S4 The Role of Pesticide Liquid Physical Properties in the Optimisation of Spray Performance for Efficient Atomisation, Retention and Targeting in Row, Tree and Vine Crop Spraying

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Abstract

The physical properties of pesticide tank mixes depend on the components which include the carrier liquid, usually water, one or more active ingredient products formulated with a specific composition and adjuvant/ inert materials which are often oil-, surfactant or polymer-based. Optimisation of the liquid physical properties for achieving maximum coverage on the intended target, spreading and uptake without losses through airborne drift, runoff or post-deposition volatilization is a complex process requiring knowledge of the spraying system with which the products will be used, the meteorological and environmental conditions of the application site and the nature of the target pest, weed or disease. The present paper describes each of the steps of this process and gives strategies for the design of chemical products to optimize spray performance and avoid off-target losses and damage to sensitive areas.

Working backwards through the problem, the target must first be defined with a view towards optimization of on-target spray deposition and coverage. For example if the target is a broad-leaf weed or the ground then coverage with large droplets at relatively high water volume rates may be preferred for avoidance of spray drift losses with minimal restrictions on application systems or conditions. However, if the target is a narrow-leaf weed or thin collector then medium or fine droplets will give optimised spray coverage with medium or low water volume rates, but the application system and conditions must be selected to avoid spray drift losses in other ways than droplet size control. Examples include the prevention of drift through the use of shields, shrouds, targeted air, directionally-optimised spraying, evaporation-reducing formulation components and in particular selection of spraying systems that produce fine or medium sprays with no droplets smaller than 100-200 μm, i.e. narrow size distribution sprays. It should be noted that most sprays have a relatively broad dynamic size range of droplets and the optimization of performance to avoid small droplets requires the use of specific chemistry types such as emulsions rather than solutions and/ or matching this chemistry with a nozzle and spraying system type such as a controlled droplet atomiser which does not use chaotic sheet breakup for spray atomization but rather uses controlled direct droplet formation or ligament breakup.

Once the target has been defined, the application conditions must be carefully considered. Air movements can help carry droplets towards the target if optimised, or can displace them away from the target if excessively high or low. Pesticide labels can define optimum conditions to achieve balance and control of this process. For example, if finer sprays are applied to achieve

optimised control of narrow targets at low to medium water volume rates, conditions must not be conducive to spray evaporation or to poor dispersion in the atmosphere. Evaporation risk can be minimized through attention to meteorological conditions at the time of spraying such as avoiding conditions of high delta T or difference between wet and dry bulb temperature measurement and avoidance of high wind speeds. Avoidance of spray concentration through a lack of dispersion can be achieved through the application of sprays only under conditions of unstable air and avoidance of stable air such as in local surface temperature inversions. Where no droplets smaller than 100-200 μm are present in the spray, these issues are greatly reduced or avoided.

The effect of water volume rate on spray evaporation dynamics and near-neighbour droplet interactions are only recently being fully understood. Higher water volume rates may help reduce evaporation and therefore reduce spray drift potential but can provide other challenges to the application process such as droplet size control and higher operating costs for carrying the additional water.

With the introduction of variable rate spraying systems, methods of controlling droplet size independently of spray pressure such as through pulsed width modulation are becoming increasingly important. Direct injection of chemical can also offer solutions to specific challenges with variable rate and with the use of drift control adjuvants when spraying near non-target sensitive areas.

Spray drift exposure to non-target sensitive areas can only occur if the wind is blowing towards the sensitive area and spray becomes displaced from the intended target by the ambient wind. Dilution helps reduce such exposure so higher winds can actually cause lower deposition exposure to terrestrial and aquatic sensitive areas but can increase airborne inhalation exposure. Optimum wind speeds for most applications are in the range 3-15 km/h.

Models facilitate the assessment of the complexly-interacting factors discussed above. Modeling the processes of atomization, transport and deposition of sprays requires appropriate data in order to run the analysis. The reliability of a given model can be assessed based on verification data to show its agreement with actual conditions. Several spray emission and fate models are discussed in this presentation and the model which is considered to be most reliable for the assessment of on- and off-target spray deposition for aerial and some ground application platforms is shown to be AGDISP.

A summary is also given of models currently under development to predict the spray dynamics of droplet size/ velocity spectra and spray composition such as air inclusions. These also allow the modeling of many other key factors affecting spray performance in field application such as spray angle and uniformity of liquid distribution across the plume cross-section. The interaction between the hardware of the spraying system and the chemistry of the pesticide tank mix components is complex and different modeling applies to Newtonian and non-Newtonian systems.