COMPARISON OF POST-DIRECT AND "OVER-THE-TOP" ROUNDUP ULTRA (GLYPHOSATE) APPLICATIONS IN ROUNDUP READY COTTON USING A SPRAY APPLICATION METHOD WITH RADIOLABELED GLYPHOSATE

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Abstract

Absorption and translocation of Roundup Ultra® (glyphosate) in Roundup Ready® cotton (*Gossypium hirsutum* L.) was evaluated utilizing previously developed and validated laboratory techniques to apply radiolabeled glyphosate as a spray. These techniques closely simulate and account for numerous factors which greatly impact the amount of glyphosate that ultimately reaches specific sites in the cotton plant after field applications with commercial equipment.

A post-direct application to the stem was compared to an "over-the-top" application to the leaf surface by directing equivalent volumes of radiolabeled spray solution to a 2.5 inch segment of stem between the soil surface and the cotyledon node and to the first (oldest) leaf of a 8-9 leaf Roundup Ready® cotton. The leaf surface application intercepted and retained 5 times as much of the spray volume that exited the spray nozzle as the stem application. Consequently, the leaf surface application absorbed and mobilized 4 times as much glyphosate as the stem application. Less than 0.1% of the total glyphosate intercepted accumulated in the developing squares from either the leaf or stem.

Introduction

In addition to the relative efficiencies of stem and leaf tissue to absorb and translocate glyphosate, numerous other factors affect the amount of glyphosate that ultimately reaches specific sites in a cotton plant after a commercial field application. Environmental conditions and plant growth stage and condition at the time of application are significant factors. Numerous application factors including spray droplet number, size and distribution, spray volume and pressure, herbicide concentration, plant part and surface area intercepted during the application also impact the amount of herbicide that is absorbed and translocated.

Laboratory research evaluating absorption, translocation and distribution of herbicides in plants often utilizes syringes to hand apply droplets of radiolabled spray solutions. Although this is a proven and valid methodology for comparing relative absorption and translocation efficiencies between treatments, there are limitations to be considered when attempting to translate results achieved with these techniques to actual field situations. Droplet applications do not accurately represent the droplet volume, size, concentration or distribution of spray droplets from commercial application equipment. There may also be limitations in the ability to account for differences in spray volumes intercepted by the plant with different field applications. To address some of these limitations, a laboratory spray application method for herbicides was developed utilizing specialized equipment which has been calibrated to generate a droplet number, size and bioefficacy similar to conventional field spray nozzles.

Label recommendations for application of Roundup Ultra herbicide to Roundup Ready cotton allow broadcast foliar applications to be made over-the-top through the 4 true leaf stage of cotton growth. After the 4 true leaf stage, applications must be made with precision post-directed spray equipment which directs the spray to the base of the cotton plants to contact the stems not the cotton leaves. Of interest to researchers are potential differences in interception, uptake and mobilization of glyphosate when these different application methods are employed, and how the interaction of these factors affect the amount of glyphosate that reaches the developing reproductive structures in the cotton plant. By utilizing a spray method to apply radiolabeled Roundup Ultra formulations, we were able to ascertain "real-world" differences in these two field spray techniques. Unlike conventional droplet application procedures, where similar amounts (both concentration and volume) are applied to both stem and leaf tissue, the spray method accounts for differences in the amount of spray intercepted by the plant with the 2 application methods as well as inherent differences in the surface of leaves vs stems which may impact spray retention. The spray application method also allowed us to avoid potential artificial influences arising from differences in the physio-chemical properties of an applied droplet and a sprayed droplet. These differences can result in significantly different uptake and mobilization profiles as well as total glyphosate loading.

The objective of this research was to utilize novel laboratory methodology applicable to field situations to compare Roundup Ultra absorption and translocation in Roundup Ready cotton applied post-directed or to the leaf surface.

Discussion

Application of radiolabeled Roundup Ultra® to stem and leaf tissue was compared using the described spray application method. Equal volumes of spray solution were sprayed and directed to the 2.5 inch segment of stem below the cotyledons and to the first (oldest) leaf of 8-9 leaf Roundup Ready cotton. The spray solution was prepared with formulated

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Roundup Ultra to a concentration simulating a field application of 0.75 lb ae/A and an aliquot of that solution was "spiked" with a small volume of C^{14}-labeled glyphosate acid. This "spiked" solution is essentially identical to the spray solutions used in field applications as the high specific activity of the radiolabel and small volume added result in virtually no differences in volume or concentration of the formulation. Sprayed areas were collected after 72 hours and washed by distilled water followed by methanol. Glyphosate contained in this wash solution represents the unabsorbed glyphosate remaining on the surface of the plant and was determined by liquid scintillation counting. All plant parts were individually dissected (leaves, stem, bracts roots, squares, etc.) and the quantity of glyphosate in these portions of the plant determined by oxidative combustion. All glyphosate concentrations are expressed as *u*g of glyphosate per plant part.

The volume of spray intercepted was 5 times greater for the leaf than the stem. The intercepted quantity is determined by summing all glyphosate found in all plant parts including the wash solution. Due to such large differences in interception, both the uptake and the mobilization of glyphosate was 4 times greater for the leaf application than for the stem. The stem tissue was an efficient vehicle for both uptake and mobilization of glyphosate but the smaller surface area intercepting the spray solution negated this effect. If the total number of leaves that would be contacted on a plant with a true over-the-top application were considered, the discrepancy between the amount of glyphosate intercepted and absorbed with the post-directed and the foliar applications would be much greater. Glyphosate was mobilized to the same tissues regardless of whether the glyphosate was applied to the stem or to the first leaf (oldest). In both cases, the majority of the absorbed glyphosate accumulated in the roots, stems and the 2^{nd}, 4^{th}, and 7^{th} true leaves. Less than 0.1% of the total glyphosate intercepted by either the stem or leaf application traveled and accumulated in the developing squares.

Summary

Spray methods designed and calibrated to simulate field application techniques and equipment allow relevant comparisons of foliar applied over-the-top and stem applied post-directed applications of herbicides in the laboratory. This technique demonstrates that differences in the volume of spray intercepted by post-directed applications to the stem vs. over-the-top applications to leaf surfaces have a greater influence on the amount of glyphosate that reaches specific plant parts than the relative absorption and translocation efficiencies of the stem vs. the leaf. Foliar applications to the leaf result in greater amounts of glyphosate absorbed and translocated.