CORPUS PUBLISHERS

Archives of Agriculture Research and Technology (AART)

ISSN: 2832-8639

Volume 6 Issue 3, 2025

Article Information

Received date : October 22, 2025

Published date: October 29, 2025

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DOI: 10.54026/AART/1086

Keywords

Prohexadione calcium; Peanut pods; Digging date; Planting date; Plant growth regulator

Research Article

Influence of Planting and Digging Date on Peanut (*Arachis hypogaea*) Response to Prohexadione Calcium

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Abstract

Prohexadione calcium is a plant growth regulator used in peanut (*Arachis hypogaea* L.) to manage vegetative growth to improve efficiency of digging pods and inverting vines. In some cases, this plant growth regulator can increase peanut yield compared with non-treated peanut. The influence of planting date and digging date on peanut response to prohexadione calcium has not been determined with cultivars that are currently grown commercially. To address this issues, one experiment was conducted in North Carolina over two years to determine if planting date and digging date affected peanut response to prohexadione calcium applied when 50% of lateral branches from adjacent rows touched, followed by a second application 14 to 20 days later. The experiment included 2 levels of prohexadione calcium (0 and 140 g ai/ha), three levels of planting date (early, mid-, and late-May), and four levels of digging date (early and late-September and early and mid-October). In a second experiment conducted over six years, these prohexadione calcium treatments were compared following a single planting date in early to mid-May each year, with six digging dates occurring approximately 115, 122, 129, 136, 143, and 150 days after planting. Peanut yield was affected by the interaction of planting date and digging date independent of prohexadione calcium treatment. Peanut response to prohexadione calcium was affected by year, with peanut yield lower when prohexadione calcium was applied compared with non-treated peanut in one year; yield was similar in the other year of the experiment. In the second experiment with six digging dates, prohexadione calcium did not affect peanut yield regardless of year or digging date. A cubic response was observed for peanut yield vs. digging date when data were pooled over years and prohexadione calcium rates. Results from these experiments suggest that peanut yield will not be affected by prohexadione calcium, irrespective of planting date or digging date. It is important to note that these experiments were conducted using accepted small-plot techniques for peanut (e.g., plot sizes of 1.8 m by 9 m). Additional research is needed to support or refute these results using larger plots in farmer's fields.

Introduction

Prohexadione calcium is registered for use in peanut *(Arachis hypogaea* L.*)* and other crops to prevent excessive vine growth [1]. This plant growth regular minimizes internode elongation by limiting expression of gibberellic acid in sensitive plants resulting in shorter stature plants [2]. Prohexadione calcium increases row visibility in peanut fields which can increase the ability of farmers to track rows more effectively during digging and vine inversion [1]. In some cases, peanut yield increased when this plant growth regulator was applied compared with non-treated peanut [3,4]. The yield increase was often attributed to less pod loss during the digging and vine inversion process [5,6]. However, yield response does not always occur even though row visibility is increased when prohexadione calcium is applied. Prohexadione calcium can decrease peanut yield when applied to peanut that are drought stressed [7,8].

Digging date can have a major impact on peanut yield and market grade characteristics [8,9]. Beam et al. [5] and Culpepper et al. [10] compared peanut response to prohexadione calcium with different digging dates. They indicated that increased pod yield following prohexadione calcium was more likely to occur when peanut pods were dug and vines inverted when pod maturity was more advanced. Peanut pods that are more advanced in maturity are prone to greater shed from plants during the digging and vine inversion process compared with pods that are less mature [8]. However, these trials [5,10] were conducted with cultivars that are no longer grown commercially in North Carolina [8]. The cultivar Bailey II [11] is the most common peanut cultivar in North Carolina at the present time [8]. This cultivar expresses the high oleic trait not found in the cultivar Bailey [12]. These cultivars (e.g., Bailey and Bailey II) were planted on most of the land in North Carolina from 2015-2025 [8]. Response of peanut to prohexadione calcium has not been determined in experiments where planting and digging date were both included as treatment factors. Additionally, information in the peer-reviewed literature is limited relative to response of the peanut cultivar Bailey [12] to prohexadione calcium with a single planting date followed by multiple digging dates. To address these gaps in research, experiments were conducted to determine if peanut yield response to the prohexadione calcium is affected by planting date and digging date or the interaction of these factors in North Carolina.

Materials and Methods

Peanut Response to Prohexadione Calcium, Planting Date, and Digging Date

The experiment was conducted in North Carolina in 2013 and 2014 at the Peanut Belt Research Station located near Lewiston-Woodville (36.07 N, –77.11 W) on a Norfolk loamy sand soil (fine-loamy, kaolinitic, thermic typic Kandiudults). The cultivar Bailey [12] was planted in conventionally prepared, raised seedbeds in rows spaced 91 cm apart at an in-row population of 15 to 17 plants/m. Plot size was two rows wide by 9 m long. Except for prohexadione calcium treatments, all other production and pest management practices were the same across the entire experiment [8].

Treatments consisted of prohexadione calcium (Apogee, BASF Corp., Research Triangle Park, NC) at 140 g ai/ha applied when 50% of lateral branches from adjacent rows were touching, followed by a second application at the same rate 14 to 20 days later compared with non-treated peanut. Prohexadione calcium was applied with crop oil concentrate (Agri-Dex, Helena Chemical Corp., Memphis, TN) and 28% urea ammonium nitrate, both at 1.0 L/ha in aqueous solution. The spray solution was applied using a CO_2-pressurized backpack sprayer calibrated to deliver 145 L/ha at 240 kPa. In order compare the effect of planting date and digging date on peanut response to prohexadione calcium, peanut was planted

in early May, mid-May, and late-May with digging dates for each planting ranging from early September through mid-October. These planting dates include the range of recommended planting dates recommended in North Carolina [8]. The range of digging dates allowed determination of response to prohexadione calcium when peanut was dug prior to and after peanut pods reached optimum maturity based on pod mesocarp color [13]. This range of digging dates also included periods when peanut pods were at optimum maturity [13].

The experimental design was a split-, split-plot with digging dates randomized within planting dates to facilitate logistics of digging and harvesting. Prohexadione calcium treatments were replicated within levels of planting date and digging date combinations. Each combination of planting date, digging date, and prohexadione calcium rate was replicated 4 times. Peanut pod yield was determined after threshing and drying pods to 8% moisture. Data for pod yield were subjected to ANOVA using the GLM procedure in SAS (PROC GLM, SAS version 9.4, SAS Institute, Cary, NC). Means of significant main effects and interactions were separated using Fisher's Protected LSD test at $p < 0.05$.

Peanut Response to Prohexadione Calcium and Digging Date

The experiment was conducted at the Peanut Belt Research Station near Lewiston-Woodville on the same soil series described earlier using the same tillage system, row width, plant population, production practices, and prohexadione calcium treatments. The experiment was conducted from 2012-2014 and 2016-2018. Peanut was planted in early to mid-May of each year with digging of pods and inversion of vines occurring approximately 115, 122, 129, 136, 143, and 150 days after planting. Peanut harvest procedures were similar to those described previously.

The experimental design was a split plot with digging date serving as the whole plot unit and prohexadione calcium rate serving as the sub-plot unit. Combinations of digging date and prohexadione calcium rate were replicated 3 or 4 times. Data for pod yield were subjected to ANOVA using the GLM procedure in SAS (PROC GLM, SAS version 9.4, SAS Institute, Cary, NC) considering the 2 (prohexadione calcium rate) × 6 (digging date) factorial treatment arrangement. Data for peanut yield were subjected to the regression procedure in SAS (PROC REG, SAS version 9.4, SAS institute, Cary, NC) to test linear, quadratic, and cubic relationships for peanut yield vs. digging date in days after planting with a significance value of $p < 0.05$.

Results and Discussion

Peanut Response to Prohexadione Calcium, Planting Date, and Digging Date

Main effects of planting date ($p < 0.0001$, $F = 14.8$), digging date ($p < 0.0001$, $F = 22.7$), and prohexadione calcium rate ($p = 0.0040$, $F = 8.6$) were significant for peanut pod yield. Although interactions among year, planting date, and digging date were significant ($p < 0.05$), the only factor interacting with prohexadione calcium was year ($p = 0.0466$, $F = 4.0$).

When pooled over years and prohexadione calcium rates, peanut yield was highest for the mid-May planting date when peanut was dug September 8 or October 7 and 15 (Table 1). Peanut yield was greater for early May plantings than late-May plantings when dug September 8 or 20. This most likely is associated with peanut planted in late May being less mature at the time of digging compared with maturity of peanut associated with the earlier plantings [8,9,13]. When peanut was dug September 20, peanut yield was similar to peanut yield when planted in early or mid-May and greater than yield for the late-May planting. When dug October 7 or 15, peanut yield was lower for the earliest planting date compared with yield for the latest planting date. Although not substantiated here, it is possible that some pods from the earliest planting date had shed from plants by the time they were dug in early and late October. A lower amount of pod shed may have been associated with a delay in maturity for the mid-May and late May plantings compared with peanut planted in early May when digging occurred in October. These results are not surprising. Previous research has shown that peanut yield [8,9] and economic return, a measure that includes pod yield and market grade characteristics [14], are often equal to or greater when peanut in North Carolina are planted in mid-May rather than early May or late-May/early June. The current recommendation for planting peanut in North Carolina is during the month of May with a focus on planting in mid-May when logistically possible [8]. Peanut pod maturity and kernel mass are affected by heat unit accumulation, and although not universal, peanut dug in late September and into October generally yield more and have higher market grade characteristics than peanut dug in early or mid-September [8,9,14]. Planting earlier in May does not always translate into more advanced pod maturity compared with mid- or late-May plantings in North Carolina [8].

When pooled over levels of year and prohexadione calcium rate, peanut yield was greatest when peanut was dug September 20 and October 7 compared with digging in September 8 or October 20 for the early May planting date (Table 1). When peanut was planted in mid-May, the highest yields were observed when peanut was dug in October rather than September; digging September 20 resulted in greater yield than digging September 8. Peanut yield increased with each subsequent delay in digging from September 8 through October 7 when peanut was planted in late May. However, delaying digging from October 7 to October 15 resulted in lower yields.

Table 1: Peanut yield as influenced by the interaction of planting and digging date in North Carolina during 2013 and 2014.[a]

Approximate digging date	Peanut pod yield		
	Approximate planting date		
	Early May	Mid-May	Late May
	kg/ha		
September 8	5,260 B b	5,490 A c	4,620 C d
September 2	5,810 A a	5,880 A b	5,550 B c
October 7	5,750 C a	6,230 A a	6,080 B a
October 15	5,360 C b	6,350 A a	5,750 B b

[a]Means with the same uppercase letter for planting dates within a digging date are not significantly different based on Fishers Protected LSD test at $\alpha = 0.05$. Means with the same lowercase letter for digging dates within a planting date are not significantly different based on Fishers Protected LSD test at $\alpha = 0.05$. Data are pooled over levels of year and prohexadione calcium rates.

Results for the interaction of year × prohexadione calcium were surprising given that pod yield was lower in 2013 when prohexadione was applied compared with non-treated peanut (Table 2). There is an abundance of data in the peer-reviewed literature indicating that prohexadione calcium increases yield or there is not a negative response to this plant growth regulator [1,3-6,15-17].

Table 2: Influence of prohexadione calcium on peanut yield.[a,b].

Prohexadione calcium rate	2013	2014
g/ha	kg/ha	
None	5,800 a	5,790 a
140 then 140	5,400 b	5,720 a

[a]Prohexadione calcium was applied when 50% of lateral branches from adjacent rows were touching followed by a second application at the same rate two weeks later. [b]Means within a year followed by the same letter are not significantly different based on Fishers Protected LSD test at $\alpha = 0.05$. Data are pooled over levels of planting date and digging dates.

Peanut Response to Prohexadione Calcium and Digging Date

The main effect of prohexadione calcium ($p = 0.3858$, $F = 0.8$) and the interaction of prohexadione calcium × digging date ($p = 0.9147$, $F = 0.3$) were not significant for peanut yield. However, the main effect of digging date was significant ($p < 0.0001$, $F = 47.5$). When pooled over years and digging dates, peanut yield was 5,360 kg/ha for non-treated peanut and 5,290 kg/ha for peanut treated with prohexadione calcium.

Peanut yield increased linearly when digging was delayed from 122 to 143 days after planting, after which a decrease in yield was noted from 143 to 150 days after digging (Figure 1). These data are consistent with previous research demonstrating that peanut yield often increases when digging is delayed until peanut pods, a proxy for increased kernel maturity and mass, reach optimum maturity for this indeterminant crop [8,9,13].

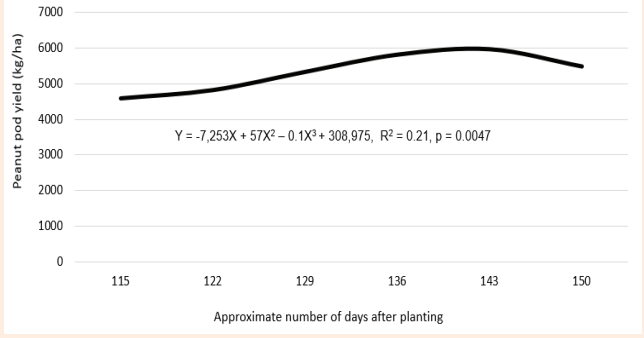

Figure 1: Influence of digging date on peanut yield. Data are pooled over six years and prohexadione calcium rates.

Conclusion

Results from these experiments indicate that peanut yield response to prohexadione calcium likely will not differ based on planting date or digging date in North Carolina. However, our results do suggest that prohexadione calcium can reduce yield in some instances. Additional research is needed to determine if the lack of response of peanut to interactions of prohexadione calcium with planting date and/or digging date is similar under irrigation or abundant rainfall and/or a more diverse set of environmental and edaphic conditions. However, this response was observed over multiple years when peanut was planted and dug over a wide range of conditions. Based on the similarity of characteristics of Bailey and Bailey II, it is expected that a response of Bailey to prohexadione calcium, planting date, and digging date would translate to Bailey II, the most commonly grown peanut cultivar in North Carolina [8,11,12]. It is also important to place our results in context of research methodology when making a conclusion on peanut response to prohexadione calcium. Research by Studstill et al. [4] and Jordan et al. [17] suggests that plot size in the experiment can influence whether a statistical difference in yield between non-treated peanut and prohexadione calcium-treated peanut is observed. In their research [4,17], prohexadione calcium often increased peanut yield in experiments when plot size was significantly larger than traditional small-plot research (plot size of 1.8 by 9 m). Additional research with larger plot size is needed to confirm or refute the findings from our results that peanut yield response to prohexadione calcium is independent of planting date and digging date.

Acknowledgement

Funding was provided by the North Carolina Peanut Growers Association. Appreciation is expressed to staff at the Peanut Belt Research Station for assistance with these experiments.

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