A possible formula for future success: Determining spray volume for pecan nut trees.

Gideon van Zyl, Bekker Wessels and Philip Rebel (Procrop Pty Ltd)

Spray application of plant protection products (PPPs) form the backbone of preharvest pest and disease control. The success of the process directly influences the success of the PPPs used on the targeted pest or disease and together with the timing of the application, will determine if you are going to achieve optimal disease control or not. Disease control is easy under low disease or pest pressure but when the pressure is on, and crops are lost due to failure of control, PPP performance are first to get blamed. What should get the blame? Well in my experience it is 90% of the time due to poor spray application.

Optimal spray application is no easy feat. It is a complex procedure with many influencing factors, all intertwined in the success of the outcome. It starts of with the correct product or products (that are compatible), added to the spray tank that is capable of propper agitation, in the correct sequence. The spray mixture must reach the target, be it leaves, nuts or tree structure, by being carried by droplets in an air stream without being lost to drift or run-off. The spray mixture reaching the target must be the correct quantity to protect or cure from pest or disease. The quantity must be distributed over the target as uniform as possible to the best quality to ensure contact with the pest or pathogen. Furthermore, this needs to be the case for all targets throughout the tree canopy – thus the uniformity between targets, leaf to leaf, nut to nut, must be as uniform as possible. This must be achieved in the most efficient manner. This is in turn achievable with the correct spray machine with the correct choice of forward speed, nozzle selection and layout, pressure and hence droplet size, delivering the correct spray volume adapted to the intended target. We refer to this process as canopy adapted spraying – where we adapt the application methodology (calibration) to the canopy being sprayed. Pecan nut trees vary in shape, size, volume, and density over time. Therefore, spray application methodology needs to be adapted to suit the needs of the pecan orchard being sprayed to ensure to correct number of droplets are formed for the size and complexity of the intended target and carried there successfully.

One of the first questions that comes to mind is what is the correct spray volume for my specific pecan orchard and how do I determine it? We set out to determine a formula to answer just that question.

This was done using an age-old method that has been successfully used in stone and pome fruit production for the past 25 years. It is the concept of tree row volume: determining and adapting

spray volume to the volume of an orchard. The concept was developed by Byers in 1971 and later streamlined Sutton and Unrath in 1984 and in the 90s built out for use by Marius Ras. For pecan nut trees we now did the same (no more thumb sucking!)

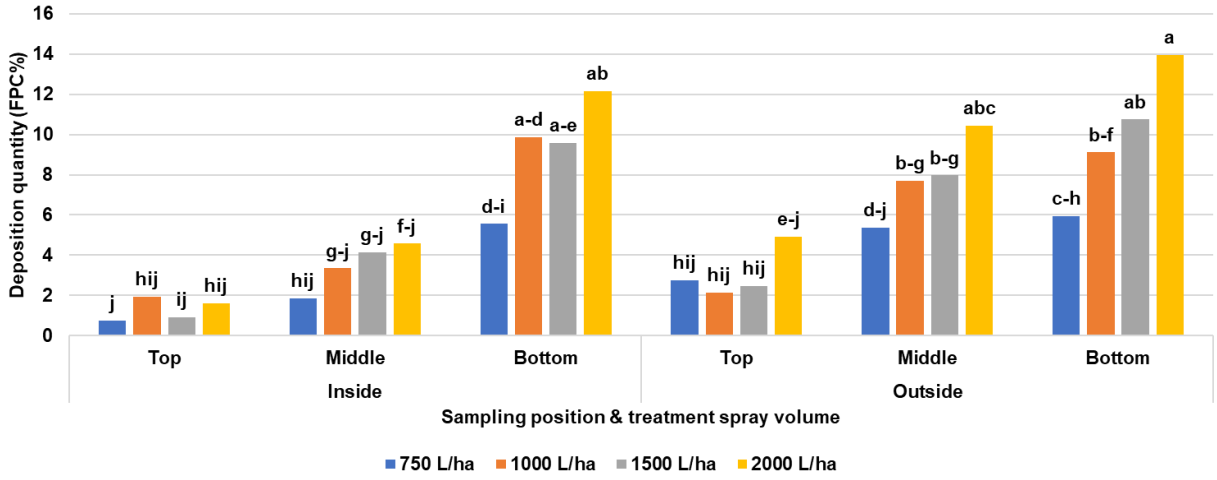
We first set out to determine how a range of spray volumes, low to high, influences deposition parameters. What is that again? Deposition parameters is the measurable product “deposited” on the target surface by the spray application process. There are three measurable deposition parameters we use to evaluate the process of application:

Deposition quantity – The amount (quantity) of active ingredient(s) (*a.i*) available on the target surface/site to protect, and in the latter cure, the target organism from disease.
Deposition quality – The uniformity/distribution of said *a.i* deposition/retention on the target site/surface.
Deposition uniformity – The uniformity of *a.i* deposition between target sites on a target organism (multiple leaves, fruit and twigs – target dependent).

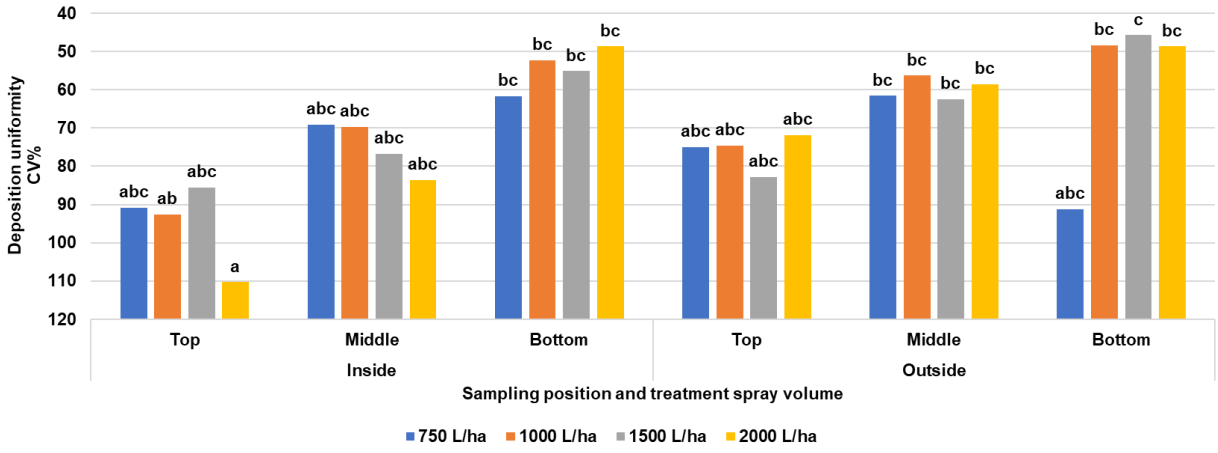
The trial:
The trial was sprayed in a pecan nut orchard outside of Hartswater, South Africa in February 2020. Trees were 10 m high and 7 m wide and had a row spacing of 10 m. Following a randomised block design, trial trees were sprayed at 750, 1000, 1500 and 2000 L/ha using a fine droplet spectrum (106 µm VMD) at 3.8 km/h with a low profile sprayer. Spray volume was manipulated with nozzle selection ensuring influencing factors was kept to a minimum. A special yellow fluorescent pigment was added to the applications do determine the deposition parameters later through macrophotography and digital image analysis in a laboratory. There have been deposition benchmarks developed on citrus for the control Alternaria brown spot (van Zyl et al., 2013) and on apples for the control of scab (Rebel et al., 2020). These benchmarks are indicative to biological control levels achievable at certain deposition parameters with the same yellow fluorescent pigment. So theoretically we can relate these values to that achieved on pecan nut trees with the pigment and determine if we can possibly achieve control. Why not use water sensitive paper? Good question. Water sensitive paper only show us where the droplets go, and not the PPPs sprayed. It is all good to know where droplets go, but droplets do not carry the same amount of PPP or sometimes any at all. Why not determine deposition on nuts? Leaves are easy to sample, does not cost anything and represents deposition parameters on nuts well.

After the trials we sprayed, leaves were sampled (1000s of leaves!) and transported to the University of Stellenbosch Department of Plant Pathology. There, leaves were individually photographed with high tech cameras under specific UV lights which actives the fluorescent pigment. This produces high quality images which is in turn analysed to determine deposition parameter data. These datasets are then scrutinised through statistics to ensure we make the correct assumptions from the data. We are building a mathematical formula after all.

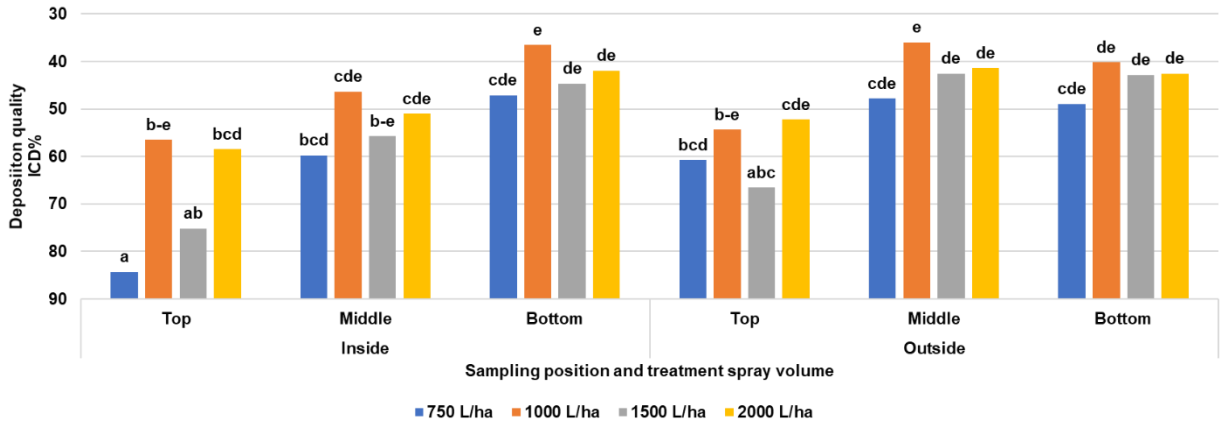
In a nutshell (no pun intended) we found the following:



Graph 1. Deposition quantity (%FPC) on pecan leaves of different spray volumes at various canopy positions. Values followed by the same letter do not differ significantly (P > 0.05) according to Tukey's honest significant test. Minimum significant difference 4.7547% FPC.



Graph 2. Deposition uniformity (CV%) on pecan leaves of different spray volumes at various canopy positions. Values followed by the same letter do not differ significantly (P > 0.05) according to Tukey's honest significant test. Minimum significant difference 46.438 CV%.



Graph 3. Deposition quality (ICD%) on pecan leaves of different spray volumes at various canopy positions. Values followed by the same letter do not differ significantly ($P > 0.05$) according to Tukey's honest significant test. Minimum significant difference 21.594 ICD%.

- Considering deposition quantity, the optimal spray volume range seems to be between 1000 and 1500 L/ha. This is indicated not by significance (due to the high variation in deposition data) but by pure observation. Any volume lower will increase variation in deposition parameters and higher would be wasteful.
- Considering deposition uniformity (considering again the high variation in deposition data) The sweet spot for water volume for the specific orchard sprayed would be between 1000 and 1500 L/ha. Lower and higher volumes would not make a significant impact on improving deposition uniformity.
- The same can be said for deposition quality.
- High variation in deposition data can be ascribed to the large canopies. There are many targets (leaves and fruit) distributed throughout the canopy. Getting similar levels of deposition quantity and quality per target (and therefore lower variation in uniformity) would be difficult to achieve due to the sheer distribution and number of targets.
- This said improved spray machine design might help to mitigate this problem, as low profile axial fan spray machines are lacking in working hight needed for the spatial volume of these tree canopies.
- Nozzle selection and layout: Liquid flow rate of spray machines needs to be distributed according to the tree canopy volume distribution. The general strategy of placing 80% of the liquid delivery rate in the top third of the spray machine nozzles (uniform nozzle selection) and 20% in the bottom third (uniform nozzle selection) proved to be effective for

the axial fan spray machines (bar using a fine droplet spectrum). This can futher be fine tuned.

- The height of the pecan nut canopies will continue to be a difficult position to spray effectively.
- It is important to note that any increase in driving speed when spraying will decrease the effective working height with low profile sprayers – speed should be adapted to canopy height.
- Using a water volume between 1000 and 1500 L/ha to determine a formula to calculate the water volume needed for a specific orchard is possible.

Deducing a formula:

The formula uses the assumption that a 1000 to 1500 L/ha is an effective spray volume for a 70 000 m^3/ha pecan orchard. This equates to each 1 m^3 tree volume per ha needs 17.86 ml spray volume to achieve sufficient deposition parameters. This can be transformed into the following formula to determine the theoretical spray volume for a specific pecan orchard:

$$spray\ volume\ \left(\frac{l}{ha}\right) = \frac{10000}{\text{Row width (m)}} \times Tree\ hight\ (m) \times Tree\ depth\ (m) \times\ 0.018\ L$$

Since the formula uses the tree row volume concept, the constant derived can only be implemented in tree rows that have already filled in the interplanted area with foliage (formed a continuous leaf wall). A spray volume of 400 – 500 L/ha is recommended for orchards where the trees have not yet filled in these gaps between the trees. Use of foliage detection tech on sprayers can help save a lot in time and input cost when spraying under these circumstances.

Will this formula magically solve application problems? No. Spray volume is only a part of the solution to achieve optimal deposition and therefore pest and disease control. The correct spray machine, nozzle (droplet) selection and layout, forward speed, spray timing and correct product choice is still is cardinal. What is most important is for growers to understand the process and the importance of it. Spray application methodology and regular calibration+ timing + PPPs = disease control.

This work forms part of a larger project on optimising spray application in pecan nut production consisting out of 4 trials sprayed over 2 years by SAPPA and ProCrop (Pty) Ltd.