Preliminary investigation of Phase Doppler derived flux measurements in a wind tunnel for the sampling of orchard spray drift

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Introduction

Air-assisted spray equipment used for horticultural cropping systems depend on high air velocities to project the spray as well as to open the canopy for greater droplet penetration and deposition. However, these sprayer-types are also at a heightened risk for spray drift as they possess the potential to place drift prone droplets in the atmosphere where they can be carried to off-target locations. Unfortunately, quantifying these droplets can be difficult and expensive using samplers such as high-volume air samplers, rotating rods and strings. However, while these measuring techniques may give some idea of flux, no particle information can be gained which is imperative to predicting the mass which may be the most prone to drift. In wind-tunnels and field studies, polyester and nylon strings have proven to be an efficient collecting surface. Therefore, it was the objective of this study to assess the potential for the use of a novel, field grade Phase Doppler Interferometer (PDI) as a replacement for strings as a sampler for driftable mass for orchard type sprayers.

Materials and Methods

This study was conducted at the University of Queensland, Wind Tunnel Facility (Gatton, Australia) 19 and 20 March 2014. Tunnel wind conditions were set to deliver 1.34, 2.24, or 4.47 m s^{-1} (3, 5, or 10 mph, respectively) laminar air flow. Examined nozzles consisted of the XR110-02 and XR110-04 flat fans which were pressurized at 3 bar (43.5 psi). The spray solution for string sampling procedure included a 0.4 gm/L pyranine solution and spray timer set at 10s; water only was used for PDI measurements and sampling time was extended to 40s to allow for more samples and statistical validity. String flux measurements were assessed using the 1,600mm x 2mm nylon strings whereas strings were stretched taunt and parallel to the tunnel floor, 2m away from the spray nozzle at 0.1, 0.2, 0.3, 0.4, and 0.5 m high. Once individual treatments were complete, the strings were given ≥5 minutes in the running wind tunnel to dry before harvesting. Samples were then directly analysed or placed in the freezer for later analysis. Analysis consisted of adding 60 mL directly to the bag in which the coiled string was stored. The bag was then pinched closed and solution distributed to extract florescent material from the string. Once this was sufficiently accomplished, a subsample was added to a test tube/cuvette and fluorescence read. These readings were compared to a base curve from a subsample taken from the spray tank before the commencement of the experiment. Once these data points were made and calculated into the percent applied, the deposition was then calculated using the diameter and length of the string, and the time exposed. PDI flux measurements were acquired at three static points measured from the tunnel wall (centre/800 mm, 528 mm and 264 mm) and at the aforementioned heights. The three flux points were then averaged and doubled to encompass the whole width of the tunnel. These data were then divided by their specific sampling time to determine a deposition reading. Finally, an analysis of variance was conducted to determine similarities between the two sampling techniques as the conducted($P \geq 0.05$).

Results

P-values (Table 1) indicate no statistical differences between the strings' deposition data and the converted flux data of the PDI for the two nozzles, three wind speeds and five heights. One disadvantage to the use of the PDI in the wind-tunnel is that the number of droplet/sample counts that is typically required is impractical; the sheer volume of solution that is needed to receive an "adequate" reading inundates the tunnel, ergo flooding the facility. Past researches have suggested sampling between 2,000 and 10,000 counts might be sufficient. Counts from the present study varied largely (0 to 4,000), however no differences were observed and it was quickly determined that it was essential that time be the constant factor in this instance. It is also important to note that while there may be a discrepancy in the number of samples that this is preliminary work for orchard spray research where air velocity and sprayer volume will immediately increase the number of counts. For field sampling it is predicted that PDI technology will not face the same issues as strings and will perform better as the PDI will not become saturated or have particle effects such as droplet shatter and bounce from the string surface. Lastly, other pertinent information is accrued via the PDI technique such as droplet size distribution (Fig 1) and velocity, for example.

Table 1. Statistical summary of PDI versus string flux data for two nozzles.

Wind Speed	Height	P-value	
m/s	cm	XR110-02	XR110-04
1.34	10	0.735	0.678
1.34	20	0.487	0.566
1.34	30	0.484	0.675
1.34	40	0.802	0.260
1.34	50	na	na
2.24	10	0.361	0.788
2.24	20	0.175	0.134
2.24	30	0.823	0.308
2.24	40	0.646	0.237
2.24	50	0.076	0.694
4.47	10	0.364	0.878
4.47	20	0.580	0.538
4.47	30	0.565	0.900
4.47	40	0.976	0.723
4.47	50	0.779	0.725

Figure 1. Example of droplet spray distribution of driftable mass using phase Doppler technology.