
# Effect of Carrier Volume and Application Height on Spray Deposition and Efficacy of Fungicides Applied with a Spray Drone in Corn

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***Abstract***

*Foliar application of fungicides is a key management strategy for corn growers in the United States to protect crop yield from diseases like southern corn rust (SCR), tar spot (TS), and northern corn leaf blight (NLB). Recently, the use of spray drones for fungicide applications has gained an interest in agriculture due to their potential as another viable application tool to ensure the timely application of fungicides. Currently, the information on optimal application parameters to maximize fungicide deposition and efficacy with spray drones is limited. Therefore, a study was conducted in 2023 to evaluate spray deposition and efficacy of fungicide applications in corn with a spray drone (DJI Agras T30) at different volumes and heights. The first experiment was a factorial arrangement of two different carrier volumes (18.7 and 46.8 L ha$^{-1}$) and four application heights (1.5, 2.3, 3.0, and 3.8 m). Spray deposition was measured across the whole swath utilizing water-sensitive paper positioned at three different locations within the corn canopy: top (2 leaves above the ear leaf), middle (ear leaf), and bottom (2 leaves below the ear leaf). For efficacy, fungicide products were applied using both carrier volumes (18.7 and 46.8 L ha$^{-1}$) from an application height of 3.0 m at the VT stage in plots (7.3 m x 24.3 m). Disease ratings were performed at 21 days after application to assess the incidence and severity of SCR, TS, and NLB within each plot. Yield was recorded by harvesting center four rows (3.7 m) within each plot. Results showed that the higher carrier volume of 46.8 L ha$^{-1}$ had significantly higher spray deposition across all positions within the canopy compared to the 18.7 L ha$^{-1}$ volume. In contrast, application height did not have a significant effect on coverage at any position within the canopy, and no significant interaction between application and volume was observed. The deposition results indicated that the majority of the coverage was concentrated towards the center of the spray swath regardless of the application height or volume, and it was greatest at the top of the canopy, with decreasing deposition at the lower positions. Both NLB and SCR severity were significantly lower for both fungicide carrier volumes when compared to the control (untreated); however, there was no significant difference between the two rates. Both TS severity and yield were not significantly different between the study treatments and the untreated control. The results from this study provide valuable information regarding the*

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*application performance and efficacy of fungicide applications in corn with spray drones and help in informing best management practices for the effective use of spray drones for pesticide applications.*

***Keywords.***
*Spray drones, Unmanned Aerial Pesticide Applications, Unmanned Aerial Application Systems, Spray Deposition, Coverage, Efficacy*

Pesticide applications with spray drones have seen increasing popularity due to their potential benefits including late-season applications in tall crops. Fungicide applications in corn have become one of the primary uses of spray drones in the midwest and southeastern United States as the timely application of fungicides is critical to protect corn yield from diseases such as southern corn rust (SCR), northern corn leaf blight (NCLB), and tar spot (TS). Despite their growing popularity, limited information is available on the effect of application parameters (volume, height, etc.) on spray deposition and pesticide efficacy using this technology. A majority of drone pesticide applications occur using carrier volumes between 18.7 and 46.8 L $ha^{-1}$ and often heights ranging from 1.5 to 3.0 m to maximize covered area while minimizing the need to charge the spray drones' batteries or refill the liquid tank. Research investigating the effect of application height on spray deposition found that increased heights result in a decrease in overall coverage, but an increase in deposition uniformity across the swath (Sinha et al., 2022). Furthermore, when evaluating a range of carrier volumes from spray drones, it was found that spray behavior can vary between different carrier volumes when using the same nozzle type (Hunter et al., 2020). A further potential benefit of spray drone applications is the downforce generated by the platform in flight which can interact heavily with spray flux by forcing it downwards into the canopy as it leaves the spray drones. This interaction results in a high concentration of spray deposition directly below the flight path of the spray drones, however, it has also been found to increase off-target movement and decrease deposition at lower application heights (Teske et al., 2018). Further, the downforce causes an increased disturbance of the crop canopy during application and has been found to result in more uniform vertical coverage within the canopy with a UAV sprayer than a ground-based implement application in corn (Gibbs et al., 2021). Research assessing the effect of different application parameters is critical in understanding their effect on spray deposition and establishing best management practices for the effective utilization of this technology. Therefore, the objective of this study was to measure and evaluate the impact of carrier volume and flight height on spray efficacy and deposition both across the swath and within the canopy.

This study was conducted on a University of Georgia research farm in Tifton, GA (31.52°, -83.55°) in 2023 planted with a disease-susceptible cultivar of corn. All study treatments were conducted utilizing a DJI Agras T30 spray drone (SZ DJI Technology Co., Shenzhen, China). Two carrier volumes of 18.7 L $ha^{-1}$ and 46.8 L $ha^{-1}$ and four application heights of 1.5, 2.3, 3.0, and 3.8 m were selected for testing. Spray deposition was assessed utilizing water-sensitive paper (WSP) placed across the swath at three positions within the canopy: top (2 leaves above the ear left), middle (ear leaf), and bottom (2 leaves below the ear leaf). The WSP were attached directly to the leaf to allow for natural movement during the spray drone pass. For the deposition testing, each treatment of rate x height was replicated three times with water as the spray solution. Each replication consisted of three passes by the T30. The WSP was analyzed using a DropScope instrument (SprayX, São Paulo, Brazil), which provides the area covered by spray droplets as coverage (%). Mean coverage was then computed from the replicated data and plotted to analyze trends across the swath. To assess application efficacy, fungicide products were applied during the VT stage using the two carrier volume treatments with a fixed height of 1.5 m in plots measuring 7.3 m (8 rows) by 24.3 m. Each fungicide treatment was replicated three times, and an untreated control block was left to assist with efficacy comparisons. Disease ratings were collected three weeks after application to assess SCR, TS, and NLB severity. Yield was collected by harvesting the center four rows (3.7 m) in each plot. All collected data was subjected to an analysis of variance (ANOVA) and means were separated using the Student's t-test ($\alpha=0.05$) in JMP Pro 16.0.

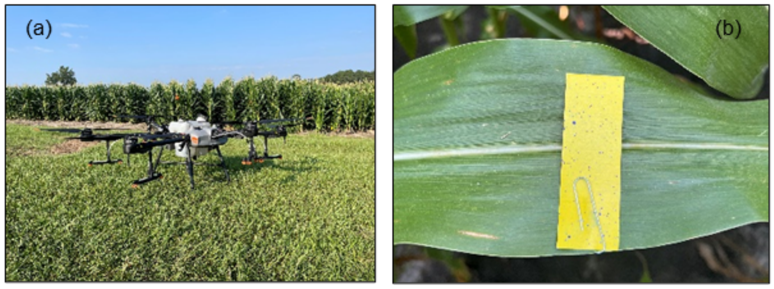


**Figure 1: (a) The DJI Agras T40 Spray Drone and (b) a water-sensitive paper attached to a corn leaf.**

Spray coverage across the treatments ranged from zero to 15%, with a majority of the deposition primarily landing directly below the flight path of the spray drones for all treatments. For the application height of 2.3, 3.0, and 3.8 m, spray coverage decreases by half or more within 1 m in both directions away from the flight path. This effect highlights the impact of the drone's downforce limiting the spread of the spray material across the swath resulting in these deposition peaks. Interestingly, as application height increased, the spray deposition increased and resulted in a wider central peak. This increase in coverage is likely the result of the drone automatically increasing the flow rate to maintain the same carrier volume for each height and the respective spray swath. However, this data shows that the increased spray flux from the drone remains primarily concentrated below the flight path suggesting that an increase in carrier volume does not inherently result in better coverage as is traditionally expected from ground-based application methods. Additionally, the wider deposition peaks observed as height increases is likely caused by the increased time for the spray flux to disperse before landing in the swath. These measured deposition curves suggest that the spray drones can effectively apply pesticides albeit at significantly smaller effective swaths than reported by the manufacturer. The increased spray volume of 46.8 L ha$^{-1}$ resulted in significantly higher deposition at the top ($p$=0.0327), middle ($p$=0.0243), and bottom ($p$=0.0016) canopy positions than the 18.7 L ha$^{-1}$ rate. In contrast, changing application height showed varying results for spray deposition at different heights within the canopy. At the 1.5 m height, where the downforce effect would be the strongest, spray coverage is similar across the canopy heights. In contrast, at the 2.3, and 3.0 m heights, the top and bottom positions showed the highest deposition while for the 3.8 m height the middle height had the greatest deposition followed by the top canopy height. These results suggest that the downwash from the spray drone has a complex interaction with the crop canopy and could potentially result in highly variable deposition trends between applications and crop types. Both the 18.7 and 46.8 L ha$^{-1}$ carrier volumes had a significant reduction on NLB (1.97% and 0.03% for the 18.7 and 46.8 L ha$^{-1}$ rates, respectively) and SCR severity (0.035% and 0.007% for the 18.7 and 46.8 L ha$^{-1}$ rates, respectively) when compared to the untreated control (6.7% and 0.435% for NLB and SCR, respectively). There were no significant differences between the two volumes and the untreated control for TS severity or yield.

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