Evaluating Plant Population and Replant Method Effects on Peanut Planted in Twin Rows

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ABSTRACT

Achieving and maintaining an adequate plant stand is a major priority when making planting and early season management decisions in peanut (*Arachis hypogaea* L.). Unpredictable and often extreme weather and high disease pressure in the southeastern United States can contribute to poor emergence and below-optimum plant stands. When plant stand is affected, replanting may be agronomically justified. This study was designed to determine i) the effect of plant stand on pod yield, market grade, and disease incidence in peanut seeded in a twin row pattern, (ii) if replanting is a viable option in a field with a below adequate stand and, iii) the best method for replanting peanut when an adequate stand is not achieved. Field trials were established at two locations in south Georgia in 2012 and 2013 to evaluate peanut production at four plant stands (7.4, 9.8, 12.3, and 14.8 plants/m [total plants/m across both units, or 'twins' of the twin row pattern) and four replant methods (no replant, destroy the original stand and replant at a full seeding rate, add a reduced rate of seed to supplement the original stand with a single row between the original rows, and supplement with two additional rows with one between and the other next to the original rows). Replanting occurred when the stand had been established, an average of 24 days after initial planting. Pod yield at a stand of 12.3 plants/m was 6.6 and 5.8% greater than at a stand of 7.4 and 9.8 plants/m, respectively, with no benefit from increasing plant stand beyond 12.3 plants/m. Market grade was also maximized at 12.3 plants/m. Disease incidence was unaffected by plant stand. Yield was increased by supplementing an initial stand of 9.8 plants/m in both a single additional row and in two additional rows by 8.3 and 6.6%, respectively. A full replant of the original stand always resulted in lower yield, while grade was slightly increased in the full replant treatment. While an initial stand of 12.3 plants/m was needed in order to maintain yield potential, replanting via supplemental seed addition can recover lost yield at stands below this level.

Key Words: Grade, plant stand, seed, stem rot, total sound mature kernels, tomato spotted wilt virus, TSMK, white mold.

There are multiple factors that a producer must consider, normally in a very short time window, when deciding whether or not to replant a peanut field with a below-optimum plant stand. The decision whether or not to replant is a difficult one to make because while poor plant stands often result in reduced pod yield and loss of revenue (Sorensen et al., 2004; Sconyers et al., 2007; Culbreath et al., 2011), replanting may lead to an economic disadvantage if costs to replant exceed the economic benefits of added yield (Sternitzke et al., 2000).

Although research is lacking on replant decisions in peanut, there are numerous studies that have reported reasons why seeds and seedlings may not survive and why plant stands may be adversely affected as a result. These stand limiting factors include soilborne pathogens (Sullivan, 1984), herbicides (Grey et al., 2001; Burke et al., 2002; Murphree et al., 2003; Grichar et al., 2004), mechanical issues at planting (Tubbs and Sarver, 2013), and improper seed nutrition, production and processing practices (Dickens and Khalsa, 1967; Bell, 1969, Sullivan et al., 1974, McLean and Sullivan, 1981; Dey et al., 1999).

While less-than-adequate plant stands may occur and replant decisions need to be made across all planting regimes, this study evaluates these scenarios in peanut seeded in a twin row pattern due to this pattern's ubiquity in southeast peanut production. The yield benefits of a twin row planting pattern have been widely researched and published (Wehtje et al., 1984; Colvin et al., 1985; Lanier et al., 2004; Sorensen et al., 2007; Tubbs et al., 2011). Research has shown that a myriad of reasons including improved disease control, improved weed suppression, shortened time to full

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ground cover, and improved light interception can be credited for this reported yield advantage.

Previous research shows that a portion of the yield increase in twin rows compared to single rows is likely due to the reduction in pressure of common peanut diseases including Tomato spotted wilt *Tospovirus* (TSWV) (Brown et al., 2005; Tillman et al., 2006; Culbreath et al., 2008) and stem rot, caused by the fungus *Sclerotium rolfsii*, (Minton and Csinos, 1986, Sorensen et al., 2004; Sconyers et al., 2007). Market grade has also been shown to increase in twin rows when compared to single rows (Mozingo and Coffelt, 1984; Sorensen et al., 2004; Sorensen et al., 2007 Nuti et al., 2008; Sorensen and Lamb, 2009).

While little research has been completed on true plant stand in twin rows as it relates to pod yield, grade, TSWV incidence, and stem rot incidence, there have been multiple studies on seeding rates in twin rows. Tubbs et al. (2011) reported reduced pod yield in twin rows at seeding rates of 17 and 20 seeds/m when compared to a seeding rate of 23 seeds/m. While not implicitly studied, the 17 and 20 seeds/m rates resulted in plant stands of 13.6 and 15.7 plants/m, respectively, while the 23 seeds/m seeding rate corresponded to a final plant stand of 16.3 plants/m. Sorensen et al. (2004) reported no yield difference between peanut seeded in twin rows at a 20 seeds/m and a 10 seeds/m rate. Lanier et al. (2004) showed no differences between stands of 12, 8, and 4 plants/m in a narrow twin row pattern. Sconyers et al. (2007) reported increased yield at seeding rates of 17.8 and 23.0 seeds/m when compared to a seeding rate of 12.4 seeds/m. In that same study no differences in stem rot or TSWV incidence were present between those three seeding rates. Sconyers et al. (2007) also showed an increase in market grade at the medium seeding rate versus the low seeding rate in one field study, and an increase at the high seeding rate over the low seeding rate in another field study.

Because of the reported advantages, many producers have gone to twin row systems only and no longer have single-row equipment, making it exceedingly necessary to provide information on when and how to replant in this increasingly popular row-pattern, especially when previous research indicates that peanut seeded in twin rows can be negatively affected as plant stands are reduced. The inherent spacing associated with twin rows, however, could present logistical challenges when attempting to replant if only twin row planting equipment is available. There were three main objectives of this study. The first objective was to determine the minimum plant stand needed in order to maintain yield potential in peanut seeded in twin rows. The second objective was to determine at what plant stand peanut can benefit from replanting, while the third objective was to determine the optimum replanting method when the practice is warranted.

Materials and Methods

Field trials were conducted at the University of Georgia (UGA) Lang Farm and at the UGA Rigdon Farm in 2012; and at the UGA NESPAL Farm and Animal and Dairy Science (ADS) Farm in 2013. All trials took place on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudult). Land preparation at all site-years included disc-harrowing, deep-turning with a moldboard plow to a depth of 30 to 35 cm, and rotary-tilling to form beds 1.8 m wide. All fertilizer requirements and applications, including those for Ca and B, were based on UGA extension recommendations (Harris, 1997). Peanut cultivar Georgia-06G (Branch, 2007) was planted using a two-row twin row Monosem precision air planter (Monosem Inc., Edwardsville, KS) at a depth of 5 cm and in rows 12.2 m long. Outer rows of the twin row planter were set 0.91 m apart, with inner twin rows set 19.1 cm inside of the outer row units. All plants stands and seeding rates are listed as totals across these two 'twins' that combine to form the row. Seeds were treated with azoxystrobin, fludioxonil, and mefenoxam fungicide seed treatment.

Trials were arranged in a three by four factorial with three plant stands (7.4, 9.8, and 12.3 plants/m) and four replant options in a randomized complete block design with four replications. Replant treatments included:

1. Retain the initial plant stand and do not replant (four total rows per 1.8 m bed).
2. Retain the original stand and supplement with additional seed at a reduced rate between the original twin rows using only one hopper per set of twins on the planter unit (resulting in six total rows per 1.8 m bed after replanting).
3. Retain the original stand and supplement with additional seed at a reduced rate using all hoppers (resulting in eight total rows per 1.8 m bed after replanting).
4. Burn down (destroy) the original plant stand with glufosinate herbicide (0.656 kg a.i./ha) upon full crop emergence and replant at the full 20.3 seeds/m seeding rate.

In treatments 2 and 3, the planter units were moved 9.5 cm to the side of the original rows so that one unit in each row of the twin row

Table 1. Initial plant stands, actual final plant stands, and replanting rates for supplemental replant treatments for peanut seeded in twin rows.

Target initial stand (plants/m)[a]	Actual final stand (plants/m)[b]	Actual final stand (plants/ha)[c]	Replant rate (seeds/m)[d]	Replant rate (seeds/ha)[e]
7.4	7.6 ± 0.3	83,114 ± 3,423	14.4	157,480
9.8	9.2 ± 0.3	100,612 ± 2,811	10.2	111,549
12.3	12.2 ± 0.3	133,421 ± 3,740	4.9	53,587

[a]Plants per meter of row immediately after hand-thinning to target stand.

[b]Plants per meter of row counted after plant inversion ± standard error.

[c]Plants per hectare based on post-inversion plants/m counts.

[d]Replant rate was either in a single unit or split between two units on the twin row planter depending on treatment. When added in a single unit, the entire quantity was seeded via that unit. When added via two units, seed was split evenly between units for a total addition at the rates listed.

[e]Replant rate as seeds/ha.

configuration was directly between the original rows and the other unit was 9.5 cm to the opposite side of the original rows. Seed was added at the rates listed in Table 1. In treatment 2, seed was added only to those units running between the original rows. All supplemental seed from Table 1 was added in those units. For treatment 3, seed was supplemented via all planter units; both in between and outside of the original rows. Supplemental seed rates listed in Table 1 were divided between two units for each row. In treatment 4, the original stand was sprayed with glufosinate herbicide (656 g a.i./ha) upon full plant emergence and was immediately replanted at a full 20.3 seeds/m seeding rate. A non-replanted control plot of the UGA recommended 14.8 plants/m was also included. All plots were initially planted at 20.3 seeds/m and upon full emergence were thinned by hand to the desired plant stands. To hand thin, all plants within the row were counted and then plants were removed until the desired number of plants per row was achieved. While plant-to-plant spacing was not exact, it was generally consistent. Replanting occurred at full crop emergence. Planting and replanting dates for each site-year are listed in Table 2. The duration between planting and replanting was 26 days at both locations in 2012 and 21 days in 2013. Fungicide applications were made based on guidelines provided by the high risk model of the Peanut Disease Risk Index (Kemerait et al., 2012) and were initiated at the beginning of flowering of the initial planting.

Each plot was evaluated for pod yield and grade [total sound mature kernels (% TSMK)]. Tomato spotted wilt virus incidence was rated in both trials in 2012 and the NESPAL field in 2013. Ratings for TSWV were conducted on 17 September at both locations in 2012 and on 29 September at the NESPAL Farm in 2013. Stem rot incidence was rated in both trials in 2012 and the ADS field in 2013 immediately following inversion of the peanut plants. Peanut maturity was determined at each site-year using the hull scrape maturity profile method (Williams and Drexler, 1981). There were three inversion and three harvest dates for each site-year (Table 2). All peanuts receiving the no-replant treatments were inverted and harvested earlier than those receiving the supplemental treatment, with those that were destroyed and completely replanted at the full seeding rate inverted and harvested last. Peanuts were inverted using a two-row KMC digger-shaker-inverter and harvested using a two-row Lilliston peanut combine. Final plant stand was determined immediately after inversion. For the purpose of discussion, stands will be referred to according to their hand-thinned target stand. Final plant stands for all hand-thinned plots can be found in Table 1. Yield was adjusted to 7% moisture. Peanuts were graded by the USDA Federal-State Inspection Service in Tifton, GA (Davidson et al., 1982).

Statistical analyses were performed using PROC MIXED in SAS 9.3. Data were analyzed by analysis of variance and differences among least square means were determined using multiple pairwise t-tests (α=0.05). Plant stand and replant treatment were treated as fixed effects, while site-years, replications, and interactions with these factors were treated as random effects. For the purpose of determining plant stand effects on pod yield, TSWV, stem rot, and grade, non-replanted plots were analyzed separately. Because site-year by plant stand interactions were not detected for any of the factors measured, data were analyzed and reported combined over site-years. For the purpose of determining replant treatment and replant treatment by plant stand effects, all data were initially analyzed combined over all years and locations. Because plant stand by replant treatment interactions were present, replant treatment effects

Table 2. Inversion and harvest dates for all trial sites in 2012 and 2013.

Treatment	Field practice	Lang 2012	Rigdon 2012	NESPAL 2013	Animal/Dairy Science 2013
All Treatments	Initial Planting	4-May	4-May	9-May	9-May
Supplemental and Complete Replant Treatments	Replanting	30-May	30-May	30-May	30-May
No-Replant Treatments	Inversion	17-Sep	17-Sep	30-Sep	1-Oct
	Harvest	24-Sep	24-Sep	3-Oct	4-Oct
Supplemental Replant Treatments	Inversion	28-Sep	28-Sep	14-Oct	14-Oct
	Harvest	9-Oct	9-Oct	24-Oct	24-Oct
Complete Replant Treatment	Inversion	10-Oct	10-Oct	24-Oct	24-Oct
	Harvest	15-Oct	15-Oct	30-Oct	31-Oct

are reported for each plant stand separately. While there were interactions between site-year and replant treatment, there were no site-year by plant stand by replant treatment interactions. There is little value to site-year by replant treatment interaction alone, as replant treatment was shown to be dependent on initial plant stand. As a result of a lack of three-way interaction, plant stand by replant treatment data are reported combined over site-years.

Results and Discussion

Plant Stand

Peanut pod yield was significantly affected by plant stand (Table 3). A minimum of 12.3 plants/m were required in order to maintain yield potential (Table 4). No yield benefit was observed when increasing plant stands to 14.7 plants/m, while yields were reduced at all stands below 12.3 plants/m. When compared to a stand of 12.3 plants/m, reductions to 9.8 and 7.4 plants/m resulted in pod yield losses of 5.8 and 6.6%, respectively. Although data is limited on plant stand effects on pod yield in peanut seeded in twin rows, Lanier et al. (2004) reported no differences in yield between stands of 4, 8, and 12 plants/m using four Virginia-type peanut cultivars. While overall plant stands tested were higher, Tubbs et al. (2011) reported a similar effect in twin rows, with a plant stand of 16.3 plants/m producing higher yields than stands of 15.7 and 13.6 plants/m across seven Runner-type cultivars.

Table 3. Analysis of Variance for site-year, plant stand, and their interactions for pod yield, grade, tomato spotted wilt virus (TSWV), and stem rot across four site-years in Georgia.

Source[a]	Pod yield	Grade	TSWV	Stem rot
	Pr > F			
Site-Year (SY)	0.5642	0.0001	0.0021	0.0021
Plant Stand (PS)	0.0364	0.0078	0.2765	0.5659
SY*PS	0.9082	0.9024	0.5325	0.0531

[a]Analysis only includes data from non-replanted plots in order to determine the true effect of plant population

Peanut grade was also affected by plant stand. Similar to pod yield, the highest grade value was observed at 12.3 plants/m. Grades at 12.3 plants/m were not higher than those at 9.8 plants/m, but they were higher than grades at both 7.4 and 14.7 plants/m, respectively. A general increase in grade from 7.4 to 12.3 plants/m without an increase at 14.7 plants/m was similar to trends observed in one study by Sconyers et al. (2007), who reported an increase in grade from 12.5 to 17.4 seeds/m without an increase when seeding rate was upped to 22.6 seeds/m in one study. Numerous other studies support increased grade at increased stand (Cox and Reed, 1965; Mozingo and Coffelt, 1984; Sorensen et al., 2004; Wynne et al., 1974). Tomato spotted wilt virus and stem rot incidence were unaffected by plant stand. While results generally trend toward reduced TSWV and elevated stem rot at higher populations, this is not always the case. Sconyers et al. (2007) found no differences in TSWV or stem rot incidence in naturally-infected fields between seeding rates of 12.5, 17.4, and 22.6 seeds/m. In that study, average TSWV and stem rot incidence were 1.1% and 8.2%, respectively. In our study TSWV and stem rot incidence were 5.1% and 4.2%, respectively. The lack of population effect in both their study and ours is likely due at least in part to these overall low levels of incidence.

Replant Treatment

The interaction of plant stand and replant treatment for yield indicates that the optimum replant treatment is dependent on initial plant stand (Table 5). Yield increases were achieved through replanting only at 9.8 plants/m (Table 6), where supplemental planting provided an 8.3% (when replanting with one hopper) and 6.6% (when replanting with both hoppers) pod yield increase when compared to not replanting. At all

Table 4. Peanut pod yield, grade, tomato spotted wilt virus incidence (TSWV), and stem rot incidence at four plant stands across four site-years in Georgia.

Target plant stand	Actual final plant stand	Pod yield	Grade	TSWV	Stem rot
Plants/m	Plants/m[b]	kg/ha	% TSMK	–% Infection–	
7.4	7.6 ± 0.3	6455 c[c]	75.4 c	6.4	4.4
9.8	9.2 ± 0.3	6511 bc	76.2 ab	3.7	4.2
12.3	12.2 ± 0.3	6911 a	76.8 a	6.0	5.3
14.7	13.9 ± 0.5	6852 ab	75.6 bc	4.2	3.0
	SE[a]	± 176.0	± 0.3	± 1.5	± 1.7

[a]Standard error of the mean

[b]Actual final plant stands ± standard error.

[c]Means within a column followed by the same letter are not significantly different according to pairwise t-tests at $\alpha = 0.05$.

initial plant stands, destroying the initial stand and completely replanting resulted in a yield loss when compared to both not replanting and supplemental addition.

Averaged across plant stands, grade was higher for the complete replant treatment (77.5%) than both the no replant (76.0%) and supplemental (75.4%) treatments. These results are different than those reported by Kvien and Bergmark (1987), who found that market grade was reduced at later versus earlier planting dates. There was no difference between the latter two treatments. The grade advantage for the complete replant treatment in this experiment was likely due to the complete replant treatment consisting of plants at only a single planting date and at an optimum stand. All plots receiving a supplemental replant treatment contained plants from two distinct planting dates, and as a result two distinct maturity trajectories. While the plots that were not replanted contained only those plants from a single planting date, results were across plant stands, which, as mentioned previously, have been shown to affect market grade. Neither TSWV nor stem rot were affected by replant treatment or the interaction of replant treatment and plant stand. While planting date has been shown to affect both TSWV (Brown et al., 1996, 2005; Tillman et al., 2007) and stem rot (Brenneman and Hadden, 1996; Hagan et al. 2001; Bowen, 2003), low overall pressure from both diseases was likely part of the reason why there were no significant differences between treatments in this study. Minimal TSWV infection was likely due, at least in part, to the use of cultivar Georgia-06G, which shows high resistance to the disease (Branch, 2007).

Table 5. Analysis of Variance for replant treatment, plant stand, site-year, and their interactions for pod yield, grade, tomato spotted wilt virus (TSWV), and stem rot across four site-years in Georgia.

Source	Pod yield	Grade	TSWV	Stem rot
	——Pr > F——			
Site-Year (SY)	0.0952	0.0538	0.0774	0.0040
Replant Treatment (RT)	0.0101	0.0235	0.5674	0.8239
Plant Stand (PS)	0.3771	0.0734	0.0696	0.6384
SY*RT	0.0021	0.0037	0.2402	0.0904
SY*PS	0.5474	0.6602	0.9873	0.0887
RT*PS	0.0486	0.2561	0.4881	0.4527
SY*RT*PS	0.9384	0.8858	0.4662	0.2883

Summary and Conclusions

The results from these trials illustrate the importance of establishing an adequate plant stand from the initial planting, as results indicated that a minimum stand of 12.3 plants/m is needed in order to maintain yield potential. Fortunately for growers, there are replanting options that can increase yield potential if stands are below 12.3 plants/m. Yield increases were observed at an initial 9.8 plants/m stand, meaning that a grower can make up for lost yield at sub-optimum plant stand through supplemental seed addition. Destroying the initial stand and completely replanting was never a viable option when compared to either the non-replanted or supplemental replant treatments. While those completely replanted plots were not limited by season length and were harvested separate from the other treatments according to maturity determination via the hull scrape method, the later planting date associated with the complete replant treatment likely contributed to reduced yield. Initial planting dates ranged from 4 May to 9 May, with an average date of 7 May; while replant date was always 30 May. The yield reduction at the later planting date was consistent with McKeown et al. (2001) and Beasley (2013), who reported decreased yield for peanut planted in late-May and June versus peanut planted in mid-May.

An initial concern when implementing the trials was the question of when to harvest those plots that receive the supplemental replant treatments, and as a result had plants from two different planting dates maturing at different times. Along with yield, grade was a production factor of notable concern in this replant scenario considering varying peanuts at varying maturities would be present within the field. This concern was not warranted according to the results, as grade was not reduced when plots were supplemented when compared to those that were not replanted (data

Table 6. Peanut pod yield and final plant stand as influenced by replant method at three target initial plant stands in peanuts planted in twin rows across four site-years in Georgia.

	Target plant stand (plants/m of row)					
	7.4		9.8		12.3	
Replant method	Yield	Actual final stand	Yield	Actual final stand	Yield	Actual final stand
	kg/ha	Plants/m[c]	kg/ha	Plants/m	kg/ha	Plants/m
None	6455 a[a]	7.6 ± 0.3	6511 b	9.2 ± 0.3	6911 a	12.2 ± 0.3
Complete	5894 b	15.4 ± 0.9	5817 c	15.2 ± 0.5	5905 b	16.4 ± 0.8
Supplement one hopper	6766 a	13.8 ± 0.7	7052 a	13.5 ± 0.7	7195 a	14.4 ± 0.6
Supplement two hoppers	6888 a	15.4 ± 0.6	6939 a	13.9 ± 0.6	6516 ab	14.5 ± 0.4
SE[b]	± 255		± 113		± 311	

[a]Means within a column followed by the same letter are not significantly different according to pairwise t-tests at $\alpha = 0.05$.
[b]standard error of the mean
[c]Actual final plant stand ± standard error.

not shown). While there was a 2.3% reduction in grade when compared to the complete replant treatment, this positive impact is not great enough to offset the yield disadvantage observed when completely replanting.

When considering the entirety of the results, a primary recommendation to peanut growers would be to do everything possible to ensure an adequate initial plant stand, which in this study was a minimum of 12.3 plants/m and based on historical UGA recommendations is 14.7 plants/m. Replanting should not be considered at plants stands of 12.3 plants/m and above. Based on these data, replanting was agronomically warranted at 9.8 plants/m. If the decision is made to replant, the best option is to supplement the initial stand with a reduced seeding rate rather than destroying the initial stand and completely replanting, as the latter option is likely to reduce yield, even at low initial stands. We chose a reduced rate of 10.2 seeds/m, in hopes that after stand losses and competition with the initial stand, half of the seed would become viable plants, giving a final stand of the UGA recommended 14.7 plants/m. A grower should also take into consideration yields achieved at below optimum plant stands. If a grower is unable to replant because of adverse field conditions, proper management of a below-optimum stand can still produce a worthwhile peanut crop. Because TSWV and stem rot were unaffected and grade was negligibly affected by replant method, pod yield should be the deciding agronomic factor when making replant decisions. Additional research is still needed to determine optimum supplemental replanting seeding rates and timing of inversion for maximized production in a replant scenario with two different maturities growing together.

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