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An Experimental Study on the Multiphase Behaviour of an Agricultural Air Induction Nozzle with Various Internal Geometry

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Extended Abstract

Agricultural nozzles are the most common means to deliver pesticides, some nutrients, and other chemicals to plants. Some of these chemicals, especially pesticides, are toxic, and there is an increasing demand to reduce their use. Whereas, during pesticide spraying, some spray droplets may not reach the target. Delivering the pesticide droplets to the exact target has always been an undeniable challenge in farms. Drifting sprayed pesticide droplets off their way and also bouncing from leaves are major sources of soil and groundwater pollution and pesticide overuse. The chance of the droplets reaching the target depends in particular on their size and their velocity [1]. Slow or small droplets may contribute to drift, whereas large and fast droplets may rebound from the leaves. Small droplets lead to an optimal coverage but may contribute to drift contaminating air, water, and soils. Large droplets are less prone to drift but may stream down. Several factors, including carrier rate, turbulence, and formulation as well as droplet size, can affect spray coverage. The physical and chemical properties of the chemicals (surface tension, viscosity, and concentration), the local meteorological environment (wind speed, wind direction, temperature, and humidity), and the application techniques (nozzle's and techniques that maximize deposition of pesticides onto the target area it is possible to both maximize the effectiveness of the pesticide application process as well as reducing the amount of off-target spray deposition and hence possible pesticide damage. There has therefore been much research into the characterization of sprays generated by agricultural nozzles and spray mixtures [2]. Different size results can be achieved depending on the type of equipment and the experimental techniques used to measure droplet size [3]. Droplet size is a major factor influencing the amount of spray drift as well as the deposition of the spray on a target [4, 5]. In the late twentieth-century air induction (also called 'Venturi' or 'air inclusion') flat fan nozzles have been developed to reduce spray drift and to increase target coverage. Air is drawn into the nozzle through small aspiration holes in the side of the nozzle body and mixes with the spray liquid [6, 7]. Air induction nozzles discharge large bubble-containing droplets which splash on the surface of target and produce small droplets when impacting the target. Air-induction nozzles are able to produce significant quantities of included air (air bubbles within the drop) [8, 9]. Spray liquid density is reduced when air bubbles are formed within the droplet. Photographic evidence showing air inclusions within droplets has been published in the literature. An earlier attempt was made to correlate the droplet size with the drift potential and also rebound potential of drops with or without microbubbles [1, 10, 11]. This parametric study aims to investigate the effect of nozzle internal geometry on the spray multiphase behavior, namely the air-liquid mixing and spray structure. A series of nozzle components with various adjustable geometries were designed and manufactured. An experimental approach is conducted using laser diagnostic methods. Mie-scattering spray visualization and high-speed photography are used to capture the spray structure and the Laser diffraction method (Malvern particlesizer) is used to acquire quantitative droplet size data. The internal geometrical parameters were found to be significantly influential to control the air and liquid flowrate, breakup length, air inclusion, spray angle, droplet size, and uniformity. This study can help the optimization of agricultural nozzles and environment protection.

Keywords: Agricultural nozzle, Air induction nozzle, Air to liquid ratio (ALR), target spraying

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