Row Pattern and Seeding Rate Effects on Agronomic, Disease, and Economic Factors in Large-Seeded Runner Peanut

R. Scott Tubbs[1]*, John P. Beasley, Jr[1], Albert K. Culbreath[2], Robert C. Kemerait[2], Nathan B. Smith[3], and Amanda R. Smith[3]

ABSTRACT

Recent peanut cultivar releases are trending to a larger seed size, but have great resistance to tomato spotted wilt virus (TSWV). Larger-seeded cultivars cost more to plant than smaller at an equivalent population. Reduced seeding rates could save growers on seed costs and impede the spread of southern stem rot, but can reduce plant stands which can lower yields and increase TSWV incidence. Therefore, the objectives of this experiment were to compare seven peanut cultivars (Georgia Green, Georgia-06G, AT 3085RO, Florida-07, Tifguard, AP-3, and Georgia-03L) in single and twin row patterns at three seeding rates (17, 20, and 23 seed/m) on a sandy loam soil at Plains, GA for disease incidence, agronomic, and economic performance. Measured variables included yield and grade, plant height and stand, TSWV and southern stem rot incidence, and adjusted net revenue in 2008 and 2009. Twin rows outperformed single rows whenever differences occurred. The only factors consistently affected by reducing seeding rate were plant height and stand, both decreased at the lowest seeding rate. There was a trend toward lower yields (approximately 6% reduction) at the 17 seed/m rate in twin row pattern, although net returns were not diminished compared to the higher seeding rates since lower seed costs offset yield reductions. The cultivars Georgia-06G and Florida-07 had the highest yield and adjusted net revenue among the seven cultivars in both years. Tifguard and Georgia Green had lowest overall yields and would not be preferred cultivars in sandy loam soils. This study demonstrates that twin rows have higher yield, plant stands, and net revenue, plus reduced TSWV incidence than single row pattern, and a reduction in seeding rate to 17 seed/m can be made without serious risk of lost revenue. However, benefits of reducing seeding rate in twin rows were not as pronounced as they were for single rows, and exhibited a greater potential for lower yield. A grower planting in single rows would likely have the most to gain from planting fewer seed, especially under heavy southern stem rot pressure, but planting in twin rows would still be a preferred option over single rows.

Key Words: grade, TSWV, southern stem rot, white mold, single-row, twin-row, cultivar.

There are numerous variables that can be manipulated in peanut (*Arachis hypogaea* L.) production to save a grower on costs. However, it can be risky when standard production practices are altered. Aside from pesticides, the greatest variable cost in peanut production is seed (Smith and Smith, 2010). Peanut is planted on a population or density basis (University of Georgia [UGA] Extension recommendation = 19.7 seed/m of row; typical row spacing = 91 cm; standard plant population = 215,000 seed/ha) (Baldwin, 1997), but is sold by weight instead of quantity, therefore seed size plays a significant role in determining cost to plant. From the 1970s to the 2000s, the cultivars Florunner (Norden *et al.*, 1969) and Georgia Green (Branch, 1996) dominated U.S. runner peanut hectares. However, recent cultivar releases are trending to a much larger seed size than the previous standards, but also have much greater levels of resistance to *Tomato spotted wilt tospovirus* (TSWV). Reducing plant population (as a result of reduced seeding rates) leads to an increased risk of TSWV (Branch *et al.*, 2003; Gorbet and Shokes, 1994; Wehtje *et al.*, 1994), but in turn negatively affects the spread of southern stem rot (caused by *Sclerotium rolfsii* Sacc.) (Black *et al.*, 2001; Wehtje *et al.*, 1994). Southern stem rot has been the most important disease in peanut since 2008, as losses to TSWV have decreased to an estimated 0.25%, the lowest level since 1990 (Kemerait *et al.*, 2011). Thus, a reduction in seeding rate may be beneficial in order to reduce severity of southern stem rot, while tolerating a slightly elevated risk of TSWV.

It is important to only plant the amount of seed necessary for obtaining a satisfactory plant stand. Recommendations from UGA are for a final stand of 13 plants/m of row (Kemerait *et al.*, 2011). Planting excessive seed is a waste of resources for several reasons. Plants will compete with each other

[1]Dept. of Crop and Soil Sciences, University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793-0748.
[2]Dept. of Plant Pathology, University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793-0748.
[3]Dept. of Agricultural and Applied Economics, University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793-0748.
*Corresponding author: R.S. Tubbs (Email: tubbs@uga.edu)
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for water, light, and physical space (Humphrey and Schupp, 2000). Planting more seed than optimal will not always result in an increased stand since stronger plants will out-compete weaker ones causing them to eventually die. Dense plant stands also hold a double negative impact with respect to controlling the spread of southern stem rot. Since the fungus spreads down the row affecting adjacent plants, having plants spaced closer together results in rapid movement down the row. Dense stands also have a tendency to grow more erect than prostrate, which impedes the ability to target fungicides down to the base of the plant and soil surface, where southern stem rot is more problematic. When TSWV was not a factor, previous studies indicate that yield potential reaches a plateau and is not improved with a greater plant stand beyond a certain point (Minton and Csinos, 1986; Wehtje *et al.*, 1994).

Selection of row pattern can also influence incidence of diseases and yield for peanut. Studies have reported a decreased incidence of southern stem rot in twin rows compared to single rows (Minton and Csinos, 1986; Sconyers *et al.*, 2007). Likewise, TSWV occurs less frequently in twin than in single rows (Brown *et al.*, 2003; Culbreath *et al.*, 2008; Tillman *et al.*, 2006). In addition, experiments have also reported yield advantages in twin versus single rows (Culbreath *et al.*, 2008; Lanier *et al.*, 2004; Nuti *et al.*, 2008; Sorensen *et al.*, 2004; Tillman *et al.*, 2006; Wehtje *et al.*, 1984).

Because of the shift in seed size among the currently available peanut cultivars, their increased resistance to TSWV, the overall reduced severity of TSWV in the southeastern U.S., and increased relative losses to southern stem rot in recent years, evaluating seeding rates in peanut is once again necessary to minimize disease impact and maximize production and profitability. In addition, the majority of seeding rate assessments in the southeastern U.S. have occurred on soils classified as a sand. Therefore, the objectives of this experiment were to compare large-seeded runner peanut cultivars in single and twin row patterns at multiple seeding rates to assess disease incidence, agronomic, and economic performance in a Greenville sandy loam (fine, kaolinitic, thermic Rhodic Kandiudults) (USDA-NRCS, 2010).

Materials and Methods

Irrigated field trials were conducted at the UGA Southwest Georgia Research and Education Center in Plains, GA in 2008 and 2009. A four replication split-split plot design was used each year with a main plot effect of two row patterns (single vs. twin rows); a sub-plot effect of three seeding rates (single row equivalents of 17, 20, and 23 seed/m of row; or 34, 40, and 46 seed/m of bed regardless of row pattern); and a sub-sub-plot effect of seven peanut cultivars [Georgia Green, Georgia-06G (Branch, 2007), AT 3085RO, Florida-07 (Gorbet and Tillman, 2009), Tifguard (Holbrook *et al.*, 2008), AP-3 (Gorbet, 2007), and Georgia-03L (Branch, 2004)]. Individual sub-sub-plots consisted of one standard 182 cm wide peanut bed with either two single rows spaced 91 cm apart, or two pair of twin rows with outer rows spaced 91 cm apart and inner rows spaced 56 cm apart. Plot lengths were 12.2 m.

Fields were limed and fertilized based on UGA soil test recommendations (Plank *et al.*, 2001). Conventional deep-tillage and bedding (disk harrow, moldboard plow, and rotary tiller) occurred prior to planting. Plots were planted on 20 May 2008 and 13 May 2009. In 2008, a six spray fungicide regime was used including chlorothalonil (Bravo Weather Stik, Syngenta Crop Protection, Greensboro, NC) (1.8 L/ha per application) on 23 June and 16 Sept. 2008, and applications of prothioconazole + tebuconazole (Provost 433 SC, Bayer CropScience LP, Research Triangle Park, NC) (0.58 L/ha per application) on 21 July, 4 and 18 Aug., and 1 Sept. 2008. A similar spray program was used in 2009, with the same rates of chlorothalonil being applied on 17 June and 9 Sept. 2009, but one additional application of prothioconazole + tebuconazole at the same rates, which occurred on 2, 16, and 31 July, and 14 and 27 Aug. 2009. All fungicide applications were made with a Hahn boom sprayer (Hahn Application Products LLC, Evansville, IN) using 190 L/ha at a pressure of 0.21 MPa through 8003 flat fan nozzles. Phorate (Thimet 20G, AMVAC Chemical Corp., Los Angeles, CA) was applied in-furrow at planting at 1.12 kg a.i./ha for thrips control. Labeled rates of herbicides were applied based on UGA Extension recommendations to control weeds (Prostko, 2009). Irrigation was supplied on an as needed basis to meet crop needs. A total of 13 cm of water in 2008 and 14 cm water in 2009 were applied through overhead irrigation over the course of each respective season to supplement rainfall. Peanuts were inverted based on optimum pod maturity (Williams and Drexler, 1981) on 6 Oct. 2008 and 28 Sept. 2009, respectively. Plots were harvested on 16 Oct. 2008 and 2 Oct. 2009, respectively.

Plant height data were collected by placing a meter stick at the soil surface level immediately adjacent to the plant crown, then determining mean maximized height of three consecutive plants. This was done in either five (2008) or six (2009) random locations within each plot, then calculating average plant height. These data were collected at approximately

Table 1. Average seed count[a] and weight of seed needed to plant each cultivar at University of Georgia (UGA) Extension recommended rate of 19.7 seed/m of row.

	2008		2009		Mean	
Cultivar	seed/kg	kg/ha	seed/kg	kg/ha	seed/kg	kg/ha
Florida-07	1379	156	1345	160	1362	158
Tifguard	1476	146	1354	159	1415	152
Georgia-06G	1452	148	1413	152	1433	150
Georgia-03L	1561	138	1403	153	1482	145
AT 3085RO	1571	137	1438	150	1504	143
AP-3	1677	128	1580	136	1628	132
Georgia Green	1856	116	1733	124	1794	120

[a]average seed values based on UGA Statewide Variety Testing Program (Day *et al.*, 2008, 2009).

the R8 growth stage (Boote, 1982) when maximized plant height had occurred. Plant stands were evaluated after peanut inversion by counting the number of taproots within a 1.5 m length of row. A random section of each plot was selected and both rows (or both pairs of twin rows) were counted to average number of plants per meter of row.

Incidence of TSWV was visually measured less than 1 wk prior to digging (Culbreath *et al.*, 1997), and southern stem rot was measured within 24 hr after digging (Rodriguez-Kabana *et al.*, 1975), by counting the number of 30.5 cm sections of row that had a symptomatic plant for each respective disease, and data were converted to percentage incidence based upon total row length. Peanut yields were adjusted to 7% moisture for uniformity of comparisons and graded according to USDA-AMS grade standards (USDA-AMS, 1997). Grade data included percent total sound mature kernels (TSMK), percent other kernels (OK), and percent foreign material (FM).

For economic analyses, cost data were based on the 2009 Peanut Enterprise Budgets for South Georgia (Smith and Smith, 2009), using seed costs of $1.76/kg in 2008 and $1.87/kg in 2009. Discounts for FM only occurred when exceeding 5%. Price was based on the $0.391/kg loan rate adjusted for grade (USDA-FSA, 2009). Price is defined as $P = \$5.348 * TSMK + \$1.543 * OK - ((FM - 4) * 1.102)$ where P is the price ($/ha) for treatment and for quality factors $TSMK$, OK, and FM. Adjusted net revenue (ANR) was calculated as $ANR = Y * (P - M) - (S - R - D)$ where Y is yield (kg/ha), P is price ($/ha), M is marketing costs (e.g. checkoff funding) ($/ha), S is seed cost ($/ha), R is costs for repair, equipment, labor, and fuel ($/ha), and D is drying costs ($/ha).

All data were subjected to analysis of variance using PROC GLIMMIX in SAS 9.2 (SAS Institute, 2009) and pooled where appropriate. Means were separated according to pair-wise t-tests.

Results and Discussion

Cultivars. When compared to the most recent industry standard cultivar of Georgia Green, the seed of the other cultivars evaluated in this test are larger, as evidenced by 10–24% fewer seed/kg and a 10–30% increase in seed weight to plant an equivalent area (Table 1) (Day *et al.*, 2008, 2009). Thus, any of these cultivars cost more to plant than Georgia Green at an equivalent seeding rate or plant population. At a representative seed price for these years of $1.76/kg, all of the cultivars in this trial (with the exception of AP-3) would cost approximately $40–67/ha more to plant than Georgia Green, if planted at the rate of 19.7 seed/m of row.

Yields of all cultivars were outstanding in both years of this test, greatly exceeding state yield averages (Table 2). Despite higher seed cost to plant, there were improved yields for Georgia-06G and Florida-07 in both years of this experiment ranging from 8–23% higher than Georgia Green at equivalent seeding rates. Florida-07 and AP-3 had the lowest grade [total sound mature kernels (TSMK)], but when adjusting net revenue for fixed and variable costs, Florida-07 still ranked among the highest in adjusted net revenue in both years along with Georgia-06G. This resulted in an improved profit potential as much as 15% over Georgia Green, thus more than compensating for the higher seed cost.

Georgia Green and Tifguard were among the lowest ranking cultivars for yield in both years, and Tifguard ranked among the lowest in net revenue both years, resulting in an 8% loss in revenue compared to Georgia Green in 2009 (Table 2). Tifguard has been reported to not yield as well in heavier soils (Day *et al.*, 2008, 2009). Although it was not a specific objective at the initiation of this experiment, there have been concerns of peg-stem strength of Tifguard causing some growers not to choose this cultivar. Observations from this experiment may offer some preliminary information to

Table 2. Yield, disease, adjusted net revenue, and grade of peanut cultivars.

Cultivar	2008 Yield[a]	2008 TSWV[b]	2008 Revenue[c]	2009 Yield	2009 TSWV	2009 Revenue	2008–2009 TSMK[d]
	kg/ha	%	$/ha	kg/ha	%	$/ha	%
Florida-07	6079 ab[e]	4.4 b	1833 ab	5609 a	13.4 bc	1681 a	65.1 de
Tifguard	5762 bc	4.1 b	1826 ab	4446 c	18.6 b	1345 c	68.1 b
Georgia-06G	6407 a	4.1 b	2011 a	5370 a	13.6 bc	1663 a	69.2 a
Georgia-03L	5639 c	9.9 a	1728 b	5083 b	12.5 c	1512 b	65.6 d
AT 3085RO	6160 a	4.4 b	1914 ab	4999 b	15.8 bc	1506 b	66.7 c
AP-3	5613 c	5.0 b	1710 b	4926 b	15.6 bc	1461 b	64.7 e
Georgia Green	5631 c	10.6 a	1830 ab	4562 c	27.7 a	1455 b	68.0 b
SE[f]	± 173	± 1.3	± 108	± 142	± 2.7	± 57	± 0.4

[a]Pod yield data pooled over row pattern and seeding rate.
[b]TSWV = tomato spotted wilt virus. Data are pooled over row pattern and seeding rate.
[c]Adjusted net revenue data pooled over row pattern, and seeding rate.
[d]TSMK = total sound mature kernels. Data are pooled over year, row pattern, and seeding rate.
[e]Means within a column followed by the same letter are not significantly different at $P=0.05$.
[f]SE = standard error of the mean.

address this topic. There is some evidence that the peg-stem strength of Tifguard is not as strong as Georgia-06G (C.C. Holbrook, pers. commun., 2010; Nuti *et al.*, 2010). Based on this information, we speculate that greater pod shed occurred with Tifguard in this trial, leaving more pods in the soil at digging. However, pod losses have not been observed in coarser, sandier soils where Tifguard has shown equivalent yield to Georgia-06G and/or Florida-07 in multiple trials (J.P. Beasley, unpubl. data, 2009; Culbreath *et al.*, 2008; Day *et al.*, 2008, 2009; R.C. Nuti, pers. commun.; R.S. Tubbs, unpubl. data, 2009). More research is needed to validate peg-strength and digging interactions of Tifguard in various soil types, especially heavier clay-fraction soils. Yet, based on the results of this trial and others (Day *et al.* 2008, 2009), Tifguard does not appear to be an optimal cultivar selection in the finer-textured soils of the peanut belt, unless peanut root-knot nematode (*Meloidogyne arenaria*) populations are present (Holbrook *et al.*, 2008) and should be reserved for planting in coarser soils where it has had more competitive results. Most published research on peanut production has been conducted on the more common loamy sand soils of the Coastal Plain region, but the sandy loam soil type used in this research is still characteristic of many peanut producing areas in the southeast and is often under-evaluated. Research results conducted on sandier soils will not always directly transfer to loamy soils and can lead to inappropriate recommendations to rectify production issues for growers in those areas. Thus, more research is needed on loamy textured soils to support growers with these soil types and to verify production factors that are universal compared to ones that are more microclimate specific.

Incidence of TSWV was relatively low in 2008 and low-moderate in 2009. Some differences in cultivar susceptibility were observed in each year. Most of the included large-seeded runner cultivars have greater yield potential and are less susceptible to TSWV than Georgia Green (Tables 2 and 3). Our results corroborate previous reports that the greater the potential for TSWV incidence, the greater the yield advantage of resistant cultivars such as AP-3, Georgia-03L, and Florida-07 compared to Georgia Green (Culbreath *et al.*, 2008). The TSWV incidence in this trial was consistently about three times greater in 2009 than in 2008 for most cultivars. When compared to Georgia Green, AP-3 and Georgia-03L improved from an equivalent yield with lighter TSWV pressure, to an 8% and 11% yield improvement under heavier TSWV incidence, respectively. In addition, Florida-07 went from an 8% yield advantage with lighter TSWV pressure to a 23% yield advantage under heavier incidence.

Southern stem rot incidence was relatively low (4.6% or less) in all cultivars when pooled across all other variables (Table 3), which is primarily attributed to the use of effective fungicide programs. However, disease incidence was twice as high for AP-3 when compared to most of the other large-seeded cultivars in this trial, despite the fact that it has good to excellent resistance to this disease (Gorbet, 2007). This cultivar is taller than the others, and had among the densest plant stand in both years (Table 3). Since it characteristically has a more erect growth habit and more prominent mainstem than most runner cultivars, the taller canopy and thicker stand likely caused more fungicide interception by the upper canopy in comparison to the other cultivars, preventing the

Table 3. Plant height, final plant stand, and southern stem rot incidence of peanut cultivars.

Cultivar	2008		2009		2008–2009
	Height[a]	Stand	Height[b]	Stand	SSR[c]
	cm	plants/m	cm	plants/m	%
Florida-07	29.8 d[d]	12.3 c	32.4 d	13.2 bcd	1.7 cd
Tifguard	25.2 e	12.6 c	29.1 e	12.9 cd	1.3 d
Georgia-06G	29.3 d	14.3 ab	35.5 c	12.2 d	1.8 cd
Georgia-03L	32.4 b	13.3 bc	38.5 b	12.7 cd	2.8 bc
AT 3085RO	31.3 c	13.9 ab	38.1 b	14.0 ab	2.3 cd
AP-3	34.6 a	14.2 ab	42.8 a	15.0 a	4.6 a
Georgia Green	29.2 d	14.4 a	38.4 b	13.6 bc	4.0 ab
SE[e]	± 0.4	± 0.5	± 0.9	± 0.5	± 0.6

[a]2008 height data taken only from single row plots, pooled over seeding rate.
[b]2009 height pooled over row pattern and seeding rate.
[c]SSR = southern stem rot. Data are pooled over year, row pattern, and seeding rate.
[d]Means within a column followed by the same letter are not significantly different at $P=0.05$.
[e]SE = standard error of the mean.

product from reaching the base of the plant where it could impede the spread of southern stem rot.

Tifguard has a more prostrate growth habit, and had the shortest canopy height and a final plant stand that was among the sparsest of all evaluated cultivars. These factors may have contributed to a very low southern stem rot incidence for Tifguard, despite not being known as a southern stem rot resistant cultivar (Holbrook *et al.*, 2008).

Row Pattern. In 2008, twin rows provided a 10% yield advantage over single rows, and resulted in a 50% decrease in TSWV compared to the single row pattern (Table 4). There was also an approximate 25% improvement in stand in favor of twin rows in 2008. Since seed are spaced much closer together in a single row pattern, it often results in greater plant mortality as there is more intra-row competition for space, light, water, and nutrients than in the twin row pattern, where seed are spread out with more room to grow and explore the soil profile for resources needed to survive (Hauser and Buchanan, 1981; Mozingo and Steele, 1989; Wehtje *et al.*, 1984). This argument is further defended with the 2009 data, as twin rows were 25–38% greater in final stand than single rows, regardless of seeding rate (Table 5). Despite statistical interactions between row pattern and seeding rate in 2009 for yield and plant height as well, the twin row pattern always had a better outcome than single rows whenever differences occurred.

No statistical differences were observed for grade or southern stem rot incidence in this test related to row patterns. However, the trend for all other measured variables, regardless of whether there was an interaction or not, resulted in advantages with the twin row pattern. This includes net revenue increases as high as 21% by using twin rows instead of single rows (Table 6). Our results agree with other research findings where yield and/or a reduction in disease incidence were improved by utilizing the twin row pattern (Baldwin *et al.*, 2001; Brown *et al.*, 2003; Culbreath *et al.*, 2008; Lanier *et al.*, 2004; Nuti *et al.*, 2008; Sconyers *et al.*, 2007; Sorensen *et al.*, 2004; Tillman *et al.*, 2006; Wehtje *et al.*, 1984).

Seeding Rate. Based on the seed sizes provided (Table 1), and using a representative seed price of \$1.76/kg, a grower could save approximately \$39–46/ha in seed cost from reducing the seeding rate by 3 seed/m. However, there were several row pattern × seeding rate interactions which influenced results and recommendations for seeding rates depending on whether single or twin row patterns were used. Although there was no statistical difference for yield among seeding rates in 2008 ($P\leq0.05$) (Table 4), there was a 6–8% increase in yield at the high seeding rate in the twin row pattern in 2009 (Table 5). Yet, even in 2008, a similar trend was observed for a row pattern × seeding rate interaction at $P\leq0.10$ (data not presented) where there was no yield difference among seeding rates in single rows, but a 6% decrease in yield at the lowest seeding rate (5958 kg/ha) compared to 20 seed/m in twin row pattern (6370 kg/ha). This was not the case for grade, as the middle seeding rate graded lower than the other two seeding rates (Table 4). Adjusted net revenue resulted in similar trends to yield, although the reduced seeding rate did not have diminished returns compared to the other seeding rates regardless of row pattern (Table 6). Thus, the lower seed cost offset any reduction in yield that may have occurred, especially related to twin row pattern where there were trends toward better yields at the higher seeding rates.

Table 4. Yield, disease incidence, plant height, final plant stand, and grade for row pattern and seeding rate effects.

	2008				2009	2008–2009	
	Yield	TSWV[a]	Height[b]	Stand	TSWV	TSMK[c]	SSR[d]
Row pattern[e]	kg/ha	%	cm	plants/m	%	%	%
Single	5620 b	8.0 a	-	12.0 b	18.0 a	66.7 a	2.9 a
Twin	6178 a	4.2 b	-	15.1 a	15.4 a	66.8 a	2.4 a
SE[f]	± 93	± 0.7		± 0.3	± 1.4	± 0.2	± 0.3
Seeding rate[g]							
17 seed/m	5787 A	7.1 A	35.2 B	12.7 B	17.6 A	67.0 A	2.3 A
20 seed/m	5937 A	5.8 AB	37.0 A	13.8 A	16.0 A	66.3 B	3.1 A
23 seed/m	5973 A	5.2 B	36.9 A	14.2 A	16.6 A	67.0 A	2.5 A
SE[g]	± 113	± 0.9	± 0.6	± 0.3	± 1.8	± 0.3	± 0.4

[a]TSWV = tomato spotted wilt virus.

[b]2008 height data taken only from single row plots, pooled over cultivar.

[c]TSMK = total sound mature kernels.

[d]SSR = southern stem rot.

[e]Data pooled over seeding rate and cultivar. Means within a column followed by the same lowercase letter are not significantly different at $P=0.05$.

[f]SE = standard error of the mean.

[g]Data pooled over row pattern and cultivar. Means within a column followed by the same uppercase letter are not significantly different at $P=0.05$.

There were significant differences in plant height and stand among seeding rates in both years (Table 4 and 5). The lowest seeding rate resulted in a 3–7% shorter canopy, and a 4–16% reduction in final plant stand compared to the other seeding rates, although plant height differences among seeding rates were more pronounced in single row pattern while stand differences were more pronounced in twin rows. However, final stand was close to the UGA Extension recommendation for an optimum stand of 13 plants/m for all seeding rate data except for the single row pattern interaction in 2009 (Table 5). A shorter canopy and thinner stand could improve deposition of fungicides through the vegetative canopy to the crown of the plant where it will be most effective.

Severity of southern stem rot was low in this trial, and there were no seeding rate differences at $P\leq0.05$. Although, as with yield, there was a row pattern × seeding rate interaction at $P\leq0.10$ (data not shown), in which there were no differences in southern stem rot incidence in twin rows, but there was nearly half as much southern stem rot in single rows at the reduced seeding rate (2.8%) than at the UGA Extension recommended rate (5.4%). Reports of seeding rate's effect on southern stem rot are mixed, with no differences reported at reduced levels of irrigation (Black *et al.*, 2001), nor with fungicide applications of azoxystrobin (Sconyers *et al.*, 2007). However, a greater incidence of southern stem rot has been reported at higher seeding rates when heavily irrigated (Black *et al.*, 2001) and when not treated with azoxystrobin (Sconyers *et al.*, 2007), and also when averaged over several planter-types (Wehtje *et al.*, 1994). Yet, the reverse relationship is often the case between plant stand and TSWV. In this study, higher seeding rates resulted in reduced TSWV incidence in 2008, which would be the expected trend and agrees with previous research (Branch *et al.,* 2003; Wehtje *et al.,*1994). However, several other

Table 5. Yield, plant height, and final plant stand for row pattern and seeding rate interaction, 2009.

	Yield		Height		Final Stand	
Seeding rate[a]	Single	Twin	Single	Twin	Single	Twin
	kg/ha		cm		plants/m	
17 seed/m	4814 A b	5091 B a	30.1 C a	28.8 B b	10.9 B b	13.6 B a
20 seed/m	4899 A a	5004 B a	31.1 B a	29.7 A b	11.4 AB b	15.7 A a
23 seed/m	4772 A b	5417 A a	32.5 A a	29.3 AB b	12.3 A b	16.3 A a
SE[b]	± 132		± 0.4		± 0.5	

[a]Data pooled over cultivar. Means within a column followed by the same uppercase letter are not significantly different at $P=0.05$. Means within a row for any given variable followed by the same lowercase letter are not significantly different at $P=0.05$.

[b]SE = standard error of the mean.

Table 6. Adjusted net revenue for row pattern and seeding rate interaction.

Seeding rate[a]	2008		2009	
	Single	Twin	Single	Twin
	$/ha		$/ha	
17 seed/m	1804 A a	1869 AB a	1504 A a	1581 AB a
20 seed/m	1684 A b	2043 A a	1491 A a	1513 B a
23 seed/m	1787 A a	1830 B a	1422 A b	1633 A a
SE[b]	± 100		± 49	

[a]Data pooled over cultivar. Means within a column followed by the same uppercase letter are not significantly different at $P=0.05$. Means comparing row patterns for any given year followed by the same lowercase letter are not significantly different at $P=0.05$.
[b]SE = standard error of the mean.

experiments did not observe a decreased risk to TSWV at higher seeding rates (Black *et al.*, 2001; Sconyers *et al.*, 2007), which is what was observed in our 2009 data. Tillman *et al.* (2006) likewise reported no differences in yield or TSWV at seeding densities equivalent to those in this test, but did observe greater TSWV incidence at a greatly reduced seeding rate (13 seed/m of row).

Summary and Conclusions

From this study, reducing seeding rate to 17 seed/m is feasible without major concern of decreased yield, net revenue, or influence on southern stem rot or TSWV in single row pattern. There were some trends that demonstrated less pronounced benefits from a reduced seeding rate when using twin rows. The twin row pattern outperformed single rows for nearly all analyzed variables. Thus, for a grower with twin row planting capabilities, a reduction in seeding rate may reduce costs, but it could potentially come at the expense of lost yield potential based on our results. Since plants in a twin row pattern would be spread further apart compared to a single row pattern at the same plant density, the negative impacts of TSWV and southern stem rot are already minimized, so a reduction in seeding rate should not have as large of an impact as it would in a single row pattern, especially when planting resistant cultivars. However, a grower that only has access to single row planting equipment will be able to capitalize on a reduction in seed cost and incidence of southern stem rot (especially in heavy pressure situations) with only minor implications on TSWV occurrence, while not sacrificing yield or revenue potential. There is a greater risk of a below optimum plant stand if seeding rate is reduced in single rows, which could be more detrimental to yield in years with heavy TSWV pressure. Therefore, when planting in reduced seeding rate situations, it is imperative that cultivars with strong TSWV resistance must be planted (Tillman *et al.*, 2006). Based on the results from our research, there were no adverse effects on yield or revenue by reducing seeding rate in the single row pattern to 17 seed/m.

The majority of runner peanut hectares in the U.S. were planted with Georgia-06G, Florida-07, and Tifguard in 2010, and will again constitute the majority of hectares in 2011. Thus, it is important for growers to assess the primary factors that will affect their operation, such as pest pressures and soil type. Georgia-06G and Florida-07 performed well in the sandy loam soil from this experiment, but Tifguard did not perform as well on this soil type as it has in the loamy sand soils that make up a larger percentage of peanut production areas. Georgia Green has not kept pace with the yield potential and TSWV-resistance available in more recent cultivar releases, including in this experiment. Thus, Georgia Green is anticipated to be grown on very few hectares commercially in the future.

Growers will gain the most out of reduced seeding rates when planting large-seeded cultivars in single row patterns in situations where heavy southern stem rot inoculum could be present, such as in field situations with a history of the disease. However, the row pattern effect appears to be a more critical factor than seeding rate for maximizing production and profitability. Additional research is needed to evaluate seeding rate effects in more detail for both single and twin row patterns on more cultivars and in other soil types characteristic of the peanut belt.

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