Application Accuracy of Two Different Sprayer Flow Control Systems During Site-Specific Pesticide Applications

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Abstract

Precise and efficient pesticide applications are crucial aspects of modern agriculture to effectively manage pests throughout the season while also reducing the negative impacts of pesticides on the environment. Recent advancements in spray technology such as pulse width modulation (PWM) and individual nozzle control have enabled capabilities for site-specific pesticide applications on modern application equipment. With increasing industry and grower interest in site-specific pesticide applications, it is important to assess and understand the performance of modern spray technologies to better understand their capabilities and limitations. The main objective of this study is to record as-applied data and evaluate application accuracy for two different spray technologies (flow-based rate controller and PWM) when implementing site-specific single-rate (SR) and variable-rate (VR) pesticide applications. During testing, the prescription (Rx) maps for both SR and VR application scenarios were generated and implemented using a TeeJet Technologies rate control (RC) and PWM system. The SS Rx map consisted of single application rate of 140.3 L ha^{-1} with spray zones varying in length from 5 to 30. The VR Rx map consisted of three different application rates of 93.5, 116.9 and 140.3 L ha^{-1} with each spray zone of a fixed length of 30 m. Both Rx maps were implemented through a John Deere display/controller at a ground speed of 9.6 km hr^{-1}. The data analysis comprised of analyzing as-applied data to determine the amount of on-target, under- and over-application (±5%, ±10%, >±10% errors) associated with each system. The results showed that the PWM system performed better in attaining and maintaining the target rates than the RC system for both SR and VR site-specific pesticide applications. However, both PWM and RC systems also exhibited application rate errors that were >±10% when implementing site-specific pesticide applications. For the SR application, the PWM system showed 88% application accuracy compared to 76% accuracy for the RC system. For the VR application, the RC system demonstrated a poor performance with application accuracy in the range of 19% to 65% compared to the >90% accuracy displayed by the PWM system. This research highlights the superior performance of PWM-equipped sprayers in maintaining target application rates during site-specific pesticide applications while also highlighting that application errors >10% can still occur when using the latest spray technologies.

Keywords. *rate controller, pulse-width modulation, site-specific application, variable rate application, prescription map.*

Pesticide applications are a critical component of modern agriculture, playing a vital role in controlling insects, pests and weed throughout the growing season. With the increasing demand for sustainable farming practices, recent advancements in spray technology have enabled capabilities for improved input use efficiency via site-specific pesticide applications. Technologies such as pulse width modulation (PWM) and individual nozzle control have enabled modern application equipment, allowing for precise and targeted applications based on prescription maps and prevalent pest pressure(Butts et al., 2018). As the interest in site-specific applications continues to grow in agriculture, it is important to assess and understand the performance of these modern spray technologies to better comprehend their capabilities and limitations. Evaluating the application accuracy and efficiency of these systems under various operational conditions can provide valuable insights regarding their use as well as inform best practices for effective utilization of these technologies for precision pest management.

Therefore, a study was conducted with the aim of recording as-applied data during single-rate (SR) and variable-rate (VR) site-specific pesticide applications and evaluating the application accuracy of two different spray technologies: a flow-based rate controller (RC) and a PWM system. For field testing, prescription (Rx) maps for both SR and VR applications were generated and implemented using a TeeJet Technologies IC45 rate control system and a DynaJet IC7140 PWM system equipped on a tractor-mounted agricultural sprayer (LMC, Albany, GA). The SR Rx map consisted of a single application rate of 140.3 L ha^{-1}, with spray zones varying in length from 5 to 30 m, representing a scenario where a single rate is desired across different zones along with no-rate zones within a field. The VR Rx map consisted of three different application rates: 93.5, 116.9, and 140.3 L ha^{-1}; with each spray zone being a fixed length of 30 m, representing an application scenario where varying rates are required based on pest pressure or field/crop conditions. Both Rx maps were implemented through a John Deere 4600 display/controller and operating the sprayer at a ground speed of 9.6 km h^{-1}, representing typical operational conditions in the field. After field applications, data was exported and analyzed using SMS Advanced (AgLeader Technology, Ames, IA) and ArcMap (ESRI, Redlands, CA). The data analysis comprised analyzing the as-applied data to determine the amount of on-target, under- and over-application (±5%, ±10%, >±10% errors for each under and over) associated with each system. This comprehensive analysis allowed for a quantitative assessment of the application accuracy and the identification of potential sources of error or variability when implementing site-specific applications.

The results demonstrated that the PWM system performed better in attaining and maintaining the target rates than the RC system for both SR and VR site-specific pesticide applications. However, both PWM and RC systems also exhibited application rate errors > ±10%, indicating the potential for inaccurate applications in the field when implementing site-specific pesticide applications. For the SR application, the PWM system showed 88% application accuracy, meaning that 88% of the application area received the intended application rate that was within the ±5% error. In contrast, the RC system achieved only 76% application accuracy for the same scenario. This improved performance of the PWM system can be attributed to its ability to precisely control and adjust the flow rate of individual nozzles, enabling more accurate and responsive rate changes as the sprayer moves through varying field zones. In the VR application scenario, the RC system demonstrated poor performance with application accuracy ranging from 19% to 65%, depending on the specific rate transition. In comparison, the PWM system consistently displayed an accuracy >90%, further highlighting its ability to swiftly adapt and maintain precise application rates across varying zones as well as transition between different rates with minimal application errors. The as-applied maps generated from both RC and PWM systems are presented in Figure 1 where application capabilities between both systems can be visually discerned for both single-rate and variable-rate applications. While the PWM system outperformed the RC system in terms of maintaining target application rates, it is important to note that both systems still exhibited few application rate errors >±10% in certain areas or during rate transitions within the field. This finding emphasizes the need for further research and considerations for further improvements in spray technology to achieve greater precision and accuracy for site-specific pesticide applications because even small deviations from the intended application could potentially lead to inadequate

efficacy and in some cases reduced crop yield.

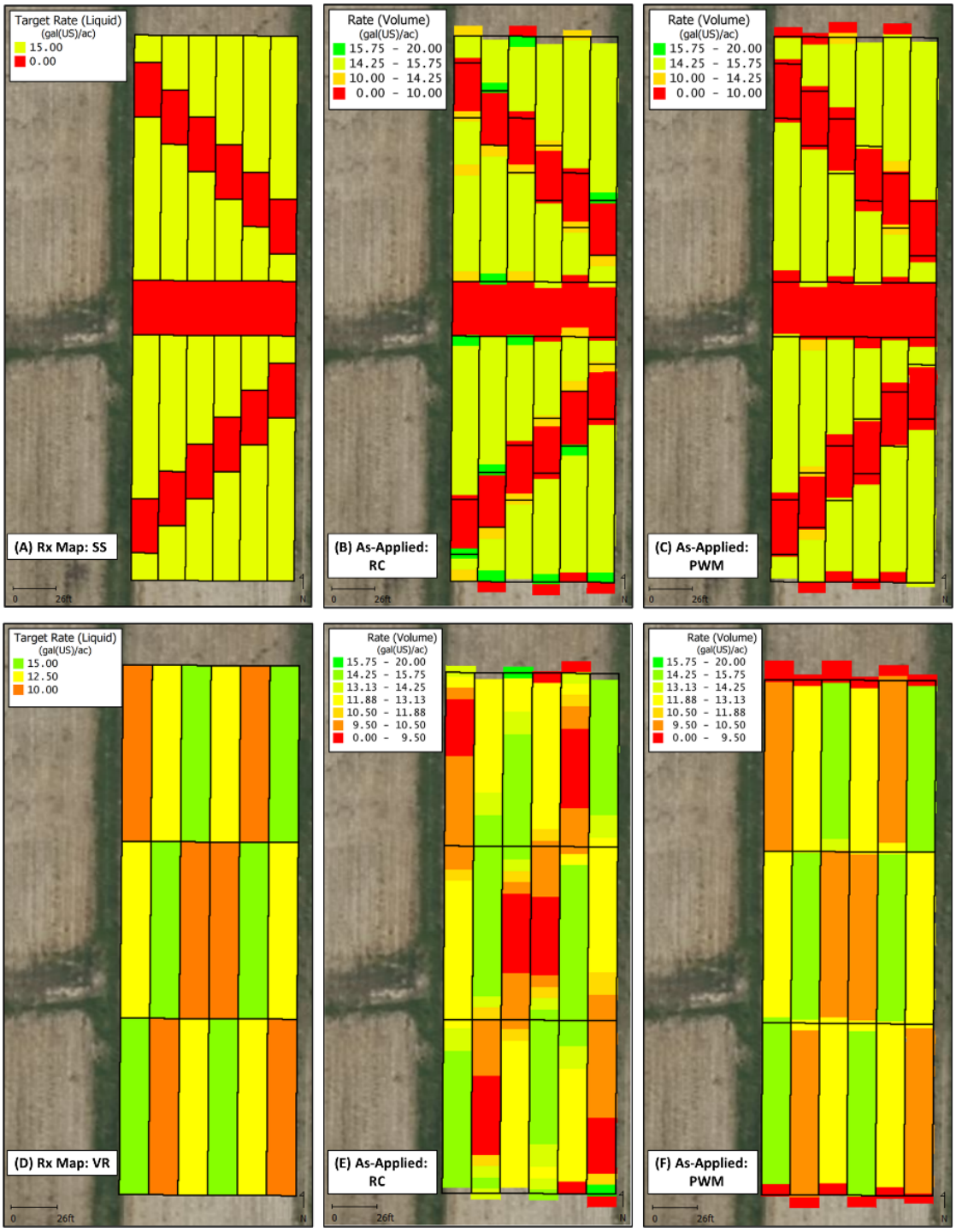

Figure 1. (A) Prescription map for single-rate (SR, 140 L ha^{-1}), site-specific application with solid yellow boxes representing varying length spray zones (5, 10, 15, 20, 25 and 30 m) in the north-south direction, and red boxes indicating non-spray (zero rate) areas. (B) As-applied map from the rate controller system for the SR application. (C) As-applied map from the pulse width modulation (PWM) system for the SR application. (D) Prescription map for variable-rate (VR), site-specific application with green, yellow and, orange boxes representing 93.5, 116.9, and 140.3 L ha^{-1} rates respectively. (E) As-applied map from the rate controller for the VR application. (F) As-applied map from the PWM system for the VR application.

References

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