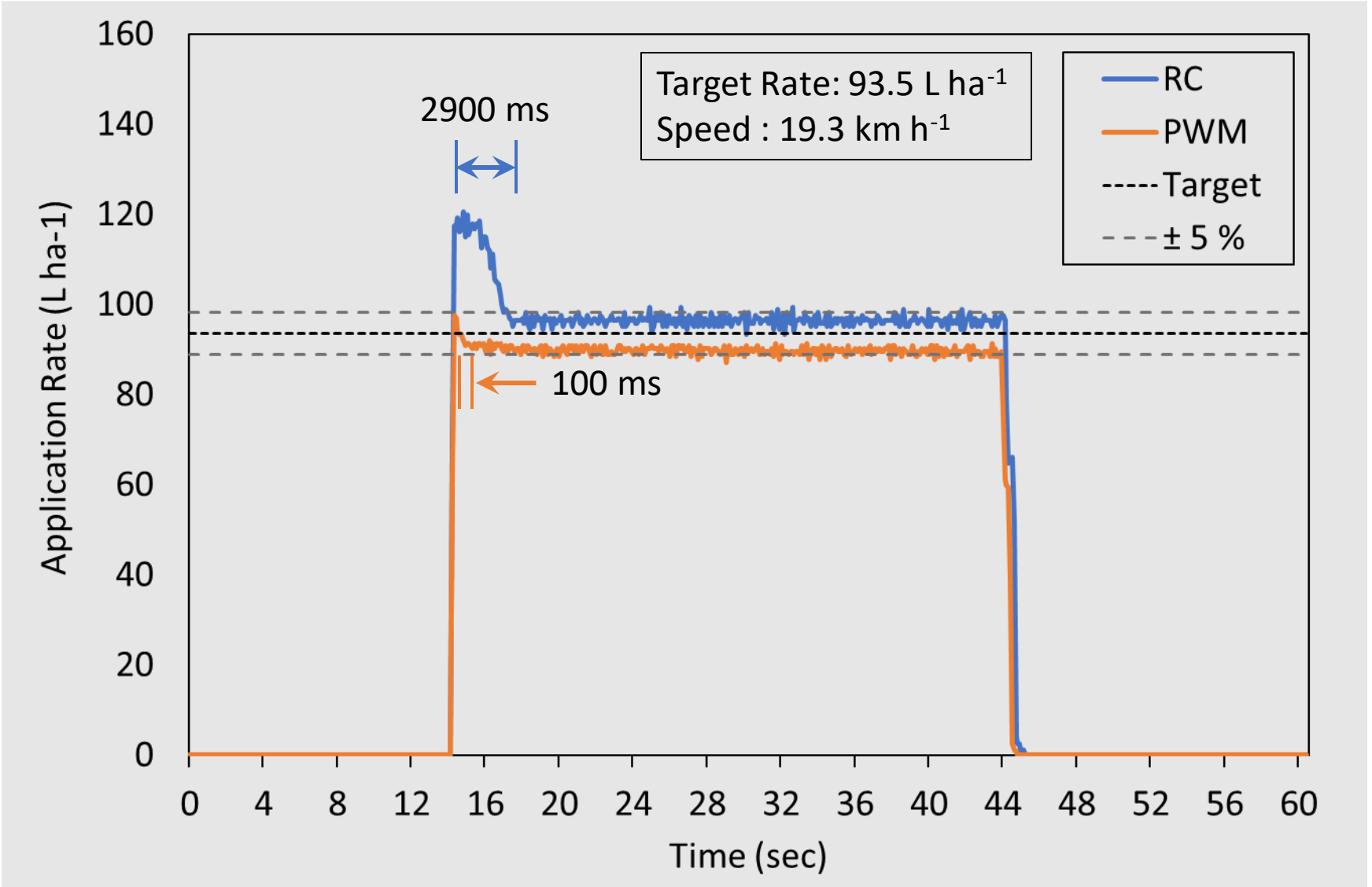
- **Variable-Rate Testing:** the time required by each system (rate controller and PWM) to make the transition from initial rate to the next the target application rate.



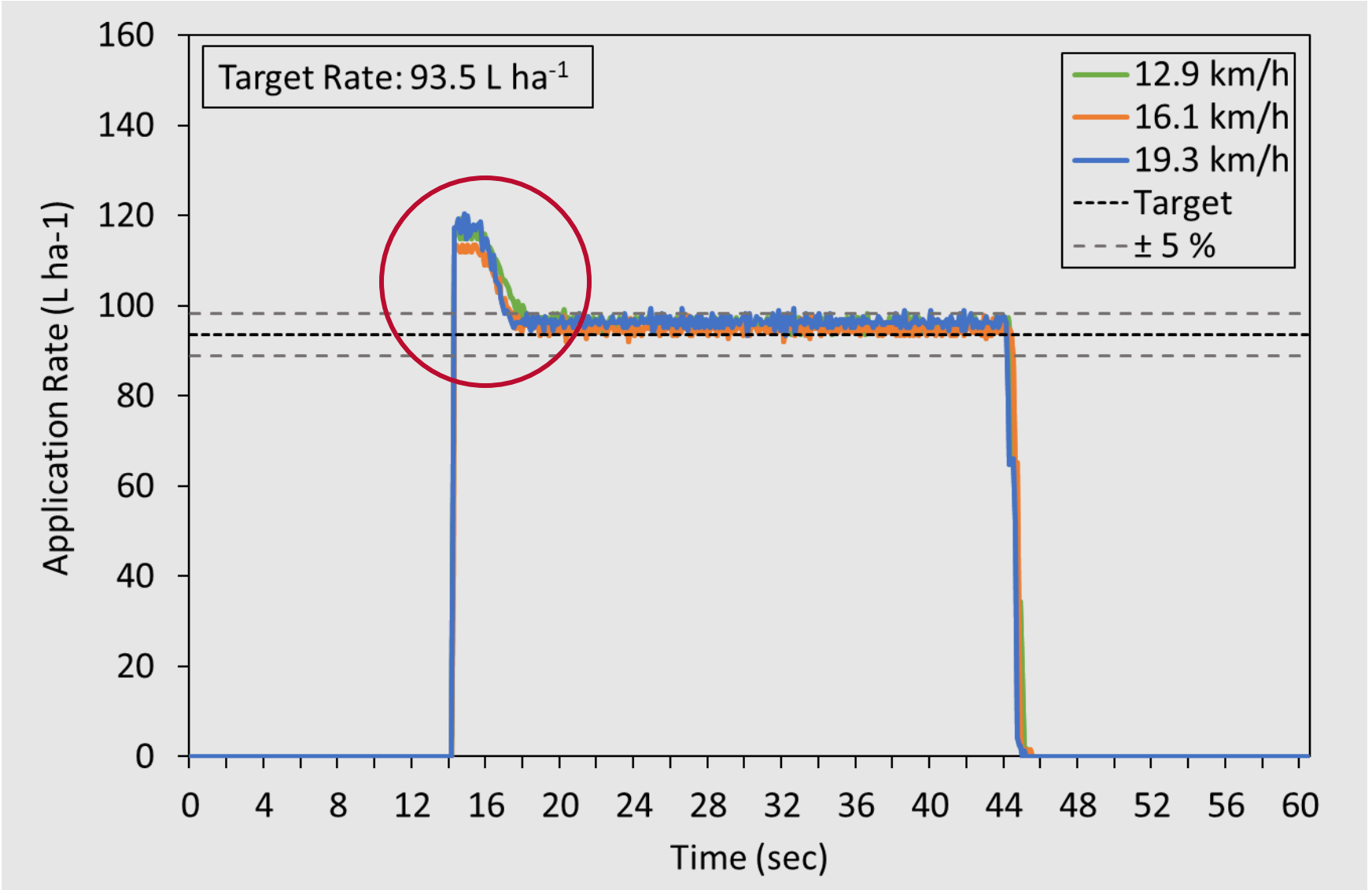
Data Analysis:

- Data was subjected to ANOVA with control system, rate (or rate transitions) and ground speed as the explanatory variables and the rate stabilization time as response variable.
- All data was statistically analyzed using JMP Pro 16 and a significance level (alpha) of 0.05.

Results – Rate Controller vs PWM (Single Rate)



Rate Controller – Effect of Ground Speed



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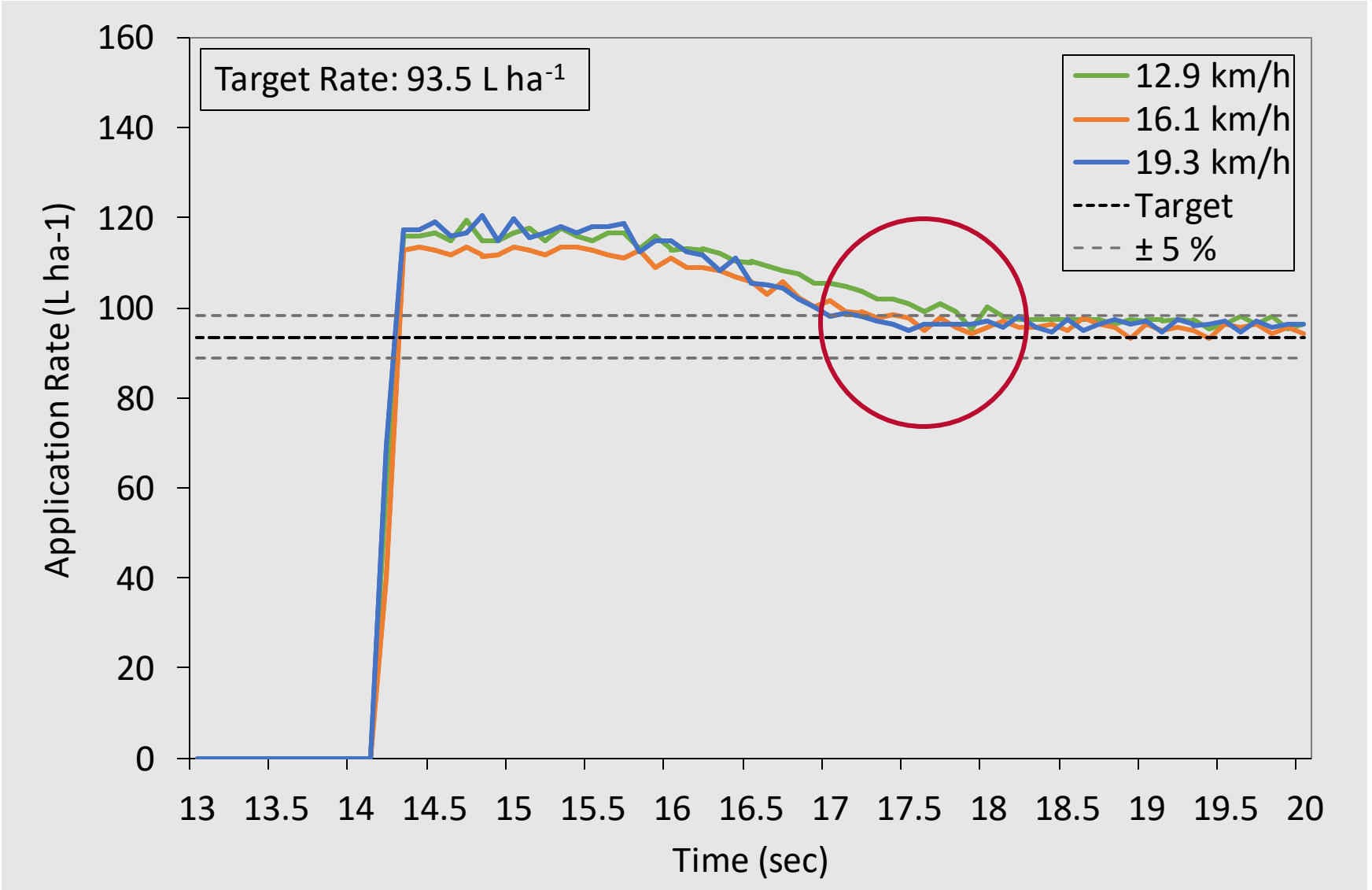
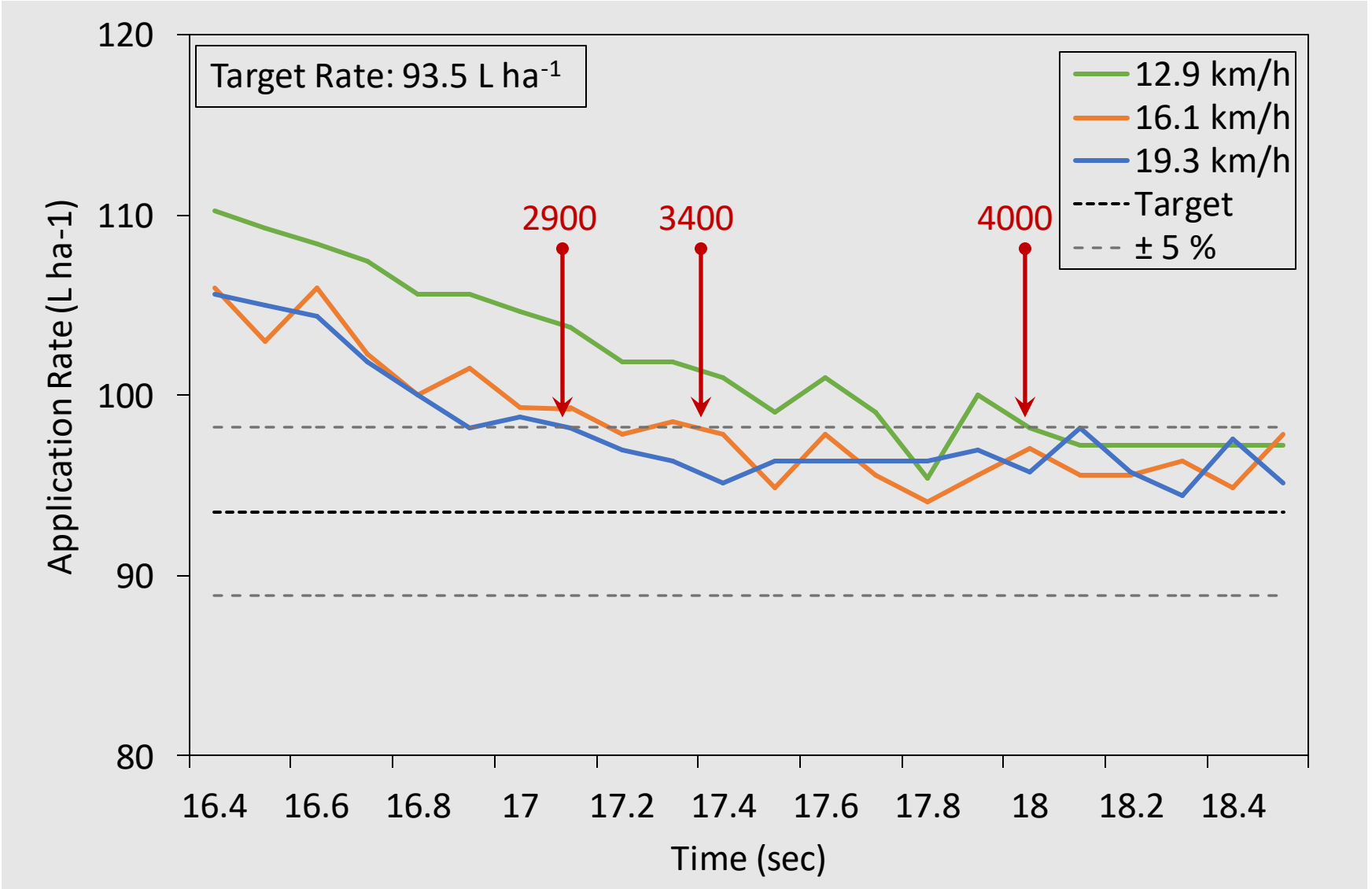
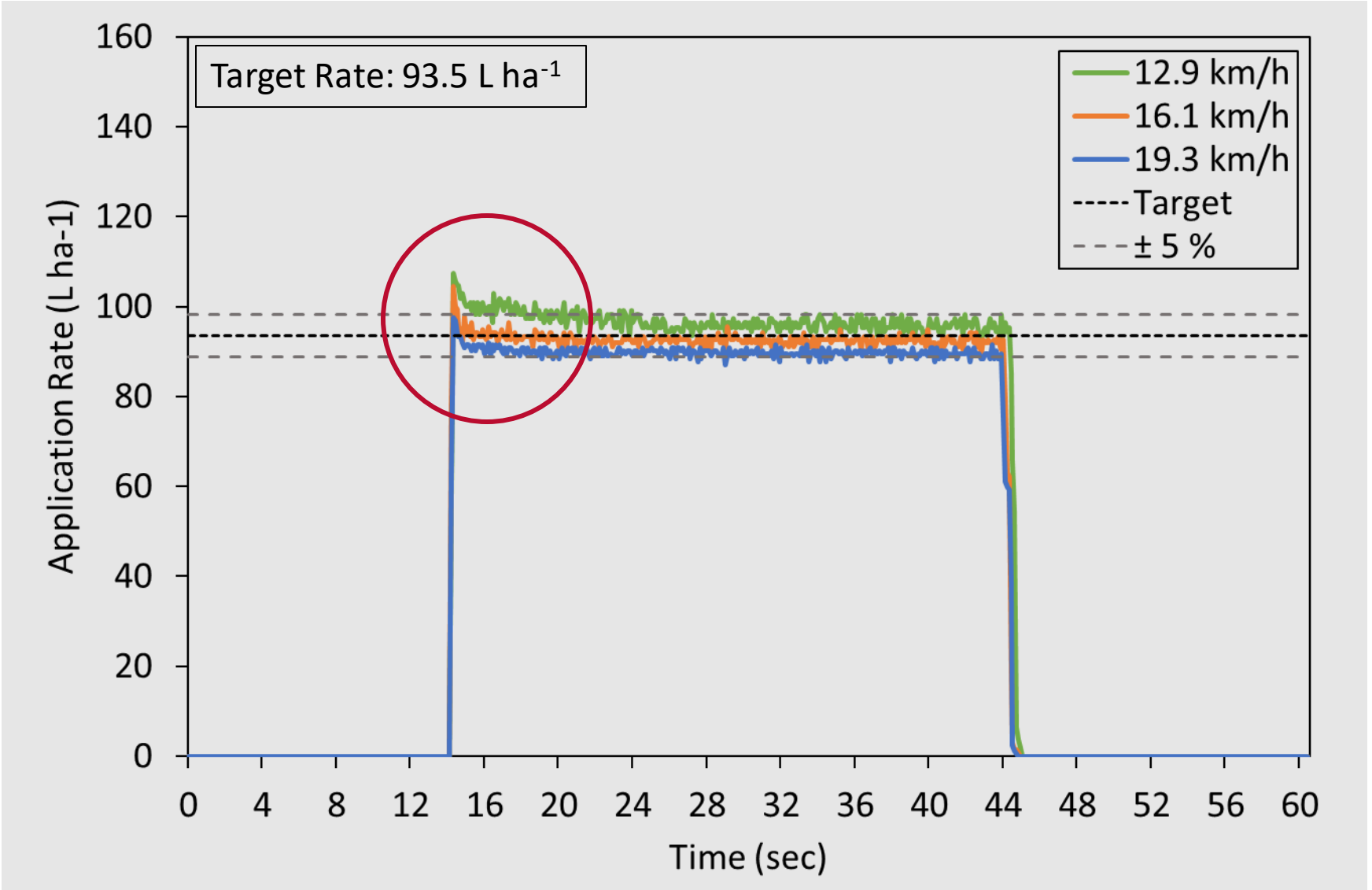


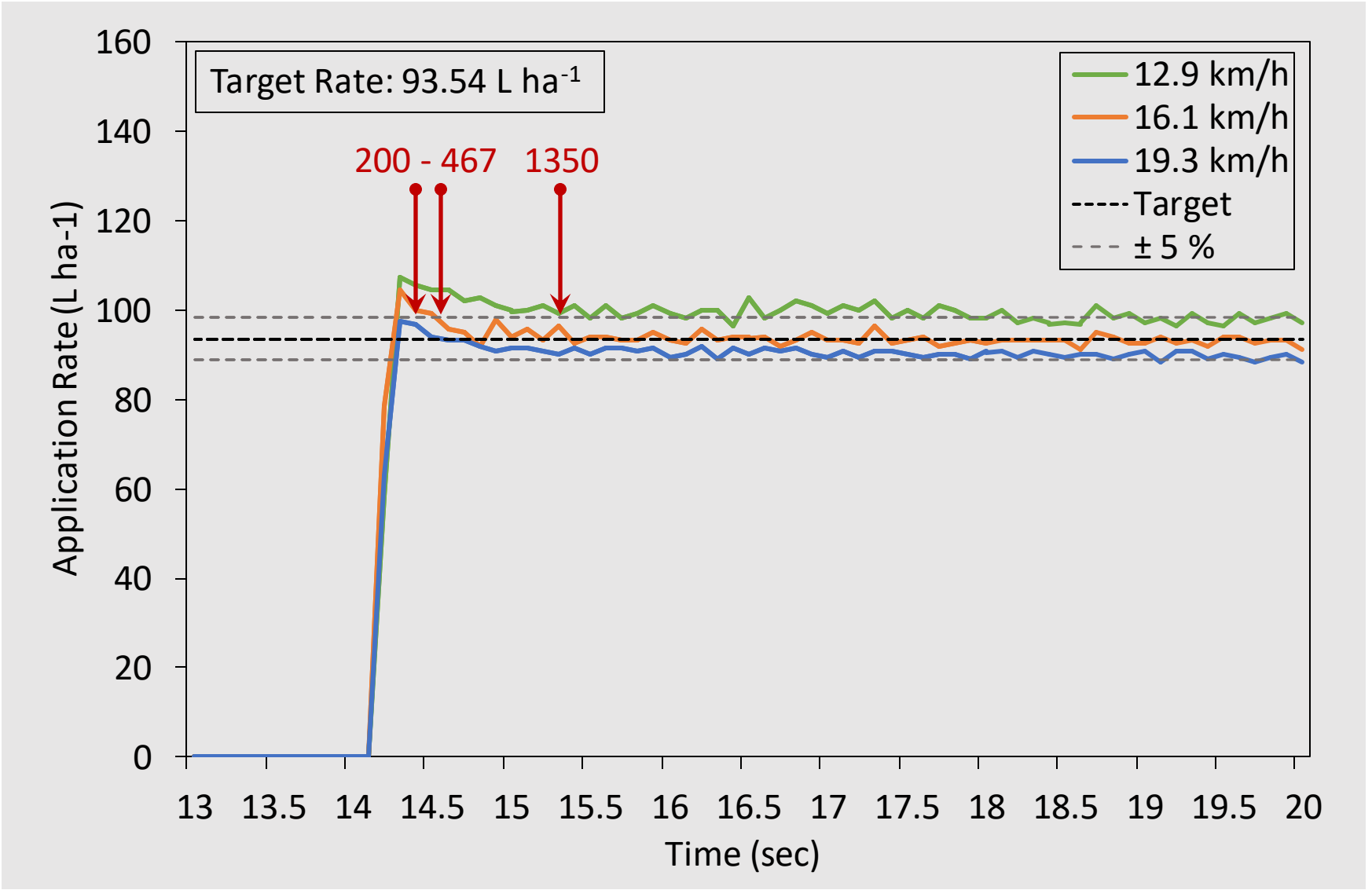
Rate Controller – Effect of Ground Speed



PWM System – Effect of Ground Speed



PWM System – Effect of Ground Speed



Single-Rate : Rate Stabilization Time

Speed (km h^{-1})	Rate (L ha^{-1})	RC	PWM
12.9	93.5	4033 a	1350 c
	116.1	3567 b	667 d
	140.3	3400 b	300 d
16.1	93.5	3300 p	467 r
	116.1	3333 p	333 r
	140.3	2233 q	200 r
19.3	93.5	2967 x	200 z
	116.1	2967 x	167 z
	140.3	1133 y	100 z

Values with same letter within a row for each speed are not significantly different (*p>0.05*).

Implications for Single-Rate Uniform Applications

Prescription Map: SR

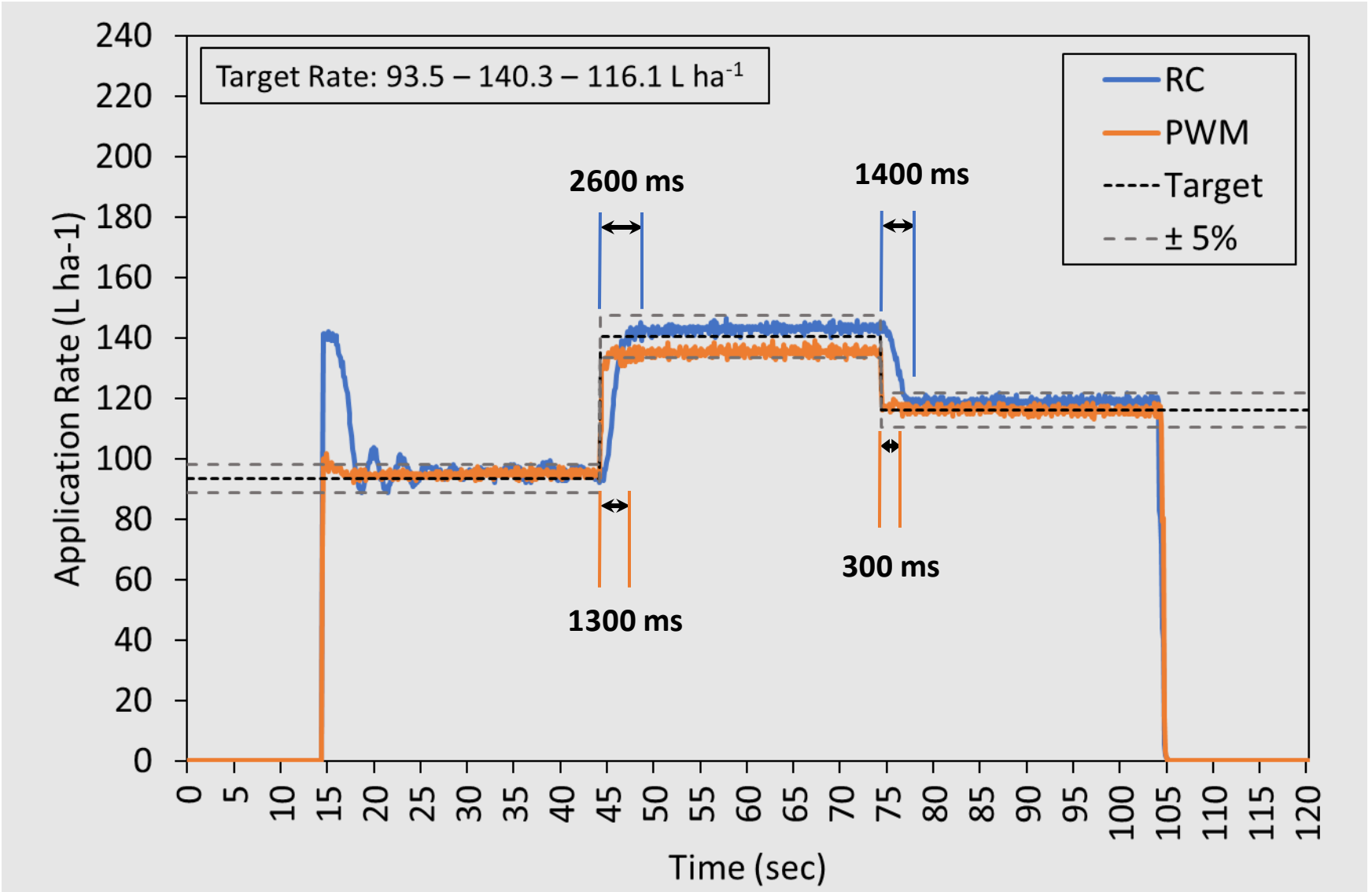
As-Applied: RC

As-Applied: PWM

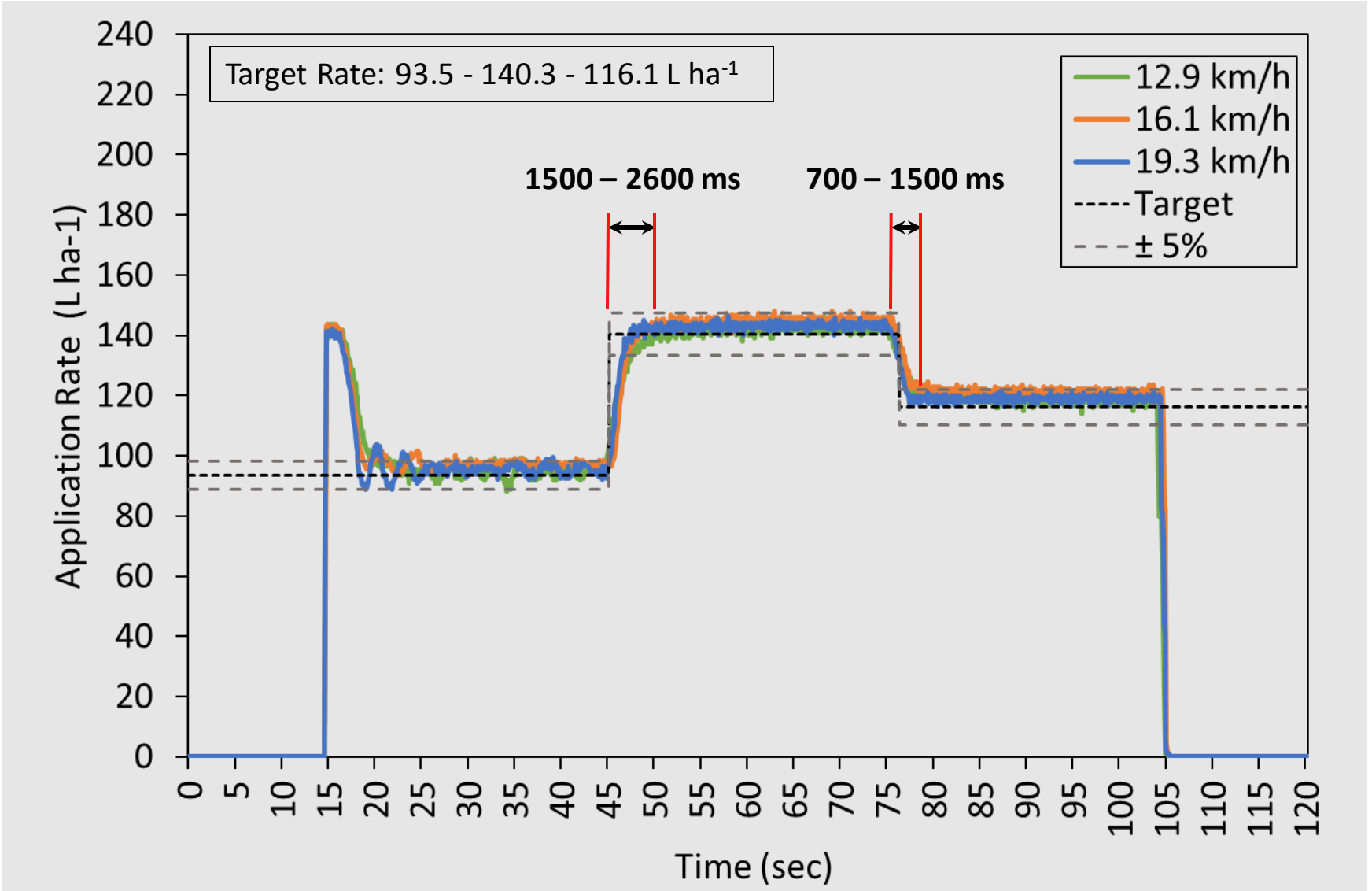
Distance required for rate stabilization (m)*		
Rate (L ha^{-1})	RC	PWM
93.5	14.4	4.8
116.1	12.8	2.4
140.3	12.2	1.1

*Distance computed using 12.9 km h^{-1}.

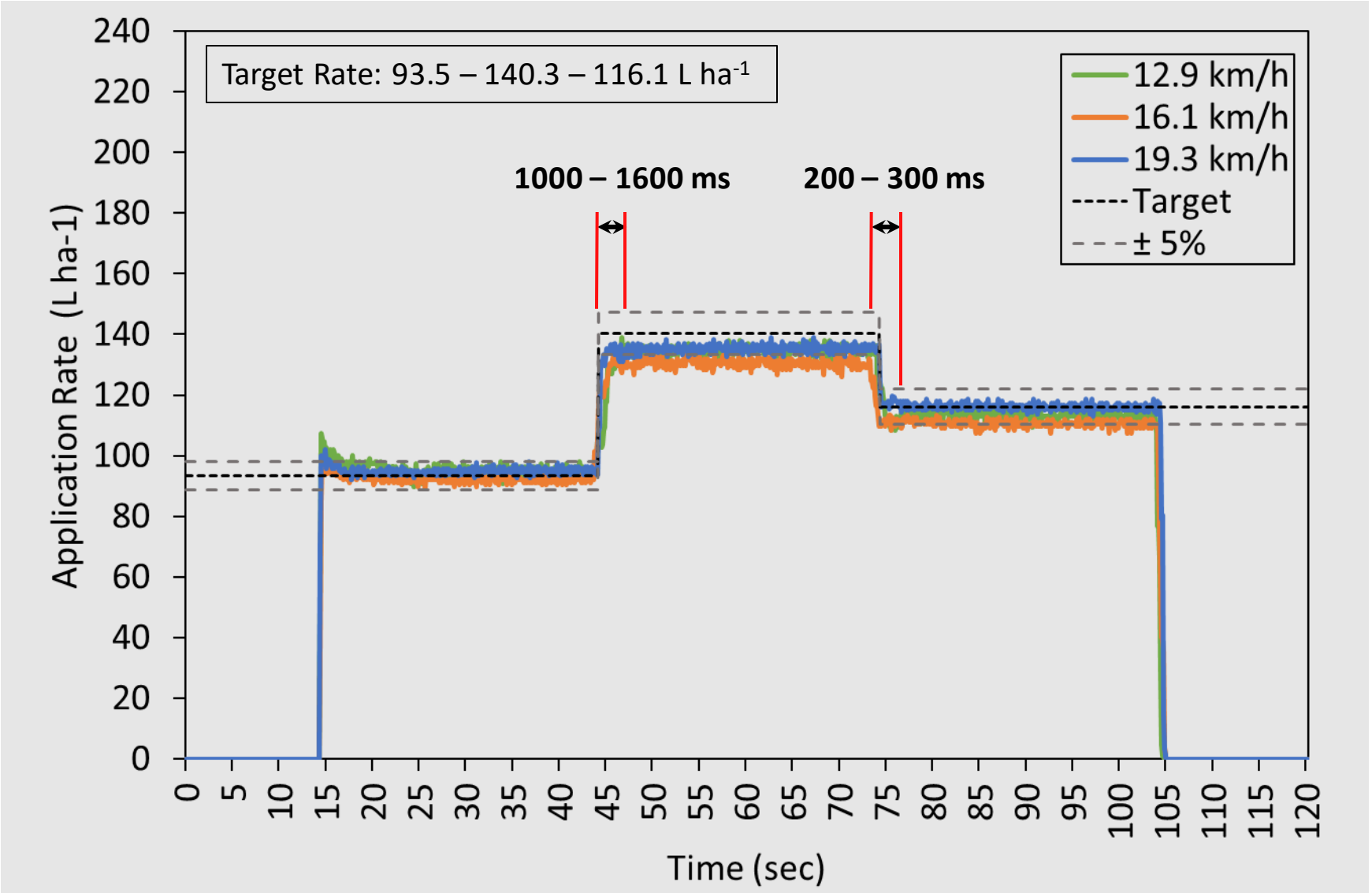
Rate Controller vs PWM (Variable-Rate)



Rate Controller – Effect of Ground Speed



PWM System – Effect of Ground Speed



Variable-Rate : Rate Stabilization Time

Speed (km h^{-1})	12.9		16.1		19.3	
Rate (L ha^{-1})	RC	PWM	RC	PWM	RC	PWM
140.3 - 93.5	3211 a	833 d	1678 A	244 E	1500 a	150 e
140.3 - 116.1	1456 c	222 f	1450 AB	300 E	711 c	233 e
116.1 - 93.5	778 de	333 f	644 D	200 E	489 d	211 e
93.5 - 116.1	511 ef	456 f	633 D	1178 C	489 d	156 e
116.1 - 140.3	789 de	500 ef	689 D	1300 BC	678 c	222 e
93.5 - 140.3	2600 b	1367 c	1433 AB	1600 AB	1417 a	1022 b

Values with same letter within a speed column for each rate transition are not significantly different ($p>0.05$).

Implications for Variable-Rate Site-Specific Applications

Prescription Map: VR

As-Applied: RC

As-Applied: PWM

Distance required for rate stabilization (m)*		
Rate (L ha^{-1})	**RC**	**PWM**
140.3 - 93.5	11.5	3.0
140.3 - 116.1	5.2	0.8
93.5 - 140.3	9.3	4.9

*Distance computed using 12.9 km h^{-1}.

Conclusions

- **Single rate Site-Specific Applications:**
  - PWM system demonstrated faster rate stabilization time (100 – 1350 ms) than rate controller (1133 – 4033 ms).
  - Higher speeds and rates showed faster rate stabilization time for both systems due to target system pressure closer to initial pressure.
- **Variable rate Site-Specific Applications:**
  - PWM system demonstrated faster rate stabilization time (156 – 1600 ms) than rate controller (489 – 3211 ms).
  - Both systems took more time for rate stabilization for larger transitions (46.8 L ha^{-1}).

Future Work: Investigate the effect of sprayer controller setup (look ahead and delay time) on accuracy of site-specific applications.

Thank You!

Ravi Kumar Meena
Graduate Research Assistant
College of Engineering
University of Georgia
Email: ravi.meena@uga.edu

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