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Effect of application rate and irrigation on the movement and dissipation of indaziflam

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ABSTRACT

Indaziflam is a new preemergence herbicide for the control of annual grass and broadleaf weeds in various cropping systems including pecan orchards. The objectives of this study were to (1) determine the mobility and dissipation of indaziflam and (2) evaluate herbicide efficacy in a flood-irrigated pecan orchard in southern New Mexico, USA. Indaziflam was applied at 0, 36.5, and 73.1 g/ha in areas with (impacted) and without (unimpacted) tree injury symptoms. Soil samples were collected at 0–15, 15–30, and 30–46 cm depths 26, 63, 90, and 126 days after the first herbicide application. Additional soil samples were collected 4, 30, and 56 days after the second application. Indaziflam was detected in soil samples collected at each depth, suggesting movement with irrigation water. Indaziflam concentrations decreased with increasing soil depth and time. Indaziflam mass recoveries were greater in the unimpacted area than in the impacted area after the first and second applications. Dissipation half-lives of indaziflam in the soil ranged from 30 to 86 days for total indaziflam recovered from the entire soil profile after the first and second applications in both areas. The percent weed control was similar in the impacted and unimpacted areas for both rates of indaziflam on 26 and 63 days after application; however, on 90 days after the application, percent weed control was lower in the impacted than unimpacted area.

Introduction

Indaziflam is an alkylazine herbicide used for preemergence control of annual grass and broadleaf weeds that inhibits the cellulose biosynthesis of weed species following germination (Alonso et al., 2011). Indaziflam was registered in 2012 for weed control in various agricultural and nonagricultural systems, and limited information is available on the transport and dissipation in soil under field and laboratory conditions. Currently, the literature on the factors that influence the fate and transport of indaziflam has been generated from laboratory studies; therefore, there is a need to evaluate the dissipation of indaziflam under field conditions. In addition, there are no published accounts available on the half-life of indaziflam in the field. The first breakdown product of indaziflam is indaziflam-triazine indanone, which is degraded to indaziflam-carboxylic acid and ultimately to indaziflam-triazinediamine; however, two of the three indaziflam breakdown products (indaziflam-carboxylic acid and indaziflam-triazinediamine) are more mobile than indaziflam (Alonso et al., 2015).

Indaziflam was reported to be low to moderately mobile in six Brazilian oxisols and three U.S. mollisols (Alonso et al., 2011). Similarly, Jhala et al. (2012a) and Jhala and Singh (2012b) reported increased leaching of indaziflam with application

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rate and amount of rainfall in soil column experiments. Jones et al. (2013a, 2013b) observed a decrease of indaziflam injury to hybrid bermudagrass established in mini-rhizotrons with increasing organic matter content and fraction of fine soil particles. Similarly, Schneider et al. (2015) reported that indaziflam caused phytotoxicity of bermudagrass planted in sandy soil under laboratory conditions decreased with increasing clay and organic matter contents.

Shortly after registration in 2012, indaziflam was extensively used in pecan (*Carya illinoinensis* (Wangenh.) K. Koch) orchards across the southwestern United States. However, in a few of those orchards, sporadic herbicide injury symptoms were reported 3–4 months after the application date (May 8, 2012). Our previous study in two pecan orchards located in New Mexico and Arizona, where the injury symptoms were detected, indicated a faster dissipation of indaziflam in the New Mexico orchard compared to the Arizona orchard (González-Delgado et al., 2015). Furthermore, the faster rate of dissipation in the New Mexico orchard was attributed to higher sand (77% ± 7.2%) and lower clay fractions (9% ± 3.7%) compared to the sand (61% ± 4.8%) and clay (17% ± 3.1%) fractions in the Arizona orchard, respectively. Higher sand content in the New Mexico orchard with attendant high soil drainage capacity could have contributed to a faster dissipation of indaziflam compared with the Arizona orchard. This study expects to generate additional information needed to understand the causes of injury to pecan trees that were evaluated by González-Delgado et al. (2015).

We are not aware of studies that have examined the half-life of indaziflam and influence of flood irrigation on the movement of indaziflam under field conditions. Therefore, this field study was conducted in the impacted (injury observed on pecan trees) and unimpacted (no injury observed on pecan trees) areas of the orchard in New Mexico, with the objectives to (1) determine the mobility and dissipation of indaziflam and (2) evaluate herbicide efficacy for two application rates. Indaziflam is classified as low to moderately mobile in the soil (Alonso et al., 2011); therefore, the hypothesis for this study was that indaziflam could move mostly over the soil surface compared to the leaching process after flood irrigations.

1. Materials and methods

1.1. Study site

The study site was a pecan orchard located in southern New Mexico, USA (32.412877 N, −106.853516 W) at 1200 m above sea level (González-Delgado et al., 2015). The soil in the orchard is a mixed, thermic Typic Torripsamments with a saturated hydraulic conductivity ranging from 1.40×10^{-5} m/sec to 4.20×10^{-5} m/sec (Soil Survey of Dona Ana County Area, 1980). The orchard was planted with the pecan variety Wichita, which is one of the important commercial varieties adapted to the climate of southern New Mexico and does not require a long growing season (Byford, 2005). A total of 16 cm of precipitation and an average temperature of 26 ± 2°C were recorded between the application day of indaziflam on May 23, 2013 and last day of collecting the soil samples on November 28, 2013. The orchard was flood irrigated and after the first irrigation using canal water on May 24, 2013, 7 more irrigations were made using well water on June 12, June 29, July 15, Aug. 3, Aug. 26, Sept. 21, and Oct. 6. About 91 cm of total irrigation water was applied. Water flow was from east to west as shown in Fig. 1. Urea nitrogen and ammonium phosphate fertilizers were also applied three times (on April 1, April 24, and June 10).

The orchard was previously treated with indaziflam on May 8, 2012, by the grower, and injury to some pecan trees was observed after July 2012. Injuries to pecan trees were mostly sporadic, and several trees in several rows showed injury symptoms. One of the rows of pecan trees was selected for this study. In this row, four pecan trees suffered extensive damage, and this area was designated as the impacted area. Trees in the contiguous area in the same row but just after the impacted area did not show any injury symptoms; this area was designated as the unimpacted area (Fig. 1). The analysis of soil samples collected from this orchard on March 20, 2013, approximately 11 months after the last application of indaziflam, showed that indaziflam was not detected in 35 out of the 36 soil samples collected from the study site (González-Delgado et al., 2015). Indaziflam was detected only in one soil sample (2.6 μg/kg of indaziflam) collected at 7–15 cm depth from the unimpacted area. Thus no (detectable) indaziflam was present in 0–120 cm depth at the start of this field study on May 23, 2013.

For this study, nine contiguous plots of 6 m × 4 m were delineated in the unimpacted and impacted areas of the orchard (Fig. 1). This plot arrangement was selected to mimic the herbicide application and transport behavior of indaziflam in the flood-irrigated field with respect to the direction of irrigation water flow. The plots were arranged in the order rate 1 (36.5 g/ha), rate 2 (73.1 g/ha), and rate 0 (control), except in the first block (Block 2) in the impacted area where the control was before the treatment plots with respect to the direction of irrigation water flow (Fig. 1). This was done to evaluate if indaziflam can move backwards or laterally with standing water in the field during irrigation. A split plot experimental design was used with 3 replicates of control (no application) and two rates of indaziflam treatments in each of the impacted and unimpacted area.

Treated plots were sprayed twice during the growing season. During the first application, plots were sprayed with the two application rates of 36.5 and 73.1 g/ha of indaziflam on May 23, 2013 (143 DOY; day of the year). The field was irrigated 24 hr after the indaziflam application. The lower of the two rates applied in May was chosen as a precaution to not cause injury to pecan trees in the orchard. During the second application on October 3, 2013 (276 DOY), indaziflam was sprayed to all the previously treated plots at the rate of 36.5 g/ha. The field was irrigated 72 hr after application. The second indaziflam application was made in October to repeat the field experiment before the experimental site became unavailable. The severely injured pecan trees were removed, and new trees were transplanted in 2014 that caused soil disturbance in the experimental plots. Pecan orchards are managed similarly year after year, and similar irrigation, fertilizer application, and tillage strategies are implemented.

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