Best Use Practices to Optimize Pesticide Applications from Pulse-Width Modulation Sprayers

PESTICIDE APPLICATION TECHNOLOGY LABORATORY

Thomas R. Butts[1], Liberty E. Butts[1], Bradley K. Fritz[2], W. Clint Hoffman[2], Joe D. Luck[3], and Greg R. Kruger[1]

University of Nebraska Lincoln

[1]University of Nebraska-Lincoln, North Platte, NE 69101, USA; [2]USDA-ARS, College Station, TX 77845, USA; [3]University of Nebraska-Lincoln, Lincoln, NE 68583, USA.

Introduction

Pulse-width modulation (PWM) sprayers allow for variable rate control of flow by pulsing an electronically-actuated solenoid valve placed directly upstream of the nozzle[1]. Flow is changed by controlling the relative proportion of time each solenoid valve is open versus closed (duty cycle). PWM sprayers allow for the precise control of individual nozzles, without manipulating pressure, increasing the accuracy and uniformity of applied spray droplets providing opportunities for site-specific management strategies[2].

Objective

To evaluate PWM duty cycle and nozzle type effects on nozzle tip pressure, droplet size, and droplet velocity to create best use practices for PWM sprayers

Materials & Methods

Droplet Size and Nozzle Tip Pressure:

- Droplet size measured using a Sympatec HELOS-VARIO/KR laser diffraction system in the low-speed wind tunnel (LSWT) at the PAT Lab in North Platte, NE (Fig. 1)

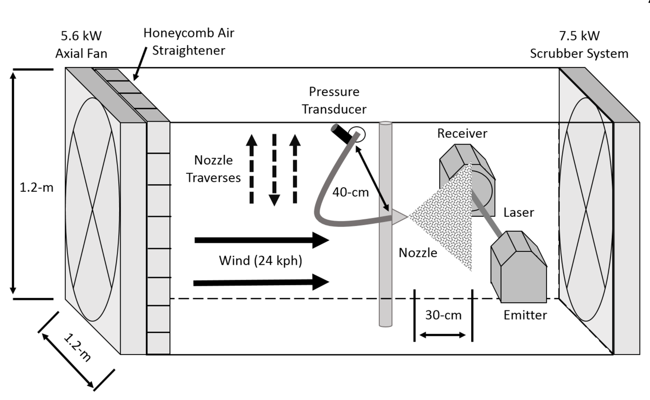

Fig. 1. Illustration of the LSWT and laser diffraction system used for droplet spectrum analysis at the PAT Laboratory.

- Nozzle tip pressure measured using a pressure transducer installed inline between the PWM solenoid valve and nozzle.
- Electrical signals from the transducer were sampled at a 100 Hz rate for five seconds with an Arduino Mega 2560 board.

Droplet Velocity:

- Droplet velocity measured using the LaVision SprayMaster high-speed image analysis function[3] (Fig. 2) in the LSWT at the USDA-ARS Research Center in College Station, TX.
- Total treatment list for both studies included: 12 nozzles (venturi and non-venturi), 7 duty cycles/nozzle body configurations, and 3 gauge pressures.
- SharpShooter® PWM system used for both studies

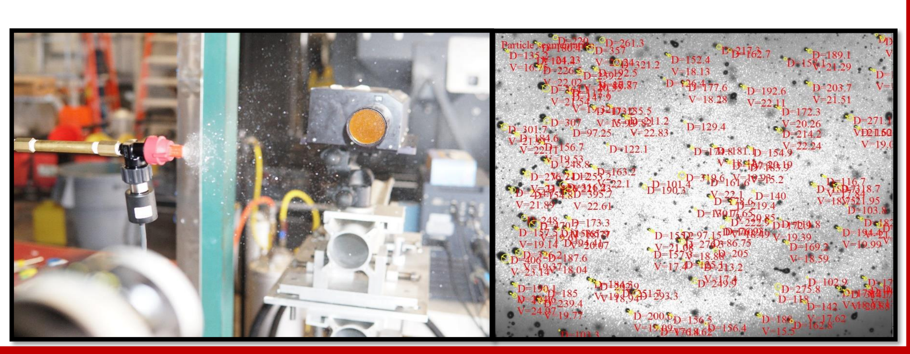

Fig. 2. LaVision SprayMaster system measuring droplet size and velocity (left) and the resulting analyzed image (right).

Results & Discussion

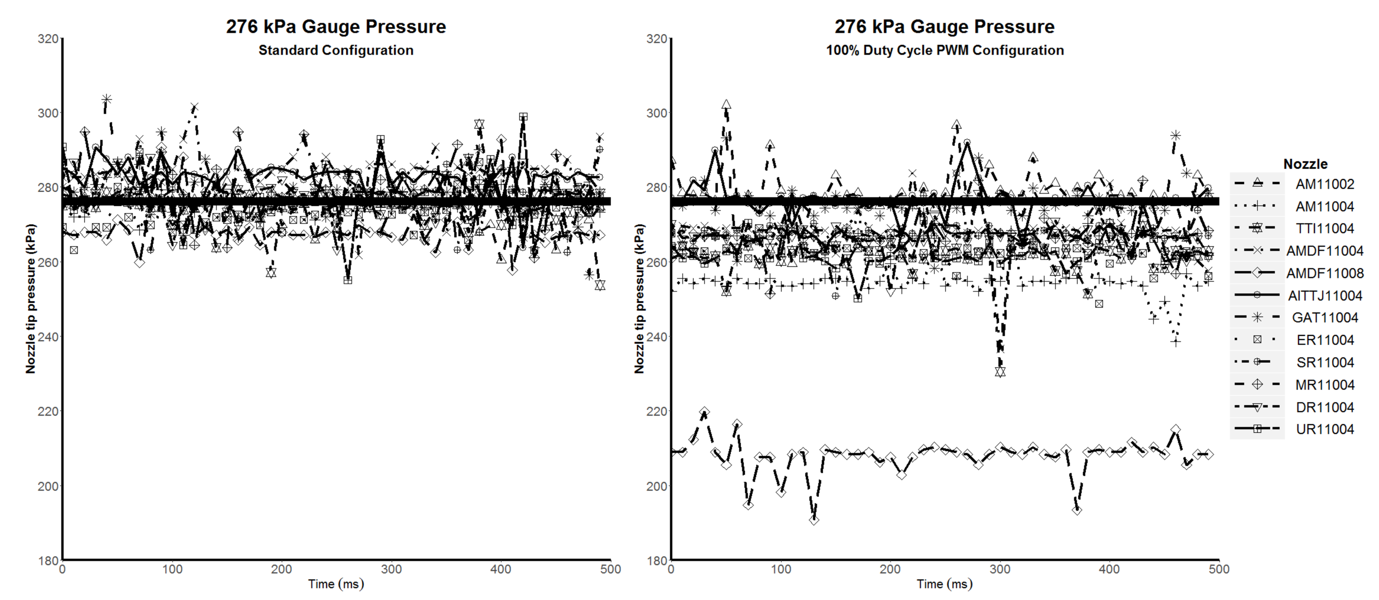

Fig. 3. Nozzle tip pressure of 12 nozzles when spraying water at 276 kPa in a standard nozzle body configuration (no solenoid valve) (left) and at a 100% duty cycle in a pulsing nozzle body configuration (with solenoid valve) (right).

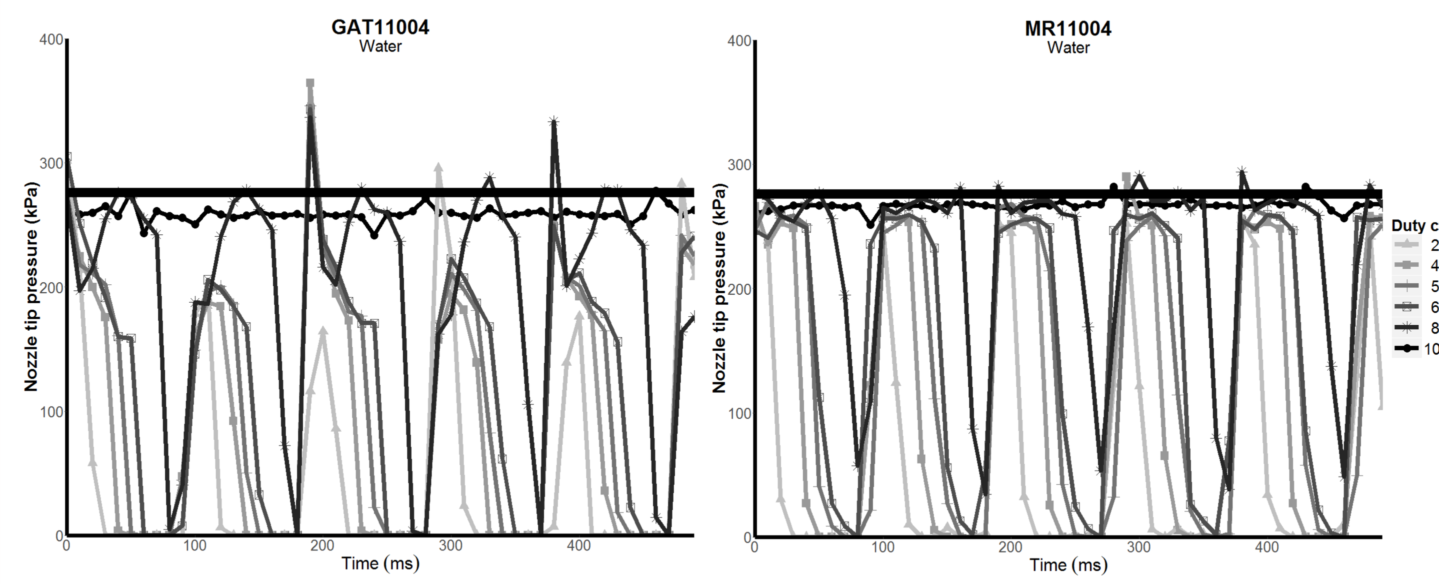

Fig. 4. Fluctuations in nozzle tip pressure (kPa) over 0.5 s for a gauge pressure of 276 kPa with water as influenced by duty cycle for the GAT11004 (left) and MR11004 (right) nozzles. The solid black bar indicates the 276 kPa gauge pressure.

- A restriction within the solenoid valve caused a pressure loss at the nozzle tip. Greater orifice sizes caused greater losses in pressure (Fig. 3).
- Nozzle tip pressure was highly variable when venturi nozzles (GAT11004) were pulsed compared to non-venturi nozzles (MR11004) (Fig. 4).
- The 20% duty cycle caused significant trend deviations and variability in droplet velocity (Fig. 5) and size (Fig. 6) regardless of nozzle type.

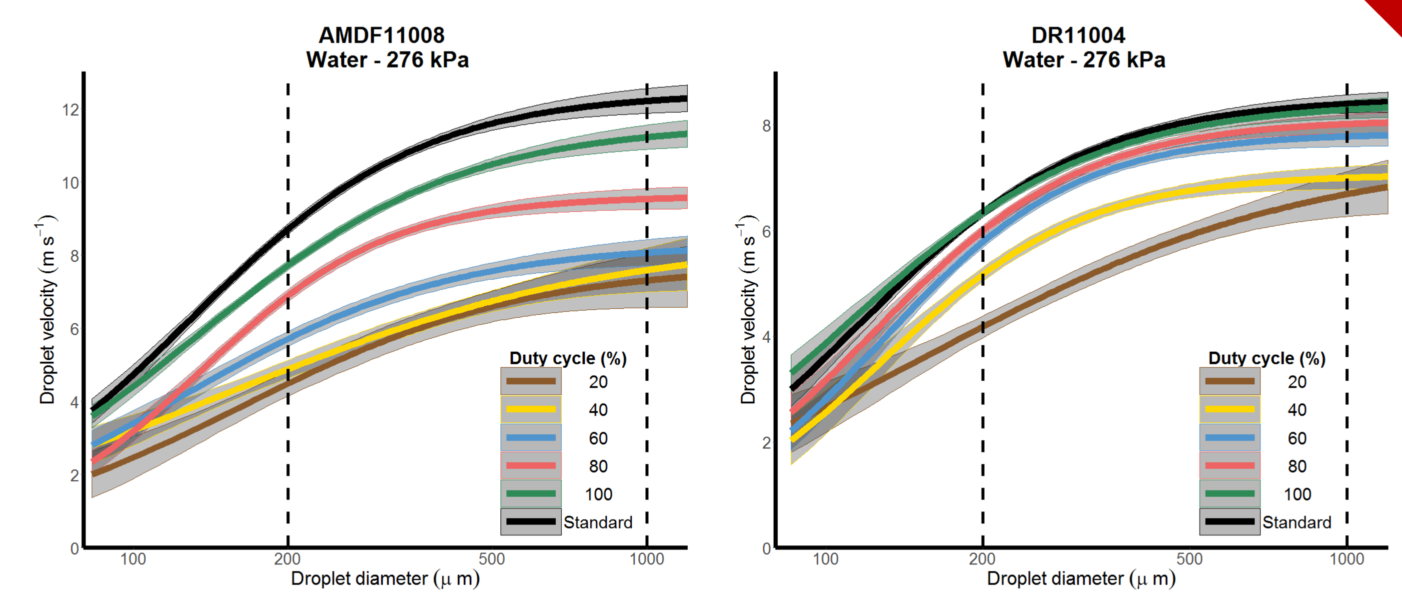

Fig. 5. Droplet velocity predictions of water at 276 kPa as influenced by duty cycle for the AMDF11008 (left) and DR11004 (right) nozzles. Standard duty cycle refers to a sprayer with no solenoid valve equipped.

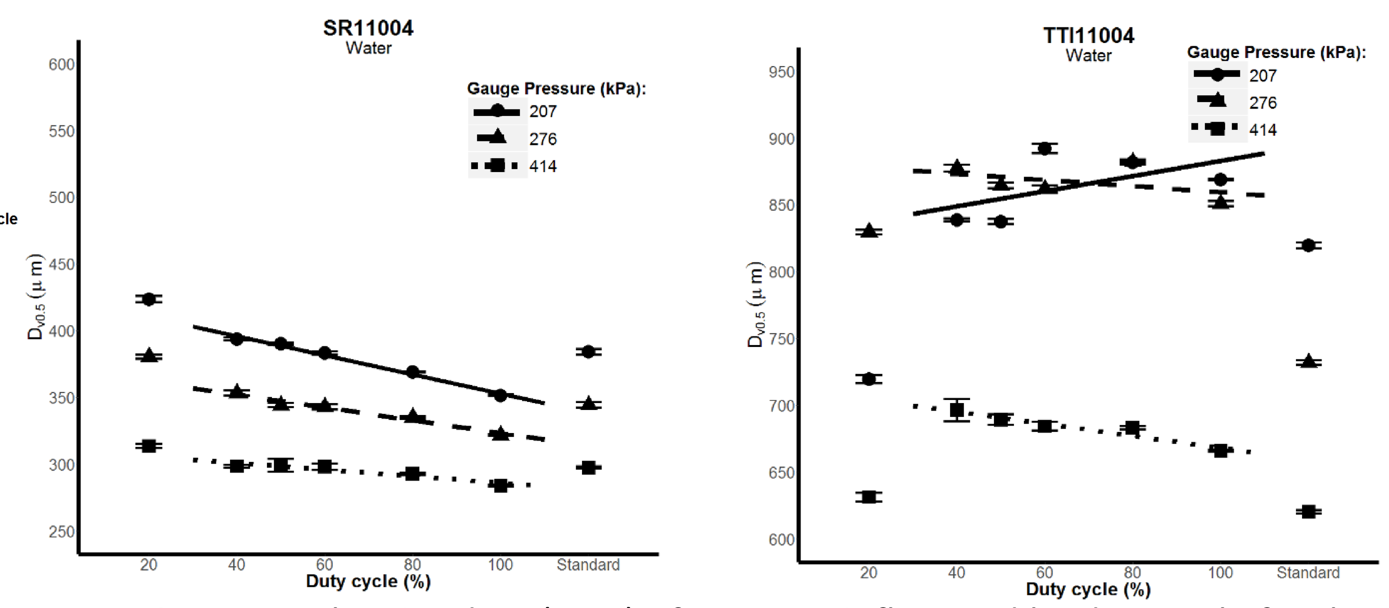

Fig. 6. Droplet size data ($D_{v0.5}$) of water as influenced by duty cycle for the SR11004 (left) and TTI11004 (right) nozzles. Linear regressions illustrated were created based on duty cycles between 40 and 100%.

- Droplet velocity decreased as duty cycle decreased (Fig. 5). The addition of a solenoid valve operated at a 100% duty cycle caused a decrease in droplet velocity with venturi nozzles (AMDF11008) but not with non-venturi nozzles (DR11004).
- Droplet size slightly increased as duty cycle decreased for non-venturi nozzles (SR11004) but the trend was disrupted for venturi nozzles (TTI11004) (Fig. 6).

Conclusions

If PWM sprayers were used for site-specific pest management, these best use practices should be followed:

1. Duty cycles should remain at or above 40%.
2. Only non-venturi nozzles should be equipped and used.
3. Applicators should be aware of pressure loss across the solenoid valve, and the resulting change in droplet size.

These practices would allow for an optimum droplet size to be maintained across a field, thereby optimizing pesticide efficacy and mitigating particle drift.

Literature Cited

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CapstanAG · Greenleaf Technologies · Pentair Hypro

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