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ARTICLE

Influence of Row Pattern and Prohexadione Calcium on Peanut (*Arachis hypogaea* L.) Maturity and Pod Distribution

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ABSTRACT

Many newer peanut cultivars are offering improved yield benefits but have larger canopies and have taken 10 or more days longer to reach maturity levels that were historically desired for optimal profitability of a crop. Prohexadione calcium growth regulator and twin row planting pattern have previously been individually reported to increase the amount of orange, brown or black pods compared to untreated alternatives. Twin row planting (i.e., planting two rows spaced 18-cm apart on 96-cm centers) has additionally been anecdotally associated with increased concentrations of pods nearer the taproot. Objectives of this work were to evaluate maturity development in single versus twin row planted peanuts and to evaluate how prohexadione calcium application would affect maturity development and pod distribution of both single and twin row planted peanut. Four cultivars were selected based on frequency of use in South Carolina then paired into experiments based on maturity requirements. Experiments were conducted at the Edisto Research and Education Center in Blackville, SC and the Pee Dee Research and Education Center in Florence, SC in 2021 and 2022. Peanut planted in twin row planting pattern yielded greater and had a higher percentage of orange, brown or black pods and total sound mature kernels. For FloRun 331 and Georgia-16HO in twin but not single rows, prohexadione calcium treatment increased the percentage of orange, brown or black pods. Although pod distribution effects for twin rows without and single rows with prohexadione calcium varied by maturity group, twin rows with prohexadione calcium exhibited pod distributions closer to the taproot than treated single rows. Twin row plots were associated with cooler ground temperatures than single rows, while the effects of prohexadione calcium on ground temperature varied between cultivars. Increased ground temperature was negatively correlated with pod maturity and main stem heights. Results from this work contribute to our understanding of potential benefits and variability across cultivars of the use of twin row planting pattern and prohexadione calcium treatment.

INTRODUCTION

Harvesting peanut (*Arachis hypogea* L.) when the highest percentage of pods are at optimal maturity is critical for farmers to attain the highest profit from their crop. For the past two decades, most growers have been using the hull scrape method in conjunction with methods akin to the maturity profile board, employing the correlation between pod maturity and mesocarp color to project optimal harvest time (Colvin *et al.*, 2014; Williams and Drexler, 1981). Predicting maturity in peanut can be difficult as peanut grows in an indeterminate manner, and how quickly a field matures is highly influenced by the amount of rainfall and the temperature during each growing season (Jordan *et al.*, 1998). Inverting a crop too early or too late leads to negative impacts on yield, market grade and profitability (Anco *et al.,* 2024; Jordan *et al.*, 1998, 2016; Mozingo *et al.*, 1991; Wright and Porter, 1991). Digging a crop prior to optimum maturity additionally leads to more immature peanuts entering storage facilities which may increase the risk of toxic mold (*Aspergillus flavus)* production (Sorenson *et al.*, 2015). Immature peanuts have also more commonly been reported to develop fruity off-flavors and less roasted peanut flavor after being cured (Sanders *et al.*, 1989; Sanders *et al.,* 1990). Conversely, when a field is dug too late, yield loss can increase due to mechanical or biological damage on overmature plants with weakened or diseased pegs (Chapin and Thomas, 2005; Sorenson *et al.*, 2015).

Many recently released cultivars offer growers yield benefits and improved disease resistance packages when compared to their predecessors (Anco and Hiers, 2022). However, many of these newer cultivars have also taken between 10 to 15 days longer to reach pod maturity levels comparable to those traditionally considered optimal (i.e., >75% mature pods, Boote 1982) to serve as a target for inversion (Anco *et al.*, 2024). This has in recent years resulted in newer cultivars Georgia-16HO (Branch, 2017), FloRun 331(Tillman, 2021), and TUFRunner 297 (Tillman, 2018) being given 150 or more days after planting (DAP) to approach pod maturity levels that older and earlier maturing cultivars Georgia-06G (Branch, 2007) and Georgia-09B (Branch, 2010) generally obtain in 140 or 135 DAP, respectively (Anco *et al.*, 2024).

There are several yield-limiting fungal diseases that can potentially cause significant economic losses in peanut production. In South Carolina, late leaf spot, caused by *Nothopassalora personata* ((Berk and M.A. Curtis) S.A. Kahn and M. Kamal), is the most consistent cause of economic losses among fungal pathogens (Anco, 2023). In order to manage late leaf spot, it is recommended that commercial growers initiate a fungicide application program beginning at 30 DAP and consisting of five to seven applications in 14-day intervals (Anco, 2023). When a growing season is extended into October and November to allow a maturing crop to reach optimal maturity, cooler temperatures and shorter days become more favorable for late leaf spot (Alderman and Nutter, 1994) and other late-season diseases (Davidson *et al.*, 1991), causing many producers to apply one more fungicide spray to extend protective coverage. If this late season fungicide spray could be avoided, it could increase revenue by ~$15 per hectare, not including equipment or labor. Another added risk of late season harvest is the increased risk of slower drying conditions and frost damage after inversion (Jordan *et al.*, 2019), both of which can lead to the crop being graded as segregation II. Segregation II peanuts have no visible *Aspergillus flavus* mold but contain over 3.49% damaged kernels, including physical, concealed (i.e. mold or decaying kernels) or freeze damage (American Peanut Shellers Association, 2020). If yield potential could be maintained while maturity was simultaneously hastened, this would save time and revenue for growers.

Peanuts are commonly planted in either single row (91 to 102 cm apart) or twin row arrangement (18 cm between two rows of peanuts, on 91 to 102 cm centers), often on an elevated bed (Lanier *et al.*, 2004; Sorenson *et al.*, 2007; Wehtje *et al.*, 1984). Planting in twin rows versus single rows increases the plant population from 19 seeds per meter in single rows to 23 seeds per meter spread between two rows, which effectively decreases the intra-row competition while also increasing plant populations (Sorenson *et al.*, 2004). Previous research has consistently reported a significant yield advantage when peanuts are planted in a twin row arrangement (Lanier *et al.*, 2004; Nuti *et al.*, 2008; Tillman *et al.*, 2006; Tubbs *et al.*, 2011; Wehtje *et al.*, 1984). The amount of thrips (e.g., *Frankliniella fusca* [Pergande] and *F. occidentalis* [Hinds]) injury and tomato spotted wilt (TSW) infection that typically follows thrips infestations has repeatedly been reported to be reduced in twins compared to single rows (Baldwin *et al.*, 2001; Culbreath *et al.*, 2008; Tubbs *et al.*, 2011). Several studies have also reported higher market grades (total sound mature kernels; TSMK) when peanut is planted in twin rows (Lanier *et al.*, 2004; Sorenson *et al.*, 2004, 2007).

Twin row configuration reduces the time normally required for peanut to lap the row. This earlier shading of the ground aids in reducing soil geocarposphere temperatures. Davidson *et al.*, (1991) reported a reduction in premium priced kernels when severe drought and high geocarposphere temperatures led to a delay in fruit initiation; additionally, high geocarposphere temperatures were typically associated with a smaller canopy, reduced yield, and poorer quality. A delay in fruit initiation can lead to an increased limb crop (addition of small pods away from the taproot) instead of a taproot crop (addition of large pods near the taproot) (Davidson *et al.*, 1991). Being set first, a taproot crop will mature earlier than a limb crop. Encouraging more of a taproot focused crop and less of a limb crop potentially may hasten maturity and produce a more uniform maturity, due to optimal maturity applying more to one crop rather than the balance between two crops (i.e., taproot versus limb crop) that have begun to be set at different points in the season. Twin row planting has anecdotally been associated with more of a taproot crop compared to single rows. However, the distribution of pods produced in association with a taproot versus limb crop and the maturity development of produced pods have not been quantitatively reported for twin versus single row planting configurations, and formal quantitative definitions delineating taproot versus limb crops are lacking.

Peanut has been reported to produce more vegetative growth than necessary to reach maximum pod yield, where nutrients and photosynthate are directed to vegetative growth instead of developing pods (Mitchem *et al.*, 1996). Excessive vine growth leads to decreased disease resistance (Phipps, 1995), and a dense canopy will inhibit pesticides from contacting lower leaves (Mitchem *et al.*, 1996). A larger canopy has been reported to decrease inversion and harvest efficiency (Beam *et al.*, 2002). Classic runner type peanuts, such as the widely used cultivar Georgia-06G, grow a smaller and more compact canopy. Virginia market types like Bailey II characteristically exhibit a larger and more robust canopy which intertwines among adjacent rows and can make digging without GPS assistance more difficult due to reduced visual distinction of rows (Beam *et al.*, 2002). Plant growth regulators have been studied and employed for decades to manage excessive vine growth in peanut, with most studies having focused on Virginia-types due to their larger canopies.

Prohexadione calcium (a calcium salt of 3,5-dioxo-4 propionylcyclohexanecarboxylic acid) is a plant growth regulator used in the production of peanut, apple (*Malus x domestica* Borkh.), pear (*Pyrus communis* L.), cherry (*Prunus avium* L.*)*, grain sorghum [*Sorghum bicolor* (L.) Moench], oilseed rape (*Brassica napus* L.), rice (*Oryza sativa* L.), tomato (*Solanum lycopersicum* L.), and wheat (*Triticum aestivum* L.) to decelerate the rate of vegetative growth (BASF, 2012; Byers and Yoder, 1999; Grossman *et al.*, 1994; Lee *et al.*, 1998; Mitchem *et al.* 1996; Nakayama *et al.*, 1992; Yamaji *et al.*, 1991). Prohexadione calcium inhibits the biosynthesis of plant hormone gibberellin, which causes a reduction in shoot growth and decreased cell elongation (BASF, 2012; Grossman *et al.*, 1994). Prohexadione calcium inhibits gibberellin biosynthesis by blocking kaurene oxidase and increases the level of abscisic acid and cytokines in certain species (Grossman *et al.*, 1994).

In the last decade, breeding programs have released runner market type peanut cultivars with larger canopies, producing a need for managing excessive vine growth. More recent studies have reported yield improvement and canopy size reduction on runner type cultivars following the application of prohexadione calcium at a 0.75× rate (Monfort *et al.*, 2021; Studstill *et al.*, 2020). Early studies of prohexadione calcium reported a significant increase in the earliness of Virginia type cultivars. Culpepper *et al.* (1997) reported a 9% increase, while Mitchem *et al.* (1996) reported a 19% increase in the percent of orange, brown or black pods near harvest when treated with prohexadione calcium. Nevertheless, cultivars that were used in those studies (AT VC 1, NC 9, NC 10C, NC-V 11, and VA-C 92R) are no longer commercially grown. Furthermore, pods collected for maturity determination in both of these studies were obtained following mechanical inversion by the digger-shaker-inverter. Consequently, this could have confounded measurements of the magnitude of response of maturity development as a result of prohexadione calcium application since it introduces the potential for non-constant pod loss as a function of varying canopy size and corresponding resistance to flow as dug peanut pass through the digger and interface with the star wheels.

Information regarding the effect of prohexadione calcium on the maturity of newer cultivars is lacking. Additionally, most research that has involved prohexadione calcium has either evaluated single row planting or Virginia market type peanut. Therefore, research was conducted to evaluate the combined and independent effects of prohexadione calcium and row pattern on maturity development and pod distribution of peanut in South Carolina, specifically with respect to newer runner cultivars.

MATERIALS AND METHODS

Field experiments were conducted during the 2021 and 2022 growing seasons in different fields at Clemson University's Edisto Research and Education Center (EREC; 33.3648N, 81.3298W) in Blackville, SC on a Barnwell loamy sand (fine-loamy, kaolinitic, thermic Typic Kanhapludults; irrigated) and at Pee Dee Research and Education Center (PDREC; 34.2898N, 79.7388W) in Florence, SC on a Norfolk loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudults; dryland). Plot dimensions consisted of four rows wide (3.9 m) by 30.5 m in length, which were separated into two yield rows and two traffic rows. Yield rows were used for data collection while traffic rows were used to drive over to apply prohexadione calcium and maintenance agrochemicals. A split plot experimental design was utilized, with the interaction of row pattern and growth regulator application as the main plot and cultivar as the sub plot. Treatments were replicated five (EREC: 2021 and 2022; PDREC: 2021) or four times (PDREC: 2022). Single rows were spaced 96-cm apart and planted at a rate of 19 seeds per m, while twin rows were spaced 18-cm apart on 96-cm centers and planted at a rate of 23 seeds per m based on planter settings.

Three runner-type cultivars and one Virginia type cultivar were selected based on frequency of use by SC farmers and desired optimal maturity requirements. Cultivars were then paired into separate experiments based on maturity – earlier maturing cultivars (E, i.e., ~138 to 140 DAP) and later maturing cultivars (L, i.e., ~145 to 150 DAP) (Anco *et al.* 2021). In 2021, planted cultivars were Bailey II (E), Georgia-06G (E), FloRun 331 (L) and Georgia-16HO (L). The later maturing experiment was planted at EREC on 10 May and earlier maturing experiment was planted 11 May. All cultivars were planted at PDREC on 1 June. In 2022, cultivars included Emery (E), Georgia-06G (E), FloRun 331 (L) and Georgia-16HO (L); EREC was planted on 5 May, and at PDREC twin rows were planted on 18 May and single rows were planted the following day, 19 May.

In 2021, TSW incidence was evaluated at 69 (E) and 70 (L) DAP (19 July) at EREC and at 65 DAP (5 August) at PDREC. In 2022, TSW incidence was evaluated at 74 DAP (18 July) at EREC and at 61 (single rows) and 62 (twin rows) DAP (19 July) at PDREC. Incidence of TSW (i.e., percent of symptomatic length from two rows) was rated using methodology previously detailed in Haynes *et al.* (2019). Late leaf spot (LLS) was measured as percentage incidence prior to inversion following its development in the field where applicable. If any defoliation from LLS was seen, it was recorded as a percentage as well. Early leaf spot was not present.

Canopy temperature at ground level was measured in 15 minute intervals using RC-5 USB temperature loggers (i.e., three replications per experiment). Loggers were installed at approximately 35 to 40 DAP, once the crop was large enough to begin shading the ground. Loggers were individually placed into a plastic bag to protect them from the elements, then installed approximately 25 cm off-center from the planted row. Daytime temperatures were approximately defined as those occurring from 6:00 am to 7:00 pm. When 50% of the lateral vines from adjacent rows began touching (i.e., 50% row lap), prohexadione calcium was applied at 0.75× the label rate, with a second application applied 14 days later, using a tractor mounted boom sprayer with two DG 8002 nozzles/row delivering 140 L/ha at 345 kPa. Per the prohexadione calcium label, crop oil concentrate and ammonium sulfate were applied with the growth regulator at respective rates of 2.33 L/ha and 1.17 L/ha.

Following prohexadione calcium application, row visibility was visually assessed using a 1 to 10 scale, with 1 being a flat canopy and 10 being a triangular canopy (Mitchem *et al.*, 1996). Main stem height in cm from four plants per plot were measured in addition to row visibility. In 2021, main stem heights and row visibility was assessed at 139 (E) and 140 (L) DAP (27 September) at EREC and 139 DAP (18 October) at

PDREC. In 2022, row visibility was assessed at 134 DAP (16 September) at EREC and 128 (twin rows) and 127 (single rows) DAP (23 September) at PDREC. Plots were dug based on pod mesocarp color (William and Drexler, 1981) at a time reasonable for each experiment. Peanut production management practices followed Clemson University Extension recommendations (Anco *et al.*, 2021).

In 2021, plots were inverted on 20 October (PDREC), 28 September (EREC E group), and 5 October (EREC L group); then combined on 18 November (PDREC), 11 October (EREC E group) and 18 October (EREC L group). In 2022, plots were inverted on 6 October (PDREC), 23 September (EREC E group), and 3 October (EREC L group); then combined on 19 October (PDREC), 28 September (EREC E group) and 17 October (EREC L group). Pod yield (kg/ha) data were collected from two rows per plot with a Hobbs 2-row combine using load cells mounted to the weight basket of the combine. A 500-g subsample of peanuts was collected from plots located at EREC and graded according to USDA standards. Grade and pod yield data was then used to calculate economic value, calculated as treatment net loan value × treatment yield – treatment costs. Net loan values were calculated using the following formulae (Haynes *et al.*, 2019; USDA FSA 2019):

Runner net loan value =

%TSMK × Loan Rate per %TSMK + %OK × Loan Rate per %OK - deductions

Virginia net loan value =

%TSMK × Loan Rate per %TSMK + %OK × Loan Rate per %OK + %ELK × Loan Rate per %ELK - deductions

where TSMK is total sound mature kernels, OK is other kernels, and ELK is extra-large kernels. Loan rates for 2021 were $5.308 (% TSMK for runner market types), $5.414 (% TSMK for Virginia market types), $1.544 (% OK), and $0.386 (% ELK) (USDA FSA 2021). Loan rates for 2022 were $5.281 (%TSMK for runner market types), $5.387 (% TSMK for Virginia market types), $1.544 (% OK), and $0.386 (% ELK) (USDA FSA 2022). Deductions were $0.88 for each percent of sound splits over 4%. Listed loan rates and deductions correspond to pod yield in units of 1,000 kg/ha. Treatment costs were obtained from the 2022 South Carolina Agronomic Crop Production Budget (https://blogs.clemson.edu/sccrops/files/2022/03/Production-Guide-2022-web-version.pdf). Local treatment cost for prohexadione calcium was $40.31 per hectare for both twin and single row planting pattern. Inoculant cost per hectare was $46.68 and $93.37 for single and twin row pattern, respectively. Phorate cost per hectare was $41.57 and $53.06 for single and twin rows, respectively.

Image Analysis

To measure maturity development, pods from six plants per plot at EREC were collected from peanut plants that were manually dug by hand from traffic rows, and the pod exocarp was removed by placing the sample in a rotating bucket then pressure washing the sample for 6-8 minutes to expose the pod mesocarp color. The sample was then transferred to a large tray and busted pods, rocks, pegs, and other foreign material were manually removed. An image was then taken of each sample to categorize pods by mesocarp color (i.e., % white, yellow, orange, brown and black pods) using Batch Load Image Processor v1.1 (Anco *et al.*, 2024; BLIP; Kirk, 2020; Renfroe-Becton *et al.*, 2022).

Limb crop versus taproot crop distribution was determined at inversion by photographing ten inverted peanut plants per plot at EREC. Photographs were then processed using Peanut Limb Crop Analyzer (Kirk, unpublished), which analyzed the distribution of the pods from the center of the taproot to calculate radii at increasing % pod pixel mass per photograph. To examine pod pixel distribution densities across a range of pixel masses, pod pixel radius ratios per image were calculated as the proportion of pod pixel radii at 10%-intervals from 10 to 90% of the corresponding total pod pixel radius (upper limit of ~98.5%) / total pod pixel radius.

On-Farm Trials

During both 2021 and 2022, on-farm experiments were conducted. In 2021 there was one field trial located in Orangeburg County, and in 2022 there were three field trials located in Bamberg County. In 2021, cultivar TUFRunner 297 was planted in twin row arrangement, whereas in 2022, cultivar Georgia-16HO was planted in twin row arrangement at all three fields. Plots were 29 m wide × 244 to 396 m in length. Treatments were replicated three times, arranged in a randomized complete block, and consisted of prohexadione calcium at a 0.75× label rate and a non-treated control in all experiments. Yield and maturity information from 2021 was obtained from 2-m sections of inverted windrow (i.e., one sampling time following inversion), in addition to total pooled treatment yield obtained from the buying point (i.e., total strip plot area of 2.8 and 3.0 ha for prohexadione and untreated plots, respectively). In 2022, samples of three to five plants per field per treatment were manually dug in biweekly intervals to track maturity development in the weeks leading up to digging. Maturity samples were then processed as previously described.

Data Analysis

Treatment effects for TSW, row visibility, main stem heights, maturity, yield, grade and economic value were analyzed using generalized linear mixed modeling (GLIMMIX procedure) with SAS 9.4 (SAS Institute, Cary, NC). Replication was considered a random effect. The random effect of the main plot error term was examined but removed from the model due to lack of model improvement. Analyses conducted across experiments additionally included random effects for experiment (i.e., location-year) and replication within experiment. Fixed effects included cultivar, row pattern, prohexadione calcium application, and interactions thereof. Response variable data were modeled using a beta (pod maturity), Gaussian (TSMK), or negative binomial (row visibility, plant height, TSW incidence, yield, and economic value) distribution, with distributional appropriateness assessed through residual plots and information criterion (i.e., Akaike's Information Criterion). To account for day-to-day variation during continued sampling of each logger while deployed in field plots, the model for average daytime canopy ground temperature incorporated day of measurement into the residual error term (i.e., residual error term = date × pattern × prohexadione calcium application × cultivar × replicate), in addition to a random effect term for experiment and a gamma distribution. In addition to the fixed effects listed for earlier-mentioned models, models for temperature included a term for the approximate point of 50% rows lapped to allow for examination of effects and interactions before and after this stage of growth. Pod pixel ratio (i.e., pod distribution) data were analyzed using glmmTMB (Brooks *et al.* 2017) in R 4.3.3 (R Core Team 2023) according to a beta distribution where fixed effects included cultivar, prohexadione calcium application, pattern, proportion of total pod pixels and interactions thereof. Random effects for pod pixel ratio models included the interaction of replicate within experiment and a term for proportion of total pod pixels within each photograph per experiment as specified according to an unstructured or reduced rank covariance structure, respectively. Estimated treatment means were separated at α = 0.10 according to the method of Fisher's protected LSD (models analyzed with GLIMMIX in SAS) or Benjamini-Hochberg (i.e., false discovery rate; Benjamini and Hochberg 1995) (models analyzed with glmmTMB in R). Variable correlations were examined using Spearman correlation coefficients with the CORR procedure. Linear regression of Spearman correlation coefficients with treatment average main stem height was conducted using glmmTMB.

RESULTS

Early maturing experiment

Incidence of TSW was significantly greater among single rows compared to twins at EREC in both 2021 and 2022 (P = 0.0051 and P = 0.038, respectively). Conversely, no significant differences between row patterns or cultivars were seen at PDREC in either year. Tomato spotted wilt incidence of all treatments was less than 5%, with pooled results across years reported in Table 1. Row visibility was significantly greater following the application of prohexadione calcium at 0.75× (P = 0.0005), indicating prohexadione calcium made the canopy more triangular. Though single row planting pattern often had a numerical advantage in row visibility over twin rows, this was only significant in EREC in 2021 (P = 0.0085). From the pooled data, main stem heights of plots treated with prohexadione calcium were significantly shorter than those of untreated plots (32.7 vs. 35.6 cm, P < 0.0001). Main stem heights of twin rows (36.6 cm) were taller than those of single rows (31.8 cm) (P < 0.0001), and Virginia cultivars were taller than Georgia-06G (38.0 vs. 30.6 cm, P < 0.0001).

Table 1. Influence of row pattern on the percentage of spotted wilt incidence from experiments conducted in 2021 and 2022 at the Edisto Research and Education Center (EREC) and the Pee Dee Research and Education Center (PDREC).

	EREC[a]		PDREC	
	Single	Twin	Single	Twin
Early group	2.9 a	1.6 b	2.1	2.3
Later group	2.9 a	1.8 b	3.4	3.1

[a] Means within a row within the same location followed by the same letter are not significantly different according to Fisher's protected-LSD at α = 0.10.

In 2021 maturity samples were dug at 121, 133 and 140 DAP. Twin row planting pattern exhibited a significantly greater percentage of orange, brown, or black (OBB) pods when compared to corresponding single row plots (57 vs. 52%, respectively, P = 0.0393). In 2022, samples were dug at 125, 132 and 144 (Georgia-06G only) DAP. In 2022, no treatment effects significantly influenced the percentage of OBB pods. When results were pooled across years, twin rows had a significantly greater percentage of OBB pods than single rows for Georgia-06G (66 vs. 60%, respectively, P = 0.0014) but not Virginia cultivars (67 vs. 65%, respectively, P = 0.2750). Maturity during the latter two assessments (> 130 DAP) were greater than that of the first (121 to 125 DAP) (P < 0.0001, Table 2).

When canopy temperature was analyzed, plots treated with prohexadione calcium overall had a significantly lower average daytime temperature than untreated plots (30.0 vs. 30.3 C, respectively, P = 0.0007). Single row plots had a greater mean daytime temperature than twins by ~0.6 C (P < 0.0001). Across the pooled cultivar data, single rows with or without prohexadione calcium had warmer canopies than corresponding twin row untreated plots (~30.5 vs. 30.1 C, respectively; row pattern × growth regulator P = 0.0004), with twin rows with prohexadione calcium treatment in turn exhibiting cooler temperatures (~29.4 C). Within the Georgia-06G data (P < 0.0001), single rows with prohexadione calcium (30.9 C) were warmer than untreated single rows (30.4 C), both of which were not different from untreated twin rows (~30.6 C), all of which being warmer than treated twin rows (29.5 C). Virginia cultivar average daytime temperatures (P < 0.0001) exhibited a slightly different response, as twin rows with or without prohexadione calcium treatment (~29.6 C) had the coolest temperatures followed by single rows with prohexadione calcium treatment (30.0 C) which were in turn cooler than untreated single rows (30.4 C).

Prohexadione calcium did not significantly affect yield at either location during either year. Twin row planted plots yielded significantly greater than single row plots when data were combined across years and locations at P = 0.0319. In 2021 at PDREC, the experimental field was heavily defoliated by LLS, in which single row planted plots had a significantly greater pod yield than twin rows at P = 0.0186 (3799 vs. 3352 kg/ha). Individual year results and combined results across years and locations can be found in Table 3.

Regardless of cultivar, twin row planted plots with no prohexadione calcium application had pod sets distributed significantly closer to the taproot than treated twin rows, both of which were closer distributed than single rows with prohexadione calcium treatment (< 60% pod pixels). Pod distributions of single rows without treatment were not different from single rows with treatment, were wider than that of twin rows without prohexadione calcium (< 60% pod pixels), and were 0.036 wider than treated twin rows from 50 to 60% pod pixels (Figure 1; prohexadione calcium application × pattern × % pod pixels interaction P = 0.0306).

Table 2. Influence of row pattern and prohexadione calcium application on % orange, brown or black (OBB) pod maturity from earlier maturing cultivars from pooled experiments conducted in 2021 and 2022.

Cultivar	Sample DAP	Row pattern	PC[b]	OBB %[c]
Georgia-06G	122	Single	-	46
			+	49
		Twin	-	62
			+	53
	133	Single	-	66
			+	66
		Twin	-	68
			+	71
	140	Single	-	65
			+	67
		Twin	-	74
			+	70
Virginia cultivar[a]	122	Single	-	60
			+	60
		Twin	-	62
			+	59
	133	Single	-	61
			+	71
		Twin	-	72
			+	72
	140	Single	-	70
			+	67
		Twin	-	68
			+	71
Pooled	122	Pooled	Pooled	57 b
	133			68 a
	140			70 a

[a] Virginia cultivar = Bailey II (2021) or Emery (2022).

[b] PC = prohexadione calcium, "+" indicates treatments with PC application, "-" indicates treatments without PC application.

[c] Means within a column followed by the same letter are not significantly different according to Fisher's protected-LSD at $\alpha = 0.10$. Mean separations were performed within each cultivar.

Twin row planting arrangement had a significantly greater percentage of TSMK than single row planted plots (69 vs. 67%, respectively, P = 0.0040). Row pattern was the only effect to have a significant influence on TSMK. At EREC in 2021, cultivar Emery planted in single rows with prohexadione calcium application had a significantly greater economic return than corresponding single rows with no prohexadione calcium application ($936 vs. $832 per hectare, respectively, at P = 0.0921). Similarly, cultivar Georgia-06G planted in single rows without prohexadione calcium was valued significantly higher than corresponding plots treated with prohexadione calcium ($929 vs. $832 per hectare, respectively). Additionally in 2021, twin row planted plots had a significantly greater economic value than single row plots ($1080 vs. $875 per hectare, respectively, at P < 0.0001), though this observation did not continue in 2022 when no treatment effects significantly affected economic return. Across the combined data, twin row planted plots exhibited significantly greater economic value than single rows ($1321 vs. $1124 per hectare, respectively, at P < 0.0001). Remaining treatment effects did not significantly affect economic return.

Table 3. Influence of row pattern and prohexadione calcium application on pod yield (kg/ha) from earlier maturing cultivars from experiments conducted in 2021 and 2022 at the Edisto Research and Education Center (EREC) and the Pee Dee Research and Education Center (PDREC).

Cultivar	Row pattern	PC[b]	EREC 2021[c]	EREC 2022	PDREC 2021	PDREC 2022	Combined
Georgia-06G	Single	-	3481 b	5252	4452	3835	4254
		+	3416 b	4889	4083	3929	4073
	Twin	-	4148 a	6271	3621	4274	4459
		+	4165 a	5630	3940	4464	4502
Virginia cultivar[a]	Single	-	3518 b	5074	3534	3772	3925
		+	3917 ab	4656	3229	4711	4075
	Twin	-	4506 a	5087	2734	4295	4070
		+	4366 a	5293	3189	4461	4255
Pooled	Single	Pooled	3192 b	4963 b	3795 a	4044 b	4080 b
	Twin		4294 a	5553 a	3339 b	4371 a	4318 a
Pooled	Pooled	-	3889	5400	3533	4037 b	4171
		+	3949	5103	3588	4381 a	4222

[a] Virginia cultivar = Bailey II (2021) or Emery (2022).

[b] PC = prohexadione calcium, "+" indicates treatments with PC application, "-" indicates treatments without PC application.

[c] Means within a column followed by the same letter are not significantly different according to Fisher's protected-LSD at $\alpha = 0.10$. Where not pooled, mean separations were performed within each cultivar.

Pod OBB maturity was negatively correlated with Temp (ρ = ~ -0.54) and Tmax36p (ρ = -0.44 to -0.53) and positively correlated with main stem height (ρ = 0.65 to 0.54), TSMK (ρ = 0.21 to 0.71), and yield (ρ = 0.67 to 0.52) for both Georgia-06G and Virginia cultivars. Main stem heights were negatively correlated with Temp and Tmax36p, with this being slightly stronger for Virginia cultivars (Table 4). Pod pixel radius ratios (70% pixels) were somewhat negatively correlated with examined temperature variables (ρ = -0.21 to -0.26) for Georgia-06G but somewhat positively correlated for Virginia cultivars (ρ = ~ 0.22). Pod ratios were also negatively associated with TSMK for Georgia-06G (ρ = ~ -0.31) but not for Virginia cultivars. Virginia cultivar pod ratios were somewhat negatively correlated with pod yield (ρ = -0.25 to -0.30) and slightly negatively associated with main stem heights (ρ = -0.17 to -0.19). Examined temperature variables were more strongly negatively correlated with TSMK for Virginia cultivars than for Georgia-06G (ρ = ~ -0.7 and ~ -0.3, respectively). Stem heights and pod yield were also more strongly correlated with TSMK for Virginia cultivars than for Georgia-06G (ρ = 0.59 and 0.60 compared to 0.37 and 0.25, respectively). Georgia-06G main stem heights were positively correlated with pod yield at ρ = 0.47, whereas this was not significant among Virginia cultivars. Pod yield for Georgia-06G was somewhat negatively correlated with examined temperature variables (ρ = -0.26 and -0.33).

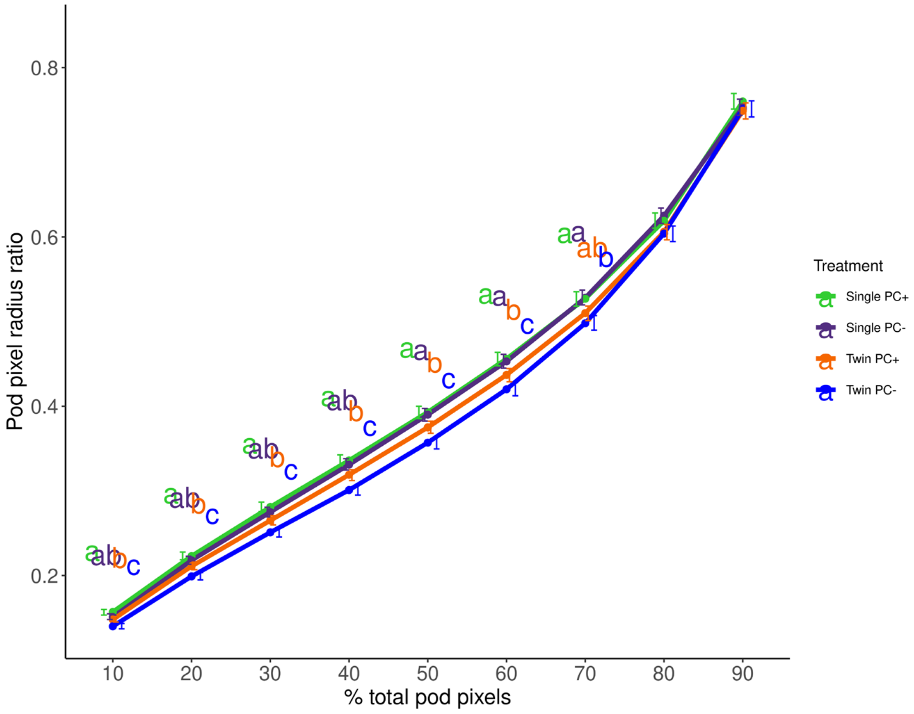

Figure 1. Influence of row planting pattern and prohexadione calcium (PC) application ("+" = applied, "-" = not applied) on the ratio of radii corresponding to % pod pixels : radii of total pixels among pooled earlier maturing cultivars. Estimated means at the same % total pod pixels followed by different letters are significantly different according to the method of Benjamini-Hochberg at α = 0.10.

Later maturing experiment

Incidence of TSW was significantly greater in single rows when compared to twins at EREC in 2021 and at PDREC in 2022 (P = 0.0011 and 0.0040, respectively). There were no significant differences between row patterns at PDREC in 2021 or at EREC in 2022. In 2021 at PDREC, cultivar Georgia-16HO had significantly greater TSW incidence than FloRun 331 (5.7 vs. 3.5, respectively, P = 0.0025). Conversely, in 2022 at EREC cultivar FloRun 331 had a significantly higher incidence than Georgia-16HO (3.4 vs. 2.0, respectively, at P = 0.0437).

Row visibility was significantly greater following application of prohexadione calcium at P = 0.0010. Cultivar FloRun 331 had a less visibly distinguishable canopy than Georgia-16HO (3.75 vs. 4.69; P = 0.0010). Additionally, FloRun 331 had a significantly taller average main stem height than Georgia-16HO (31.3 vs. 28.6 cm, P < 0.0001), potentially accounting for reduced row visibility. Main stem height was found to be ~3.5 cm shorter in both single and twin row plots following treatment with prohexadione calcium (P < 0.0001). Twin rows exhibited greater main stem lengths compared to single rows (32.3 vs. 27.8 cm, P < 0.0001).

When maturity development was evaluated at EREC in 2021, plots were sampled at 121, 133, and 140 DAP. The greatest percentages of OBB pods were found among samples pulled at 140 DAP (59%, P < 0.0001). Single row plots had a higher percentage of OBB pods than corresponding twin row plots at 133 DAP (46 vs. 37%, respectively, P = 0.0125), but when maturity was evaluated again at 140 DAP, there was no significant difference between single and twin row plots (58 vs. 59% OBB, respectively). In 2022, maturity was sampled at 133, 144 and 158 DAP. In 2022, twin row plots overall had a greater percentage of OBB pods compared to single rows at 133 DAP (83 vs. 75%, respectively, P < 0.0001). The highest percentage of OBB pods was detected at the 144 DAP sampling time (86 vs. 79% at 133 DAP and 81% at 158 DAP, P = 0.0020). Plots treated with prohexadione calcium had a greater percentage of OBB pods in 2022 compared to untreated plots, regardless of row pattern or DAP (83 vs. 79%, respectively, P = 0.0090). When maturity results were pooled across years, twin row plots were more mature than single row plots (64 vs. 59%, respectively, P = 0.0209, Table 5). Twin row plots with prohexadione calcium treatment exhibited a greater percentage of OBB pods than untreated twins or single rows with or without prohexadione calcium (P = 0.0366, Table 5). Across sampling dates, plots exhibited the greatest levels of maturity at 141 to 147 DAP. The interaction of growth regulator × sample date was significant (P = 0.0075), whereby prohexadione calcium treated plots at 133 DAP exhibited pod maturity greater than corresponding untreated plots at the same timing (65 vs. 58%) (Table 6). Treatment interactions did not significantly vary by cultivar (P > 0.15).

Table 4. Spearman correlation coefficients of variable[a] measurements for Georgia-06G (above the diagonal) and Virginia cultivars (below the diagonal).

	OBB[b]	Temp	Tmax36p	Sh	ratio50	ratio60	ratio70	TSMK	Yield
OBB		-0.53 *** (92)	-0.44 *** (92)	0.65 *** (160)	0.10 (156)	0.07 (156)	0.08 (156)	0.21 *** (160)	0.67 *** (144)
Temp	-0.55 *** (95)		0.96 *** (180)	-0.46 *** (180)	-0.16 (92)	-0.14 (92)	-0.26 ** (92)	-0.24 ** (92)	-0.26 *** (180)
Tmax36p	-0.53 *** (95)	0.99 *** (180)		-0.49 *** (180)	-0.14 (92)	-0.11 (92)	-0.21 ** (92)	-0.26 ** (92)	-0.33 *** (180)
Sh	0.54 *** (159)	-0.63 *** (179)	-0.64 *** (179)		0.04 (156)	0.00 (156)	0.02 (156)	0.25 *** (160)	0.47 *** (288)
ratio50	0.04 (151)	0.11 (91)	0.09 (91)	-0.19 ** (151)		0.97 *** (156)	0.87 *** (156)	-0.31 *** (156)	0.00 (140)
ratio60	0.06 (151)	0.11 (91)	0.10 (91)	-0.17 ** (151)	0.98 *** (151)		0.93 *** (156)	-0.31 *** (156)	-0.02 (140)
ratio70	-0.03 (151)	0.23 ** (91)	0.22 ** (91)	-0.19 ** (151)	0.87 *** (151)	0.92 *** (151)		-0.30 *** (156)	-0.01 (140)
TSMK	0.71 *** (159)	-0.71 *** (95)	-0.67 *** (95)	0.59 *** (159)	0.11 (151)	0.09 (151)	-0.04 (151)		0.37 *** (144)
Yield	0.52 *** (143)	0.14 * (179)	0.16 ** (179)	-0.05 (287)	-0.25 *** (135)	-0.26 *** (135)	-0.30 *** (135)	0.60 *** (143)	

[a] OBB = % orange, brown, or black pod maturity; Temp = average daytime canopy ground temperature; Tmax36p = proportion of days with maximum daytime canopy ground temperature > 36 C; Sh = main stem height; ratio50-70 = proportion of total pod pixel radius represented by the radius corresponding to 50%, 60%, or 70% of pod pixels; TSMK = % total sound mature kernels; Yield = pod yield (kg/ha).

[b] * = P < 0.1, ** = P < 0.05, *** = P < 0.01. Numbers in parentheses = n.

Table 5. Influence of row pattern and prohexadione calcium application on % orange, brown or black (OBB) pod maturity from later maturing cultivars from pooled experiments conducted in 2021 and 2022.

Cultivar	Row pattern	PC[a]	OBB %[b]
Pooled	Single	-	60 b
		+	58 b
	Twin	-	61 b
		+	66 a
Pooled	Single	Pooled	59 b
	Twin		64 a
Pooled	Pooled	-	61
		+	62

[a] PC = prohexadione calcium, “+” indicates treatments with PC application, “-” indicates treatments without PC application.

[b] Means within a column followed by the same letter are not significantly different according to Fisher’s protected-LSD at $\alpha = 0.10$.

Table 6. Influence of digging date and prohexadione calcium application on % orange, brown or black (OBB) pods from later maturing cultivars from pooled experiments conducted in 2021 and 2022.

Cultivar	Sample DAP [a]	PC[b]	OBB %[c]
Pooled	121	-	47 e
		+	36 f
	133	-	58 d
		+	65 c
	141_147	-	73 ab
		+	75 a
	158	-	63 cd
		+	69 bc
Pooled	121	Pooled	41 c
	133		62 b
	141_147		74 a
	158		66 b

[a] Samples collected at 141 (2021) and 147 (2022) days after planting (DAP) were grouped for the pooled data.

[b] PC = prohexadione calcium, "+" indicates treatments with PC application, "-" indicates treatments without PC application.

[c] Means within a column followed by the same letter are not significantly different according to Fisher's protected-LSD at $\alpha = 0.10$.

Average daytime temperature was greater in single row plots than corresponding twin row plots (29.6 vs. 29.1 C, respectively, $P < 0.0001$). The interaction of row pattern and cultivar was also significant ($P = 0.0034$), with either cultivar planted in twin rows having cooler temperatures (~29.1 C) compared to single rows of FloRun 331 (29.4 C) followed by Georgia-16HO (29.8 C). Temperatures additionally varied at the row pattern × prohexadione calcium × cultivar level with regard to approximate dates of 50% of row having lapped ($P = 0.0495$). Differences were not evident prior to rows lapping ($P = 0.8928$) for FloRun 331 but were recorded following rows lapping ($P = 0.0112$) where twin rows without prohexadione calcium application were cooler than single rows with or without prohexadione calcium treatment (25.9 vs. ~26.5 C, respectively); temperatures for FloRun 331 planted to twins with prohexadione calcium (26.3 C) were not different compared to twins or singles without application. Georgia-16HO daytime ground temperatures were different both prior to and following 50% rows lapping ($P < 0.0005$). Prior to rows lapping, single rows were overall warmer than twin row configurations. Following rows lapping, a similar pattern was evident as for FloRun 331, with twins exhibiting cooler temperatures (~26 C) than single rows, in addition to smaller single row canopies associated with prohexadione calcium treatment having been warmer than those without treatment (27.2 vs. 26.7 C, respectively).

Across pooled pod density results from 2021 and 2022, Georgia-16HO treated with prohexadione calcium exhibited a more taproot-focused pod set (0.01 to 0.04 smaller ratio from 10 to 90% pod pixels) than when prohexadione calcium was not applied, while FloRun 331 showed an inverse and smaller-magnitude (i.e., differences of 0.013 to 0.018) relationship across a narrower range of pod pixels (10 to 60%) (Figure 2; cultivar × prohexadione calcium application × % pod pixels interaction $P = 0.0893$). Additionally, twins with or singles without prohexadione calcium had the most taproot-focused crop from 20 to 70% of pod pixels, followed by singles with prohexadione calcium (i.e., 60 to 70% pod pixels), while twins without prohexadione calcium had the most limb-set crop (> 60% pod pixels, Figure 3; prohexadione calcium application × pattern × % pod pixels interaction $P < 0.0001$). Pod ratios for twin rows without prohexadione calcium were ~0.05 larger than twin rows with or single rows without treatment from 60 to 90% pod pixels.

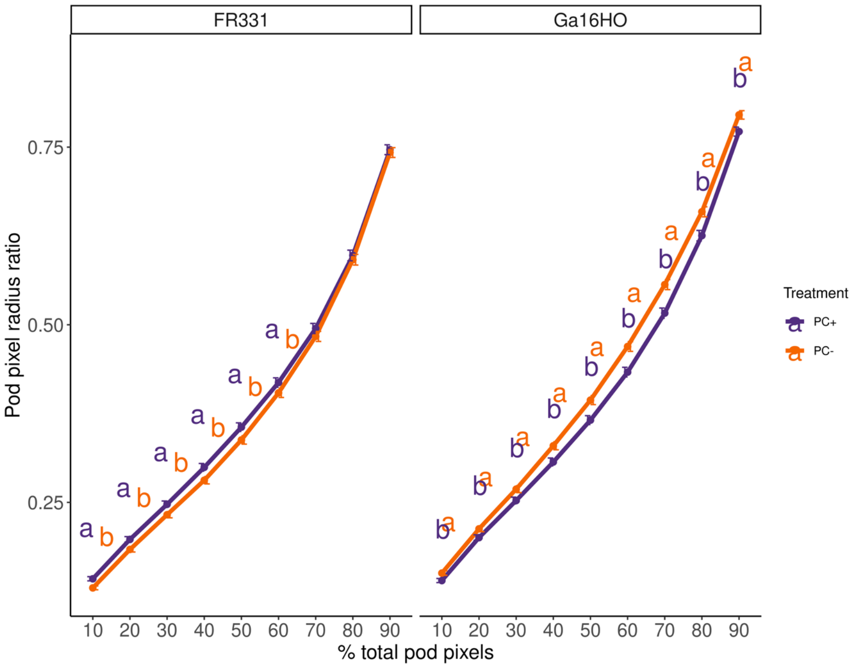

Figure 2. Influence of prohexadione calcium (PC) application ("+" = applied, "-" = not applied) on the ratio of radii corresponding to % pod pixels : radii of total pixels in individual later maturing cultivars. FR331 = FloRun 331; Ga16HO = Georgia-16HO. Estimated means at the same % total pod pixels per cultivar followed by different letters are significantly different according to the method of Benjamini-Hochberg at α = 0.10.

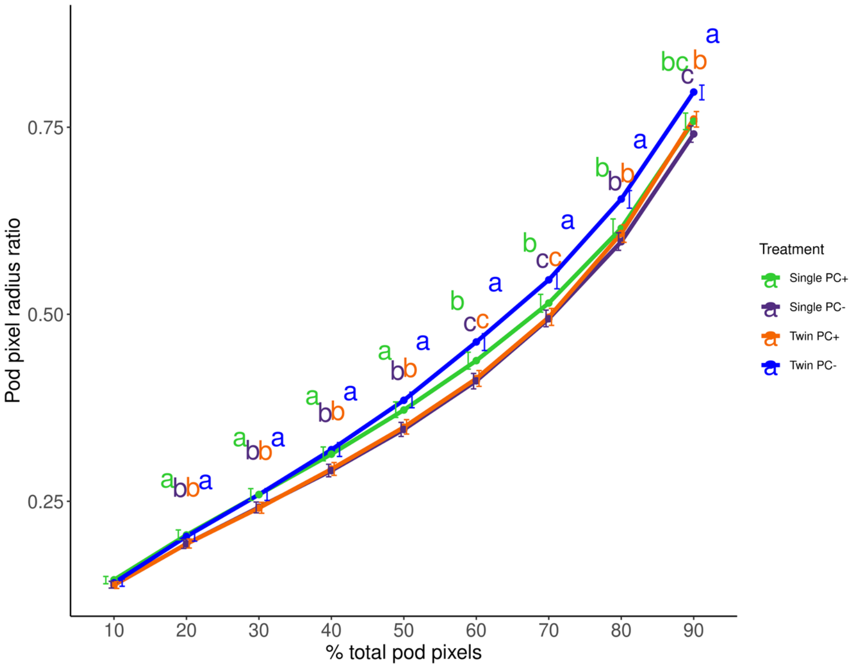

Figure 3. Influence of row planting pattern and prohexadione calcium (PC) application ("+" = applied, "-" = not applied) on the ratio of radii corresponding to % pod pixels : radii of total pixels among pooled later maturing cultivars. Estimated means at the same % total pod pixels followed by different letters are significantly different according to the method of Benjamini-Hochberg at α = 0.10.

Pod yield was greater in twin row versus single row planted plots at P = 0.0018. Plots treated with prohexadione calcium overall yielded significantly less than untreated plots (4427 vs. 4594 kg/ha, respectively, P = 0.0865). The interaction of cultivar, row pattern and prohexadione calcium application was significant at P = 0.0774. FloRun 331 planted in twin rows without prohexadione calcium yielded significantly greater than single rows with or without prohexadione calcium application, whereas Georgia-16HO planted in twin rows with or without prohexadione calcium application or single rows without prohexadione calcium yielded greater than corresponding single rows treated with prohexadione calcium (Table 7). Individual year results and results combined across years and locations can be found in Table 7.

At EREC in 2022, plots without prohexadione calcium treatment had a greater percentage of TSMK compared to those receiving prohexadione calcium (70 vs. 68% respectively, P = 0.0942). Conversely, both at EREC in 2021 and across the pooled data, there were no significant differences in TSMK observed among treatments. Nevertheless, twin row plots tended to have a slightly higher TSMK than single rows, as was observed in the early maturing group. At EREC in 2021, plots without prohexadione calcium had greater economic value than treated plots ($1410 vs. $1306 per hectare, respectively, at P = 0.0909). In contrast, in 2022 prohexadione calcium application was not significant regarding economic return at P = 0.2287. In 2022, single row planting pattern had a greater economic return when compared to twin rows ($1649 vs. $1565 per hectare, respectively, at P = 0.0675). When economic return values were combined across years, treatment effects did not significantly influence value.

Pod OBB maturity was negatively correlated with examined temperature variables (ρ = ~ -0.7 and ~ -0.6), positively correlated with main stem heights (ρ = 0.71 and 0.64), and somewhat positively correlated with pod radius ratios (ρ = 0.18 to 0.37) for both FloRun 331 and Georgia-16HO. Maturity was also somewhat positively correlated with pod yield for Georgia-16HO (ρ = 0.34). Main stem heights were negatively correlated with examined temperature variables and somewhat positively correlated with pod radius ratios and yield (Table 8). Increased temperatures were somewhat associated with a decrease in pod radius ratios for Georgia-16HO, though this was not consistent among FloRun 331 data. FloRun 331 pod yield was also somewhat positively correlated with pod radius ratios and TSMK (ρ = 0.2 to 0.4). When cultivar × row pattern × prohexadione calcium application level data were pooled across maturity group experiments, correlation coefficients of main stem heights with pod yield were significantly and negatively related to main stem height at the rate of -0.039 (P = 0.0008) (concordance correlation coefficient = 0.62; Figure 4).

Table 7. Influence of row pattern and prohexadione calcium application on pod yield (kg/ha) from later maturing cultivars from experiments conducted in 2021 and 2022 at the Edisto Research and Education Center (EREC) and the Pee Dee Research and Education Center (PDREC).

Cultivar	Row pattern	PC[a]	EREC 2021[b]	EREC 2022	PDREC 2021	PDREC 2022	Combined
FloRun 331	Single	-	5858	6000	3341 b	3210	4422 b
		+	5889	5983	3424 ab	2952	4385 b
	Twin	-	6249	5833	4077 a	3619	4838 a
		+	6009	5771	3860 ab	3393	4636 ab
Georgia-16HO	Single	-	5275	6222	3998 a	3164	4553 a
		+	5213	6102	2887 b	2952	4087 b
	Twin	-	5748	6090	3442 ab	3623	4576 a
		+	5106	6534	3929 a	3426	4625 a
Pooled	Single	Pooled	4951	5421	3033 b	3453 b	4358 b
	Twin		5141	5397	3407 a	3956 a	4667 a
Pooled	Pooled	-	5150	5384	3301	3827 a	4594 a
		+	4943	5434	3130	3570 b	4427 b

[a] PC = prohexadione calcium, "+" indicates treatments with PC application, "-" indicates treatments without PC application.

[b] Means within a column followed by the same letter are not significantly different according to Fisher's protected-LSD at $\alpha = 0.10$. Where not pooled, mean separations were performed within each cultivar.

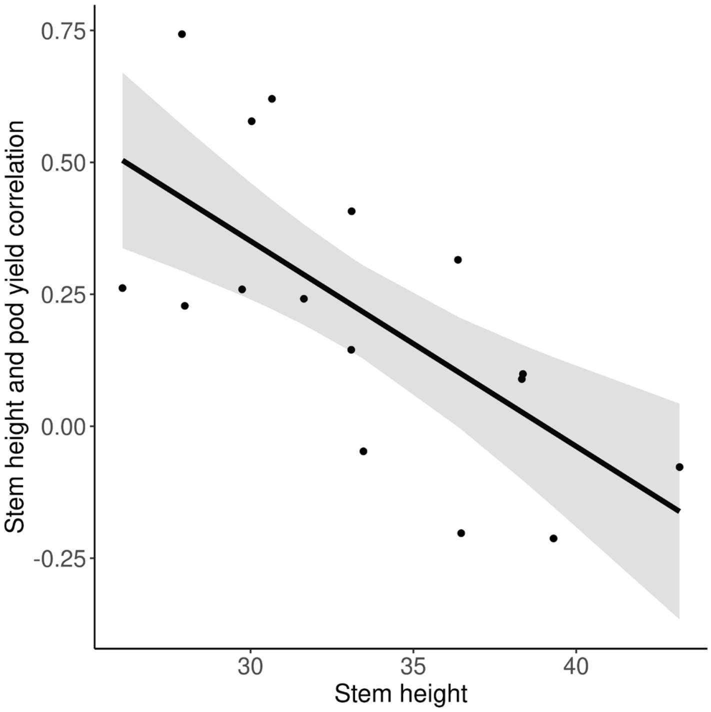

Figure 4. Linear regression plot of cultivar × row pattern × prohexadione calcium application Spearman correlation coefficients of main stem height with pod yield as predicted by corresponding average main stem heights (cm). Slope = -0.039 (P = 0.0008); intercept = 1.52 (P = 0.0001); concordance correlation coefficient = 0.62. The shaded band is the estimated 90% confidence interval.

On-Farm Trials

At Orangeburg County in 2021, plots without prohexadione calcium had a greater percentage of OBB pods than corresponding plots with growth regulator treatment (75 vs. 67%, respectively, P = 0.0209). Conversely, plots with prohexadione calcium yielded significantly greater than untreated plots (5715 vs. 4857 kg/ha, respectively, P = 0.0168; corresponding treatment total plot area yield was 7760 and 6820 kg/ha). In 2022 at on-farm trials in Bamberg County, no significant differences in percentage of OBB pods were observed between treatments (P = 0.8773).

DISCUSSION

The goal of this work was to evaluate the combined and independent effects of row planting pattern and prohexadione calcium application on the growth, maturity development and pod distribution of newer peanut cultivars that have recently been commercially planted in South Carolina. Corroborating earlier reports (Culbreath *et al.*, 2008; Tillman *et al.*, 2006), twin row planted stands typically exhibited less TSW incidence than single row planted stands.

Results from these experiments showed canopy architecture of both runner type and Virginia type peanut treated with prohexadione calcium to have consistently exhibited a more triangular shape than untreated peanut regardless of cultivar, year, or row planting pattern. This corroborated earlier studies that reported the change in canopy architecture following prohexadione calcium application at 50% row closure (Beam *et al.*, 2002; Culpepper *et al.*, 1997; Faircloth *et al.*, 2005; Jordan *et al.*, 2004, 2008, 2009; Mitchem *et al.*, 1996; Studstill *et al*; 2020). Results of this experiment also supported previous reports that two applications of prohexadione calcium at 0.75× the label rate was efficient at significantly reducing main stem growth and increasing row visibility (Studstill *et al.*, 2020). Results additionally detailed prohexadione calcium to have varying effects on canopy temperature. Among Virginia cultivar single rows and Georgia-06G twin rows, prohexadione calcium treatment reduced ground temperature (i.e., through increased shading). In those cases, this was not associated with a parallel significant effect on yield across the pooled data, though the Virginia cultivar yields exhibited a trend of being higher for treatments with cooler ground temperature with this having been more prominent at EREC in 2021. With respect to collective FloRun 331 and Georgia-16HO row patterns and Georgia-06G single rows, prohexadione calcium was conversely linked to increased ground temperatures. Although it is yet to be mechanistically determined as to the cause of the differing results among examined cultivars, which may or may not be related to unmeasured canopy architecture or density effects and subsequent modifications to balances of shading and insulation efficacies, within the FloRun 331 and Georgia-16HO data, the increased yields seen among some treatments in the absence of prohexadione calcium application may be a result of their correspondingly cooler ground temperatures. Results from the correlation analysis (and furthermore, the correlation-regression analysis) support temperature effects on pod yield as having varied by cultivar canopy size. Georgia-06G and Georgia-16HO overall exhibited smaller canopies than FloRun 331 and stronger positive correlations between main stem height and pod yield; this helps to explain their negative correlations between canopy temperature and yield having been significant whereas it was not significant for FloRun 331. Similarly, Virginia cultivars exhibited the largest canopies where main stem heights were no longer significantly correlated with pod yield; Virginia cultivars in turn were the only ones examined where canopy temperature was significantly yet slightly positively correlated with pod yield. Overall, plots planted in twin rows exhibited cooler daytime ground temperatures compared to single rows. While measuring pollen viability was not part of the scope of this study, the cooler overall temperatures and reduced proportion of days with maximum daytime canopy ground temperature > 36 C (e.g., as twin row planting increased main stem height which was in turn correlated with decreased temperatures) created a less stressful environment for fertilization and subsequent peg and pod development (Ketring 1984).

Table 8. Spearman correlation coefficients of variable[a] measurements for FloRun 331 (above the diagonal) and Georgia-16HO (below the diagonal).

	OBB[b]	Temp	Tmax36p	Sh	ratio50	ratio60	ratio70	TSMK	Yield
OBB		-0.72 *** (92)	-0.71 *** (92)	0.71 *** (160)	0.37 *** (140)	0.20 ** (140)	0.18 ** (140)	0.06 (160)	-0.02 (160)
Temp	-0.62 *** (96)		0.95 *** (136)	-0.53 *** (136)	0.20 * (72)	0.09 (72)	0.03 (72)	0.03 (92)	0.13 (136)
Tmax36p	-0.60 *** (96)	0.97 *** (137)		-0.64 *** (136)	0.25 ** (72)	0.16 (72)	0.13 (72)	0.14 (92)	0.08 (136)
Sh	0.64 *** (160)	-0.59 *** (136)	-0.62 *** (136)		0.47 *** (140)	0.34 *** (140)	0.33 *** (140)	0.13 (160)	0.22 *** (232)
ratio50	0.29 *** (140)	-0.24 ** (76)	-0.26 ** (76)	0.29 *** (140)		0.91 *** (140)	0.83 *** (140)	0.12 (140)	0.34 *** (140)
ratio60	0.26 *** (140)	-0.26 ** (76)	-0.27 ** (76)	0.29 *** (140)	0.96 *** (140)		0.93 *** (140)	0.18 ** (140)	0.39 *** (140)
ratio70	0.21 ** (140)	-0.26 ** (76)	-0.24 ** (76)	0.25 *** (140)	0.83 *** (140)	0.92 *** (140)		0.06 (140)	0.28 *** (140)
TSMK	-0.17 ** (160)	-0.11 (96)	-0.12 (96)	-0.15 * (160)	-0.10 (140)	-0.07 (140)	-0.10 (140)		0.21 *** (160)
Yield	0.34 *** (160)	-0.16 * (136)	-0.22 *** (136)	0.40 *** (232)	0.10 (140)	0.11 * (140)	0.16 * (140)	0.12 (160)	

[a] OBB = % orange, brown, or black pod maturity; Temp = average daytime canopy ground temperature; Tmax36p = proportion of days with maximum daytime canopy ground temperature > 36 C; Sh = main stem height; ratio50-70 = proportion of total pod pixel radius represented by the radius corresponding to 50%, 60%, or 70% of pod pixels; TSMK = % total sound mature kernels; Yield = pod yield (kg/ha).

[b] * = P < 0.1, ** = P < 0.05, *** = P < 0.01. Numbers in parentheses = n.

Twin row planting was associated with a greater amount of yield, % OBB and % TSMK. Twin row planting was greater in economic return when compared to single rows in the earlier maturing group. In the later maturing group, however, no significant difference in economic return was seen between twin and single row plots. The later maturing runner cultivars used, FloRun 331 and Georgia-16HO, have larger and bushier canopies than Georgia-06G, the runner cultivar used in the earlier maturing group. Thus, it is interesting that yield improvements were not observed for these cultivars when planted in twin rows in the presence of prohexadione calcium application.

In the small plot experiments (i.e., plot length = 30.5 m), prohexadione calcium application was not associated with a significant difference in yield in the earlier maturing group but generally resulted in a significant yield reduction in the later maturing experiment with pooled results showing a loss of 170 kg/ha following application. Conversely, in 2021 at the large on-farm experiment, prohexadione calcium application increased yield by 770 kg/ha. Studstill *et al.* (2020) reported a similar relationship in which prohexadione calcium treated small plots (~5.5 to 11 m in length) did not show significant yield differences, but large treated plots (~155 to 455 m in length) yielded significantly greater than untreated plots. While the plot size selected and used in the research plots of this study were intermediate in length according to the plot length groups reported by Studstill *et al.* (2020), they were closer in size to small plots than large plots. Multiple studies have found the influence of prohexadione calcium on yield to be inconsistent and cultivar dependent (Beam *et al.*, 2002; Faircloth *et al.*, 2005; Jordan *et al.*, 2008, 2009), but reports have varied or not been explicit on the mechanism as to why this happens. Beam *et al.* (2002) reported up to 4% decrease in pod loss upon inversion in single row plots treated with prohexadione calcium when compared to untreated single rows, which they surmised was due to the gynophores being more strongly attached to the pod and axillary branch of the peanut. When single rows of Georgia-16HO were treated with prohexadione calcium, yield was significantly reduced, indicating that if prohexadione calcium does make gynophore attachment stronger, that is plausibly a cultivar-dependent effect.

Based on this research, both twin row planting pattern and prohexadione calcium independently influenced peanut to set pods significantly closer to the taproot, with results varying by cultivar group. Ortiz *et al.* (2013) reported that for every two centimeters a tractor operator deviates off the row center, yield losses of up to 186 kg/ha can be expected. If the rows are easier to distinguish and pods are located more centrally to the taproot, the yield increases associated with prohexadione calcium may simply or in part be due to greater digging and/or inversion efficiency. The pod distribution data presented is novel and contributes informative measurements, and the use of ratios allowed pod concentrations among varying total pod set areas to be compared. Unsurprisingly, the difference in pod pixel radius ratios for twins compared to singles (~3% for Georgia-06G or Virginia cultivars overall and ~2% for FloRun 331 or Georgia-16HO treated with prohexadione calcium) was less than the difference in intra-row seed spacing based on planter settings (i.e., single rows at 19 seed/m compared to 11.5 seed/m per individual twin corresponding to ~65% greater seed density among single rows). This was to be expected, as areas of pod set naturally extend beyond the point of sowing and subsequent taproot. Measuring pod distribution characteristics serves as an additional tool to characterize pod distribution effects and relationships in future studies. Furthermore, profiling pod distribution ratios across the range of pod set area allows for greater capture and examination of treatment responses (i.e., as opposed to examining differences or distributions at a single [relative] distance from the taproot).

Prohexadione calcium had variable effects on the percentage of TSMK, similar to previous reports (Beam *et al.*, 2002; Culpepper *et al.*, 1997; Mitchem *et al.*, 1996; Monfort *et al.*, 2021). Results from maturity samples indicated prohexadione calcium only caused a significant gain in % OBB pods in conjunction with twin row planting for the later maturing FloRun 331 and Georgia-16HO. Whereas this effect was not observed among the Virginia cultivar data in the present study, it was so reported for Virginia cultivars in single rows by Culpepper *et al.* (1997). This discrepancy may be explained by the different sample collection methods in how Culpepper *et al.*'s (1997) samples were obtained after mechanical inversion whereas those in the present study were manually collected via gently digging. The difference in approaches corresponds to sampling pods produced and available in the ground at the time of collection (manual digging) or only those available and retained on the plant following mechanical inversion, which is more aggressive. As a result, samples collected from mechanically prepared windrows would be subject to varying levels of interference from canopy-associated resistance as affected by examined treatments (i.e., prohexadione calcium application reduces main stem height which could contribute to less digger-related pod loss). In addition to twin planting overall, pod maturity of FloRun 331 or Georgia-16HO treated with prohexadione calcium was associated with greater pod maturity at 133, 141 to 147, and 158 DAP than at the same timings when prohexadione calcium was not applied, with this being significant at 133 DAP. Though the combining of 141 and 147 DAP sample timings from 2021 and 2022, respectively, facilitated comparison of interpretable groupings across independent years, it is possible the difference may have reduced the ability to detect a shorter yet viable length of time where treatments could have contributed maturity levels not different from later-assessed values (e.g., 7 days compared to the subsequent approximation of 11 days). Nevertheless, while corresponding benefits of prohexadione calcium application did not consistently translate over to improved yield for these two runner cultivars from the available (small plot) data, more importantly across cultivars, twin row planting with prohexadione calcium treatment did not result in decreased yields, and it moreover increased yield on the large on-farm test.

Based on results from this work, development of pod maturity was overall improved through the use of twin row planting for the three examined runner cultivars and its combined use with prohexadione calcium for FloRun 331 and Georgia-16HO. Maturity of Virginia cultivars was not significantly improved with examined treatments, although their twins were numerically more mature than corresponding singles. While the increased maturity seen among select treatments for runner cultivars (i.e., + ~6% for FloRun 331 or Georgia-16HO twins with prohexadione calcium or for Georgia-06G twins) was significant and thus represents improved maturity development, this would not be anticipated to automatically result in a ready reduction of a fungicide application toward the end of the growing season. Rates of pod maturity development prior to relative optimal economic value reported by Anco *et al.* (2024) translate the estimated magnitude of increased treatment maturity (e.g., 6%) as representing a time savings of approximately 5 days. Even so, any time potentially saved is potentially able to contribute to the possibility of reducing the need for such a fungicide application and, more importantly, an earlier harvest, as late-season application and harvest decisions depend on a variety of factors not limited to environmental conditions, cultivar susceptibility to diseases, canopy health, present and impending weather conditions, and logistical constraints (Anco *et al.* 2020, 2024; Jordan *et al.* 2016, 2019, 2024). Favorably contributing to the reduced-risk nature of such treatments with a potential for improved maturity is their innate compatibility with producer and practitioner capabilities to examine fields for pod maturity in evaluating digging decisions (Anco *et al.* 2024).

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