Response of Four Virginia-Type Peanut Cultivars to Prohexadione Calcium as Affected by Cultivar and Planting Pattern

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ABSTRACT

An experiment at Suffolk, VA in 2001 and 2002 evaluated the response of virginia-type peanut (*Arachis hypogaea* L.) to the growth regulator prohexadione calcium as affected by cultivar and planting pattern. In both years, prohexadione calcium at 140 g/ha was applied at 50% row closure and 2 wk later to the cultivars Gregory, Perry, VA 98R, and Wilson. Cultivars were seeded in single rows spaced 91 cm apart at a seeding rate of 145,000 seed/ha (145-single) or in twin rows spaced 18 cm apart on 91 cm centers at seeding rates of 145,000 seed/ha (145-twin) and 218,000 seed/ha (218-twin). Row visibility was enhanced by prohexadione calcium for all cultivars although response was greatest with Perry and least with Wilson. In twin rows, row visibility was less compared to single rows irrespective of year or variety. Prohexadione calcium enhanced row visibility for all planting patterns. Row visibility in the absence of prohexadione calcium was highest in the single row planting pattern. Response to prohexadione calcium was greatest in the twin row treatments regardless of cultivar. Pod yield was higher in the 218-twin row pattern compared to the 145-single and the 145-twin. Combined over years, planting patterns and cultivar, mean yield was lower when prohexadione calcium was applied. Additional research should be focused on explaining the inconsistent response of virginia-type peanuts to prohexadione calcium.

Key Words: *Arachis hypogaea*, prohexadione calcium, twin row, row visibility, plant growth regulator.

Various factors including environmental conditions, seeding rate, plant growth regulators, and genetics dictate peanut growth and development. Virginia-type peanuts frequently produce vegetative growth in excess of what is required to maximize pod yield (Mitchem *et al.*, 1996). Excessive vegetative growth can increase disease incidence (Phipps, 1995) and mechanical damage to vines associated with mid- and late-season pesticide applications, and reduce pesticide penetration in the bottom region of the canopy (Bauman and Norden, 1971; Wu and Santleman, 1977; Henning *et al.*, 1982). Row visibility at harvest can also be reduced by excessive vegetative growth, adversely affecting harvest efficiency and yield (Beasley, 1970; Culpepper *et al.*, 1977; Jordan *et al.*, 2001).

Agrichemicals with plant growth regulator activity have been examined in peanut for vegetative growth suppression. Foliar applications of daminozide resulted in enhanced row visibility although yield response was inconsistent (Brown and Ethredge, 1974; Mozingo and Steele, 1984; and Hodges and Perry, 1970). This product is no longer commercially available as a plant growth regulator in peanut. Wu and Santleman (1977) reduced vine growth with several plant growth regulators in spanish-type peanuts and observed no significant yield enhancements. Bauman and Norden (1971) examined the effects of applying daminozide and TIBA (2,3,5,-triiodobenzoic acid) to peanut cultivars displaying various growth habits and reported reduced vegetative growth in some cultivars but no increases in yield. Prohexadione calcium is a commercially available plant growth regulator registered for vegetative growth suppression in peanut (Mitchem *et al.*, 1996).

Prohexadione calcium is a plant growth regulator that inhibits gibberellin biosynthesis by blocking kaurene oxidase, and increasing abscissic acid and cytokinin levels in certain plant species (Grossman *et al.*, 1994). It is registered as a plant growth regulator in peanut, apple (*Malus* spp.) and several grass species and has been reported to reduce vegetative growth in other crops including rice (*Oryza sativa* L.), tomato (*Lycopersicon esculentum* Mill.), grain sorghum [*Sorghum bicolor* (L.) Moench], oilseed rape (*Brassica napus* L.), and wheat (*Triticum aestivum* L.) (Byers and Yoder, 1999; Grossman *et al.*, 1994; Lee *et al.*, 1998; Nakayama *et al.*, 1992; Yamaji *et al.*, 1991). In peanut, the registration recommends making one application when 50% of the peanut vines are touching in the row middles (row closure) followed by a second application at 100% row closure. Increases in row visibility (measured by visual observation at harvest) and decreases in mainstem

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and cotyledonary lateral branch length have been reported following prohexadione calcium applications (Jordan *et al.*, 2001; Beam *et al.*, 2002; Culpepper *et al.*, 1997; Mitchem *et al.*, 1996). Mitchem *et al.* (1996) reported reduction in mainstem and cotyledonary lateral branch length up to 34 and 32% respectively, following prohexadione calcium applications to virginia-type peanuts.

Yield response of virginia-type peanuts to prohexadione calcium applications in the literature is inconsistent (Jordan *et al.*, 2001; Culpepper *et al.*, 1997; Jordan *et al.*, 2000). Beam *et al.* (2002) reported increases in combined yield and reductions in pod loss at harvest, but no changes in maximum yield (measured as sum of pods combined and the pods remaining on the soil surface and in soil following harvest). Reports of yield reduction have been isolated to early application timings, specific cultivars, and locations within a study (Mitchem *et al.*, 1996; Culpepper *et al.*, 1997; Jordan *et al.*, 2000).

Prohexadione calcium application can alter the grade and quality of peanut. Increases in extra large kernels (ELK) have been reported following application of prohexadione calcium at 50% row closure followed by a subsequent application several weeks later (Culpepper *et al.*, 1997; Jordan *et al.*, 2001). However, Mitchem *et al.* (1996) reported decreases in ELK percentage when prohexadione calcium was applied at the early pegging stage. Inconsistent changes in yield and grade may have been influenced by changes in maturity due to prohexadione calcium application. Culpepper *et al.* (1997) reported prohexadione calcium hastened pod maturity. However, research by Beam *et al.* (2002) suggested that a higher percentage of brown and black pods using mesocarp pod color determination may have been associated with greater pod retention rather than hastening maturity.

Peanut vine growth and yield responses to prohexadione calcium application can vary by cultivar. Culpepper *et al.* (1997) examined the response of six Virginia type cultivars to application of prohexadione calcium at row closure followed by one application several weeks later. Row visibility was enhanced by prohexadione application for all cultivars although response was greatest for NC-V 11 and NC 9. Yield response in plots where prohexadione calcium was applied ranged from 16% increase to 8% reduction depending on the cultivar. Beasley *et al.* (1998) also reported variability across runner-type peanut yield response to prohexadione calcium application.

Peanut is typically produced on single rows spaced 91 to 102 cm apart in the U.S. (Sholar *et al.*, 1995). Early research demonstrated no yield advantage to planting peanut in rows spaced 45 cm versus 90 cm (Hodges and Perry, 1970). Some producers grow peanuts in twin row configuration, consisting of two rows planted on the same bed. Increased yield and reduced infection from tomato spotted wilt tospovirus (TSWV) has been reported in peanuts planted in twin-row relative to single-row configuration (Baldwin *et al.*, 1998). Other researchers have reported no change in yield or grade in peanut planted to twin rows unless plant populations in the twin-rows were higher than single row plantings (Jordan *et al.*, 2001; Mozingo and Coffelt, 1984). Increasing plant density through either increasing seeding rate or planting in twin-rows may impact the amount of above ground vegetative growth present in a peanut field.

While peanut response to prohexadione calcium in single and twin row planting patterns or response to prohexadione calcium by different cultivars have been evaluated, information is not available on the response of virginia-type cultivars planted in varying patterns to prohexadione calcium application. Additionally, past research evaluating response of virginia-type peanut to prohexadione calcium application utilized cultivars that are no longer planted on substantial hectarage. Response of the cultivars Gregory, Perry, VA 98R, and Wilson to prohexadione calcium has not been reported in the literature, and these cultivars comprised 60% of the planted hectarage in 2004 (Virginia Crop Improvement Association, Inc, pers. commun.). Therefore, research was conducted to determine if recently released, commonly grown virginia-type cultivars respond variably to prohexadione application and if planting pattern and plant population together influence response.

Materials and Methods

The experiment was conducted in Virginia at Tidewater Agricultural Research and Extension Center (TAREC) research farm located in Suffolk during 2001 and 2002. Soil at this location was a Kenansville loamy sand (loamy, siliceous, thermic Arenic Hapludults) with pH 5.4 and 1.2% organic matter (2001) and pH 5.7 and 1.03% organic matter (2002). The cultivars Gregory, Perry, VA 98R, and Wilson were tested in each year. Gregory and Perry display an intermediate growth habit between runner and bunch type while VA 98R and Wilson display runner growth habit (Swann, 2002).

Peanut was planted on 7 May 2001 and 6 May 2002 in conventionally prepared, elevated beds in single rows spaced 91 cm apart at a seeding rate of 145,000 seed/ha (145-single) or in twin rows spaced 18 cm apart on 91 cm centers at seeding rates of 145,000 seed/ha (145-twin) or 218,000 seed/ha (218-twin). Pest control and fertility practices were implemented based on recommendations of Virginia Cooperative Extension. Irrigation was applied in 2002 (2.54 cm on 9 July and 14 August) but not in 2001. Prohexadione calcium was applied with a CO_2-pressurized unicycle sprayer calibrated to deliver 140 L ha^{-1} at 221 kPa. Crop oil concentrate (Agri-Dex, Helena Chemical Co., Memphis, TN) at 1.22 L/ha and 30% urea ammonium nitrate solution at 2.44 L/ha were included with prohexadione calcium. In both years, prohexadione calcium was applied at 140 g ai/ha at 50% row closure and 2 wk later. A no prohexadione calcium control was included for each cultivar/planting pattern combination. Fifty-percent row closure was defined when 50% of the vines from adjacent rows were touching and occurred on 13 July 2001 and 29 July 2002 for the twin row planting pattern and 20 July 2001 and 30 July 2002 for single row planting pattern.

The experimental design was a split split plot with four replications. Cultivar was the main plot, prohexadione calcium treatment was the subplot, and planting pattern was the sub subplot. Individual plots were two rows (1.8 m) wide by 12.2 m long. Visual estimates of row visibility were recorded on 28 August 2001 and 27 September 2002 using a scale of 1 to 10 where 1 = flat canopy with vines completely overlapping in the row middles with rows indistinguishable and 10 = triangular-shaped canopy with no vines from adjacent rows touching in the row middles (Mitchem *et al.*, 1996). Both rows of all plots were mechanically dug and inverted on 12 October 2001 and 28 September 2002 and allowed to dry in the field for periods of 5 to 10 d. In the current study, plots were mechanically harvested and dried using conventional dryers. Yields were adjusted to 7% moisture.

Data for row visibility and pod yield were subjected to combined analysis of variance for the two years, four cultivars, two prohexadione calcium application levels, and three planting patterns using the Proc Mixed procedure of SAS software (Table 1) (SAS Institute 1997). All possible interactions were tested and treatment means were separated where appropriate using LSMEANS and the PDIFF option at the $P \leq 0.05$ level. Where interactions were significant, contrast statements were used to compare row visibility response to prohexadione calcium for cultivars and planting patterns.

Table 1. Analysis of variance of peanut row visibility and yield across two years. Tidewater Agricultural Research and Extension Center, Suffolk, VA (2001 and 2002).

Effect	Row visibility	Yield
	p-value	
Year (Y)	**	**
Prohexadione calcium (PC) [a]	**	*
Y × PC	**	NS
Planting pattern (PP) [b]	**	**
Y × PP	**	NS
PC × PP	*	NS
Y × PC × PP	NS[d]	NS
Cultivar (C) [c]	**	**
Y × C	NS	*
PC × C	**	NS
Y × PC × C	NS	NS
PP × C	NS	NS
Y × PP × C	NS	NS
PC × PP × C	NS	NS
Y × PC × PP × C	NS	NS

*significant at the 0.05 probability level.

**significant at the 0.01 probability level.

[a]Prohexadione calcium (PC) applied at 140 g/ha at 50% row closure followed by a repeat application at 140 g/ha 2 wk later.

[b]Cultivars included Gregory, Perry, VA 98R, and Wilson.

[c]Peanut was planted on elevated beds in single rows spaced 91 cm apart at a seeding rate of 145,000 seed/ha (145-single) or in twin rows spaced 18 cm apart at seeding rates of 145,000 seed/ha (145-twin) and 218,000 seed/ha (218-twin).

[d]NS, not significant at $P \leq 0.05$.

Results and Discussion

Row Visibility. The interaction of year by prohexadione calcium was significant for row visibility (Table 1). Mitchem *et al.* (1996) noted that in years of high rainfall, the top of the peanut crop canopy is often flat with reduced row visibility compared with years with limited rainfall. From June to August 2001, 40.4 cm of rainfall were recorded versus 23.9 cm in 2002 (data not presented). Although row visibility was enhanced by prohexadione calcium application in both years, increased vegetative growth and a more pronounced response to prohexadione calcium was noted in 2001 when rainfall was more abundant. Row visibility following prohexadione calcium in 2001 and 2002 was 9.0 (data not presented). When prohexadione calcium was not applied, row visibility was 3.2 and 8.4 in 2001 and 2002, respectively (data not presented).

The interaction between planting pattern and year was significant for row visibility (Table 1).

Table 2. Effect of prohexadione calcium (PC)[a] on row visibility[b] for 145-single[c], 145-twin, and 218-twin planting patterns. Tidewater Agricultural Research and Extension Center, Suffolk, VA (2001 and 2002).

	Row visibility		
Treatment	No PC	PC	Change
145-single	6.9 a[d]	9.6 a	2.7 b
145-twin	5.3 b	8.7 b	3.4 a
218-twin	5.2 b	8.5 b	3.3 ab

[a]Prohexadione calcium applied at 140 g/ha at 50% row closure followed by a repeat application at 140 g/ha 2 wk later.

[b]Row visibility is based on a scale of 1 (flat canopy with vines overlapping in row middles) to 10 (triangular-shaped canopy with no vines from adjacent rows overlapping in row middles.

[c]Peanut was planted on elevated beds in single rows spaced 91 cm apart at a seeding rate of 145,000 seed/ha (145-single) or in twin rows spaced 18 cm apart at seeding rates of 145,000 seed/ha (145-twin) and 218,000 seed/ha (218-twin).

[d]Column means followed by the same letter are not significantly different at the P ≤ 0.05 level. Data are pooled over years and planting patterns.

Difference in row visibility between single- and twin-row treatments was more pronounced in 2001 compared to 2002 regardless of planting pattern treatment (Table 4). As previously mentioned, this may have been due to excessive vegetative growth associated with higher rainfall totals in 2002. Rows were more visible in the single-row configuration compared to twin-row planting patterns. No differences were observed due to seeding rate between twin-row treatments in either year (Table 4). Previous research has shown few differences in row visibility of virginia-type peanut planted in single-row versus twin row plantings across multiple years and locations (Jordan *et al.*, 2001). Observed differences between studies in the relationship of row visibility and planting pattern appear to be moderated by seasonal weather.

Table 3. Effect of prohexadione calcium (PC)[a] on row peanut row visibility[b] for VA 98R, Wilson, Perry, and Gregory peanut cultivars. Tidewater Agricultural Research and Extension Center, Suffolk, VA (2001 and 2002).

	Row visibility		
Treatment	No PC	PC	Change
VA 98R	5.7 b	9.0 bc[c]	3.3 ab
Wilson	7.0 a	9.3 ab	2.3 c
Perry	4.9 d	8.9 bc	4.0 a
Gregory	5.6 b	8.7 c	3.1 b

[a]Prohexadione calcium applied at 140 g/ha at 50% row closure followed by a repeat application at 140 g/ha 2 to 3 wk later.

[b]Row visibility is based on a scale of 1 (flat canopy with vines overlapping in row middles) to 10 (triangular-shaped canopy with no vines from adjacent rows overlapping in row middles.

[c]Column means followed by the same letter are not significantly different at the P ≤ 0.05 level. Data are pooled over years and planting patterns.

Table 4. Influence of planting pattern and year on peanut row visibility[a]. on row visibility[b] for 145-single[c], 145-twin, and 218-twin planting patterns. Tidewater Agricultural Research and Extension Center, Suffolk, VA (2001 and 2002).

	Row visibility	
Treatment	2001	2002
145-single	7.3 a[c]	9.1 a
145-twin	5.5 b	8.5 b
218-twin	5.5 b	8.3 b

[a]Peanut was planted on elevated beds in single rows spaced 91 cm apart at a seeding rate of 145,000 seed/ha (145-single) or in twin rows spaced 18 cm apart at seeding rates of 145,000 seed/ha (145-twin) and 218,000 seed/ha (218-twin).

[b]Row visibility is based on a scale of 1 (flat canopy with vines overlapping in row middles) to 10 (triangular-shaped canopy with no vines from adjacent rows overlapping in row middles.

[c]Column means followed by the same letter are not significantly different at the P ≤ 0.05 level. Data are pooled over cultivars and prohexadione application.

The interaction between planting pattern and prohexadione application was significant (Table 1). With or without prohexadione calcium, row visibility was higher in 145-single compared to 145- and 218-twin (Table 2). Row visibility response to prohexadione calcium was greater in the 145-twin compared to the 145-single. Jordan *et al.* (2001) reported enhanced row visibility in single- and twin-row plots due to prohexadione calcium application although response was not consistently greater for either row pattern. For twin row configuration, seeding rate did not impact row visibility regardless of prohexadione calcium application as there were no differences in row visibility between 145-twin and 218-twin.

The interaction between prohexadione calcium and cultivar was also noted with respect to row visibility (Table 1). In the absence of prohexadione calcium, rows planted to Wilson were most visible followed by VA 98R and Gregory which were not significantly different (Table 3). Perry had the lowest row visibility in the absence of prohexadione calcium. Although row visibility of all cultivars was enhanced through prohexadione calcium application, the magnitude of response varied. Perry, displaying the lowest row visibility value in the absence of prohexadione calcium, was enhanced to a greater extent than Wilson and Gregory, which had the higher row visibility values in the absence of prohexadione calcium. Variable response to prohexadione calcium across virginia-and runner-type cultivars has been reported in earlier research (Culpepper *et al.*, 1997; Beasley *et al.*, 1998).

Pod Yield. Yield averaged over all plots varied across years (6700 kg/ha in 2001 and 4600 kg/ha in 2002) (Table 1). This variation was consistent with state of Virginia state average yields in 2001 and 2002 at 3550 and 2380 kg/ha, respectively (National Agricultural Statistics Service 2004). Yields in prohexadione calcium treatments were pooled across year, planting pattern, and cultivar as no significant interactions with prohexadione calcium were noted (Table 1). Yield in prohexadione calcium treated plots was significantly ($P \leq 0.05$) less than the no-prohexadione calcium controls (5520 kg/ha versus 5790 kg/ha). Regarding cultivars, a differential yield response to prohexadione calcium was not observed in the current studies. In contrast, other researchers have reported yield increases due to prohexadione calcium application to virginia-type peanuts (Jordan *et al.*, 2001; 2000). Furthermore, Culpepper *et al.* (1997) reported yield increases in virginia-type peanuts treated with prohexadione calcium versus nontreated with variations in magnitude of response across cultivars. Mitchem *et al.* (1996) reported no changes in yield in plots where prohexadione calcium was applied midseason and decreases in yield as a result of early-pegging stage applications. Beam *et al.* (2002) reported increases in mechanically harvested yield due to prohexadione calcium application, attributing these increases to reduced pod loss as differences in maximum yield (sum of pods remaining in soil and on the soil surface and mechanically harvested pods) were not observed.

When averaged across cultivar and prohexadione calcium treatment, yield differences were noted between planting patterns (Table 1). Yields increased as a result of increasing seeding rate by 50% (218-twin yield 5980 kg/ha) in twin rows but there was no difference between 145-single and 145-twin (5410 and 5570 respectively) (data not presented). Jordan *et al.* (2001) reported higher yields in twin row compared to single row where virginia-type seeding rate was increased by 21% (from 120 to 145 kg/ha) in twin rows at several locations in North Carolina although there was no additional benefit to increasing twin row seeding rate by 58% (190 kg/ha) . Likewise, Sullivan (1991) reported yield increases in twin row versus single row where seeding rate was increased by 25%.

The year by cultivar interaction was significant (Table 1). In each year, VA 98R had the lowest yield numerically (data not presented). Mean yield rankings of cultivars across years were consistent with the exception of Perry. The numerically highest yielder was Perry in 2001 with yields significantly higher than VA 98 R and Wilson. In 2002, the yield of Perry was not significantly different than VA 98 R, the lowest yielding cultivar.

Conclusions

The results of this research demonstrate the potential for enhancing row visibility of virginia-type peanut through the application of prohexadione calcium at 50% row closure followed by an application 2 wk later. Delineating rows at the end of the season can be more difficult in twin-row planted peanut, when cultivars producing a flat canopy with excessive vegetative growth. Furthermore, the response to prohexadione calcium appears to be variable across cultivars, being greatest for those producing a flat canopy with excessive vegetative growth. Similar variation in cultivar response to prohexadione calcium has been previously reported (Culpepper *et al.*, 1997). While row visibility can be improved by prohexadione calcium in either single- or twin-row plantings, twin-row planting patterns may respond to a greater extent.

These results document the potential for yield reduction following prohexadione calcium application in virginia-type peanut irrespective of planting pattern and cultivar. Further research is needed to elucidate the mechanism of yield reductions. In a two-year, 12 location study, Jordan *et al.* (2000) reported numerical yield reductions of 210 kg/ha in 1997 and 100 kg/ha in 1998 in prohexadione calcium-treated plots in two years at TAREC in Suffolk, Virginia. Data from the fields at this location were not analyzed separate from the other 10 locations, however. As noted by Jordan *et al.* (2001), digging peanuts in relatively short rows utilized in small-plot research may not adequately account for the yield benefit a producer would derive from enhanced row visibility. Furthermore, yield in the current and previous research may have been confounded where only one digging date was utilized. The number of days needed to reach maturity varies across virginia-type cultivars (Swann, 2002). Although Culpepper *et al.* (1997) suggested that maturity of pods was hastened by prohexadione calcium, Beam *et al.* (2002) suggested that higher percentages of brown and black pods following mesocarp color determination may have been associated with greater pod retention following prohexadione calcium. Variations in maturity can result in significant changes in peanut yield and grade (Jordan *et al.*, 1998). More research is needed to further elucidate the mechanisms behind reported variable yield response to prohexadione calcium application.

Based on findings in the current study, there is no yield advantage to altering planting pattern of virginia-type peanut provided seeding rate is similar. However, increasing seeding rate from 145,000 seed/ha to 218,000 seed/ha in twin rows will likely enhance yield of virginia-type peanut.

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