PEANUT SCIENCE

The Journal of the American Peanut Research and Education Society

ARTICLE

# Peanut Response to Soil and Foliar Applications of Imazapyr

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ARTICLE INFORMATION

*Keywords:*
carryover, drift, injury, yield loss

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DOI: 10.3146/0095-3679-51-PS24-7

ABSTRACT

Georgia leads the nation in both pine tree (*Pinus* spp.) timber volume and peanut (*Arachis hypogaea* L.) ha harvested annually. Off-target movement of pine forest herbicides into peanut fields can occur from aerial applications. Research was conducted from 2020-2022 in Ty Ty, Georgia to determine peanut response to imazapyr from preemergence (PRE) and postemergence (POST) applications. Imazapyr was applied to peanut (cv. Georgia-06G) at the following timings and rates: PRE (1 day after planting) (DAP), 30 DAP, and 60 DAP; and 420 (1X, manufacturers suggested use rate), 84 (1/5X), 42 (1/10X) and 4.2 g ai/ha (1/100X). Peanut density was not reduced by any PRE application of imazapyr. Significant stunting, chlorosis, and reductions in peanut plant height and width occurred from 420 g ai/ha, regardless of application timing. Peanut was more susceptible to imazapyr injury from PRE applications, as peanut heights were reduced by rates ≥ 42 g ai/ha and peanut widths were reduced by rates ≥ 84 g ai/ha. With POST applications, only 420 g ai/ha resulted in plant height and width reductions of 66% and 48% when applied 30 DAP. Peanut treated at 60 DAP had 30% and 57% height reductions with rates of 84 and 420 g ai/ha, respectively. The 420 g ai/ha rate resulted in yield losses of 79%, 66%, and 56% when applied PRE, 30 DAP, and 60 DAP, respectively. PRE applications of imazapyr at 42 or 84 g ai/ha resulted in 31% and 59% yield reductions, respectively. These results suggest that peanut should not be planted to fields exposed to full rates of imazapyr until rates decline to < 42 g ai/ha (~three half-lives or 426 d). Peanut exposed to POST applied imazapyr ≤ 84 g ai/ha (1/5X) during the growing season should not result in significant yield losses.

## INTRODUCTION

Georgia is the nation's top producer of pine tree (*Pinus* spp.) timber volume harvested annually and has ~4.49 million ha of pine production which are separated between natural and planted stands (Georgia Forestry Commission, 2024). Herbicides play a crucial role in pine tree timber production as they have effectively changed the way pine silviculture is performed (Bullock, 2011; Lauer and Quicke, 2022; Minogue, 2021). To promote successful pine production and reduce or eliminate herbaceous or woody competition, herbicides such as imazapyr are used to release pines by controlling various types of grass, herbaceous broadleaf weeds, and other trees (Anonymous, 2011).

Imazapyr is an acetolactate synthase (ALS) inhibiting herbicide that is a member of the imidazolinone family (Shaner 2014). Imazapyr's herbicidal activity is broad-spectrum, offering control of weeds from a wide window of application timings from residual activity to postemergence (POST) applications (Douglass *et al.,* 2016; Gianelli *et al.,* 2014). The average half-life of imazapyr is 25 to 142 d which can be influenced by soil type and environmental conditions with weed control that can last from three months up to two years depending on the rate of application (Shaner, 2014). Due to imazapyr's high water solubility, long persistence and weak absorption in some soils, the potential for leachability to sensitive areas is a concern (Gianelli *et al.,* 2014). However, imazapyr generally remains within the top 50 cm of soil (Shaner, 2014). The herbicide is primarily degraded by soil microbial organisms under aerobic conditions with photodegradation being another potential pathway for breakdown (Shaner and O'Connor, 1991).

With the wide spectrum of weed control, efficacy at relatively low doses, and ability to persist in the soil, imidazolinone herbicide carryover to rotational crops can be of concern (Loux *et al.*, 1989; Loux and Reese, 1993; Shaw and Wixson, 1991). The persistence of these herbicides is affected by many factors including soil moisture, soil pH, organic matter, and soil type (Loux *et al.,* 1989; Loux and Reese, 1993; Shaw and Wixson, 1991). Yields of certain crops including field corn (*Zea mays* L.), grain sorghum [*Sorghum bicolor* (L.) Moench], cotton (*Gossypium hirsutum* L.) and cucumber (*Cucumis sativus* L.) have been reduced when these crops were planted the year following application of imidazolinone herbicides (Alister and Kogan, 2004; Goetz *et al.,* 1990; Loux and Reese, 1993; York *et al.*, 2000).

Similar to pine tree production, Georgia is also the nation's top producer of peanuts harvesting 637,247 ha and accounting for approximately 53% of the nation's crop in 2023 (USDA-NASS, 2024). Peanut production in Georgia has a farm gate value of $791 million with production concentrated in the Coastal Plain region (Anonymous, 2024). With both pine trees and peanuts common to the region, the proximity in production is often very close. For example, Mitchell County (133,000 ha) is one of the top peanut-producing counties in Georgia with 18,031 ha while also maintaining 34,668 ha of pine forest (USDA-CropScape, 2023). This gives a ratio of 1.92 ha of pine trees to peanut further demonstrating the close proximity to which pine trees and peanut could be grown or managed within Georgia.

With both pine tree and peanut production relying on the use of herbicides to manage weeds in conjunction with their close proximity in the Coastal Plain region, the potential for crop damage to occur from herbicide drift is enhanced. In fact, University of Georgia Extension has documented this event occurring with imazapyr applied to pine trees moving off-target to peanut fields. Forestry herbicides can be applied using ground application methods or aerially via the use of helicopters (Bullock, 2011). Depending on the pines' age class, imazapyr's herbicide application to pine trees could occur before peanut planting or during the growing season. Due to the variability of application and timings of this forestry herbicide, implications of off-target herbicide drift into surrounding crop fields pose a significant risk.

A paucity of information about the response of peanut to imazapyr exists. Therefore, the objective of this research was to determine the effects of imazapyr, applied preemergence (PRE) or POST, on peanut growth and yield.

## MATERIALS AND METHODS

Field trials were conducted from 2020 through 2022 (three site-years) at the Ponder Research Farm in Ty Ty, Georgia (31.507654° N, -83.658395° W) to determine the effects of direct imazapyr applications to peanut. Soil was a Tifton sand with 94% sand, 0% silt, 6% clay, 0.91% organic matter, and a pH of 6.0. Conventional tillage practices were used and peanut (cv. Georgia-06G) (Branch, 2007) was planted using a vacuum planter calibrated to deliver 18 peanut seed/m at a depth of 5 cm (Monosem Precision Planters, 1001 Blake St., Edwardsville, KS). Peanuts were planted in twin rows spaced 23 cm apart on a 91 cm center, plots were 1.8 m (two sets of twin rows) wide and 7.6 m in length.

Treatments were arranged in a randomized complete block design with a three (application timings) X five (herbicide rates) factorial arrangement having three to four replications. Imazapyr (Arsenal® Powerline™ 2SL, BASF Corp, Research Triangle Park, NC) application timings consisted of PRE 1 day after planting (DAP), 30 DAP, and 60 DAP with herbicide rates consisting of 0, 4.2 (1/100X), 42 (1/10X), 84 (1/5X), and 420 g ai/ha (1X, manufacturers suggested use rate). Herbicide treatments were applied using a $CO_2$-pressurized backpack sprayer calibrated to deliver 140 L/ha at 5.3 km/hr. Peanut growth stage at 30 and 60 DAP was beginning bloom (R1) and beginning pod to full pod (R3 – R4), respectively (Boote, 1982). Plots were maintained weed-free throughout the season using an herbicide program recommended by the University of Georgia Extension (Prostko *et al.,* 2022) and hand-weeding. Supplemental overhead irrigation was applied as needed to maintain optimum peanut yields (Porter, 2022). Production, and pest management practices other than specific treatments were held constant over the entire experiment to optimize peanut growth and development (Monfort, 2022).

Data collected included peanut density (stand) at 17 to 30 DAP, visual estimates of peanut injury (stunting and chlorosis), plant height and width, and pod yield. Peanut density was obtained by counting the number of emerged plants/1-row m. Visual estimates of crop injury (stunting and chlorosis) were obtained 65 DAP using a scale of 0 to 100 (0=no injury; 100=plant death). Plant height (cm) and width (cm) data were collected at 110 DAP by measuring 5 plants/plot. Heights were measured from individual plants from the soil line to the top of the terminal and plant width measurements were recorded from measurements of the lateral branches from the twin-row. Peanut yield data were obtained using commercial harvesting equipment. Yields were adjusted to 10% moisture. A complete summary of planting/harvesting dates and rainfall totals can be found in Table 1.

Data were subjected to ANOVA using PROC GLIMMIX in SAS, version 9.4 (SAS Institute, Cary, NC). Peanut density, injury (stunting and chlorosis), plant height/width, and yield were set as the response variables with year and replication within year included in the model as random factors. All data were pooled over years. All P-values for tests of differences between least-square means were compared and separated using the Tukey-Kramer method ($P<0.05$).

Table 1. Planting dates, inversion dates, harvest dates, and rainfall totals for the imazapyr peanut studies in Georgia, 2020-2022.

| Year | Planting Date | Inversion Date | Harvest Date | Rainfall Totals (planting to inversion) | Historical Rainfall [a] (planting to inversion) |
|---|---|---|---|---|---|
| | | | | ---------------cm--------------- | |
| 2020 | 27 Apr | 21 Sep | 1 Oct | 53 | 50 |
| 2021 | 3 May | 23 Sep | 28 Sep | 67 | 50 |
| 2022 | 25 Apr | 19 Sep | 23 Sep | 55 | 50 |

[a]Averages for years 1981-2010.

## RESULTS AND DISCUSSION

### Peanut Density

Peanut density was not influenced by imazapyr applied PRE (Table 2). Matte *et al.* (2018) conducted research evaluating imidazolinone-tolerant soybeans [*Glycine max* (L.) Merr.] treated PRE with a mixture of imazapyr + imazapic and reported no significant stand loss or injury when treated with twice the labeled rate of the herbicide mixture. POST applications of imazapyr did not influence plant density (data not reported).

### Peanut Injury

Visual estimates of herbicide injury were obtained at 65 DAP (Table 3). A significant interaction between timing and rate was observed. Peanut stunting was observed when imazapyr PRE was applied at rates greater than 4.2 g ai/ha, resulting in 37% to 79% injury. Peanut stunting was also observed when imazapyr was applied 30 DAP at rates of 42 g ai/ha or greater (33% to 75% stunting). Significant peanut stunting was not observed five days after the 60 DAP timing with any rate of imazapyr. Peanut chlorosis increased when imazapyr was applied at rates greater than 84 g ai/ha with either the PRE or 30 DAP application. However, no differences in chlorosis were noted within the 60 DAP application.

### Peanut Plant Height and Width

Peanut heights at 110 DAP were reduced by the 420 g ai/ha rate, regardless of timing. Peanut height reductions were greatest when imazapyr was applied PRE. Peanut heights were reduced 30%, 67%, and 75% when treated with PRE applications of imazapyr at 42, 84, and 420 g ai/ha, respectively. When treated 60 DAP, imazapyr at 84 and 420 g ai/ha reduced plant heights by 31% and 57%, respectively. Peanut plant width was reduced when treated with imazapyr at 420 g ai/ha regardless of timing. Peanut widths were reduced 59% and 56% when imazapyr was applied PRE with rates of 84 and 420 g ai/ha, respectively.

Table 2. Peanut density as influenced by preemergence applications of imazapyr in Georgia, 2020-2022.

| Imazapyr Rate | Peanut Density[a] |
|---|---|
| g ai/ha | plants/1-row m |
| 0 | 16a[b] |
| 4.2 | 16a |
| 42 | 16a |
| 84 | 15a |
| 420 | 14a |

[a]Peanut density/stand data collected 17-30 days after planting.

[b]Means in the same column with the same letter are not significantly different according to Tukey-Kramer method (P<0.05). All data averaged over three site-years.

Table 3. Peanut injury (stunting, chlorosis), height, width, and yield as influenced by imazapyr applied at five rates at three different timings in Georgia, 2020-2022.

| | | Peanut Injury[a] | | | | |
|---|---|---|---|---|---|---|
| Timing of Application | Imazapyr Rate | Stunting[a] (65 DAP[b]) | Chlorosis (65 DAP) | Plant Height (110 DAP) | Plant Width (110 DAP) | Yield |
| DAP | g ai/ha | ------------%------------ | | ------------cm---------- | | kg/ha |
| PRE[c] | 0 | 0d[d] | 0c | 42a | 91a | 6212a |
| | 4.2 | 22cd | 0c | 39ab | 91a | 5988a |
| | 42 | 37bc | 2bc | 29c | 78ab | 4320b |
| | 84 | 61ab | 2bc | 14de | 38c | 2546cd |
| | 420 | 79a | 12b | 10e | 40c | 1335d |
| 30[e] | 0 | 0d | 0c | 42a | 91a | 6086a |
| | 4.2 | 4d | 0c | 41ab | 91a | 5908a |
| | 42 | 33bc | 4c | 37abc | 91a | 5318ab |
| | 84 | 38bc | 7bc | 37abc | 87ab | 4759ab |
| | 420 | 75a | 37a | 14de | 47c | 2089cd |
| 60[f] | 0 | 0d | 0c | 41ab | 91a | 6187a |
| | 4.2 | 2d | 0c | 39ab | 91a | 6236a |
| | 42 | 2d | 15b | 34bc | 91a | 5664ab |
| | 84 | 2d | 2bc | 29c | 86ab | 5262ab |
| | 420 | 9cd | 10bc | 18d | 68b | 2706c |

[a]Ratings are visual estimates of peanut injury based on percent of non-treated control (0 = no crop injury, 100 = complete crop death) and are averaged over three site-years.

[b]DAP = days after planting.

[c]PRE = preemergence at 1 DAP.

[d]Means in the same column with the same letters are not significantly different according to the Tukey-Kramer method ($P<0.05$).

[e]Beginning bloom (R1).

[f]Beginning pod to full pod (R3-R4).

## Peanut Yield

Peanut yield was reduced, regardless of application timing, when imazapyr was applied at 420 g ai/ha (Table 3). This rate resulted in yield losses of 79, 66, and 56% when applied PRE, 30 DAP, or at 60 DAP, respectively. PRE applications of imazapyr at 42 and 84 g ai/ha also resulted in 31% and 59% yield reductions, respectively. No other yield reductions were observed and yield loss was not associated with delayed peanut maturity. Conversely, numerous studies have evaluated the safety of imazethapyr and imazapic (formally AC 263,333), two commonly used imidazolinone herbicides for PRE and POST weed control in peanut (Grichar *et al.,* 2005; Richburg *et al.,* 1995; 1996; Webster *et al.,* 1997). Richburg *et al.* (1995) reported that the use of imazapic across eight peanut cultivars exhibited <13% visual injury which was transient, had minimal impact on canopy widths, and had no impact on peanut yields. Grichar *et al.* (2005) reported that the use of imazethapyr and imazapic was costly. However, when used in a peanut herbicide program, positive net returns occurred and peanut yield was not negatively influenced.

These three herbicides are not only in the same chemical family and have the same mode of action, but they share a uniquely similar chemical structure and only differ at the R[1] binding site (Shaner and O'Connor, 1991). Given the nearly identical chemical structures, it is interesting to note the differences in peanut tolerance between the safety of imazethapyr and imazapic versus the negative effects that imazapyr can have on peanut when applied to either the soil or foliage. Herbicide structure and chemical properties can strongly influence adsorption, translocation, bioactivation, and environmental stability (Duke, 1990). The selectivity of herbicides is also influenced by other physical (environment, position and timing of herbicide application, and plant morphology) and physiological factors (herbicide retention, translocation, and detoxification) (Gwatidzo *et al.*, 2023).

## SUMMARY AND CONCLUSIONS

Peanut density was not affected by any rate of imazapyr when applied PRE or POST. However, rates greater than 4.2 g ai/ha applied PRE reduced peanut yields at least 30%. Assuming normal temperature, rainfall patterns, and supplemental irrigation programs, these data suggest that peanut could be planted following imazapyr after approximately three field half-lives, or ~ 426 d have occurred in coarse-textured soils. Peanut subjected to imazapyr applied POST at rates ≤ 84 g ai/ha (1/5X) during the growing season did not result in significant yield losses. Thus, it is unlikely that off-target or drift rates will cause peanut yield losses. Maybank *et al.* (1978) reported that particle drift from ground applications was 1% to 8% and 20% to 35% from aerial applications depending upon nozzle type and wind speed. This would equate to a range of 1/100X to 1/3X rates of imazapyr. In peanut fields without supplemental irrigation or with inadequate fertility, greater yield losses could be observed than reported herein.

## ACKNOWLEDGMENTS

This research could not have been conducted without the technical support of Charlie Hilton, Tim Richards, and Dewayne Dales. The contributions of A.S. Culpepper, W.S. Monfort, M.A. Abney, and C.J. Bryant were also greatly appreciated.

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