NOZZLE PRESSURE UNIFORMITY AND EXPECTED DROPLET SIZE OF PULSE WIDTH MODULATION (PWM) SPRAY TECHNOLOGY

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ABSTRACT

Pulse width modulation (PWM) system is one of the technologies currently implemented in agricultural sprayers. **PWM is expected to deliver the target flowrate by managing the duty cycle and maintaining the target pressure to provide the desired droplet size. But there are still concerns about the application errors due to pressure variation when using such systems, which may cause pesticide resistance and product loss**. The pressure uniformity and expected droplet size of the PWM system were evaluated in a 54.0 hectare (ha) field.

The result showed the systems' capability to maintain the application pressure within the acceptable range even at varying field conditions. However, pressure deviates during speed transitions indicating the system's latency to respond immediately, particularly on the outer section of the boom, wherein there is a frequent duty cycle variation. Due to varying pressure, the droplet size also deviates from the expected droplet spectra, mostly caused by incorrect nozzle selection.

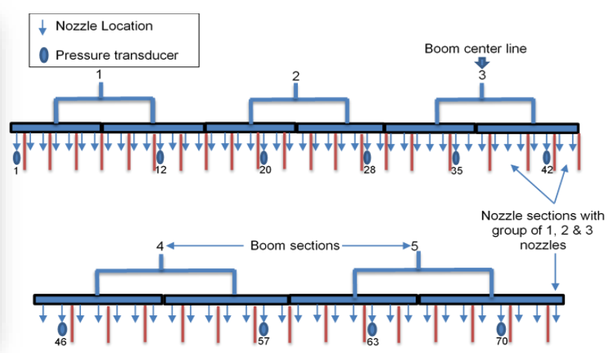
Keywords: Agricultural sprayer, droplet size, nozzle pressure, pulse width modulation

INTRODUCTION

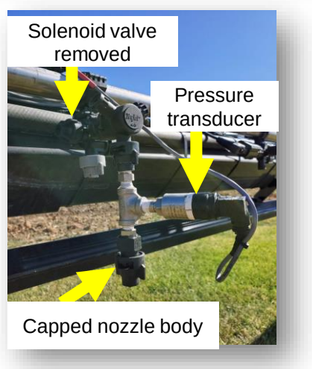
- One of the variable-rate technologies that may minimize the application errors due to pressure variation is the pulse width modulation (PWM) technology.
- The PWM system should be able to deliver the product at the target application pressure to achieve the desired nozzle flow rate.
- Any variation in application pressure may impact the spray angle and the droplet size as it manages the velocity of the liquid exiting the nozzle.
- It is important to follow the product label specification to effectively control pests, achieve proper spray coverage, and minimize spray drift.
- There are still issues regarding the use of PMW technology, especially when operating at lower duty cycles and the controller's ability to maintain the target pressure at varying field conditions.
- Limited studies exist regarding pressure stability during solenoid valve actuation during speed transitions and curvilinear passes wherein the duty cycle may quickly vary for each nozzle and the section control actuation that may shut off several nozzles during application.
- The objective of this study is to evaluate the PWM spray technology performance in terms of nozzle pressure and droplet size uniformity under field setting wherein rapid and continuous sprayer speed transition and section actuation may happen.

METHODOLOGY

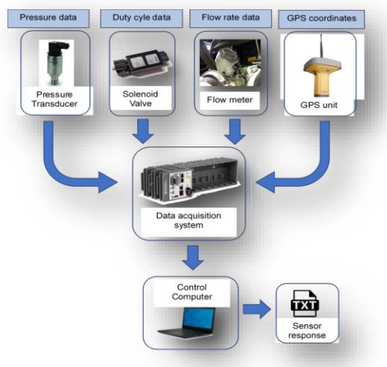
The sprayer used in the study



Layout of the sprayer boom with 73 nozzle sections with group of either 1, 2, or 3 nozzles.



Capped nozzle body to measure real-time boom pressure



Data acquisition system set-up.

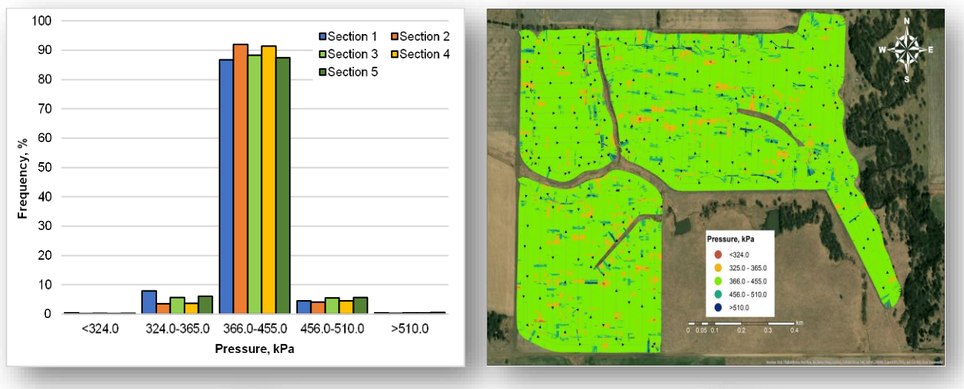
Machine setup
- Field Area – 54.0 ha
- Raven Hawkeye PWM system
- Application Rate – 112.0 L ha^{-1}
- Application Pressure – 462.0 kPa
- Speed Range – 14.0 -29.0 kph

Instrumentation
- High frequency pressure transducer
- CAN Bus
- GR5 GPS unit
- National Instruments cRIO-9047
- C-Series modules – NI-9221, NI-9870, and NI-9853

RESULTS AND DISCUSSIONS

PRESSURE UNIFORMITY

- The application pressure remains within the range of 366.0 kPa to 455.0 kPa for 89.0% of the time (Figure 1a).
- The result showed that the system was able to adjust and maintain the pressure within the acceptable range regardless of varying conditions (Figure 1b).
- Compared to a flow-based system where pressure varies a lot during application which could impact the application rates, the PWM system showed a great improvement in maintaining the application pressure.



(a) (b)

Figure 1. Pressure uniformity plot (a) and pressure uniformity map (b) when using a PWM system.

EXPECTED DROPLET SIZE SPECTRA

- Results show that the nozzle's droplet size spectra during operation were under a fine category for only 37.0% of the time (Figure 2a and 2b).

(a) (b)

Figure 2. Droplet size spectra uniformity plot (a) and map (b) when using a PWM system

- A slight variation in application pressure could change the droplet size since the nozzle boundary limit of the target droplet size was very close to the target pressure.
- Since the PWM system maintained the application pressure within the acceptable range for 87.0% of the time, the system will be expected to provide the desired droplet size for a similar amount of time if a correct nozzle size will be used.

CONCLUSIONS

1) PWM system provided an application pressure that will not vary the application rate beyond the ±5.0% of the target.
2) Nozzle pressure deviates beyond the target on nozzles at the outer boom sections due to frequent duty cycle changes, and
3) Selecting nozzles to provide the target droplet size in a wide range of pressure will improve the droplet size uniformity.